FINAL PROGRAM

MUSCULOSKELETAL TUMOR SOCIETY

Hyatt Regency San Francisco
San Francisco, California
OCTOBER 3-5, 2013
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Educational Goals and Objectives

At the conclusion of this CME activity, the attendee should be able to:

1. Understand and better manage common aseptic, septic, and other complications that are encountered by limb salvage patients.
2. Cite recent progress in basic and translational research as it relates to the care of the orthopaedic oncologic patient.
3. Be familiar with existing and emerging technologic advances in the care of the amputee patient, including the fields of osseointegration, prosthetics, and rehabilitation.
4. Identify new approaches for targeted therapy in the areas of medical and radiation oncology for the field of musculoskeletal oncology.
5. Discuss ongoing humanitarian and collaborative efforts directed towards improving patient health and outcomes.
6. Formulate a differential diagnosis for bone and soft tissue tumors and tumor-like conditions based upon clinical, radiologic, and pathologic information.
**EXECUTIVE COMMITTEE**

President .............................................................. John H. Healey, MD, FACS  
President-Elect .......................................................... Kristy L. Weber, MD  
Secretary ............................................................... Richard M. Terek, MD  
Treasurer ............................................................... Theodore W. Parsons III, MD, FACS  
Immediate Past President ............................................... Edward Y. Cheng, MD  
Past President ........................................................... Richard D. Lackman, MD  
Education Committee Chair ........................................... Joseph Benevenia, MD  
Research Committee Chair ............................................ R. Lor Randall, MD, FACS  
Membership Committee Chair .......................................... Douglas J. McDonald, MD

<table>
<thead>
<tr>
<th>Hosts – Annual Meetings</th>
<th>Chairs and Co-Chair – Specialty Day</th>
</tr>
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<tbody>
<tr>
<td>2013 – San Francisco, CA</td>
<td>2014 – New Orleans, LA</td>
</tr>
<tr>
<td>Richard J. O’Donnell, MD</td>
<td>Robert H. Quinn, MD, Chair</td>
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<tr>
<td>Program Chair</td>
<td>Michelle A. Ghert, MD, Co-Chair</td>
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<td>Co-Chair - TBD</td>
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<tr>
<th>2013 ANNUAL MEETING PROGRAM COMMITTEE</th>
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<tr>
<td>Raffi Avedian, MD</td>
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<tr>
<td>John H. Healey, MD, FACS</td>
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<td>Valerae O. Lewis, MD</td>
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<td>David G. Mohler, MD</td>
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<td>Richard J. O’Donnell, MD</td>
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<td>Christian M. Ogilvie, MD</td>
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<td>R. Lor Randall, MD, FACS</td>
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<td>Peter S. Rose, MD</td>
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<td>Robert L. Satcher, MD</td>
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<td>Rosanna Wustrack, MD</td>
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<tr>
<th>EDUCATION COMMITTEE</th>
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<tr>
<td>Joseph Benevenia, MD, Chair</td>
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<tr>
<td>Megan E. Anderson, MD</td>
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<td>B. Hudson Berrey, MD</td>
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<td>C. Douglas Letson, MD</td>
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<td>Joel L. Mayerson, MD</td>
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<td>Richard L. McGough, MD</td>
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<td>Kevin A. Raskin, MD</td>
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<td>Douglas J. McDonald, MD, Chair</td>
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<td>Joseph H. Schwab, MD</td>
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<td>R. Lor Randall, MD, FACS, Chair</td>
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<tr>
<td>Benjamin Miller, MD</td>
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<td>Francis Y. Lee, MD, PhD</td>
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<td>Bang H. Hoang, MD</td>
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<td>Michelle A. Ghert, MD</td>
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<td>Robert E. Turcotte, MD</td>
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<td>John P. Heiner, MD, Chair</td>
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<td>Richard D. Lackman, MD</td>
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<td>Howard G. Rosenthal, MD</td>
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<td>Michael J. Joyce, MD</td>
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<tr>
<td>Robert H. Quinn, MD, Chair</td>
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<td>H. Thomas Temple, MD</td>
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<td>Kurt Weiss, MD</td>
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<th>BOS REPRESENTATIVES</th>
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<tr>
<td>John H. Healey, MD, FACS</td>
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<tr>
<td>Edward Y. Cheng, MD</td>
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<td>Bruce T. Rougraff, MD, Chair</td>
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<tr>
<td>Hue Luu, MD</td>
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<td>Wakenda Tyler, MD</td>
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<th>ACS REPRESENTATIVE</th>
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<tr>
<td>William G. Ward, MD</td>
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<tr>
<th>DEPUTY EDITOR, Clinical Orthopaedics and Related Research (MSTS’s Official Journal)</th>
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<tr>
<td>John H. Healey, MD, FACS</td>
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**2013 MSTS Annual Meeting**

Visit www.msts.org for more information
Dear Colleagues and Guests,

Welcome to the Annual Meeting of the Musculoskeletal Tumor Society! This year’s meeting marks the 37th MSTS gathering, and a return to San Francisco after nearly 30 years.

We trust that you will agree that the program is composed of presentations of the highest academic caliber. The MSTS Program Committee has worked hard to select 60 podium papers from amongst a record of 185 abstract submissions. In addition to discussing limb salvage advances, care of the amputee patient will be a focus, including osseointegrated transdermal prosthetic devices and other strides in rehabilitation practice. With attendees from several continents and many countries, international humanitarian and collaborative efforts for improving the care of orthopaedic oncology patients will be featured.

There will be a concurrent Allied Health Program for registered nurses, nurse practitioners, physicians’ assistants, and staff. Our very own James O. Johnston, MD, will do his best to “Stump the Professors,” who will be vying for the latest in iPad technology. Friday night will allow us the opportunity to step out on the town in one of the world’s most beautiful cities, in a season that typically offers the best climate.

Finally, we extend our thanks to all those who have made this meeting possible. We greatly appreciate the efforts of the MSTS Executive Committee and membership, the MSTS Staff, the scholars who have submitted their latest work, our visiting colleagues, and our generous sponsors.

Enjoy the Meeting!

Richard J. O’Donnell, MD
Program Chair

John H. Healey, MD, FACS
MSTS President
MSTS Annual Meeting History

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Local Hosts &amp; Program Chairs:</th>
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<tr>
<td>1977</td>
<td>Boston, MA</td>
<td>Hugh G. Watts, Henry J. Mankin</td>
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<td>1979</td>
<td>Houston, TX</td>
<td>John Murray</td>
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<tr>
<td>1980</td>
<td>Gainesville, FL</td>
<td>William F. Enneking</td>
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<tr>
<td>1981</td>
<td>Iowa City, IA</td>
<td>Michael Bonfiglio</td>
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<tr>
<td>1982</td>
<td>New York, NY</td>
<td>Joseph M. Lane</td>
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<td>1983</td>
<td>Cleveland, OH</td>
<td>John T. Makley</td>
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<tr>
<td>1984</td>
<td>Kansas City, KS</td>
<td>James R. Neff</td>
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<tr>
<td>1985</td>
<td>San Francisco, CA</td>
<td>Theodore Boville, James R. Johnston</td>
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<tr>
<td>1986</td>
<td>Bologna, Italy</td>
<td>Mario Campanacci (cancelled)</td>
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<td>1987</td>
<td>Toronto, ON</td>
<td>Fred Langer</td>
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<tr>
<td>1988</td>
<td>Minneapolis, MN</td>
<td>Roby C. Thompson</td>
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<td>1989</td>
<td>Bologna, Italy</td>
<td>Mario Campanacci</td>
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<tr>
<td>1990</td>
<td>Chicago, IL</td>
<td>Michael A. Simon</td>
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<tr>
<td>1991</td>
<td>Buffalo, NY</td>
<td>Eugene R. Mindell</td>
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<td>1992</td>
<td>Boston, MA</td>
<td>Dempsey Springfield, Henry J. Mankin, Mark C. Gebhardt</td>
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<td>1993</td>
<td>Houston, TX</td>
<td>John Murray</td>
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<td>1995</td>
<td>Florence, Italy</td>
<td>Rudolfo Campana, Dempsey S. Springfield</td>
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<td>1996</td>
<td>Seattle, WA</td>
<td>Ernest U. Conrad</td>
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<td>1997</td>
<td>Cleveland, OH</td>
<td>John C. Makley</td>
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<td>1999</td>
<td>Denver, CO</td>
<td>Ross M. Wilkins, Stephen J. Withrow</td>
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<tr>
<td>2000</td>
<td>Gainesville, FL</td>
<td>B. Hudson Berrey, William F. Enneking, Mark T. Scarborough</td>
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<td>2001</td>
<td>Baltimore, MD</td>
<td>Albert J. Aboulafia &amp; Alan M. Levine</td>
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<tr>
<td>2002</td>
<td>Toronto, ON, Canada</td>
<td>Robert S. Bell, Christopher P. Beauchamp, Norman S. Schachar, Robert E. Turcotte</td>
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<tr>
<td>2003</td>
<td>Chicago, IL</td>
<td>Terrance D. Peabody, Steven Gitelis, Robert Satcher</td>
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<tr>
<td>2004</td>
<td>Long Beach, CA</td>
<td>Jeffrey J. Eckardt, Erik N. Zeegar, J. Dominic Femino, Lawrence R. Menendez, R. Lor Randall, J. Michael Kabo</td>
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<tr>
<td>2005</td>
<td>Nashville, TN</td>
<td>Herbert S. Schwartz, Ginger E. Holt</td>
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<tr>
<td>2006</td>
<td>Key West, FL</td>
<td>Mary I. O’Connor, William G. Ward</td>
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<td>2007</td>
<td>St. Louis, MO</td>
<td>Douglas McDonald, Timothy Damron, Kristy Weber</td>
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<td>2008</td>
<td>Phoenix, AZ</td>
<td>Christopher P. Beauchamp, Bruce A. Malin, Albert Aboulafia</td>
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<td>2009</td>
<td>Boston, MA</td>
<td>Edward Y. Cheng, J. Sybil Biermann</td>
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<td>2010</td>
<td>Philadelphia, PA</td>
<td>Richard D. Lackman, Albert J. Aboulafia</td>
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<td>2011</td>
<td>Chicago, IL</td>
<td>Edward Cheng, J. Sybil Biermann, Richard Gorlick, Poul Sorenson</td>
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<tr>
<td>2012</td>
<td>Tampa, FL</td>
<td>Douglas Letson</td>
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</tbody>
</table>

Future MSTS Meetings

**2014 Specialty Day March 15, 2014**
Morial Convention Center, New Orleans, LA  
President: Kristy L. Weber, MD  
Program Chair: Robert H. Quinn, MD  
Co-Chair: Michelle A. Ghert, MD

**Annual Meeting October 9–11, 2014**
Houston, TX  
President: Kristy L. Weber, MD  
Program Chair: Valerae O. Lewis, MD

» Visit www.msts.org for more information
## MEETING AT A GLANCE

### Thursday, October 3, 2013

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
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<tr>
<td>2:00 – 5:00 pm</td>
<td>Executive Committee Meeting</td>
<td>Grand Ballroom Foyer</td>
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<tr>
<td>2:00 – 5:30 pm</td>
<td>Registration</td>
<td>Grand Ballroom Foyer, Market Street Foyer</td>
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<tr>
<td>2:00 – 5:30 pm</td>
<td>Scientific Poster Set-up</td>
<td>Grand Ballroom Foyer, Market Street Foyer</td>
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<tr>
<td>2:00 – 5:30 pm</td>
<td>Technical Exhibit Set-up</td>
<td>Grand Ballroom B–C</td>
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<tr>
<td>5:30 – 7:30 pm</td>
<td>Welcome Reception</td>
<td>Hospitality Room</td>
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<tr>
<td>2:00 – 5:30 pm</td>
<td>Technical Exhibit Set-up</td>
<td>Grand Ballroom B–C</td>
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<tr>
<td>5:00 – 7:00 pm</td>
<td>Welcome Reception</td>
<td>Hospitality Room</td>
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### Friday, October 4, 2013

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<tr>
<td>6:30 – 8:30 am</td>
<td>Continental Breakfast</td>
<td>Grand Ballroom B–C</td>
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<tr>
<td>7:00 am – 5:30 pm</td>
<td>Registration</td>
<td>Grand Ballroom Foyer</td>
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<td>7:00 am – 5:00 pm</td>
<td>Scientific Posters</td>
<td>Grand Ballroom Foyer, Market Street Foyer</td>
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<tr>
<td>7:00 am – 5:00 pm</td>
<td>Technical Exhibits</td>
<td>Grand Ballroom B–C</td>
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<tr>
<td>8:00 am – 5:00 pm</td>
<td>PA/ARNP/Allied Health Scientific Session</td>
<td>Marina Room</td>
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<tr>
<td>7:30 – 7:45 am</td>
<td>Welcome</td>
<td>Grand Ballroom A</td>
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<tr>
<td>7:45 – 10:00 am</td>
<td>Session I: Limb Salvage Aseptic Complications</td>
<td>Grand Ballroom A</td>
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<tr>
<td>10:00 – 10:20 am</td>
<td>Morning Break</td>
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<td>10:20 am – 12:00 pm</td>
<td>Session II: Limb Salvage Septic and Other Complications</td>
<td>Grand Ballroom B–C</td>
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<td>12:00 – 1:00 pm</td>
<td>Lunch</td>
<td>Grand Ballroom B–C</td>
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<td>1:00 – 3:00 pm</td>
<td>Session III: Stem Cells and Other Basic Science Frontiers</td>
<td>Grand Ballroom B–C</td>
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<td>3:00 – 3:20 pm</td>
<td>Afternoon Break</td>
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<td>3:20 – 5:30 pm</td>
<td>Session IV: Amputation, Osseo integration, Prosthetics, Rehabilitation and Quality of Life</td>
<td>Grand Ballroom B–C</td>
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<td>7:00 pm</td>
<td>Dinner</td>
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### Saturday, October 5, 2013

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<td>Continental Breakfast</td>
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<td>7:00 am – 12:00 pm</td>
<td>Registration</td>
<td>Grand Ballroom Foyer</td>
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<td>Scientific Posters</td>
<td>Grand Ballroom Foyer, Market Street Foyer</td>
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<tr>
<td>7:00 am – 12:30 pm</td>
<td>Technical Exhibits</td>
<td>Grand Ballroom B–C</td>
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<tr>
<td>6:45 – 7:30 am</td>
<td>MSTS Business Meeting; Members Only</td>
<td>Grand Ballroom A</td>
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<tr>
<td>7:30 – 9:30 am</td>
<td>Session V: Targeted Therapy in Musculoskeletal Oncology</td>
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<td>9:30 – 10:00 am</td>
<td>Morning Break</td>
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<td>10:00 am – 1:00 pm</td>
<td>Session VI: Humanitarian and Collaborative Efforts in Orthopaedics</td>
<td>Grand Ballroom B–C</td>
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<td>1:00 pm</td>
<td>Closing Remarks</td>
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GENERAL INFORMATION

Meeting
Date: October 3 – 5, 2013
Venue: Hyatt Regency San Francisco
5 Embarcadero Center,
San Francisco, California, 94111
(415) 788 – 1234
Website: www.msts.org
Program Chair: Richard J. O’Donnell, MD

Registration
The MSTS registration desk is located in the
Grand Ballroom Foyer of the Hyatt Regency
San Francisco Hotel.

Registration Fees:
Early Rate expired August 5, 2013
MSTS Member: $425
Non Member: $550
Resident/Fellow/
RN/PA/Research/
Allied Healthcare Professional $275
Welcome Reception Guest: $50

CME
This activity has been planned and implemented in
accordance with the Essential Areas and policies of
the Accreditation Council for Continuing Medical
Education through the joint sponsorship of the
American Academy of Orthopaedic Surgeons and
Musculoskeletal Tumor Society. The American
Academy of Orthopaedic Surgeons is accredited by
the ACCME to provide continuing medical education
for physicians.
The American Academy of Orthopaedic Surgeons
designates this live activity for a maximum of
13 AMA PRA Category 1 Credits™. Physicians
should claim only the credit commensurate with the
extent of their participation in the activity.

Evaluation Forms
Please return to the MSTS registration desk
(Grand Ballroom Foyer)

Certificate of Attendance
Certificates will be distributed at Registration to
all registered attendees onsite at the 2013 MSTS
Annual Meeting.

2013 MSTS Annual Meeting

Presenter Information
A technician will be available onsite Friday and
Saturday, October 4 – 5 in the Grand Ballroom A to
accept materials for the oral presentations. Presenters
are required to submit their presentation to the
技ician at least 3 hours prior to their presentation
time via USB drive. Please have the USB drive labeled
with both title and session name.

IMPORTANT: The Speaker Ready Desk is NOT
equipped with laptops and printers for review
of presentations. The technician will only accept
presentations delivered in a USB drive.

Scientific Poster Exhibition
Grand Ballroom Foyer, Market Street Foyer
Friday, October 4, 7:00 am – 5:00 pm

MSTS Technical Exhibits
Grand Ballroom B – C
Friday, October 4, 7:00 am – 5:00 pm
Saturday, October 5, 7:00 am – 12:30 pm
The MSTS Tabletop Exhibition will be held in the
Grand Ballroom B – C during all breakfasts, morning,
and afternoon refreshment breaks and luncheons.

2013 MSTS Exhibitors
Biomet
Carbofix Orthopedics, Inc.
Cura Surgical
Deupy Synthes Joint Reconstruction
DFINE, Inc.
Etex Corporation
Exactech
LifeNet Health
Merete Medical, Inc.
Musculoskeletal Transplant Foundation
Orthopaedic Research and Education Foundation
Skeletal Kinetics LLC
Stanmore Implants
Stryker Orthopaedics
Wright Medical Technology
Zimmer
TheMusculoskeletalTumorSocietyand
theOrthopaedicResearchandEducationFoundation
wish to thank the following:

MSTS Members of the Alfred R. Shands, Jr. Circle Recognition Society

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<thead>
<tr>
<th>B. Hudson Berrey Jr., MD</th>
<th>Mary I. O’Connor, MD</th>
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<tr>
<td>Gary D. Bos, MD</td>
<td>Regis J. O’Keefe, MD, PhD</td>
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<td>John P. Dormans, MD, FACS</td>
<td>Theodore W. Parsons III, MD, FACS</td>
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<td>Frank J. Frassica, MD</td>
<td>Randy N. Rosier, MD, PhD</td>
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<td>Gary E. Friedlaender, MD</td>
<td>Michael A. Simon, MD</td>
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<td>Mark C. Gebhardt, MD</td>
<td>Kimberly J. Templeton, MD</td>
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<td>John H. Healey, MD, FACS</td>
<td>Kristy Weber, MD</td>
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<tr>
<td>Thomas A. Lange, MD</td>
<td>Michael J. Yaszemski, MD, PhD</td>
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<td>George F. Muschler, MD</td>
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2012–2013 Donors to the Musculoskeletal Tumor Society

<table>
<thead>
<tr>
<th>Megan E. Anderson, MD</th>
<th>C. Parker Gibbs Jr., MD</th>
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<td>Steven Gitelis, MD</td>
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<td>John P. Heiner, MD</td>
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<td>James C. Binski, MD</td>
<td>Francis J. Hornicek Jr., MD, PhD</td>
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<td>Felix H. Cheung, MD</td>
<td>Jonathan H. Lee, MD</td>
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<tr>
<td>Mr. and Mrs. Kenneth Chirba</td>
<td>Patrick P. Lin, MD</td>
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<tr>
<td>Aaron C. Cook, MD</td>
<td>Douglas J. McDonald, MD</td>
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<td>Timothy A. Damron, MD</td>
<td>David K. Monson, MD</td>
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<td>Cynthia L. Emory, MD</td>
<td>Michael P. Mott, MD</td>
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<td>Gary E. Friedlaender, MD</td>
<td>Mary I. O’Connor, MD</td>
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<td>Mark C. Gebhardt, MD</td>
<td>Richard J. O’Donnell, MD</td>
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<tr>
<td>Patrick J. Getty, MD</td>
<td>Christian M. Ogilvie, MD</td>
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Theodore W. Parsons III, MD, FACS
Joshua C. Patt, MD
Francis R. Patterson, MD
R. Lor Randall, MD, FACS
Kevin A. Raskin, MD
Mr. Mark Romasanta
Mark T. Scarborough, MD
Joseph H. Schwab, MD
Dempsey S. Springfield, MD
Richard M. Terek, MD
Wakenda Tyler, MD
William G. Ward, MD
Kristy Weber, MD
Henock T. Wolde-Semait, MD
L. Daniel Wurtz, MD
# ROOM ASSIGNMENTS

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<tr>
<td>General Session:</td>
<td>Grand Ballroom A</td>
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<tr>
<td>PA/ARNP/Allied Health Scientific Session</td>
<td>Marina Room</td>
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<tr>
<td>Scientific Posters:</td>
<td>Grand Ballroom Foyer, Market Street Foyer</td>
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<tr>
<td>Breakfast and Lunch:</td>
<td>Grand Ballroom B–C</td>
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<td>Technical Exhibits:</td>
<td>Grand Ballroom B–C</td>
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## Thursday, October 3, 2013

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<tr>
<td>2:00 – 5:00 pm</td>
<td>Executive Committee Meeting</td>
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<td>2:00 – 5:30 pm</td>
<td>Registration</td>
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<tr>
<td>2:00 – 5:30 pm</td>
<td>Poster / Technical Exhibit Set-up</td>
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<tr>
<td>5:30 – 7:30 pm</td>
<td>Welcome Reception</td>
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<td>5:30 – 7:30 pm</td>
<td>Dinner on your own</td>
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## Friday, October 4, 2013

<table>
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<tr>
<th>Time</th>
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<tr>
<td>6:30 – 8:30 am</td>
<td>Continental Breakfast</td>
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<tr>
<td>7:00 am – 5:30 pm</td>
<td>Registration</td>
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<tr>
<td>7:00 am – 5:00 pm</td>
<td>Poster / Technical Exhibits</td>
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<tr>
<td>8:00 am – 5:00 pm</td>
<td>PA/ARNP/Allied Health Scientific Session</td>
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7:30 – 7:45 am  Welcome  
Richard O’Donnell, MD

Session I: Limb Salvage / Aseptic Complications  
7:45 – 10:00 am  Moderators: John H. Healey, MD, FACS  
David G. Mohler, MD

7:45 – 8:45 am  Session IA: Endoprosthetic Limb Salvage. Aseptic Complications and Outcomes

7:45 am  Paper 1  p. 27  FRACTURES IN MASSIVE INTERCALARY BONE ALLOGRAFTS. MANAGEMENT AND RESULTS  
Luis Aponte-Tinao, MD

7:52 am  Paper 2  p. 28  A REVIEW OF LITERATURE AND META-ANALYSIS OF PROXIMAL HUMERUS RECONSTRUCTIONS IN ORTHOPEDIC TUMOR SURGERY  
John Groundland, MD

7:59 am  Paper 3  p. 29  COMPRESSIVE ENDOPROSTHETIC OSTEO-INTEGRATION FIXATION FOR LIMB SALVAGE OF THE EXTREMITY: 5 YEAR FOLLOW-UP.  
R. Lor Randall, MD, FACS

8:06 am  Paper 4  p. 30  ANTI-ROTATION PINS MAY DECREASE ASPECTIC FAILURE OF COMPRESSION OSSSEOINTEGRATION IMPLANTS: A BIOMECHANICAL AND CLINICAL OUTCOME STUDY  
Raffi S. Avedian, MD

8:13 am  Paper 5  p. 34  BONE LOSS ASSOCIATED WITH THE REPIPHYSIS EXPANDABLE PROSTHESIS FOR TREATMENT OF PEDIATRIC DISTAL FEMORAL MALIGNANCIES  
Cara Cipriano, MD

8:20 am  Paper 6  p. 35  HIGH MECHANICAL FAILURE RATE OF REPIPHYSIS EXPANDABLE ENDOPROSTHESIS  
Annie Arteau, MD

8:27 am  Paper 7  p. 36  TIBIAL GROWTH DISTURBANCE FOLLOWING DISTAL FEMUR RESECTION WITH EXPANDABLE ENDOPROSTHESIS RECONSTRUCTION  
Annie Arteau, MD

8:30 am  Paper 8  p. 37  CONSISTENT TIBIAL FIXATION FAILURE RESOLVED WITH A NEW GENERATION TIBIAL DESIGN FOR THE EXPANDABLE REPIPHYSIS PROSTHESIS  
Matthew Siedel, MD

8:33 am  Panel Discussion

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8:45 – 9:50 am  Session IB: Soft Tissue Sarcoma Limb Salvage. Aseptic Complications and Outcomes

8:45 am  p. 38  PERCUTANEOUS BIOPSIES PERFORMED AT COMMUNITY HOSPITALS ARE ASSOCIATED WITH INCREASED POST-OPERATIVE WOUND COMPLICATION RATES IN PATIENTS WITH SOFT TISSUE SARCOMAS
  Meena Bedi, MD

8:52 am  p. 40  DOES PROPHYLACTIC STABILIZATION IN THE SETTING OF IRRADIATED SOFT-TISSUE SARCOMAS PREVENT FRACTURES?
  Timothy A. Damron, MD

8:59 am  p. 41  OUTCOMES FOLLOWING INITIAL MANAGEMENT OF NON-METASTATIC SOFT TISSUE SARCOMA OF THE FOREARM: A MULTI-INSTITUTIONAL STUDY
  Maher Baroudi, MD

9:06 am  p. 43  THE EFFECT OF MARITAL STATUS ON TREATMENT AND SURVIVAL OF SOFT TISSUE SARCOMA
  Ginger E. Holt, MD

9:13 am  p. 44  THE RELATIONSHIP BETWEEN SYSTEMIC INFLAMMATION BASED PROGNOSTIC SCORES AND OUTCOME IN PATIENTS UNDERGOING SURGERY FOR BONE AND SOFT TISSUE SARCOMA
  Rossel Morhij, MD

9:20 am  p. 45  RADIATION AND CHEMOTHERAPY FOR EXTRAOSSEOUS OSTEOSARCOMA
  Patrick P. Lin, MD

9:27 am  p. 46  A SIMPLE FORMULA PREDICTS THE NECESSITY FOR COMPLEX RECONSTRUCTIVE SURGERY DURING THE RESECTION OF PRIMARY APPENDICULAR SOFT TISSUE SARCOMAS
  Gary O’Toole, MD, FRCS

9:30 am  p. 47  FUNGATING SOFT TISSUE SARCOMAS: RISK FACTORS THAT AFFECT TREATMENT OUTCOME AND SURVIVAL
  Nadine Williams, MD

9:33 am  Panel Discussion

9:50 am  CORR UPDATE
  Seth Leopold, MD

10:00 am  Morning Break
## Session II: Limb Salvage / Septic and Other Complications

10:20 am – 12:00 pm  
**Moderators:** Peter S. Rose, MD  
Robert L. Satcher Jr., MD, PhD

<table>
<thead>
<tr>
<th>Time</th>
<th>Presentation</th>
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| 10:20 am | AAOS-ADA AND IDSA GUIDELINES AND OTHER INFECTIOUS TOPICS IN ORTHOPAEDIC ONCOLOGY  
Douglas R. Osmon, MD |
| 10:40 am | PROPHYLACTIC ANTIBIOTIC REGIMENS IN TUMOR SURGERY (PARITY): UPDATE OF A MULTI-CENTER INTERNATIONAL RANDOMIZED TRIAL  
Michelle A. Ghert, MD, FRCSC |
| 10:47 am | PERI-PROSTHETIC INFECTION IN THE ONCOLOGIC PATIENT  
Daniel C. Allison, MD, MBA, FACS |
| 10:54 am | MAKING ENDOPROSTHESSES LESS SUSCEPTIBLE TO INFECTION: AN IN VIVO ASSESSMENT OF THE ANTIMICROBIAL ACTIVITY OF POROUS TANTALUM  
Nicholas Bernthal, MD |
| 11:01 am | PREDICTORS OF INFECTION IN PROXIMAL TIBIA ALLOGRAFT AND ALLOGRAFT-PROSTHESIS COMPOSITE RECONSTRUCTIONS  
Santiago A. Lozano-Calderon, MD, PhD |
| 11:08 am | RISK FACTORS FOR WOUND COMPLICATIONS FOLLOWING PELVIC RESECTIONS  
Nader A. Nassif, MD |
| 11:15 am | FACTORS AFFECTING WOUND HEALING IN SOFT TISSUE SARCOMAS OF THE ANTERIOR THIGH  
Robert Kulwin, MD |
| 11:22 am | NON-INVASIVE EXPANDABLE ENDOPROSTHESSES USED FOR LIMB SALVAGE OF LOWER EXTREMITY MALIGNANT BONE TUMORS IN SKELETALLY IMMATURE PATIENTS: FOURTEEN PATIENTS WITH MINIMUM 2 YEAR FOLLOW-UP  
George T. Calvert, MD |
| 11:29 am | EARLY RESULTS OF A 73 CONSECUTIVE NON-INVASIVE PROSTHETIC EXPANSIONS IN SKELETALLY IMMATURE PATIENTS TREATED FOR MUSCULOSKELETAL TUMORS  
Joseph Benevenia, MD |
| 11:36 am | EARLY RESULTS OF MODULAR INTERCALARY ENDOPROSTHESIS USED IN MUSCULOSKELETAL TUMORS  
Joseph Benevenia, MD |
| 11:39 am | ARTICULATING DISTAL FEMUR ANTIBIOTIC CEMENT SPACERS  
Jeremy White, MD |
| 11:42 am | Panel Discussion |
| 12:00 pm | Lunch |

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Session III: Frontiers in Basic Science
1:00–3:00 pm  Moderators: Jay Wunder, MD
              Bang C. Hoang, MD

1:00–2:00 pm  TUMOR UNKNOWNS
               James O. Johnston, MD, Andrew E. Horvai, MD, PhD

2:00 pm  p. 59  THE ENDOGENOUS PEPTIDE ANGIOTENSIN-(1–7) PREVENTS
             RADIATION-INDUCED MUSCLE FIBROSIS: AN IN VIVO MURINE MODEL
             Cynthia L. Emory, MD

2:07 pm  p. 60  THE VALIDITY OF A RAT MODEL FOR ANALYZING MICRO-RNA
              IN CHONDROSARCOMA
              Nicholas B. Frisch, MD, MBA

2:14 pm  p. 61  MICRO-RNA AND CHONDROSARCOMA METASTASIS
              Richard M. Terek, MD

2:21 pm  p. 63  EXTRASKELETAL MYXOID CHONDROSARCOMA: MICRO-RNA ANALYSIS
              AND PATHOGENESIS
              Chandhanarat Chandhanayingyong, MD

2:28 pm  p. 64  PRELIMINARY ANALYSIS OF PHASE I, FIRST-IN-HUMAN, CATHEPSIN
              ACTIVATED FLUORESCENT IMAGING PROBE
              Brian E. Brigman, MD

2:35 pm  p. 65  INCREASED EXPRESSION OF CADHERIN 11 IN BONE-DERIVED 786-O
              RENAL CELL CARCINOMA CELLS
              Robert L. Satcher Jr., MD

2:38 pm  p. 66  THE ROLE OF TWIST IN ANGIGENESIS AND CELL MIGRATION IN GIANT
              CELL TUMOR OF BONE
              Isabella Mak, MD

2:41 pm  p. 67  A NOVEL PATIENT-DERIVED INTRA-FEMORAL XENOGRAFT MODEL OF
              BONE METASTATIC PROSTATE CANCER THAT RECAPITULATES MIXED
              OSTEOLYTIC AND OSTEOBLASTIC LESIONS
              Anna Andranik Kulidjian, MD

2:44 pm  Panel Discussion

3:00 pm  Afternoon Break
Session IV: Amputation, Osseointegration, Prosthetics, Rehabilitation and Quality of Life
3:20–5:30 pm

Moderators: Richard J. O’Donnell, MD, Program Chair
Raffi S. Avedian, MD

3:20 pm
THE OPRA BONE ANCHORED AMPUTATION PROSTHESIS
Örjan Berlin, MD

3:40 pm
OPRA SURGICAL TECHNIQUE
Örjan Berlin, MD

4:00 pm
THE LÜBECK EXPERIENCE WITH ENDO-EXO / ILP PROSTHESES FOR BELOW KNEE AMPUTEES
Horst Aschoff, MD

4:20 pm
A MINIMUM 2 YEARS FOLLOW UP OF 100 IMPLANTS USING THE ENDO-EXO/INTEGRAL LEG PROSTHESIS (ILP)
Munjed Al Muderis, MD

4:27 pm
OSSEOINTEGRATION GROUP AUSTRALIA ACCELERATED PROTOCOL (OGAAP): COMBINING THE BEST OF GERMAN TECHNOLOGY AND THE SWEDISH MULTI-DISCIPLINARY APPROACH TO OSSEOINTEGRATION
Munjed Al Muderis, MD

4:34 pm
FUNCTIONAL OUTCOMES MEASURES FOLLOWING HEMIPELVECTOMY
Matthew T. Houdek, MD

4:41 pm
THE RISK OF AMPUTATION AFTER UNPLANNED SOFT TISSUE SARCOMA EXCISIONS
Chigusa Sawamura, MD

4:48 pm
SPORTS ACTIVITY AFTER MODULAR ENDOPROSTHETIC RECONSTRUCTION OF THE KNEE FOR OSTEOSARCOMA
Phillipp T. Funovics, MD

4:55 pm
STEPWATCH ACTIVITY MONITOR ASSESSMENT AFTER SARCOMA LIMB SALVAGE SURGERY - A COMPARISON OF PATIENT AGE AND DIAGNOSIS COHORTS
Kenneth R. Gundle, MD

5:02 pm
STANDARDIZED REHABILITATION PROTOCOL AFTER LIMB SALVAGE SURGERY IMPROVES PATIENTS’ OUTCOME
Ahmad M. Shehadeh, MD

5:09 pm
LONG-TERM OUTCOMES, QUALITY OF LIFE AND FUNCTION OF LIMB SALVAGE SURGERY FOR SARCOMAS IN CHILDREN
Megan E. Anderson, MD

5:12 pm
MEASURING QUALITY OF LIFE IN PATIENTS WITH SOFT TISSUE SARCOMA WHO PRESENT WITH MULTIPLE LUNG METASTASES
William C. Eward, DVM, MD

5:15 pm
QUALITY OF LIFE AFTER EN-BLOC RESECTION OF MALIGNANT TUMORS OF THE MOBILE SPINE
Matthew Colman, MD

5:18 pm
Panel Discussion

5:30 pm
Adjourn

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Session V: Targeted Therapy in Musculoskeletal Oncology
7:30–9:30 am  Moderators: Valerie O. Lewis, MD, 2014 Program Chair
Joseph H. Schwab, MD

7:30 am  Young Investigator’s Award

7:40 am  Best Poster Award

7:50 am  ADVANCES IN SARCOMA MEDICAL ONCOLOGY
Kristen N. Ganjoo, MD

8:10 am  IORT AND OTHER PROGRESS IN SARCOMA CARE
Alexander R. Gottschalk, MD, PhD

8:30 am  p. 79  FUNCTIONAL CHARACTERIZATION OF BONE MORPHOGENETIC
PROTEINS (BMPS) AND ELUCIDATION OF THEIR ROLES IN THE
PATHOGENESIS OF OSTEOSARCOMA
David S. Geller, MD

8:37 am  p. 80  TARGETED INHIBITION OF OSTEOSARCOMA: EFFECT OF 2-ME ON WNT
PATHWAY
Dalibel M. Bravo

8:44 am  p. 81  AXL IS A NOVEL THERAPEUTIC TARGET FOR OSTEOSARCOMA
Ashley Rettew, PhD

8:51 am  p. 82  NF1 DELETION GENERATES MULTIPLE SUBTYPES OF SOFT-TISSUE
SARCOMA THAT RESPOND TO MEK INHIBITION
William Eward, DVM, MD

8:58 am  p. 84  EXTRA-ABDOMINAL SPONTANEOUS DESMOID TUMORS: IS SURGICAL
MARGIN REALLY IMPORTANT? EXPERIENCE ON 23 CONSECUTIVE CASES
Olavo Pires De Camargo, MD

9:05 am  p. 85  PERIOPERATIVE OUTCOMES IN THE TREATMENT OF SOFT TISSUE
SARCOMAS USING REDUCED DOSE PREOPERATIVE RADIATION
COMBINED WITH A RADIOSENSITIZING AGENT
Shannon Puloski, BSc, MD, FRCSC

9:08 am  p. 86  A COMPARISON OF BRACHYTHERAPY AND EXTERNAL-BEAM RADIATION
IN TREATMENT OF SOFT TISSUE SARCOMA
Nathan Donaldson, DO

9:11 am  p. 87  TARGETING RANKL IN ANEURYSMAL BONE CYST: CASE PRESENTATION
AND POST-HOC VALIDATION OF TARGET
Matthew R. Steensma, MD

9:14 am  Panel Discussion

9:30 am  Morning Break

Disclosures listed in handout
Session VI: Humanitarian and Collaborative Efforts in Orthopaedics
10:00 am – 1:00 pm  Moderators: Christian M. Ogilvie, MD
                        Rosanna L. Wustrack, MD

10:00 am  HUMANITARIAN CARE IN ORTHOPAEDIC ONCOLOGY
          David G. Mohler, MD

10:10 am  IGOT AND SUSTAINABLE ORTHOPAEDIC OUTREACH
          R. Richard Coughlin, MD

10:20 am  ORTHOPAEDIC RESPONSE TO MASS CASUALTY: LESSONS FROM
          THE BOSTON MARATHON
          Mark Gebhardt, MD

10:30 am  MSTS ORTHOPAEDICS ONE COLLABORATIVE WEB PROJECT
          Joseph F. Alderete MD, MAJ MC

10:40 am  MULTI-INSTITUTIONAL QOL ASSESSMENT OF SACRRECTOMY PATIENTS
          Joseph H. Schwab, MD

10:50 am  MUSCULOSKELETAL ONCOLOGY RESEARCH INITIATIVE (MORI)
          Benjamin J. Miller, MD

11:00 am  PRIMARY OSSEOUS TUMORS OF THE ELBOW: A REVIEW OF 50 YEARS
          EXPERIENCE FROM A NATIONAL BONE TUMOR REGISTRY AND HOW TO
          AVOID DELAY TO DIAGNOSIS
          Mansur Halai, MBBS

11:07 am  A NEW APPROACH TO TERTIARY SARCOMA SERVICES: AN AUDIT OF A
          NOVEL SERVICE REDESIGN FOR A NATIONAL SERVICE
          David Wallace, MD

11:14 am  THE OUTCOME OF LIMB SALVAGE SURGERY IN A DEVELOPING COUNTRY,
          KHCC EXPERIENCE
          Ahmad M. Shehadeh, MD

11:21 am  DEMOGRAPHIC PROFILE OF OSTEOSARCOMA FROM A TERTIARY CARE
          CENTRE IN A DEVELOPING COUNTRY- RETROSPECTIVE ANALYSIS OF THE
          LAST EIGHT YEARS
          Shah Alam Khan, MS, DNB, MRCSEd, FRCS, MChOrth

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### Session VI: Humanitarian and Collaborative Efforts in Orthopaedics (cont.)

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<tr>
<td>11:28 am</td>
<td>p. 93</td>
<td>HUMANITARIAN AID AS A TEACHING TOOL</td>
<td>Audrey Goelz, MD</td>
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<td>11:35 am</td>
<td>p. 94</td>
<td>CHALLENGES IN DELIVERING SARCOMA CARE IN PORT-AU-PRINCE HAITI</td>
<td>Nadine Williams, MD</td>
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<td>11:38 am</td>
<td>p. 95</td>
<td>RACIAL DISPARITIES IN EXTREMITY SOFT TISSUE SARCOMA OUTCOMES –</td>
<td>Ginger E. Holt, MD</td>
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<td>A NATIONWIDE ANALYSIS</td>
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<td>11:41 am</td>
<td>p. 96</td>
<td>DOES HISTOLOGIC DIAGNOSIS REALLY DETERMINE PROGNOSIS – AN NCDB</td>
<td>William G. Ward, MD</td>
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<td>ANALYSIS OF OSTEOSARCOMA CHONDROSARCOMA AND EWINGS SARCOMA</td>
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<td>11:44 am</td>
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<td>Panel Discussion</td>
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<td>12:00 pm</td>
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<td>FOUNDER’S LECTURE</td>
<td>Irving Weissman, MD</td>
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<td>1:00 pm</td>
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<td>Closing Remarks</td>
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Disclosures listed in handout
| Poster #1 | p. 99 | BRACHYTHERAPY COMBINED WITH VACCUM-ASSISTED CLOSURE IN THE TREATMENT OF SOFT-TISSUE SARCOMAS  
Trevor Schott, BS; Alma Heyl; Kurt R. Weiss, MD; Mark A. Goodman, MD; William Swartz, MD; Michael Gimbel, MD; Richard L. McGough III, MD |
|----------|------|--------------------------------------------------------------------------------------|
| Poster #2 | p. 100 | PSEUDOMYOGENIC HEMANGIOENDOTHELIOMA OF BONE: A CASE REPORT AND LITERATURE REVIEW OF A RARE TUMOR  
Kurt R. Weiss, MD; Uma Rao, MD |
| Poster #3 | p. 101 | SARCOMA ARISING IN A PREVIOUSLY REPLANTED LIMB  
Kurt R. Weiss, MD; Richard L. McGough III, MD; Michael Gimbel, MD; Stephen Burton, MD; Hussein Tawbi, MD, PhD; Uma Rao MD |
| Poster #4 | p. 102 | ACCURACY AND PRECISION OF A BIDIRECTIONAL INFRARED SURGICAL NAVIGATION SYSTEM  
Kenneth R. Gundle, MD; Jed K White, MD; Ernest Conrad III, MD; Randal Ching, MD |
| Poster #5 | p. 103 | CLINICAL OUTCOMES OF A COMPOSITE BONE GRAFT SUBSTITUTE TO TREAT BENIGN BONE LESION DEFECTS  
William B. Payne, MD; Judd E. Cummings, MD; Matthew J. Seidel, MD |
| Poster #6 | p. 104 | LEIOMYOSARCOMA SURVIVAL IS INDEPENDENT OF ANATOMIC LOCATION  
Srikanth Divi, MD; Richard L. McGough III, MD; Kurt R. Weiss, MD |
| Poster #7 | p. 105 | ALDEHYDE DEHYDROGENASE (ALDH) IS A MARKER FOR METASTATIC DISEASE IN MUSCULOSKELETAL TUMORS ORIGINATING IN BONE  
Kurt Weiss, MD; Xiaodong Mu; Adel Majoub; Trevor Schott, MD |
| Poster #8 | p. 107 | MULTI-VITAMIN USE MAY DECREASE THE RISK OF METASTASIS IN PATIENTS WITH SOFT TISSUE SARCOMAS  
Meena Bedi, MD; David M. King, MD; John A. Charlson, MD; Donald A. Hackbarth, MD; Dian Wang, MD, PhD; John C. Neilson, MD |
| Poster #9 | p. 109 | EVALUATING THE READABILITY OF ONLINE PATIENT EDUCATION MATERIALS RELATED TO BONE AND SOFT TISSUE SARCOMAS  
Herrick J. Siegel, MD; Shaan Patel, BA, Brent Ponce, MD; Evan Sheppard, BS |
| Poster #10 | p. 110 | TRANEXAMIC ACID IN ORTHOPAEDIC ONCOLOGY: SAFETY AND EFFICACY  
Herrick J. Siegel, MD; Jonathon K. Jennings, MD; Jason Gay, CRNFA |
| Poster #11 | p. 111 | OSTEOPOOROTIC DISTAL FEMUR FRACTURES TREATED WITH MODULAR ONCOLOGIC REPLACEMENT PROSTHESES  
Herrick J. Siegel, MD; Brian Etier, MD; Jason Gay, CRNFA |

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Poster #12  p. 112  THE ROLE OF SPINOPELVIC RECONSTRUCTION AFTER AMPUTATIVE SACRECTOMY
Grigory G. Arutyunyan, MD; Peter S. Rose, MD; Franklin H. Sim, MD; Michael J. Yaszemski, MD, PhD

Poster #13  p. 113  EPhiphysEAL AND GROWTH PLATE SPARING IN CHILDREN WITH MALIGNANT BONE TUMOR ABOUT THE KNEE: THE BIOLOGICAL SOLUTION
Samuel Kenan, MD; Adam Levin, MD

Poster #14  p. 114  INTRAMEDULLARY NAILING OF FEMORAL DIAPHYSEAL METASTASES: IS IT REALLY NECESSARY TO PROTECT THE FEMORAL NECK?
Bryan Moon, MD; Patrick P. Lin, MD; Robert L. Satcher, MD; Justin E. Bird, MD; Valerae O. Lewis, MD

Poster #15  p. 115  EStAblishing CRITICAl STEPS IN OPEN BIOPSY: A DELPHI Consensus STUDY
Brian L. Seeto, MD; Peter C. Ferguson, MD

Poster #16  p. 116  THE SURGICAL MANAGEMENT OF LOWER EXTREMITY BONE TUMORS: LEVELS OF EVIDENCE AND QUALITY OF REPORTING
Nathan Evaniew, MD; James Nuttall, MBB Ch BAO; Forough Farrokhyar, MPhil, PhD; Mohit Bhandari, MD, PhD, FRCSC; Michelle Ghert, MD, FRCSC

Poster #17  p. 117  INVISIBLE STABILIZATION OF IMPENDING AND PATHOLOGICAL FRACTURES A PRELIMINARY REPORT ON CARBON FIBER TECHNOLOGY
Howard G. Rosenthal, MD, FACS

Poster #18  p. 119  ADVANCED IMAGING IS OVERUSED PRIOR TO REFERRAL TO A MUSCULOSKELETAL ONCOLOGIST: A PROSPECTIVE, MULTI-CENTER INVESTIGATION
Benjamin J. Miller, MD, MS; Raffi S. Avedian, MD; Judd Cummings, MD; Tessa Balach, MD; Kevin MacDonald, MD on behalf of the Musculoskeletal Oncology Research Initiative

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FRACTURES IN MASSIVE INTERCALARY BONE ALLOGRAFTS. MANAGEMENT AND RESULTS

Luis Aponte-Tinaco, MD; German L. Farfalli, MD; Migeul Ayerzas, MD; Domingo Luis Muscolo, MD

The use of massive bone allografts implies the risk for fractures, however, there is no general consent with the management of these complications and the results of their treatment. The purpose of this study was to analyze an homogeneous group of massive bone allografts in the lower extremities analyzing the fracture rate, the management of this specific complication and the final outcome after this complication.

We retrospectively reviewed the patients treated with massive bone allografts between 1991 and 2011. To obtain an homogeneous group of patients we excluded APC, osteoarticular and hemicylindrical intercalary allografts from this study. We analyzed the fracture rate of 135 patients reconstructed with segmental intercalary bone allografts of the lower extremities (98 femurs and 37 tibias). We evaluated treatment of the complication and final outcome.

At final follow-up 19 patients (14%) had a fracture of the allografts [16 femurs (16%) and 3 tibias (8%)]. Six patients were treated with internal fixation and autologous graft (3 femur and 3 tibias) and thirteen patients were treated with a second intercalary allograft (13 femurs). The three patients with femoral allograft fractures treated with internal fixation and autologous grafts failed and were treated with a second allograft, while those patients with tibia allograft fractures healed without secondary complications. When we analyzed the 16 patients with a second intercalary allografts (13 as primary treatment of the fracture and 3 as secondary treatment of the fracture), 5 failed (31%) and were treated with resection of the allograft and reconstructed in 4 cases with an endoprosthesis and in the remaining case with an osteoarticular allograft.

The fracture rate in this series was 14%. Fractures of intercalary allografts of the tibia were successfully treated with internal fixation and autologous graft, however, this treatment failed when was used in femur allografts fractures. All femur allograft fractures were finally treated with a secondary allograft. The failure rate in the 16 patients with a secondary allograft was 31%.

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Objectives: Several methods of surgical reconstruction of the proximal humerus following bone tumor excision have been described in the orthopedic oncology literature. Despite a growing literature, the outcomes of the various proximal humerus reconstructions have not been specifically and systematically reviewed for surgical complications, failures and functional outcomes. The purpose of the present study was to perform a review of literature of the outcomes following proximal humerus reconstruction, comparing metallic endoprosthesis, allograft and allograft-prosthesis composite (APC). A meta-analysis assessed statistically significant differences between the groups.

Materials and Methods: A systematic review of literature was performed on Medline and Pubmed, using the keywords: proximal humerus reconstruction, humeral allograft, endoprosthesis, megaprosthesis, allograft-prosthetic composite, APC, bone tumor. Article inclusion required outcome data following proximal humerus reconstructions in tumor surgery. Metallic endoprosthesis, allograft and allograft-prosthesis composites were included, whereas arthodeses, clavicula pro humero procedures, scapular resections, and total humerus replacements were excluded. Demographics, complications, failure modes and functional outcomes were compiled and the data were sorted by type of reconstruction. A meta-analysis was performed to determine if differences in outcomes between the metallic endoprosthesis, allograft and APC groups reached statistical significance.

Results: Sixty-nine papers met inclusion criteria. When multiple manuscripts from a given institution were found with overlapping inclusion dates, the study with the greatest number of patients reported was included. This additional partitioning left fifty-four distinct papers, reporting on 1,349 patients. Eleven of the included papers reported on multiple types of reconstruction. Thirty-five manuscripts reported on metallic endoprostheses, fourteen described allografts and fifteen described APC. The overall complication rate for metallic endoprosthesis reconstruction was 23.7%, allograft was 40.5%, and APC was 29.1%. The failure rate for the endoprosthesis reconstruction was 12.2%, allograft was 37.1%, and APC was 19.1%. Of the metallic endoprostheses that failed, the most common failure mode was evenly distributed between soft tissue failure (24.8%), infection (25.6%) and tumor recurrence (24.8%). Proximal humerus allografts most commonly failed due to structural failure of the osseous construction (63.6% of the allograft failures). APC failed most commonly due to aseptic loosening (43.3% of APC failures). Musculoskeletal Tumor Society scores were 72.4%, 70.8% and 75.8%, for metallic endoprosthesis, allograft and APC, respectively. Post-operative active flexion range was 41.4 degrees, 47.1 degrees and 65.2, respectively. The meta-analysis revealed significant overall estimates of failure rate were found for both the endoprosthesis and APC groups. In addition, the results of the analyses indicate a statistically significant estimation of the combined complication effect for endoprosthesis and APC groups. Results of the random effects model did not provide sufficient evidence of a precise, overall measure of failure or complication for the allograft group.

Conclusions: The surgical and functional outcomes of metallic endoprostheses, allografts and APCs demonstrate high failure and complication rates in the literature. Assessment of function, as measured by active flexion range of motion, reveals that these reconstructions provide limited overall elevation of the upper extremity.

Level of Evidence: Level III, Retrospective study. See the Guidelines for Authors for a complete description of levels of evidence.
Introduction: Selection of the ideal endoprosthetic implant for oncologic limb salvage reconstructions remains controversial. Long-stem cemented and uncemented megaprostheses are the standard options for limb salvage procedures. However, aseptic complications such as bone loss, stress shielding, cement extrication and bony fracture are major issues associated with implant revisions. Endoprosthetic reconstruction utilizing compressive osseointegration fixation provides a relatively new limb salvage alternative, designed to enhance osteointegration, prevent stress shielding and provide fixation for short end-segments.

Questions/Purposes: We have previously published our minimum 2 year follow-up. The purpose of the present study is to report on the survivorship of compressive osseointegration fixation of limb salvage endoprosthetic reconstructions in patients with a minimum 5 year follow-up.

Methods and Patients: A single center, retrospective review of patients with a minimum 5 year follow-up treated with an osseointegration compressive device for fixation of endoprosthetic limb salvage procedures in the extremity was performed. The primary outcome measured was re-operations for mechanical failures (aseptic failures). Secondary outcomes included implant removal for non-mechanical failures and any patient, oncological or surgical related variables associated with implant removal. Primary outcomes were analyzed using the Kaplan-Meier method and secondary outcomes were assessed using a Cox regression analyses.

Results: A total of 19 osseointegration sites in 18 patients were reviewed. Fixation sites included the distal femur (14; 74%), proximal femur (4; 21%) and distal humerus (1; 5%). A total of 8 implants (44%) were removed for a variety of reasons (oncological failure, infection and arthrofibrosis), while 3 of these implants (17%) were removed because of mechanical failure. All mechanical failures occurred within the first 30 months. Univariate and multivariate analyses did not demonstrate any demographic, oncological or implant related features predictive of mechanical failure.

Conclusions: Our intermediate experience with compressive osseointegration fixation for endoprosthetic limb reconstructions demonstrates no additional failures as compared to our early analysis. Overall implant survivorship is greater than 80% at a minimum of 5 years follow-up. All mechanical failures occurred early, in the first 30 months.

Level of Evidence Level IV, Therapeutic study
ANTIS-ROTATION PINS MAY DECREASE ASEPITC FAILURE OF COMPRESSION OSSEOINTEGRATION IMPLANTS: A BIOMECHANICAL AND CLINICAL OUTCOME STUDY

Raffi S. Avedian, MD; Timothy Chen, MD; David Mohler, MD; Ariel Palanca, MD; Derek Lindsey, MD

Introduction: A significant number of patients who undergo limb salvage surgery with an endoprosthesis will experience a complication such as aseptic loosening or mechanical failure and require complex revision surgery. Stemmed intramedullary implants can fail due to aseptic loosening, particle induced osteolysis, stress shielding, and infection. Compression osseointegration is an alternative method of attaching implants to bone and has short and intermediate term survivorship that is at least equivalent if not superior to stemmed implants, but there is concern that rotational forces at the bone prosthetic interface can lead to loosening and failure of the implant (Figure 1). A strategy to overcome this important problem is to insert anti-rotation pins through the implant into the host bone (Figure 2). A theoretical disadvantage of using anti-rotation pins is that the presence of drill holes and pins may act as a stress riser and increase the risk of fracture. Another consideration is that drilling may cause damage to the periosteum and inhibit osseointegration. However there are no studies to indicate how the number of pins affects rotational stability, increases the risk of fracture, or interferes with osseointegration.

Purpose: The purpose of this combined biomechanical and clinical outcome study was to determine the effect of anti-rotation pins on implant stability, risk of periprosthetic fracture, and osseointegration. We specifically sought to evaluate the following questions: (1) When tested in a cadaver model does the use of anti-rotation pins increase the torque required to cause implant failure? (2) In a cadaver model and in clinical practice does the use of anti-rotation pins increase the risk of periprosthetic fracture compared to not using pins? (3) When compared to implants without anti-rotation pins do implants with anti-rotation pins have an increased risk of not osseointegrating at the bone prosthesis interface?

Methods: The biomechanical portion of this study involved the use of eight matched pairs of formalin fixed adult human femora. These specimens were divided into four groups of two pairs each. The femora were osteotomized at the mid-diaphysis to yield two testing specimens per femur. Dual-energy X-ray absorptiometry was performed to ensure uniform bone mineral density among the specimens. Group I was designed to be a comparison between four femurs that had no anti-rotation pins and four femurs with 1 anti-rotation pin. Group II was made up of femurs with 1 pin and femurs with 2 pins. Group III was made up of femurs with 2 pins and femurs with 3 pins. Group IV was made up of femurs with 3 pins and femurs with 4 pins. Each femur was potted in acrylic cement and a compression implant was attached to the cut end of the femur using standard surgical techniques and instruments. The exposed end of the compression implant device was mated to a servohydraulic device. An axial force of 600lbs was applied at the bone prosthesis interface to simulate the standard load applied in clinical practice. Testing was done by applying a rotational force at a rate of one degree per second until failure occurred, which was defined as spinning of the implant or femur fracture. A power analysis for superiority (α=0.05, power 0.8) indicated four specimens were needed per group to detect a difference of 5N-m in torque to failure.
The clinical portion of this study involved a retrospective review of our orthopaedic oncology database which identified 49 patients who had undergone limb salvage surgery with a compression osseointegration implant and had minimum 1 year follow-up. The subjects were divided into two groups: Group I was comprised of 29 subjects that had implants without anti-rotation pins, and Group II was comprised of 20 subjects that did have anti-rotation pins. We reviewed the medical records of the study subjects and recorded relevant patient and treatment information including demographics, diagnosis, age, sex, BMI, treatment dates, adjuvant treatments, and implant details (Table I). All patients had similar post-operative rehabilitation protocols. We performed radiographic analysis after surgery, at 6 weeks, 3 months, 6 months, and yearly after surgery to assess osseointegration at the bone implant interface. We recorded outcome variables including need for revision due to aseptic loosening, incidence of periprosthesis fracture, and evidence of implant osseointegration.

Results: The biomechanical study revealed that insertion of anti-rotation pins increased the torque needed to cause failure, and the risk of fracture decreased with the use of more pins (Figure 3). After accounting for BMD, a linear regression analysis demonstrated a significant correlation between adding pins and increasing torque required for failure (p<0.0001) (Figure 2). The mode of failure was motion at the bone prosthesis interface for the no pin study group and fracture at the pin site for the remaining femurs. In the clinical portion of this study there was one periprosthetic fracture in Group I and no fractures in Group II. The periprosthetic fracture occurred 7 years after the index surgery while the patient was dancing. Two years after ORIF surgery she has a stable implant and experiences minimal pain. There were three failures due to aseptic loosening in Group I (3/29; 10.3%) and no aseptic failures in Group II (0/20; 0%). Except for the three aseptic failures in Group I all patients experienced bone growth and radiographic evidence of osseointegration within one year of surgery.

Conclusions: The results of the study indicate that the torque needed to cause rotational failure of the device increases with each additional pin and the risk of fracture decreases with additional pins. The stability of this compression osseointegration implant appears to be sufficient to withstand forces of activities of daily living which were estimated to be 9 Nm while jogging and 6Nm in the stance phase of level walking in a telemetry study of prosthetic knee joints. The use of anti-rotation pins may confer a margin of safety for implant stability which would be especially important in patients undergoing chemotherapy who are at risk of delayed osseointegration. The fact that all 20 implants with anti-rotation pins achieved osseointegration strongly suggests that the process of drilling and inserting anti-rotation pins does not lead to osteonecrosis nor interfere with bone growth, and may in fact promote osseointegration by conferring implant stability. The biomechanical and clinical evidence presented in this study suggests that anti-rotation pins do not increase the risk of fracture. Advantages of using these pins in the clinical setting are that they may decrease the failure rate of this device, allow for earlier full weight bearing after surgery, and may decrease the need for revision surgery. This is especially important for patients on strict chemotherapy regimens where delays in treatment while managing surgical complications may be detrimental to cancer related outcomes.

Figure 1A-B. AP RADIOGRAPHS OF A 45 YO MAN WITH DISTAL FEMUR REPLACEMENT WHO EXPERIENCED (A) ROTATIONAL FAILURE 3 MONTHS AFTER SURGERY (NOTE 45 DEG EXTERNAL ROTATION OF DISTAL FEMUR COMPONENT) AND (B) AFTER REVISION SURGERY.
Table 1. PATIENT AND IMPLANT VARIABLES

<table>
<thead>
<tr>
<th>Patient Information</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Statistical Significance</th>
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<td>29</td>
<td>20</td>
<td></td>
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<tr>
<td>Average Age (years)</td>
<td>38.5 (9-78)</td>
<td>38.6 (4-76)</td>
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<td>Sex</td>
<td></td>
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<tr>
<td>Male</td>
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<td>15</td>
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</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>5</td>
<td></td>
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<tr>
<td>Average Followup</td>
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<td></td>
<td>P&lt;0.05</td>
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<tr>
<td>Months (range)</td>
<td>39.6 (2-168)</td>
<td>15.6 (3-27)</td>
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</tr>
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<td>Malignant Tumor</td>
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<td>25</td>
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<td>5</td>
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</tr>
<tr>
<td>Anatomic Location</td>
<td></td>
<td></td>
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<tr>
<td>Proximal Tibia</td>
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<td>Adjuvant Chemotherapy</td>
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<td>14</td>
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<td>Force</td>
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Disclosures listed in handout
Table II. OUTCOME VARIABLES

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<th>Group II</th>
<th>p value</th>
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<tr>
<td>Number of Implants</td>
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<tr>
<td>Failures</td>
<td>3 (10.3%)</td>
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<tr>
<td>Periprosthetic Fractures</td>
<td>1</td>
<td>0</td>
<td>p&gt;0.5</td>
</tr>
<tr>
<td>Radiographic evidence of osseointegration</td>
<td>28</td>
<td>20</td>
<td>p&gt;0.5</td>
</tr>
</tbody>
</table>

Figure 3. REGRESSION ANALYSIS OF TORQUE TO FAILURE OF INDIVIDUAL BIOMECHANICAL TEST SPECIMENS.

Figure 4. COMPARISON OF TORQUE TO FAILURE OF BIOMECHANICAL TESTING GROUPS

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FDA information not available at the time of printing. For full information, refer to inside back cover.
Introduction: Although multiple surgical options for pediatric distal femur malignancies exist, the treatment of choice remains controversial. An expandable endoprosthetic device (Repiphysis Limb Salvage System) allows for limb preservation without repeated invasive procedures; however the short-term complications associated with its use have been significant. A paucity of data exists regarding long-term outcomes associated with the Repiphysis device, and the extent and implications of bone loss associated with this implant have not been evaluated. The purpose of this study is to report clinical and radiographic outcomes following placement of the Repiphysis expandable prosthesis for pediatric patients with distal femur malignancies.

Methods: The study population consisted of 12 consecutive osteosarcoma patients (7 males and 5 females; mean age 9.9 years) who underwent distal femoral resection and reconstruction with the Repiphysis device by a single surgeon between 2002 and 2011. Medical records were retrospectively reviewed for demographic information, implant specifications, and postoperative course (number of lengthenings, total amount lengthened, complications, recurrence rate, reoperation rate, survival rate, and MSTS scores). Radiographs at final follow up were reviewed for bone loss (length and cortical thinning) and analyzed by the 2 senior authors to determine reconstruction options available for future revisions.

Results: At final follow up (mean 62.2, range 9.8-119.4 months) MSTS scores averaged 66.9 %. There were 3 cases of progression to multicentric disease, 1 case of local recurrence, and 1 death secondary to malignancy. We observed 15 minor and 22 major implant-related complications requiring a total of 15 reoperations. Three patients underwent conversion to adult modular oncology prostheses, 2 underwent revision to total femoral replacements, and 1 required hip disarticulation for disease progression following conversion to an adult modular prosthesis. The length of remaining femoral bone from the lesser trochanter to the proximal end of the implant averaged 9.4 (0-16) cm; however, all patients showed radiographic evidence of extensive metadiaphyseal compromise. Due to lack of supportive femoral bone stock, options for subsequent revision would be limited to complex reconstruction or total femoral replacement in 7 of the 9 remaining implants.

Conclusion: While less invasive than other limb preserving procedures for pediatric patients, the Repiphysis device was associated with significant complications, including bone loss and high rate of revision procedures with relatively poor clinical outcome. While the decision to use the Repiphysis device must be made on an individual basis, the potential for significant bone compromise limiting revision options should be taken into consideration.
HIGH MECHANICAL FAILURE RATE OF REPIPHYSIS EXPANDABLE ENDOPROSTHESIS
Annie Arteau, MD; Patrick P. Lin, MD; Bryan S. Moon, MD; Robert L. Satcher, MD, PhD; Justin E. Bird, MD; Valerae O. Lewis, MD

Introduction: In growing children, limb salvage presents unique challenges. Limb length discrepancies often result after physis resection. Data suggesting a single superior reconstruction technique are lacking. Non-invasive expandable endoprostheses can be used to address this issue. Complications have been reported with all designs of expandable endoprostheses. The objective of the study was to determine the rate of mechanical failure of The Repiphysis, a non-invasive expandable prosthesis.

Method: Fourteen distal femur Repiphysis expandable endoprostheses were implanted in skeletally immature patients between 2004 and 2010. Patient demographic and surgical data were reviewed. Fourteen distal femur osteosarcomas were treated with chemotherapy, tumor resection and Repiphysis endoprosthetic reconstruction. A total of 20 expandable prostheses were implanted. Survival of these prostheses was evaluated.

Results: A total of 62 expansions were performed with an average of 10 mm (range 4-23 mm) per expansion. Thirteen of the 20 prostheses (65%) had implants related complications. Nine (45%) prostheses were revised for mechanical failure, one (5%) was revised for sepsis, 2 (10%) for aseptic loosening and one prosthesis (5%) mechanically failed but was re-expanded. Seven prostheses had no complications: 2 (10%) prosthesis are still actively expanding and 2 (10%) were exchanged after maximal expansion capacity was achieved. The three remaining implants were implanted in patients who developed progressive disease: one patient (5%) died of disease and 2 patients required amputations for recurrence. Mean time to revision for mechanical failure is 29.3 months (range 17-58). Mean leg length discrepancy among skeletally mature patients is 9.5 mm (range 0-20 mm). Only one skeletally mature patient required a shoe lift to correct limb length discrepancy.

Discussion: When the distal femur is resected in skeletally immature patients, reconstruction options remain limited. Patients with expandable endoprostheses have high MSTS scores (range 68 to 90%), good emotional acceptance, and minimal leg length discrepancy at skeletal maturity. Unfortunately, the Repiphysis implant has a high complication rate of 65%. Mechanical failure rate of the prosthesis was 50% and was the most common reason for revision. High mechanical failure rate of Repiphysis may limit the indications for this specific device. Careful patient selection, informed consent, and consideration for alternative reconstruction technique are recommended for skeletally immature patients.
Introduction: In growing children, limb salvage presents unique challenges. Limb length discrepancies often result after distal femoral physeal resection. Expandable endoprostheses can be used to address this issue. The tibial growth plate is preserved with resection and reconstruction of the distal femur. However, the effect on tibial growth has not been studied. Our hypothesis is that the tibial growth plate does not resume normal growth with those implants and this can contribute to overall leg length discrepancy at skeletal maturity or cause progressive angular deformity.

Patients and Methods: Twenty-eight distal femoral expandable endoprostheses of different designs were implanted in skeletally immature patients between 1994 and 2012. Patient demographic, surgical and radiological data were reviewed. Twenty-three patients had adequate data to be included in the present study. The effect of the tibial component on tibial growth plate was assessed using successive scanograms, telograms and conventional radiographs of the knee.

Results: Among the 23 patients studied, none had radiographic injury to the proximal tibial physis at the time of surgery other than insertion of the tibial stem. Fifteen patients (65%) had tibial length discrepancy at last follow up; in 10 patients, the discrepancy was progressive during growth. Five patients (22%) had 20 mm or more of tibial length discrepancy at last follow up. Only five patients reached skeletal maturity with identical tibial lengths. Among the 10 patients presenting progressive tibial length discrepancy, the discrepancy increases at an average rate of 3.1 mm (+/- 1.7 mm) per year of growth. Average tibial length lost per year of growth was 1.6 mm when all patients are included. Three patients required corrective surgery. One patient had physeal bar resection to correct a progressive varus deformity. A contralateral proximal tibial epiphysiodesis was performed later on the same patient after his tibial physis prematurely completely closed. Final tibial discrepancy at maturity is 2 cm for this patient. Another patient had a contralateral tibial epiphysiodesis for premature growth arrest on the surgical leg. One patient had a prosthesis revision for progressive varus deformity.

Conclusion: Leg length discrepancy after distal femoral growth plate resection in skeletally immature patients can be managed with a growing prosthesis. However, the tibial growth plate may not resume normal growth after implantation of the prosthesis even if the physis is carefully preserved at initial surgery. This growth disturbance will contribute to overall leg length discrepancy and is proportional to the number of years of growth remaining. In patients with abnormal tibial growth, the tibia was found to grow about 50% slower than expected. Significant angular deformity can also occur if asymmetric physis growth disturbance is present. Close monitoring of tibial growth and alignment should be a part of routine follow-up in patients with expandable distal femur endoprostheses. If growth disturbance occurs, physeal bar resection, prosthesis revision or timely contralateral tibial epiphysiodesis can be used to ensure overall leg length equality, neutral mechanical axis and leveled knee height at skeletal maturity.
Background: Osteosarcoma is the most common primary bone malignancy in children. The primary treatment goal is resection with wide margins. Expandable implants have been developed which can be lengthened in a non-invasive manner. The Repiphysis expandable prosthesis was developed specifically for limb salvage in skeletally immature children. Several failure modes for the repiphysis have been reported in the literature. Aseptic loosening is the most common mode of failure. In addition, failures of the expansion mechanism, fracture of the prosthesis and deep infection have also been reported. We present a previously unreported failure involving aseptic loosening of the tibial component.

Questions/Purposes: Based on our observed mode of failure of the tibial component, a modification involving porous coating was made. Here, we examine and report the short term results of this modification

Methods: Between 2005 and 2010, the senior author (Seidel) used the Repiphysis implant on 6 patients. An IRB approved retrospective chart review was performed. Data regarding the time to first radiographic signs of loosening, survivorship of the first and second generation components and details regarding revision surgery were collected. Demographic data diagnosis was also collected. Between 2005 and 2010 the senior author implanted the Repiphysis distal femoral replacement in six pediatric patients (age range 8-13) with diagnosis of osteosarcoma or Ewing's sarcoma of the distal femur.

Results: Four patients initially implanted with a first generation tibial Repiphysis component were revised to a second generation component, with the modification of a porous-coated tibial baseplate with four porous-coated spike pegs. All four had developed a common radiographic failure pattern at the tibia/implant interface which includes initial radiographic haloing at the distal stem followed by tibial component flexion and impingement on the posterior cortex and finally fracture and/or remodeling of the posterior cortex. The mean time to development of the first radiographic finding of loosening was 15 months. One patient who was implanted primarily with the second generation tibial component and the four patients who underwent revision did not show clinical or radiographic loosening. The mean follow up of the second generation component was 24.8 months. Two of the patients who were revised to the second generation implant were recently converted to an adult implant and were observed to be solidly ingrown at the time of revision surgery.

One of the six patients was revised to an adult distal femoral replacement prosthesis at 14 months due to being close to skeletal maturity. The tibial component was grossly loose at time of revision.

Conclusion: In our series, a common failure mode of the Repiphysis tibial component was observed. Modification of the tibial component to a porous coated base plate appears to have resolved this issue.

Level of evidence: IV, case series

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PERCUTANEOUS BIOPSIES PERFORMED AT COMMUNITY HOSPITALS ARE ASSOCIATED WITH INCREASED POST-OPERATIVE WOUND COMPLICATION RATES IN PATIENTS WITH SOFT TISSUE SARCOMAS

Meena Bedi, MD; David M. King, MD; Donald A. Hackbarth, MD; John C. Neilson, MD; John A. Charlson, MD; Dian Wang, MD; PhD; Robert Whitfield, MD

Objectives: Patients treated with neoadjuvant radiation followed by limb-salvage resection are known to have higher wound complication (WC) rates compared to those treated with post-operative radiation. In an attempt to minimize our institution’s wound healing complication rates, we identified predictors for WC in patients with soft tissue sarcomas (STS) of the extremity and chest-wall treated with neoadjuvant radiation (RT) with or without chemotherapy followed by limb-salvage surgery.

Materials and Methods: From 2000-2010, 125 patients with STS of the extremity and chest-wall were treated with neoadjuvant radiation with or without chemotherapy followed by limb-sparing resection. We retrospectively reviewed patient demographic and treatment variables as well as wound outcomes. Biopsies at the authors’ institution were performed by fellowship trained musculoskeletal radiologists or surgeons. WC were defined as those requiring operation, prolonged wound care, or antibiotics ≤ 6 months after their definitive surgery and graded based on severity (Table 1). Predictors for WC were evaluated using fisher exact test for univariate analysis (UVA) and logistic regression analysis for multivariate analysis (MVA).

Results: The median follow-up was 3.5 years. Median age at diagnosis was 55 and the median tumor size was 8.6 cm. The median preoperative radiation dose was 50 Gy. Fifty-five (44%) of patients underwent neoadjuvant chemotherapy. Plastic surgery was involved in 43% of closures. Wound closures were primary or local in 59.2%, rotational in 32%, and free-tissue transfers in 8.8% of patients. Major veins were sacrificed in 27% of patients. The overall WC rate was 27%. The WC rate for both open and percutaneous biopsies was 21.5% when the biopsy was performed at our tertiary (sarcoma) center and 42% when performed in the community. Predictors for WC are located in Table 2. On UVA, lower extremity STS (p=0.003), sacrifice of a major vein (p=0.01) and biopsies done in the community setting (p=0.03) led to increased rate of WC post-operatively. On MVA, lower extremity STS (p=0.01, OR 2.0) and biopsies performed in the community setting (p=0.03, OR 4.01) led to increased WC post-operatively.

Of the percutaneous biopsies performed, 68 were done at our tertiary (sarcoma) center and 24 were done at a community institution. Twelve (17.6%) of the 68 percutaneous biopsies done at our sarcoma center versus 11 (46%) of the 24 biopsies done in the community developed post-operative WC (p=0.02). In addition to a higher WC rate, the severity of WC was higher in the community setting, with a 33% grade 3 or 4 WC rate when the biopsy was done at our tertiary (sarcoma) center compared to an 80% grade 3 or 4 complication rate when performed in the community (p=0.04).

Of the open biopsies performed, 25 were done at a tertiary center and 7 were done in the community. 8 (32%) of the 25 biopsies done at our tertiary (sarcoma) center versus 3 (43%) of the 7 biopsies done in the community developed post-operative WC (p=0.67). Of these WC, 50% were grade 3 or 4 complications when the biopsy was done at a tertiary center compared 67% with grade 3 or 4 complication when performed in the community (p=0.87).

Conclusions: Percutaneous biopsies performed at community hospitals correlated with an increased propensity for WC after limb-salvage resection at our tertiary (sarcoma) center. Moreover, the severity of post-operative WC was greater when percutaneous biopsies were performed in the community. These results confirm previous recommendations that biopsies of STS should be done at an experienced sarcoma center.
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<tr>
<th>Wound Complication Grade</th>
<th>Definition</th>
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<tr>
<td>1</td>
<td>Prolonged infection requiring antibiotics. No surgical intervention</td>
</tr>
<tr>
<td>2</td>
<td>One re-operation for wound complication, No wound vac required</td>
</tr>
<tr>
<td>3</td>
<td>One or more operations for wound complications and wound vac required</td>
</tr>
<tr>
<td>4</td>
<td>One or more re-operations with need of flap closure</td>
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*Table 1. Grading of Wound Complications in Soft Tissue Sarcomas*

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<td>Sex</td>
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<td>Performance Status</td>
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<td>Diabetes</td>
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<td>Cardiovascular Disease</td>
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<td>BMI</td>
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<td>Smoking History</td>
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<td>Time from Radiation to Surgery</td>
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<td>Biopsy performed at sarcoma center vs community setting</td>
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<td>Open vs Percutaneous Biopsy</td>
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*Table 2. Predictors for Wound Complication*

*Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
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DOES PROPHYLACTIC STABILIZATION IN THE SETTING OF IRRADIATED SOFT-TISSUE SARCOMAS PREVENT FRACTURES?
Timothy A. Damron, MD; Ali Syed, MD

Introduction: Patients undergoing treatment for soft-tissue sarcomas of the extremities, particularly those receiving adjuvant radiotherapy, are at increased risk for long-bone fracture. Risk factors include periosteal stripping, bone removal, and female gender. Some authors have suggested prophylactic stabilization as a means to reduce the likelihood of fracture. In this retrospective series of patients treated with radiotherapy and surgery for soft-tissue sarcoma as well as initial or delayed prophylactic long-bone stabilization, we examine the hypothesis that the prophylactic stabilization eliminates risk of fracture.

Methods: From a database of 103 cases of lower extremity soft-tissue sarcomas treated with both surgery and radiotherapy from 1998-2009 and an additional more recent similar case of interest, 7 patients were identified who underwent prophylactic long-bone stabilization procedures either at the time of the index sarcoma resection (6) or post-operatively (1). The patient population was predominately female (5) at a mean age of 65 (range 48-77) with intermediate to high-grade undifferentiated pleomorphic sarcomas (5) involving the lower leg (5) treated with high dose radiotherapy (mean 6060, range 5040-6400 cGy). Periosteal stripping was done in all cases, and in nearly all (6) some bone was removed at the time of the sarcoma resection. Prophylactic treatment for the five tibial cases consisted of plate/screw fixation in 4/5 and one locked intramedullary tibial nail. For the two femoral cases, locked femoral reconstruction nails were used.

Results: At a mean follow-up of 38 months (5-95), 3 of the 7 subjects (43%) incurred a total of 6 fractures. Initial fractures occurred 10, 20, and 42 months post-op original sarcoma surgery, although in the only delayed post-op stabilization case (long Gamma nail in the femur 18 months post sarcoma resection), the fracture was evident by the 3 month post-op stabilization visit. Ultimately, the patient who incurred 3 fractures from 42 to 68 months post-op after prophylactic IM tibial nailing underwent AKA and the patient who incurred two tibial fractures at 10 and 17 months following tibial plate fixation continues to have chronic pain attributed to micro-fractures of the irradiated bone. The single patient stabilized prophylactically in a delayed fashion by intramedullary fixation of the femur healed uneventfully and has been pain-free over an additional 14 months follow-up.

Conclusions: In this patient population predisposed to highest risk of fracture (6/7 had bone removed in addition to periosteal stripping), prophylactic stabilization did not prevent subsequent fracture in 3 of 7 patients. However, the morbidity in these patients may be lower, as two of three fractures went on to heal. Conversely, one required an amputation and one has chronic pain in the region. Hence, careful consideration must be given before routinely recommending prophylactic stabilization in patients with radiotherapy and soft-tissue sarcoma surgery.
OUTCOMES FOLLOWING INITIAL MANAGEMENT OF NON-METASTATIC SOFT TISSUE SARCOMA OF THE FOREARM: A MULTI-INSTITUTIONAL STUDY

Maher Baroudi, MD; Peter Ferguson, MD; Jay Wunder, MD; Marc Isler, MD; Sophie Mottard, MD; Joel Werier, MD; Robert Turcotte, MD

**Background:** Limb salvage is to be preferred in the management of forearm soft tissue sarcoma if function is to be preserved. The complex anatomy of the forearm and margin status may impact on local control and function. Multimodality management and complex reconstruction may help achieving these goals. Little is known about oncologic and functional outcomes following treatment for these and this was the purpose of our study.

**Patients and Methods:** 122 patients with primary soft tissue sarcoma located between the elbow and the wrist creases have been identified through a prospective sarcoma database held at participating centers (Mount Sinai/Princess Margaret hospitals in Toronto, McGill University Health Centre, Maisonneuve-Rosemont hospital in Montreal and the Ottawa Hospital in Ottawa). Patients referred for local recurrence or exhibiting metastases at diagnosis were excluded. Demographic and tumor data were collected and analyzed. Overall survival, disease free survival and metastasis free survival were calculated. Function and activity were assessed using the 1987 version of the Musculoskeletal Tumor Society rating scale and with the Toronto Extremity Salvage score before surgery and at 3, 6 and 12 months and then at 2 and 3 years post-surgery. Factors of prognostic significance in outcomes were to be identified through univariate and multivariate analysis.

**Results:** There were 78 males (64%) with a mean age of 58 years (16-91). 57 patients (47%) were treated following unplanned excision. Follow-up averaged 49 months (3-170). Pleomorphic undifferentiated sarcoma was most frequent with 51 patients (42%) followed by leiomyosarcoma 18 patients (15%), synovial sarcoma 15 patients (12%), and myxofibrosarcoma 12 patients (10%). Based on histology 17 patients (14%) were of grade I, 40 patients (33%) of grade II and 65 patients (53%) of grade III. Average size was 5.2 cm (1.2cm–14cm) with 43% of tumors greater than 5 cm. AJCC stages were: IA 33 patients (27%), IB 13 patients (11%), IIA 10 patients (8%), IIB 25 patients (20%), IIC 12 patients (10%), III 28 patients (24%). Tumors depth was equally distributed between superficial and deep with 61 patients each. Location was in proximal third of the forearm in 56%, middle third 20% and distal third 24%. The dorsal side of the forearm was involved in 67 patients (55%). The right side was affected in 67 patients (55%) while 61 patients (50%) have their dominant hand involved (57 right, 4 left). Limb salvage surgery was performed for 118 patients and 4 were amputated. Surgical margins were wide in 60 patients (49%), marginal in 42 (34%) and intrallesional in 20 patients (17%). Primary closure was achieved in 48 patients (39%) while soft tissue coverage was necessary for 74 cases (37 split thickness skin graft (50%), 22 rotation flaps (30%) and 15 free flaps (20%)). Radiotherapy was given to 88 patients (73%). Delivery was as neoadjuvant in 68 patients, adjuvant in 11 patients and both modalities used in 9 patients. Local recurrence was observed in 8 patients (7%) at an average time of 36 months (14-72 months). Surgical Margins in case of local recurrence were wide in 4 patients, marginal in 3 patients and intracapsular in 1 patient.
Thirty patients (24%) developed metastasis at an average time of 15 months (1-83 months). At last follow up the overall survival was 83%, disease free survival (DFSR) was 74%, local recurrence free survival rate (LRFS) was 75% and metastasis free survival rate (MFSR) was 74%. Univariate analysis showed better survival for grade I histology (80% vs 60% for grade II-III), and small size (<5cm) (72% compared to 47% if larger than 5cm). MSTS 1987 and TESS scores were available for 40 patients at 3, 6 and 12 months. MSTS score significantly increased between 3 and 6 months (27.3 ± 0.9 vs 30.5 ± 1.2, p=0.0001) but not between 6 and 12 months (30.5 ± 0.9 vs 30.9 ± 1.0 ns). This was also true for the TESS score at 3 and 6 months (81.4 ± 3.6 vs 90.1 ± 2.4, p=0.003) and plateauing at 6 months (90.1 ± 2.4 at 6 months vs 92.4 ± 2.1 at 12 months, ns). Interestingly, the function improvement seen at 6 months plateaued thereafter up to 3 years after surgery. There were no statistical difference observed within MSTS 1987 and TESS values at 1 year regarding depth, size, site of tumor, use of radiotherapy and the need for soft tissue coverage.

Conclusion: Soft tissue sarcoma of the forearm is often referred after unplanned excision. Most STS involving the forearm can be treated successfully with limb salvage. In the context of radiotherapy, local recurrence remained low. The proximal third of the forearm was most often involved. Low grade and small size were positive predictors of survival. Metastatic progression remained frequent. We did not find a relationship between function and size, depth, location, radiotherapy or the types of wound closure.
THE EFFECT OF MARITAL STATUS ON TREATMENT AND SURVIVAL OF SOFT TISSUE SARCOMA

Ginger E. Holt, MD; Vignesh K. Alamanda, MD; Yanna Song, MD

Background: Spousal support has been hypothesized as providing important psychosocial support for patients and as such has been noted to provide a survival advantage in a number of chronic diseases and cancers. However, the specific effect of marital status on survival in soft tissue sarcomas (STS) of the extremity has not been explored in detail.

Methods: A total of 7,384 patients were evaluated for this study using a SEER registry query for patients over 20 years old with extremity STS diagnosed between 2004–2009. Survival outcomes were analyzed after patients were stratified by marital status. Multivariable regression models were used to identify independent predictors of sarcoma specific death. Wilcoxon rank sum test was used to compare continuous variables and either \( \chi^2 \) or Fisher’s exact was used to compare categorical variables. Kaplan Meier and Gray’s test for cumulative risk were performed to generate the survival curve with statistical significance maintained at \( p < .05 \).

Results: Analysis of the SEER database showed that single patients were more likely to die from their STS and at a faster rate than married patients. No differences were noted in tumor size and tumor site on presentation between married and single patients. However, single patients presented with higher grade tumors more frequently (\( p=0.013 \)), received less radiotherapy (\( p<0.001 \)) and had less surgery performed (\( p<0.001 \)) compared to their married peers. Regression analysis showed that increasing tumor size and grade, lack of radiotherapy, certain histological subtypes, lack of surgery and being single served as independent predictors of sarcoma specific death; \( p<0.0001 \).

Conclusion: Overall survival is worse for single patients as compared to married patients with STS. Single patients do not undergo surgical resection or receive radiation therapy as frequently as their married counterparts. Social support systems and barriers to care should be evaluated at time of diagnosis and addressed in single patients to potentially improve survival outcomes.

Level III Study
THE RELATIONSHIP BETWEEN SYSTEMIC INFLAMMATION BASED PROGNOSTIC SCORES AND OUTCOME IN PATIENTS UNDERGOING SURGERY FOR BONE AND SOFT TISSUE SARCOMA

Rossel Morhij, MD; Ashish Mahendra; Mike Jane; Helen Findlay; Donald C. McMillan

Introduction: The prognostic significance of systemic inflammatory response has been demonstrated in a variety of common solid tumours. The value of such markers has not been compared in patients with soft tissue and bone sarcoma. The aim of the present study was to examine the prognostic value of a number of markers of the systemic inflammatory response in patients undergoing surgery for primary soft tissue and bone sarcoma.

Method: Patients who underwent resection of primary soft tissue/bone sarcoma in West of Scotland sarcoma service between 2008–2012 were included. Blood measurements, within a week prior to surgery, of pre-operative C reactive protein, albumin, white cell, neutrophil, lymphocyte and platelet counts were recorded.

Results: 111 patients were identified. The majority of patients were ≤ 50 years old (84%), were female (63%), had soft tissue sarcoma (62%), had tumours > 10cm (52%) and of high grade (85%). The median follow up of survivors was 31 months and 33 (30%) developed distant metastases and 28 (25%) died of their cancer. On univariate analysis, tumour size (P<0.001) tumour grade (P<0.01) C-reactive protein (P<0.001), albumin (P<0.001), neutrophil count (P<0.05) and oGPS (P<0.001) were significantly associated with recurrence free survival. On a multivariate analysis, only tumour size (HR 3.08, 95%CI 1.31-7.23, P<0.05) and the oGPS (HR 1.53, 95%CI 1.13-2.09, P<0.01) were independently associated with recurrence free survival. On univariate analysis, tumour grade (P<0.01), C-reactive protein (P<0.001), albumin (P<0.01), white cell count (P<0.05) and the oGPS (P<0.001) were significantly associated with cancer specific survival. On a multivariate analysis, only tumour size (HR 2.85, 95%CI 1.10-7.39, P<0.05) and the oGPS (HR 1.60, 95%CI 1.13-2.25, P<0.01) were independently associated with cancer specific survival.

Discussion: The results of the present study indicate that the systemic inflammatory response, as evidenced by the oGPS, is an important independent predictor of recurrence free survival and cancer-specific survival in patients with soft tissue and bone sarcoma.
Background: Few large series provide data regarding the effectiveness of radiation and chemotherapy for extraosseous osteosarcoma (EOO). Controversy exists over the indications for these modalities. Previous analyses may have been compromised by the inclusion of small (<5 cm) tumors and low grade histologies. The purpose of this study is to determine whether radiation and high-dose chemotherapy improve survival and local control for large, intermediate-to-high grade EOO.

Patients and Methods: We retrospectively analyzed the clinicopathologic factors of 26 consecutive cases of pathologically confirmed AJCC (7th edition) stage IIB and III EOO treated at our institution between 1992 and 2012. Eighteen patients presented to us with primary disease and 8 with locally recurrent tumors. No patient had metastasis at the time of presentation. The Cox proportional hazard model was used to determine the effect of the treatments on survival distribution. The hazard ratios (HR) with 95% confidence intervals were calculated, and statistical significance was defined as p<0.05.

Results: At 5 years, local recurrence-free survival (LRFS) and disease-specific survival (DSS) were .34 and .34, respectively. There were 22 R0 resections and 4 R1 resections. There was no difference in LRFS and DSS between patients who presented with primary and locally recurrent disease (p=0.78 and p=0.91, respectively). Radiation (mean dose 57 Gy) was associated with better LRFS (HR=0.32 [0.11-0.97], p=0.04) but not DSS (HR=0.45 [0.14-1.42], p=0.17). Eight patients received high dose chemotherapy, which usually consisted of 4-6 cycles of doxorubicin (75 mg/m2) and ifosfamide (10 gm/m2). Chemotherapy was associated with marginally better LRFS (HR=0.37 [0.11-0.18], p=0.09) after adjusting for radiation. At 10 years, DSS of patients receiving chemotherapy was .48 compared to .10 for patients not receiving chemotherapy, but the difference was not statistically significant (HR=0.41 [0.12-1.43], p=0.16).

Conclusions: The prognosis for intermediate stage (AJCC IIB and III) EOO may be worse than previously recognized, both in terms of local recurrence and patient survival. Radiation was associated with better local control and should be strongly considered because of the high rate of local recurrence without radiation. This effect is interesting since osteosarcoma of bone is believed to be relatively resistant to radiation. The effect of doxorubicin-ifosfamide chemotherapy on local recurrence seems encouraging and suggests some efficacy of treatment. While DSS was better for the chemotherapy group, the small number of patients receiving chemotherapy may have precluded the improvement in survival from reaching statistical significance. Further work is needed to clarify this question. Finally, it should be emphasized that the results of this study pertain to localized, large (>5 cm), intermediate-to-high grade EOO. Optimal treatment of patients with small tumors, low-grade histology, or metastatic disease may differ substantially.
A SIMPLE FORMULA PREDICTS THE NECESSITY FOR COMPLEX RECONSTRUCTIVE SURGERY DURING THE RESECTION OF PRIMARY APPENDICULAR SOFT TISSUE SARCOMAS

Derek Cawley, MRCS, MMed, Sc, MCh; Gary O’Toole, MCh, FRCS

Background: Conventional surgical treatment of appendicular sarcoma involves limb-sparing surgery in over 90% of cases. Pre-operative planning is reliant on MRI scanning to define tumor morphology and surrounding anatomy. Wide-local excision may necessitate removal of overlying skin which will facilitate a negative histological margin but may compromise wound closure. Opting for primary wound closure versus secondary wound reconstruction is a decision loosely based on the nature and size of the wound, the quality of the skin and host factors.

Purpose: Using tumor, skin and limb dimensions from the pre-operative MRI, we aimed to devise a simple formula to guide this decision for primary surgical candidates.

Methods: We included all patients who had pre-operative digital MRI scanning with a diagnosis of an appendicular soft-tissue sarcoma. Excluded cases were those proximal to the shoulder or distal to the wrist and proximal to the lesser trochanter or distal to the ankle. OsiriX digital software (Version 3.9, Pixmeo) was used to measure local anatomical structures including limb, bone and tumor cross-sectional areas (CSA) and tumor depth. Parameters were analysed independently and as combinations to identify a predictive formula for requiring wound reconstructive surgery over that of primary wound closure.

Results: 58 patients fitted the selection criteria. Of these, 16 patients required additional reconstructive surgery. When applying testing for sensitivity, specificity and accuracy, we generated an optimal formula (p=0.05). A critical value of 0.2 predicted a requirement for reconstructive surgery (sensitivity 100%, specificity 76%).

Conclusions: We have devised a formula based on a patient’s pre-operative MRI scan that can accurately predict the necessity for reconstructive surgery to aid wound closure in soft-tissue sarcoma resection.

Level of Evidence 4
FUNGATING SOFT TISSUE SARCOMAS: RISK FACTORS THAT AFFECT TREATMENT OUTCOME AND SURVIVAL

Nadine Williams, MD; Michael Mijares, MD; David Landy, Medical Student, PhD; Sheila Conway, MD; H. Thomas Temple, MD

Study performed at the University of Miami Hospital, Miami, FL

Background: Sarcomas are uncommon, and tumor fungation is rare. There is limited data on patients at risk.

Patients and Methods: We performed a retrospective review of all soft-tissue sarcomas treated at our institution between 1989 and 2013 that had been followed for a minimum of five months or until patient death. The study group contained 42 patients with a primary high-grade fungating tumor, and the control group had 196 consecutive patients with a similar grade nonfungating tumor. The cohorts were compared with regard to disease presentation, treatment, oncologic outcomes, healthcare access, race, and ethnicity.

Results: Among the fungating and nonfungating groups there was a significant association between gender (female 62% and males 38%, P=0.026), age (mean 63 vs. 56 years, P=0.04), insurance type (charity/medicaid 24% vs. 9%, P=0.012), and duration of symptoms. The mean duration of symptoms was greater in the fungating than nonfungating groups (30 vs. 10 months, P<.001) but there were no differences in: diagnosis, mean tumor size (11cm vs. 11cm, P=0.69), or stage (57 vs. 57% with IIB, P=0.13). After adjusting for gender, age, and duration of symptoms, patients with charity care/medicaid had a greater risk of presenting with a fungating sarcoma (OR= 4.9, 95% CI= 1.8—13.3).

Among the fungating and nonfungating groups there was no association between insurance type and amputation rate (Charity 40% vs. Private 44%, P=.99) or the need for flaps (Charity 20% vs. Private 19%, P=.99). Among the fungating group, there was no association between insurance type and local recurrence, tumor metastasis, or overall survival (Figure).

Conclusion: Patients that are women, older, underinsured, and have a longer duration of symptoms are more likely to present with a fungating sarcoma. Fungating tumors were not associated with stage and diagnosis. There was no significant relationship between insurance status and local recurrence, the development of metastases and overall survival among patients with a fungating sarcoma.

Level of Evidence: Level II, Prognostic
Objective: Deep infection following endoprosthetic reconstruction in tumor surgery is a common and devastating complication. There is significant support among Orthopaedic Oncologists for a clinical trial aimed at establishing guidelines to decrease infection rates.

Methods: PARITY is a multi-center randomized trial in which patients with a primary bone tumor of the lower extremity treated with resection and endoprosthetic reconstruction are randomized by the site pharmacist to one of two study arms: 1 day of post-operative antibiotics, or 5 days of postoperative antibiotics. Patients are then followed at regular intervals for one year and assessed for deep infection according to the CDC definition. By superiority design, approximately 900 patients will provide study power for the primary outcome (deep infection). All participants in the study, with the exclusion of the site pharmacists and the Method Center coordinator, are blinded to treatment allocation.

Results: To-date there are sixteen active sites in Canada, the United States (US), the United Kingdom (UK) and Argentina. Nine further sites in the US, the UK, New Zealand, Japan, Israel, Scandanavia and South Africa have expressed interest and are expected to become active. Funding for the PARITY study vanguard phase has been awarded by the OREF/MSTS, the Physician Services Incorporated Foundation and the Canadian Cancer Society. Currently there are 8 sites that are enrollment ready and screening patients. The first patient was randomized into PARITY in January 2013 and sixteen patients have been randomized at the time of abstract preparation.

Conclusion: The PARITY study is the first international prospective randomized collaborative study in Orthopaedic Oncology. Due to the support of the MSTS and OREF, this study is up-and-running and gaining international momentum. PARITY will establish a collaborative network throughout our specialty that will pave the way for future generations of research and patient care.
PERI-PROSTHETIC INFECTION IN THE ONCOLOGIC PATIENT

Daniel C. Allison, MD, MBA, FACS; Eddie Huang, MD; Elke Ahlmann, MD; Scott Carney, MD; Lingjun Wang, MD; Lawrence R. Menendez, MD, FACS

This research was conducted at the University of Southern California Medical Center

Background: Infection complicates traditional joint reconstruction prostheses in at least 1–2.2% of cases, with higher rates in oncologic cases.

Questions/Purposes: We ask if prosthetic infection in our oncologic patients is associated with any epidemiologic, treatment, or outcome variables that could influence management of these difficult conditions.

Materials and Methods: We retrospective case reviewed 329 consecutive oncologic patients treated with hip or knee tumor resection and joint reconstruction, comparing infected and non-infected cases with regard to comorbidities, adjuvant therapies, and treatments.

Results: Of lower extremity oncologic joint reconstructions, 13.1% developed periprosthetic infection (6.1% knee and 20.5% hip). The most common organism cultured was Staphylococcus aureus. Debridement with implant retention procedures achieved a 42% infection remission rate, as opposed to 62% with two-staged treatment, and 100% with amputation. Adjuvant radiation and chemotherapy were associated with statistically increased infection rates, (3.85 and 1.5 relative risk, respectively). Infection cases correlated with statistically increased revision rates.

Conclusions: Infection complicates lower extremity prosthetic joint reconstructions in oncologic patients in approximately 13% of cases. The most common organism remains Staphylococcus species, and eradication rates are lower than those for periprosthetic infections in non-oncologic patients. Oncologic prosthesis infection correlates with radiation and chemotherapy administration, as well as an overall increase in revision surgery.

Level of Evidence III – retrospective comparative study

† Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
• FDA information not available at the time of printing. For full information, refer to inside back cover.
MAKING ENDOPROSTHESES LESS SUSCEPTIBLE TO INFECTION: AN IN VIVO ASSESSMENT OF THE ANTIMICROBIAL ACTIVITY OF POROUS TANTALUM
Alexandra I. Stavrakis, MD; Jared A Niska, MD; Amanda Loftin, BS; Fabrizio Billi, PhD; Lewis M. Kwong, MD; Nicholas M. Bernthal, MD

Background: Despite innovations in endoprosthesis material and surgical technique, implant infection remains the most common mode of endoprosthetic failure. Porous tantalum (Ta) is an ideal material for use in endoprostheses given its high volumetric porosity, low modulus of elasticity, and high frictional characteristics. Recent in vitro literature has suggested that Ta may also be innately antimicrobial, thereby potentially decreasing implant infections. The purpose of this study was to use an established in vivo mouse model of orthopaedic implant infection to compare the susceptibility to infection among Ta, stainless steel (Ss), and titanium (Ti).

Methods: Thirty-six mice were randomized to a survival surgery with a Ta, Ss, or Ti implant placed in a retrograde fashion into the femur. The joint was then inoculated with 1e3 colony forming units of a bioluminescent strain of S. aureus. The bacterial burden was then tracked longitudinally with quantitative bioluminescence imaging at post-op day (POD) 0, 1, 3, 5, 7, 10, and 14. Implants were extracted at POD 14 and imaged using variable-pressure scanning electron microscopy (VP-SEM). Implants were then cultured and bacterial colony counts were performed. Statistics were performed using ANOVA analysis to identify significant differences using the f test (p<0.05) among the three groups.

Results: No statistically significant differences in bacterial burden were found among the three groups. Mean bioluminescent bacterial signal at POD 14 were 7.88e4 (+/- 1.14e5), 4.45e4 (+/- 3.95e4), and 2.33e4 (+/- 1.96e4) for Ta, Ti, and Ss, respectively. A trend towards a decrease in bacterial burden in the Ti group was observed on POD 7 but did not reach statistical significance. CFU quantification did not reveal a significant difference in the number of colonies among groups harvested from both implant and surrounding tissue. In addition, there was no qualitative difference in biofilm formation among implants assessed by VP-SEM.

Discussion: These findings suggest that while Ta may have beneficial structural properties for endoprostheses, the material does not appear to be antimicrobial when tested in vivo.

2 Schildhauer TA et al. Bacterial adherence to tantalum versus commonly used orthopedic metallic implant materials. J Orthop Trauma 2006; 20(7):476-84
PREDICTORS OF INFECTION IN PROXIMAL TIBIA ALLOGRAFT AND ALLOGRAFT-PROSTHESIS COMPOSITE RECONSTRUCTIONS

Santiago A. Lozano-Calderon, MD, PhD; Megan E. Anderson, MD; Sara O. Swaim, BSN, RN; Mark C. Gebhardt, MD; Amy Federico, MSN, CPNP; Cristopher Sampson, MD

Introduction: Reconstruction of the proximal tibia after wide resection is challenging. Advocates argue advantages of allografts or allograft-prosthetic composites are bone preservation; biological reconstruction that facilitates reattachment of the extensor mechanism and other soft-tissue structures; delayed need for a metallic prosthesis; and distal femoral growth plate preservation in the pediatric population. However, complications are numerous, infection being the most common. It is believed that infection is related to the poor soft-tissue envelope in this area.

This investigation evaluates our experience with 32 patients, analyzing incidence and management of infection.

Materials and Methods: Under IRB approved protocol, 32 patients (17 males, 15 females), average age 13 (range 2-18), who underwent 33 allograft proximal tibia reconstructions were evaluated for occurrence of infection. Potential predictors of infection, categorized as pre- and peri-operative factors, were analyzed for associated risk of developing allograft infection.

Results: All patients had primary sarcomas of bone, 23 osteosarcoma and 9 Ewing sarcoma. Most reconstructions -21- were osteoarticular allografts. Fifty percent of patients had flap coverage at the index procedure. Allograft survival rate was 73% at 4.6 years. Allograft infection rate was 15%. Two patients were converted to a metallic endoprosthesis, 2 to a new allograft, and 1 to a knee disarticulation. The most common complications were wound dehiscence (48%), non-union (33%) and allograft fracture (24%). No specific predictors of infection could be identified, likely due to the low number of infections. There was an expected trend of lower WBC in patients who developed infections; however this was not statistically significant. All patients with infections had a previous wound dehiscence. While 56% of wound dehiscences had a positive bacterial culture, only 30% progressed to allograft infection after aggressive irrigation and debridement and culture specific antibiotic treatment.

Conclusion: Despite being unable able to identify predictors of infection, based in our experience, we recommend nutritional and immunological optimization of patients before surgery and a low threshold for flap coverage at the index surgery. Wound dehiscence is a common complication for which we recommend aggressive surgical treatment to avoid progression to allograft infection. Allograft infection reduction rate as high as 25% can be attained with this approach.
RISK FACTORS FOR WOUND COMPLICATIONS FOLLOWING PELVIC RESECTIONS
Nader A. Nassif, MD; John H. Healey, MD; Carol Morris, MD; Nicola Fabbri, MD; Patrick Boland, MD

Introduction: Many studies have reported high rates of wound complications following pelvic resections; there has been no study, however, that has focused on the potential factors that may contribute to that increased risk in this select group of patients. The intent of the study was to evaluate host and surgical factors that may increase complications rates.

Methods: 72 patients who underwent pelvic resections were identified. 25 patients in this cohort (study group) sustained wound complications were compared to 47 patients (comparison group) who healed without intervention. Host factors, including preoperative hemoglobin, albumin, chemotherapy and radiation were evaluated. Surgical factors including size of tumor, extent of resection, blood loss, and transfusion requirements were also analyzed.

Results: 23 of the 25 patients with wound complications required at least one surgical debridement with an average of 4 procedures required per patient. Eight of 25 patients (32%) required delayed closure with a myocutaneous flap. Preoperative hemoglobin and albumin were not statically different between the 2 groups (p = 0.6 and 0.4 respectively). 56% of the study group as compared to 51% of the comparison group received chemotherapy. 24% of the study group received radiation as opposed to 30% of the comparison group who did. The mean size of the tumor in the study group was 11.8 cm compared to 7.3 cm in the comparison group (p <0.001). 60% of the study group underwent a combined pelvic resection (Type 1+2, 2+3, 1+2+3) whereas only 23% in the comparison group did. In addition, blood loss tended to be higher in the study group (4532 cc vs 3003 cc) but did not reach statistical significance (p = 0.07) Mean intraoperative blood transfusions were higher in the study group (8.3 vs 4.8 units of packed RBCs) but again did not reach statistical significance (p = 0.06).

Conclusion: In this case-cohort series, host factors did not differ between the patient groups. The size of the tumor and extent of pelvic resection appear to be the most significant factors that predict postoperative wound complications. Thus, it may be beneficial to consider an immediate myocutaneous flap or a planned debridement in these selected patients at higher risk.
**FACTORS AFFECTING WOUND HEALING IN SOFT TISSUE SARCOMAS OF THE ANTERIOR THIGH**

Robert Kulwin, MD; Tessa Balach, MD; Mark P. Cote, DPT, MSCTR; Terrance D. Peabody MD; Rex C. Haydon, MD, PhD

**Introduction:** Management of soft tissue sarcomas consists of wide local excision, often in combination with radiation therapy and chemotherapy. Although these methods allow for limb-sparing resections, wound complications and their associated morbidity can complicate the course of treatment. While it has been established that overall rates of wound healing complications differ between anatomic sites, no study has addressed whether the risk factors for complications also differ. This study sought to determine the risk factors for wound healing complications in the proximal anterior thigh.

**Methods:** The records of patients who underwent resection of soft tissue sarcomas of the proximal thigh at a single institution from August 1, 1998 to May 30, 2012 were reviewed to evaluate for risk factors for wound healing complications. Age at surgery, greatest dimension of the excised specimen, immediate flap, adjuvant or neoadjuvant radiation therapy, adjuvant or neoadjuvant chemotherapy, wound healing complications, and additional surgical procedures to address the surgical wound were evaluated. A wound healing complication was considered to be major if an additional surgical procedure was required. Chemotherapy was categorized as none, neoadjuvant, or adjuvant. Univariate and bivariate logistic regression models were used to determine which factors were associated with an increased frequency and risk of wound healing complications.

**Results:** The medical records of 59 patients (29 female, 30 male, mean age 59.8 ± 16.4 years) were included in the study. Twenty-two of 59 patients (37%) developed a wound healing complication and 13/59 (22%) required an additional surgical procedure, 12 of which were related to a wound healing complication. Both neoadjuvant (OR=3.9, p=0.04) and adjuvant chemotherapy (OR 11.2, p=0.04) were found to be significant risk factors for wound healing complications whereas age, greatest dimension, immediate flap, neoadjuvant (OR=2.1 p=0.19) and adjuvant radiation (OR=2.4, p=0.20), and were not predictive. Both neoadjuvant (OR=6.8, p=0.02) and adjuvant chemotherapy (OR=14.3, p=0.01) were also significant risk factors for major wound healing complications whereas age, greatest dimension, immediate flap, neoadjuvant and adjuvant radiation were not predictive. There were no additional risk factors identified with bivariate analyses.

**Conclusions:** Wound healing complications are a significant source of morbidity in patients with soft tissue sarcomas of the proximal anterior thigh. This study supports the hypothesis that risk factors for wound healing complications may vary between anatomic sites. Chemotherapy for soft tissue sarcomas of the anterior thigh, in any stage of treatment, was found to be a significant risk factor for wound healing complications and additional surgery. Radiation therapy, though not statistically significant, was associated with an increased risk of wound healing complications. A larger, multicenter study may more accurately describe the wound healing complication risk profiles associated with individual treatment modalities on a site-specific basis.
Introduction: Optimal treatment of malignant bone tumors about the knee in young patients remains controversial. Leg length inequality is a major challenge with limb salvage in this group. Non-invasive expandable endoprostheses were introduced in hopes of reducing the morbidity associated with the multiple open procedures required with invasive expandable devices. Data on the outcomes of this technique are limited.

Methods: Fourteen consecutive limb salvage cases performed by the senior author using the RepiphysisR non-invasive expandable tumor prosthesis were reviewed in an IRB approved retrospective study. Medical records and radiographs of the 14 patients were studied to determine their limb salvage rate, complication rate, functional outcomes, and length discrepancy at skeletal maturity.

Results: Two patients died of disease; one of the two had expansion mechanism failure and the other died with a well functioning implant. The remaining twelve patients (6 male, 6 female; average age 9.7 years at surgery) were reviewed. Average follow-up was 76 months with minimum of 2 years. There were 4 proximal tibia replacements and 8 distal femur replacements. The limb salvage rate was 7/12 (58%). Four patients required amputation due to infection. Two of the infections occurred after conversion of the RepiphysisR to a definitive prosthesis. The other amputation was due to nerve palsy after definitive prosthesis conversion performed at another institution. Device specific complications included 2 failures of the expansion mechanism, 2 peri-prosthetic fractures, and 1 aseptic loosening requiring early revision. Total prosthesis lengthening averaged 5.2 centimeters. Final length discrepancy averaged 1.8 centimeters, and only one patient uses a shoe lift. The seven successful limb salvage patients all ambulate without assist device and do not require narcotic pain medication.

Discussion: Similar to other reports of this technique, a high complication rate was noted in this series. The amount of lengthening with this device cannot be precisely controlled, and the expansion mechanism failed in two of 14 cases. The RepiphysisR device is composed largely of polyetheretherketone (PEEK) rather than metal. Durability concerns necessitate revision to a metal prosthesis at the completion of lengthening. Three of the five amputations in this series occurred after the completion of lengthening and conversion to a definitive prosthesis. The authors now favor use of an expandable prosthesis with a stouter, more precise expansion mechanism which does not require revision surgery at the completion of lengthening.
Noninvasive expandable prostheses are used for limb-preservation when musculoskeletal tumor resection permanently alters the growing physis. This study reports one institution’s functional results, complications, and outcomes using the Repiphysis. The implant was used in the lower and upper extremity, according to FDA guidelines. From 2003 until present, 22 prostheses have been implanted in 19 primary and 3 revision cases. The average follow up was 47 months (range 1-96 mos). Patients were expanded when limb lengths were at least 1.5cm shorter than the opposite limb. Before they had the lengthening, all patients reached 0-90° of motion at the knee (n=12) and 20-120 motion at elbow (n=3). Intraoperatively patients had manipulation of the joint following expansion when necessary.

Of the 18 patients, 13 underwent a total of 73 expansion procedures. At each procedure, patients were allowed to expand an average of 1cm (range 0.9-1.5cm), with an average of 5 (range 1-10) expansions for an average total expansion of 4.7cm (range 1.8-10.2cm). Patients had a mean ISOLS MSTS functional score of 25/30 points (83%).

Of the 6 patients that were not lengthened, 3 are dead of disease and 3 have not required a procedure to date. The oncologic complications include 5 patients’ dead of disease, including one patient who had a local and regional recurrence resulting in hip disarticulation prior to death. All 4 patients that had revision to adult prosthesis had an average of 6.4cm lengthening prior and currently have equal limb length.

There were 7 complications requiring additional surgery. Average time to complications was 39 months. Two patients had aseptic loosening of one femoral and one tibial stem. The patient with the tibial stem loosening was revised to an adult prosthesis. Two patients experienced a deep infection at 24 and 48 months. One patient was successfully treated by explant and exchange arthroplasty with an adult prosthesis. The other patient is currently being treated with intravenous antibiotics and a prostalac spacer. Two patients had a traumatic peri-prosthetic fracture requiring revision, one of which was revised to an adult prosthesis. One patient, who was re-implanted with a Repiphysis following an explant of an infected second generation expandable, has a 120° flexion contracture of the elbow. At present time, 10 patients are continuing with planned expansions.
Two patients experienced mechanical instability near maximum expansion and were revised with a new Repiphysis.

Overall patient’s limb retention was 18/19 (95%), with one amputation as a result of recurrent sarcoma. All patients maintained their limb length, ambulation, and range of motion.
EARLY RESULTS OF MODULAR INTERCALARY ENDOPROSTHESIS USED IN MUSCULOSKELETAL TUMORS
Joseph Benevenia, MD; Bastian Himpe, MD; Max Friedrich, MD; Mark J. Palma; Kathleen S. Beebe, MD; Francis R. Patterson, MD; Rainer Kirchner, MD

Intercalary endoprostheses provide an option for patients with diaphyseal and meta-diaphyseal defects related to musculoskeletal tumor surgery. The records from three musculoskeletal oncology centers between 2008 until present were reviewed. We identified 40 patients with diaphyseal and meta-diaphyseal defects following treatment for musculoskeletal tumors that were treated using the Osteobridge modular intercalary prosthesis. There were 41 separate anatomic locations in 40 patients to include 18 humeri, 5 tibial, and 18 femora. Eight patients had primary tumors with an average age of 49 years (range 18-74) while 33 had secondary metastatic lesions with a mean age of 68 years (range 46-91). Thirty-eight patients had resection of tumors followed by endoprosthetic reconstruction using standard oncologic principles. Three patients had revision surgery of failed limb preservation using the osteobridge surgery. Four patients had modular intercalary implants used to treat a periprosthetic failure of limb salvage. Twenty-seven (66%) patients had implants cemented with PMMA while 14 (34%) had cementless fixation. The average defect size was 9cm (humerus = 7cm, tibia =11cm, femur =10cm). Patients were evaluated using the ISOLS-MSTS functional evaluation system. The average MSTS score was 77% (humerus = 83%, tibia = 77%, femur = 70%). The average follow up was 13 months (range 1-51). There were 10 non-oncologic, implant related complications (24%): 5 patients with cementless fixation were found to have aseptic loosening of the stem and 5 patients with cemented fixation were found to have spacer-clamp failure. One patient died of an acute MI within 14 days of the procedure and was excluded from the functional evaluation. The average time to complication was 21 months. There was one postoperative hematoma. Oncologic outcome and complications included: 7 patients completely disease free, 28 patients alive with disease, 4 dead of disease, and 2 dead of condition.

Chi-squared analysis of limb complications showed that patients with femoral reconstruction had a higher risk for complications (p<0.001). All 10 prosthetic complications were seen in femoral implants. Cementless fixation was associated with implant stem failure (5 pts. p=0.004) and cemented fixation was associated with implant spacer failure (5 pts. p=0.004). Patients with cemented implants had significantly higher MSTS scores than did those with cementless (83% vs 63%, p = 0.001). There was a trend for patients with cementless fixation to have an increased risk of complications compared to those with cemented fixation (36% vs 19%, p=0.20). There was only one reoperation for non-implant related reasons (postoperative hematoma). Overall the results of this reconstructive method using the Osteobridge prosthesis compare with other implants and series with respect to tumor histology, follow-up, functional scans, and complications. Femoral clamp fixation may require larger screws and body segments. The femoral location and reliance on cementless fixation are associated with the most complications. Cemented fixation is associated with significantly higher MSTS scores (83% vs. 63%; p=0.001).
ARTICULATING DISTAL FEMUR ANTIBIOTIC CEMENT SPACERS

Justin Clayton, MD; William Ertl, MD; Jeremy White, MD

Background: While the use of antibiotic impregnated cement spacers is not new, the use of such spacers with articulating knee components in the presence of significant bone loss of the distal femur has not been well studied.

Question / Purpose: In this study we ask whether a novel technique that combines an articulating knee spacer with a cement component that replaces the distal femur can be used in the two-stage treatment of an infection with acceptable treatment outcomes and complication rates.

Methods: Three patients were retrospectively identified at our center that sustained distal femur fractures (OTA type 33) and then developed infected nonunions. Each of these patients underwent staged reconstruction. The initial surgery involved removal of the infected hardware (a locking distal femoral plate in two cases and an intramedullary nail in one case). During this first surgery the infected distal femur bone segment was resected, leaving a significant bone defect. Components for an articulating knee spacer were constructed with cement molds and attached to a humeral nail coated in cement to fill the bony defect and fix the construct to the femur. The second surgery involved removal of the spacer and placement of a rotating hinge knee arthroplasty. Prospectively the Oxford Knee Score and Musculoskeletal Tumor Rating Scale were completed at the most recent follow up visits.

Results: Follow-up ranged from 11–34 months. All three patients achieved soft tissue healing, appropriate alignment on plain radiographs, and functional range of motion and mobility for the implant used. There were no major complications identified. Outcome measures demonstrated acceptable results in all three cases. At the time of this publication none of the patients have had a recurrent infection or required further surgery.

Conclusions: Our method of using stemmed articulating spacers to convert infected distal femur nonunions to rotating hinged arthroplasties shows promise. The long term results of this technique will still need to be assessed. We believe as more patients undergo this procedure it will be found to be a viable option not just for infected fracture nonunion, but also for staged reconstruction of infected tumor prostheses or complicated knee arthroplasty infections. This technique may provide benefits when compared to static spacers for the same indication.
THE ENDOGENOUS PEPTIDE ANGIOTENSIN-(1-7) PREVENTS RADIATION-INDUCED MUSCLE FIBROSIS: AN IN VIVO MURINE MODEL

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Introduction: Over 1,000,000 patients are diagnosed with cancer annually and nearly 67% of them receive radiotherapy (RT). Radiation-induced fibrosis (RIF) is a debilitating late effect of RT that causes muscle weakness, joint contracture, and functional limitations. Currently, no standardized therapy prevents RIF in muscle, and animal models for testing therapeutics are poorly established. Angiotensin-(1-7), an endogenous peptide hormone in the nonclassical renin-angiotensin system, has previously been shown to prevent collagen deposition associated with tumoral fibrosis. We hypothesize that Angiotensin-(1-7) prevents RIF in skeletal muscle after modeled sarcoma RT.

Methods: Seven-week-old Swiss Albino mice received either sham surgical procedure or subcutaneous osmotic minipump delivering angiotensin-(1-7) at 24 µg/kg/hr beginning three days before undergoing a two-week course of fractioned radiation (7.3 Gy/fraction; 2 fractions/week) using 300 kV x-rays targeting one hindlimb. This RT regimen provided the biological equivalent dose for sarcoma treatment (100.2 Gy) despite 29.2 Gy total dose. Controls received no irradiation or treatment. Animals were sacrificed at 1.5 and 4 months after RT.

Fibrosis in the gastrocnemius was assessed with in vivo load-relaxation testing before sacrifice. Tension generated by displacing the immobilized muscle 5% and 10% of its resting length was recorded with a force transducer. Muscle relaxation properties were evaluated with Fung’s quasi-linear viscoelastic (QLV) model. Following testing, muscles were processed, sectioned and stained with picrosirius red for histological analysis. Interstitial and perivascular fibrosis were quantified by averaging the percentage of the field stained for collagen in five random sections taken from the mid portion of each gastrocnemius muscle.

Results: Radiation (n=9) increased stiffness of the gastrocnemius (107%, p<0.001) relative to control (n=12) at 1.5 months and 4 months, as determined from passive displacement muscle tension. Angiotensin-(1-7) treatment (n=11) mitigated this response at 1.5 months (27% increased stiffness) and 4 months (37% increased stiffness), a significant reduction compared to sham treatment (p<0.001 and p<0.01, respectively). Relaxation data in the Fung framework showed no difference between groups (parameters C, τ₁, τ₂) suggesting that the increased peak tension found in irradiated animals was not compensated for by altered relaxation magnitude. Coincident with functional stiffening, histologic quantification demonstrated that modeled sarcoma RT induced skeletal muscle fibrosis compared to control animals (0.6% fibrosis/field to 1.1% fibrosis/field, p<0.01) and perivascular fibrosis (7.4% fibrosis/field to 15.8% fibrosis/field, p<0.05). Angiotensin-(1-7) treatment prevented these fibrotic changes (skeletal muscle, 0.7% fibrosis/field; perivascular, 8.4% fibrosis/field) which was a significant reduction compared to sham treatment (p<0.05).

Discussion: Angiotensin-(1-7) mitigated RIF resulting from modeled sarcoma RT. Clinical translation of these findings will determine whether prophylactic angiotensin-(1-7) treatment can prevent RIF in patients who require adjuvant radiotherapy for treatment of extremity soft tissue sarcoma.
THE VALIDITY OF A RAT MODEL FOR ANALYZING MICRO-RNA IN CHONDROSARCOMA
Nicholas B. Frisch, MD, MBA; Christopher Dobson, MS; Gary Gibson, PhD; Theodore W. Parsons, MD, FACS; Michael P. Mott, MD

Introduction: MicroRNA (miRNAs) expression has been previously shown to be linked to tumor growth and progression. Analysis of miRNA expression has also provided biomarkers that define tumor type and stage. Several studies have looked at miRNA expression in human sarcomas but no studies have been reported the use of miRNAs signatures to define chondrosarcoma stage or to distinguish enchondroma from chondrosarcoma. The Swarm rat chondrosarcoma has for many years provided a resource for studying cartilage biochemistry and chondrosarcoma development. In our institution we have established a widely used chondrosarcoma cell line derived from the original Swarm rat chondrosarcoma that produces a highly reproducible tumor when injected subcutaneously in rats. To validate the use of the rat chondrosarcoma for studies miRNA function in the development of the chondrosarcoma we have compared the expression of miRNAs in the rat chondrosarcoma relative to normal rat cartilage with miRNA expression in human chondrosarcoma relative to normal human cartilage.

Methods: Twenty healthy Sprague-Dawley rats age 10-15 weeks were sacrificed, sterna and rib cartilage were collected and RNA extracted. 380 miRNAs were analyzed by Taqman low-density arrays from the rib and the sternum samples. The results were then directly compared to an array analysis of chondrosarcoma dissected from a tumor in a rat swarm chondrosarcoma cell line. Normal human tissue was similarly compared with human chondrosarcoma tissue. CT values of miRNA in each sample were normalized by the loess method. MiRNAs were then selected that showed differences between normal human cartilage and fresh chondrosarcoma, and between normal rat cartilage and rat chondrosarcoma.

Results: Several miRNA that showed a difference between normal human cartilage and fresh chondrosarcoma showed similar difference between normal rat cartilage and rat chondrosarcoma. Of particular interest during preliminary analysis were: miR-181a, miR-145, miR-143, miR-21, miR-138, miR-489 and miR-320. More extensive analysis is currently underway in human tissues and the rat model, but at present time it appears that miRNA expression in the rat chondrosarcoma closely resembles that human chondrosarcomas.

Conclusion: At present time, the similarities in miRNA between normal human and rat samples, and human and rat chondrosarcoma samples suggest that the rat model is a viable model for further study of chondrosarcoma and will enable us to determine the role of miRNAs in chondrosarcoma development and progression. We anticipate that these studies will provide rational new targets for the development of much needed therapeutic intervention.
MICRO-RNA AND CHONDROSARCOMA METASTASIS
Richard M. Terek, MD; Xiaojuan Sun, MD, PhD

Introduction: New treatments to inhibit metastasis for patients with intermediate and high grade chondrosarcoma are needed since chemotherapy is generally ineffective. Metastatic pathways in chondrosarcoma are enhanced by hypoxia and regulate expression of factors such as MMPs and VEGF. Regulation of metastatic pathways could also involve microRNAs (miRs), short noncoding RNAs that negatively regulate gene expression. In cancer, miRs can function analogous to tumor suppressors or oncogenes, and may be master regulators of the malignant phenotype through complementarity with multiple target genes. We identified candidate miRs using overlapping screens in which miR microarrays were used to compare miR expression in primary human tumors, xenograft tumors, normal cartilage, and chondrosarcoma cell lines and chondrocytes cultured under normoxic and hypoxic conditions. We performed functional screens of candidate miRs using secreted MMP1 and VEGF as readouts. We identified miR-181a as a hypoxia responsive miR that is overexpressed in chondrosarcoma whose overexpression increases VEGF and MMP1 expression. We hypothesized that anti-miR-181a would inhibit chondrosarcoma angiogenesis, invasion, tumor growth, and metastasis. We demonstrate that the mechanism of miR-181a activity involves enhancement of C-X-C chemokine receptor type 4 (CXCR4) signaling. miR-181a is the first identified onco-miR that promotes chondrosarcoma growth and invasion in vitro and in vivo.

Methods: Real-time RT-PCR was used to quantitate expression of Regulator of G-protein signaling 16 (RGS16) mRNA and miR-181a. RGS16 is a negative regulator of CXCR4 signaling.

ELISA was used to measure secreted VEGF and active MMP1 in conditioned media and Western blotting for RGS16 in cell lysates after miR-181a knockdown.

Lentivirus expression constructs for mir-181a, anti-miR-181a, or control sequences were used to induce miR knockdown or overexpression in chondrosarcoma cell line JJ (a gift from Joel Block, MD).

Luciferase assay was used in conjunction with wild type and mutated pEZX-RGS16 promoter to assess miR-181a regulation of RGS16.

In vitro proliferation assay, xenograft tumor volume, in vitro invasion assay, in vivo bioimaging of MMP activity, and quantification of lung metastases in a mouse xenograft tumor model were used to measure the effect of anti-miR-181a on invasion, tumor growth, and metastasis.

Statistics: ELISA, luciferase activity, proliferation, and invasion assays were compared with one-way ANOVA, followed by the Student’s t-test. qRT-PCR and Western blot were analyzed with the Student’s t-test. Lung metastases were analyzed with Fisher’s Exact test. The null hypothesis of no difference was rejected at a significance level of 5%.
Results: Anti-miR-181a knockdown compared to control reduced in vitro proliferation (43%), invasion (70%), MMP1 and VEGF protein in conditioned media (60 and 47%), in vivo bioimaging of MMP (56%), tumor volume at 5 weeks (62%) and lung metastases (71%).

To determine the mechanism of miR-181a activity, we performed a bioinformatics analysis to identify target genes. We have previously shown that CXCR4 signaling is overactive in chondrosarcoma and inhibiting CXCR4 with a receptor antagonist inhibits metastasis. RGS16, a negative regulator of CXCR4, is a putative target of miR-181a. By inhibiting an inhibitor, CXCR4 signaling would be enhanced by mir-181a overexpression. Knock-down of miR-181a increased RGS16 3'UTR luciferase activity (46%), RGS16 mRNA (133%), and protein (102%), while overexpression had the opposite effects.

Conclusions: miR-181a functions as an onco-miR in chondrosarcoma. Overexpression of miR-181a increases the invasive phenotype. Antagomir therapy aimed at miR-181a reduces expression of pro-angiogenic and metastatic factors, and reduces tumor growth and metastasis. The mechanism of mir-181a is through regulation of RGS16, an innate inhibitor of chemokine receptor signaling. Knockdown of miR-181a restores expression of RGS16, thereby inhibiting CXCR4 signaling. Antagomir therapy is a promising approach for chondrosarcoma treatment.
EXTRASKELETAL MYXOID CHONDROSARCOMA: MICRO-RNA ANALYSIS AND PATHOGENESIS
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Objectives: Extraskeletal myxoid chondrosarcoma (EMC) is a malignant soft tissue tumor of uncertain differentiation. EMC has distinguished characteristic chromosomal translocation, mostly is t(9;22) (q22;q12.2), results in fusion of EWSR1-NR4A3. The given key types of translocation are not readily explained why morphological low grade tumor resulted in high rate of local recurrence, but prolonged survival after metastasis and eventually high rate of death. We hypothesize that EMC is also driven by epigenetic dysregulation, specially miRNA and aberrant methylation. The aim of the study is to investigate role of miRNA in EMC.

Materials and Methods: miRNA was extracted from paraffin embedded tissue of sixteen EMC patients. Differentially expressed miRNA were determined by means of miRNA sequencing. miRNA overexpression was confirmed by immunofluorescence staining and quantitative polymerase chain reaction (qPCR). The predicted target genes and pathway analysis were obtained.

Results: Twenty cases of EMC were identified. The ratio of male: female was 2.3:1. The median age was 64 years (range; 41-96). Fifty percent of all tumors occurred in proximal extremities and limb girdles. The median tumor size was 10 cm (range; 2.2-30). Mean follow-up time was 5.4 years (range, 0.6-19.7). Eight patients (40%) were continuous disease free, six (30%) were alive with disease and six (30%) were died of disease. Local recurrence was found in 8 (40%) patients and seven (35%) patients developed distant metastases. 5, 10 and 15-year overall-survival rates were 76.3%, 55.3% and 33.8% and event-free survival rates were 75%, 32.1% and 0% respectively (Fig 1). Fused red/green signals represent an intact 22q12 region, whereas the split red/green signals indicate a rearrangement involving the EWSR1 gene (Fig 2). Clustering analysis of miRNA frequencies showed separation of EMC from normal soft tissue and other myxoid sarcomas. We identified high expression of miR-99a, miR-10b, miR-30a, miR-106a and miR-21.

Conclusions: This analysis revealed positive and negative correlation pathways to EMC, as well as novel miRNAs. Our findings established miRNA signature of EMC that associated with pathogenesis, tumor subtypes and prediction of metastasis. These miRNAs and their products also represent potential therapeutic targets for EMC.

Key words: Extraskeletal myxoid chondrosarcoma, prognostic factors, EWSR1, NR4A3, miRNAs

Figure 1. KAPLAN-MEIER OVERALL AND EVENTFREE SURVIVAL CURVE

Figure 2. FISH ANALYSIS OF EWSR1-NR4A3 TRANSLOCATION

† Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
• FDA information not available at the time of printing. For full information, refer to inside back cover.
The goal of surgical management of sarcoma is complete resection of the tumor. The completeness of resection is difficult to assess, particularly intraoperatively. An intra-operative, cathepsin-activated fluorescent probe and imaging camera is able to predict local recurrence in a genetically engineered mouse model of soft tissue sarcoma. This system is able to image soft tissue sarcoma in de novo canine tumors as well. Here we present preliminary phase I, first-in-human, results of the use of the probe (LUM015) in human sarcoma patients.

The purpose of the study is to determine a safe dose of LUM015 that effectively labels tumors.

Methods: An IRB approved phase I, open-label, single center, nonrandomized trial comparing up to four dose cohorts employs a modified 3+3 design, with dose cohorts: -1 to 3 (0.25, 0.5, 1 and 1.5 mg/kg). At the highest dose that does not cause a clinically meaningful side effect in the 3 patient cohort, an additional 3 patients will be enrolled. Inclusion criteria include sarcoma patients greater than 18 years old with at least 1 cm of tumor undergoing resection surgery. Other inclusion criteria include ECOG performance status of 0 or 1, ALT, AST, and total bilirubin within 1.5x normal limits, alkaline phosphatase within 2.5x normal limits and serum creatinine of 1.5 mg or less, creatinine clearance greater than 30 ml/min. Exclusion criteria include a BMI >35, IDDM, chronic renal, hepatic or pulmonary disease. The Safety Monitoring Committee meets after each dose cohort is full or if a clinically meaningful side effect is noted.

Results: Patients are admitted to the research unit the day prior to surgery and monitored overnight after administration of the probe through a slow IV push. Blood is drawn serially for pK determination and monitoring of hepatic and renal function. The patient undergoes standard resection surgery ~24h after probe administration. In the pathology suite, the tumor and samples of surrounding margin are imaged with the imaging camera. Specimens from imaged areas are harvested for histological evaluation and cathepsin measurement.

Figure 1. Fluorescent imaging (top) and correlative histology (bottom) from multiple areas of a single case of undifferentiated pleomorphic sarcoma in a human patient.

Conclusion: Preliminary results of LUM015 in human patients indicate that the drug is safe and well tolerated at the dosages that have been given and that we can differentially label tumor and normal tissue. Additional patients will be enrolled at higher dosing cohorts to better evaluate safety, pK and labeling efficacy.
INCREASED EXPRESSION OF CADHERIN 11 IN BONE-DERIVED 786-O RENAL CELL CARCINOMA CELLS
Robert L. Satcher, MD; Tianhong Pan, MD; Yu-Chen Lee, MD; Song-Cheng Lin, MD; Guoyu Yu, MD; Sue-Hwa Lin, MD

**Background:** Bone is one of the most common sites for metastasis of renal cell carcinoma (RCC). Metastasis are typically lytic, destructive, and difficult to treat.

**Question/Purposes:** What are the specific factors involved in RCC bone metastasis formation?

**Methods:** We generated organ-tropic cell lines by in vivo selection using human 786-O RCC cells and characterized the expression of several adhesion molecules, angiogenesis factors, and factors that modulate bone homeostasis in these cell lines using real-time PCR and/or Western blot assay.

**Results:** Our results show that cadherin11 expression was significantly increased in bone-derived 786-O cells compared to parental or liver/lymph node-derived 786-O cells. It was also evidenced by FACS analysis using anti-cadherin11 antibody (2C7). Western blot didn’t show significant differences in the protein levels of CXCR4, a membrane receptor for SDF-1, although the gene expression by real-time PCR showed an increase in organ-derived 786-O cells. Among the angiogenesis factors examined (VEGF and HIF-1α), there were no significant differences in the expression among the organ-specific cell lines, whereas, the levels of angiopoietin-1 were very low in all cell lines. Interestingly, among the factors that modulate bone homeostasis, the levels of PTHrP and IL-6 in Bone-derived 786-O cells were lower compared to that in parental 786-O, while the levels of RANKL were too low to be detected.

**Conclusions:** The specific increase of cadherin-11 in bone-derived 786-O cells indicates that cadherin-11 may contribute to the colonization of RCC in bone.

**Clinical Relevance:** Our studies suggest that cadherin-11 may be a promising target for developing strategies to prevent RCC bone metastasis.
THE ROLE OF TWIST IN ANGIOGENESIS AND CELL MIGRATION IN GIANT CELL TUMOR OF BONE
Michelle A. Ghert, MD; Isabella Mak, MSc; Shalini Sing

This research project was performed at Juravinski Cancer Centre, Hamilton, Ontario, Canada

Background: Giant Cell Tumor of Bone (GCT) is a benign aggressive tumor with metastatic potential. The tumor consists of multi-nucleated giant cells which direct bone resorption and neoplastic mesenchymal cells with pre-osteoblast features. TWIST is an important osteoblastic transcription factor which is also necessary for epithelial-mesenchymal transition (EMT) and cell motility in cancer. We have previously shown that TWIST suppresses osteoblastic differentiation in the mesenchymal cells in GCT. In this study we investigated the functional role of TWIST in GCT cell angiogenesis and migration.

Methods: Cell cultures were established from two patient GCT specimens following Ethics guidelines. Patient specimens were also studied with immunohistochemistry (IHC). A stable cell line with TWIST overexpression was created with plasmid transfection. Down-regulation of TWIST expression was achieved with siRNA gene knockdown. Gene and protein expression for TWIST, vascular endothelial growth factor (VEGF), its receptor VEGFR1, CD-31 (vascular maker) and E-cadherin (EMT) were evaluated with real-time PCR and western blot analysis. A wound closure assay was used evaluate GCT cell migration.

Results: IHC confirmed in vivo expression of TWIST, VEGF and CD-31 in GCT specimens. Over-expression of TWIST significantly increased mRNA and protein expression of VEGF and VEGFR1 in vitro (Figure 1A), whereas knockdown of TWIST resulted in decreased VEGF and VEGFR1 expression (Figure 1B). TWIST overexpression also resulted in features of EMT including increased cell migration and down-regulation of E-cadherin.

Conclusions: The results of our study indicate that TWIST may play an important role in angiogenesis and cell migration in GCT. We have previously reported significant up-regulation of TWIST in patient GCT specimens and therefore the aggressive features of GCT may be related to the abnormal expression of TWIST in these tumors.

Figure 1. A. The effect of TWIST overexpression and B. TWIST knockdown on the expression of VEGF and VEGFR1 in GCT cells determined by real-time PCR (left) and Western blot (right).
A NOVEL PATIENT-DERIVED INTRA-FEMORAL XENOGRAFT MODEL OF BONE METASTATIC PROSTATE CANCER THAT RECAPITULATES MIXED OSTEOLYTIC AND OSTEOBLASTIC LESIONS

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Introduction and Objective: Prostate cancer metastasizes to bone in the majority of patients with advanced disease leading to painfully debilitating fractures, spinal compression and rapid decline. Prostate cancer bone metastases often become resistant to therapies including androgen deprivation, radiation and chemotherapy. There are currently few models to elucidate mechanisms of interaction between the bone microenvironment and prostate cancer. It is, thus, essential to develop new patient-derived, orthotopic models. Here we report the development of PCSD1 (Prostate Cancer San Diego 1), a novel patient-derived intra-femoral xenograft model of prostate bone metastatic cancer that recapitulates mixed osteolytic and osteoblastic lesions.

Methods: A femoral bone metastasis of prostate cancer was removed during hemiarthroplasty and transplanted into \( \text{Rag}^{2-};\text{g}^{f} \) mice either intra-femorally or subcutaneously. Xenograft tumors were analyzed for prostate cancer biomarker expression using RT-PCR and immunohistochemistry. Osteoblastic, osteolytic and mixed lesion formation was measured using micro-computed tomography (mCT).

Results: PCSD1 cells isolated directly from the patient formed tumors in all mice that were transplanted into \( \text{Rag}^{2-};\text{g}^{f} \) mice. Xenograft tumors expressed human prostate specific antigen (PSA) in RT-PCR and immunohistochemical analyses. PCSD1 tumors also expressed AR, NKX3.1, Keratins 8 and 18, and AMACR. Histologic and microCT analyses revealed that intra-femoral PCSD1 xenograft tumors formed mixed osteolytic and osteoblastic lesions. PCSD1 tumors have been serially passaged in mice as xenografts intra-femorally or sub-cutaneously as well as grown in culture.

Conclusions: PCSD1 xenografts tumors were characterized as advanced, luminal epithelial prostate cancer from a bone metastasis. PCSD1 intra-femoral xenografts formed mixed osteoblastic/osteolytic lesions that closely resembled the bone lesions in the patient. Castration-resistant growth in the bone niche was evaluated in young and aged mice as well as in the presence and absence of novel bone signaling pathway inhibitors. PCSD1 is a new primary prostate cancer bone metastasis-derived xenograft model to study castrate-resistant metastatic disease in the bone and to develop novel therapies for inhibiting prostate cancer growth in the bone niche.

Prostasphere growth was characterized in 3D co-culture model of the bone niche with human bone marrow derived stromal cells. PCSD1 tumors grew in mice treated with the anti-androgen, bicalutamide, thus, demonstrating castrate resistance with standard of care therapy.
A MINIMUM 2 YEARS FOLLOW UP OF 100 IMPLANTS USING THE ENDO-EXO/integral leg prosthesis (ILP)

Munjed Al Muderis, MD

Methods: Between 1999 and 2011 we performed one hundred operations using the Integral Leg Prosthesis (ILP), a transcutaneous osseointegration technology for rehabilitation of amputees. The surgeries were performed in two centers: Lübeck, Germany and Sydney, Australia by the two principle surgeons acquainted with this technology.

Results: Altogether there were 74 males and 18 female patients with 100 implants in total, including 8 bilateral cases. The age range was between 2 and 76 at time of amputation and 17 to 76 at time of implantation. 76% of our patients had amputations due to traumatic accidents, 12% due to infection, 10% due to neoplastic disease and 4% due deformities. Preoperative assessments included medical, psychological and radiological examinations. All patients underwent the standardized two-stage procedure with a six-week interval. All patients were allowed early mobilization and full weight bearing two weeks after the second stage surgery.

Discussion: Following up the complications that were experienced using the ILP procedure, there were seven different subgroups defined. These are infections that needed surgical intervention, fractures, implant failure, adapter failure, granulation tissue, sciatic neuroma with pain issues, and other not further classified problems that occurred either peri-operatively or were of rather psychological relevance. Different treatment options were chosen to encounter these problems and numbers for above- and below-knee amputations were interpreted separately where appropriate. Despite several pitfalls that had to be encountered, a positive learning curve can be described and the overall patient’s satisfaction is encouraging. The experience made in more than a decade emphasizes the importance of a close relationship between patients, surgeons and other allied health professionals regarding the bone-anchored ILP method and subsequent stoma region. The need for a global network with vivid and educated members to ensure a safe treatment option for amputees has to be contented in the future as the technique becomes more and more established.
Introduction: The Integral Leg Prosthesis (ILP) procedure was first introduced to Australia in 2009 and since 2011 OGAAP protocol was established in Sydney. The OGAAP was designed to possibly meet every aspect of an amputee’s need during rehabilitation and the process before, during and after surgery using the bone-anchored ILP technique.

Methods: The team consists of the surgeon, an anaesthetist, a psychologist, a rehabilitation doctor, prosthetists, physiotherapists, nurses and other allied health professionals. The OGAAP includes guidelines for pre- and post-operative surgical considerations, prosthetic care and physiotherapy. It specifies exclusion criteria, effective and significant follow-up assessments and parameters that need to be collected in order to come up with future studies. These include clinical follow-ups, video analysis of pre- and post-op gait, energy expenditure, return to work studies and psychological outcomes.

Results: Between 03/2011 and 06/2013 the protocol has been applied to successfully treat 38 cases in 36 patients, including 28 males and 8 females. Seventeen surgeries (45%) were done for the left leg, 21 cases (55%) for the right leg. In 75% (28) the amputation was performed due to trauma, in 12% (5) due to infection, 10% (4) due to neoplasia, and a single case due to congenital deformity. An analysis of the data shows promising prospective, with 100% of implanted patient stating their satisfaction with the procedure subjectively, as well as in the more objective testing including K-scale and functional tests such as Six Minutes Walk Test, and Time Up an Go. Prior to surgery eight patients (21%) were wheelchair bound while 79% of patient were able to ambulate to varying degrees, the functional improvement as shown in the average K-scale results for wheelchair bound and ambulators was 2.6 points and 1.3 points, respectively.

Discussion: Using the OGAAP we were able to achieve a favorable treatment for amputated patients that were either wheelchair bound due to inability to use their prosthesis, or for the very young and active patient’s, who aspired for a better solution than the regular prosthesis. Since the advent of OGAAP, within two years we were able to provide solution to a large population, were every single wheelchair bound patient were able to ambulate after implantation. In the more active young patient, the improvement of functionality was remarkable but to a lesser degree than the K-0 population. A presentation of challenges encountered using the technique demonstrates the importance of a standardized and continual protocol. We share our experience to ensure evidence-based advances to meet our patients’ very high expectations towards their prosthetic rehabilitation.
**Introduction:** Major amputations are indicated for curative treatment of most primary tumors of the sacrum and pelvis. Previous literature suggests that patients with a hemipelvectomy level amputation are more efficient walking with crutches than walking using a prosthesis. With new advances in prosthetic components, patients are choosing to use their prostheses for primary mobility. Our objective was to investigate the difference in functional outcome measures walking with a prosthesis compared to one-legged walking with crutches following hemipelvectomy.

**Methods:** We identified five patients who underwent hemipelvectomy amputation over a six-year period and are successful prosthetic users. All prostheses used the same components. All patients had worn their prostheses for at least six months. Patients were timed while doing various functional measures including: timed up and go (TUG), 5-meter walk, 400-meter walk, and stair climb tests; to evaluate functional performance ambulating with a prosthesis and without. Sex matched, age similar controls from the general population were also tested performing the same functional measures. Testing was performed during unrestrained walking at the patient's chosen velocity. Quality of life was measured by having the patients and controls respond to a SF-36 (version 1) questionnaire.

**Results:** Controls performed better than patients following a hemipelvectomy level amputation ambulating with crutches or prosthesis in all physical categories (Table 1). However when comparing patients with a hemipelvectomy level amputation functional measures while ambulating with a prosthesis or crutches, there was a statistical advantage for using crutches over wearing a prosthesis in the TUG, 5 meter walk and 400 meter walk; but no difference in stair climb between the two modalities. Similarly, patients physical SF-36 score was impacted by the procedure. There was a significant decline in the patients’ physical component score; however, the mental component score was no different from the general population.

**Discussion and Conclusion:** In line with previous reports, a hemipelvectomy has a drastic effect on the patients' functional status physically. Although patients still function at a physically lower level compared to the general population, they are functioning at a higher level compared to historical reports, and mentally they are on par with their peers. We feel that all patients who undergo a hemipelvectomy should be offered a prosthesis, and with this data we hope that it will better educate physicians as well as patients as to what they can expect functionally following this life-changing event. With continued advances in prosthetic design and components, hopefully the gap in physical function will continue to close.
### Table 1. Average Functional Measures in Patients with a Hemipelvectomy vs. Control

<table>
<thead>
<tr>
<th>Functional Test</th>
<th>Control</th>
<th>Patients with Crutches</th>
<th>Patients with Prosthesis</th>
<th>P Value for Control vs. Crutches</th>
<th>P Value for Control vs. Prosthesis</th>
<th>P Value for Crutches vs. Prosthesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>400-Meter Brisk Pace (Seconds)</td>
<td>229.6</td>
<td>351.2</td>
<td>485.2</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>TUG (Seconds)</td>
<td>8.4</td>
<td>14.4</td>
<td>20.2</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>5-Meter Walk Pace (Meters/Second)</td>
<td>1.42</td>
<td>1.07</td>
<td>0.84</td>
<td>0.06</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Stairs (Seconds)</td>
<td>10.5</td>
<td>33.5</td>
<td>37.6</td>
<td>0.06</td>
<td>0.06</td>
<td>0.44</td>
</tr>
<tr>
<td>SF-36 Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Component</td>
<td>55.02</td>
<td>-</td>
<td>35.46</td>
<td>-</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Mental Component</td>
<td>52.62</td>
<td>-</td>
<td>55.64</td>
<td>-</td>
<td>1.0</td>
<td>-</td>
</tr>
</tbody>
</table>

* Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
* FDA information not available at the time of printing. For full information, refer to inside back cover.
THE RISK OF AMPUTATION AFTER UNPLANNED SOFT TISSUE SARCOMA EXCISIONS
Chigusa Sawamura, MD; Seiichi Matsumoto; Keisuke Ae; Takashi Shimoji; Atsushi Okawa

Background: Unplanned excisions of soft tissue sarcoma may adversely affect local recurrence and overall survival. Tumor bed excisions are recommended after most cases of unplanned excision, although these procedures may be more extensive compared to planned excisions. In some cases skin grafting, muscle flaps or even amputation are used for those patients. We compared patients who had tumor bed re-excisions after unplanned excisions with those who had no prior procedure. We expected a higher incidence of amputation and need for flap/skin grafts for those who had unplanned excisions. We also evaluated the effect of unplanned excisions on the development of local recurrence and overall survival.

Methods: Patients diagnosed with soft tissue sarcomas and who underwent surgical excision of tumor at Cancer Institute Hospital in Tokyo between 1980 to 2009 were retrospectively reviewed. Age, histologic diagnosis, grade, tumor location, size, surgical procedure (amputation, limb-sparing procedure) and the use of flap or skin graft were reviewed for each patient. We used Chi square test to compare each prognostic variable between planned and unplanned excision patients. We compared the incidence of local recurrence free survival and overall survival by Cox regression in both groups.

Results: 841 patients with a median age at diagnosis of 52-years were eligible for analysis. 76 % of patients had initial surgical excision in our hospital and 24 % of patients had tumor bed excision after unplanned excision elsewhere. Patients who had unplanned excisions had smaller (p<0.001), more superficial (p<0.001) and low grade (p=0.001) tumors than in the planned group. Most patients who required amputation were in the planned excision group; unplanned excisions did not increase a risk of amputation (p=0.07). Those who had unplanned excisions were more likely to have a muscle flap (p=0.02) or skin graft (p=0.03).

Conclusions: Patients who had unplanned excisions were more likely than patients with planned excisions to have small, superficial and low grade tumors. Those who had unplanned excisions did not have an increased risk of amputation, but were more likely to require additional coverage with muscle flap and/or skin grafting. Unplanned excisions did not affect local recurrence free survival and overall survival.
Background: Little is known about participation in sports following limb-salvage surgery for osteosarcoma of the knee joint. The purpose of this study was to evaluate sports activity in long-term survivors with modular tumor endoprostheses of the knee joint following osteosarcoma.

Methods: This retrospective single-center study includes 27 patients (13 m, 14 f) with osteosarcoma of the knee joint who were treated between 1995 and 2005 with an implantation of a modular tumor endoprosthesis. The average age at the time of surgery was 25.5 ± 13.5 (12.6 - 60.1) years and mean follow up period was 11.2 ± 3.7 (5.3 – 15.6) years. The tumor was located at the distal femur in 16 cases and at the proximal tibia in 11 cases. We assessed type frequency and duration of sports prior to osteosarcoma, 1, 3 and 5 years post surgery. Moreover the assessment included sports activity scores. Furthermore, the effect of complications on activity levels was assessed.

Results: Prior to osteosarcoma 89% (24/27) of the patients were regularly performing sports. At 1-, 3- and 5-years following osteosarcoma, 33%, 74% and 89% respectively were able to perform sports. There was a change from high to low impact sports. The most common types of sports postoperatively were bicycling and swimming. At five years post surgery patients reached their maximum post op levels of UCLA Activity Score (UCLA), Tegner Activity Score (TAS) and modified Weighted Activity Score (WAS). We found significant correlations between pre- and postoperative sports activity levels (UCLA: r = 0.62 (p < 0.0005); TAS r = 0.69 (p <0.0001); WAS r = 0.49 (p < 0.01)). Fourteen patients (51%) had to undergo revision surgery. However neither oncological nor non-oncological complications had a significant effect on sports activity levels. Moreover no sports activity related complications were found.

Conclusion: Long-term survivors of osteosarcoma of the knee joint who underwent limb-salvage surgery with a modular tumor endoprosthesis can achieve high levels of sports activity. However, the type of sports, duration change and recovery takes up to five years. Patients who were very active prior osteosarcoma tended to be more active postoperatively.
Objective: The restoration and maximization of physical function is a goal of limb salvage surgery. Patient-generated data from ambulatory activity monitors allows assessment of objective function during activities of daily living. The StepWatch Activity Monitor is a pedometer with accelerometer that measures total step count as well as activity intensity. Previous research has validated this monitor against patient-reported outcomes. The purpose of this study was to compare the function of a cohort of adult and pediatric patients with bone and soft tissue sarcoma.

Materials and Methods: In a cross-sectional population of patients with lower extremity sarcoma treated with limb salvage at two institutions, 75 patients with adequate assessments with the ambulatory activity monitor were included. There were 37 in the adult group (mean age 52, range 30-76) and 38 in the pediatric group (mean age 15.8, range 11.7-20.8). Patients were instructed in monitor use and wore it for at least six days. Average time from surgery was 1.44 years. The main outcome was comparison of total steps between groups. Secondary outcomes included comparisons of activity intensity and comparisons to normative means, as well as subgroup analyses.

Results: While adults averaged 2499 total steps (S.D. 1804), the pediatric group averaged 6454 (S.D. 2289, p<0.001). Both adults and children with limb salvage were less active than age-matched normative data (p<0.01). Patients with osseous tumors were less active than those with soft tissue sarcoma (p<0.05).

Conclusions: In a population of lower extremity sarcoma patients treated with limb salvage, the objective number of steps taken and intensity of activity were significantly below normative values in age-matched normative groups. The adult cohort of sarcoma patients had less than half the total step activity compared to the pediatric group and osseous tumor patients had less activity than soft tissue resection patients. Although this is a heterogeneous cross-sectional study, patient-generated objective measurement of function level by ambulatory activity monitors show ability to describe and discriminate limb salvage outcome. Further study of objective ambulation with pedometer-accelerometers will add to the understanding of functional impairments and outcomes in sarcoma patients, and allow comparison of reconstruction options.
STANDARDIZED REHABILITATION PROTOCOL AFTER LIMB SALVAGE SURGERY IMPROVES PATIENTS’ OUTCOME
Ahmad M. Shehadeh, MD; Iyad Sultan, MD; Robert M. Henshaw, MD; Albert J. Aboulafia, MD

Background: Limb salvage surgery (LSS) has become the treatment of choice for the vast majority of patients with primary sarcomas of the bone in lieu of amputation; however, no published rehabilitation protocols are available for these patients, which can be important for improvement of function and decrease hospital stay as the case for hip and knee arthroplasty.

Objectives: We have undertaken a pilot study to assess the feasibility of establishing a standardized postoperative rehabilitation protocol in the treatment of patients with primary bone sarcomas for the 5 major anatomical locations (Distal femur, Proximal tibia, Proximal and total femur, Humerus and shoulder girdle resections and Pelvic resections), and show the applicability of this protocol.

Methods: All LSSs performed by orthopedic oncology surgeon and rehabilitation of all patients was based on a standardized rehabilitation protocol. Fifty nine patients received LSS in the above mentioned locations: endoprosthesis (n=49), bone allograft (n=5), or No replacement (n=5). Patients received limb salvage surgery for other locations were not included in this study.

Patient outcomes were measured using the modified Musculoskeletal Tumor Society – International Symposium on Limb Salvage (MSTS/ISOLS) scoring system.

Result: The mean modified MSTS/ISOLS score for all patients was 87% (95% CI, 0.85,0.89), at a mean follow up of 24 months. The highest scores were for patients with distal femur =93% (95% CI,0.91,0.95). Seven patients had interruption of more than 6 weeks in their rehabilitation and had a mean score of 71% (95%CI,0.64,0.82).

Conclusion: The proposed rehabilitation protocol is a comprehensive, organized, and applicable guide to be used after performing LSS at mentioned anatomical locations. Standardized rehabilitation resulted in improved patient functional outcome.
LONG-TERM OUTCOMES, QUALITY OF LIFE AND FUNCTION OF LIMB SALVAGE SURGERY FOR SARCOMAS IN CHILDREN
Megan E. Anderson, MD; Patricia E Miller, MS; Kelsey van Nostrand, BS; Sara O. Swaim, RN, BSN; Mark C. Gebhardt, MD

Background: Pediatric patients with a primary sarcoma of bone now have options for local control surgery. While the goal remains wide resection of the involved portion of the bone, when the tumor involves the femur or tibia, this may be accomplished with limb salvage surgery, rotationplasty, or amputation. Each of these has long-term effects on a patient’s function and quality of life, an aspect of musculoskeletal tumor surgery with limited long term data.

Questions/Purposes: What are the complications and longevity associated with limb salvage? How do complications of limb salvage surgery compare to those of rotationplasty and amputation? What are the functional and health-related quality of life outcomes for patients who have undergone these different types of procedures and how do they compare to each other?

Patients and Methods: The study population included 151 patients with demographic and index procedure information in Table 1. Index procedures took place from 1983 to 2011 and mean follow-up was 5.8 years (SD ±4.7). Limb salvage patients had allografts (90), endoprostheses (18), and allograft-prosthetic composites (12) for reconstruction. Amputation was above knee in 6, through knee in 1, and below knee in 4. Review of medical records was performed to assess complication numbers and types as well as conversion to an alternate reconstruction. Of the 114 surviving patients, 44 completed functional and quality of life surveys and returned for independent physical evaluation (mean follow-up 10.5 years [SD ±6.4, rage 2-27]). Results were compared amongst limb salvage types and across limb salvage, rotationplasty, and amputation with two-sample Mann Whitney U tests.

Results: Complications arose in 78% of limb salvage reconstructions, 30% of rotationplasties, and 64% of amputations. This resulted in the need for an additional operation in 72% of limb salvage (74% allografts, 72% endoprostheses, 73% allograft-prosthetic composites), 15% of rotationplasty and 27% of amputation patients. An additional 36 patients (25 limb salvage and 2 rotationplasty) required a second major reconstruction.

Disclosures listed in handout

Of the limb salvage patients, 91% have retained their limbs and 69% have retained their original reconstruction. Statistical analysis of outcome data demonstrated the only significant differences were rotationplasty patients had higher SF-36 physical composite scores compared to limb salvage and amputation patients and higher MSTS scores than limb salvage patients.

Conclusions: Limb salvage surgery for sarcomas of the femur or tibia is associated with higher rates of complications and need for additional operations compared to rotationplasty and amputation. However, 91% of patients have retained their limbs. Current functional and quality of life instruments detect minor differences between patients with limb salvage compared to those with rotationplasty and amputation.

Table 1. PATIENT DEMOGRAPHICS.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>78</td>
<td>52</td>
</tr>
<tr>
<td>Female</td>
<td>73</td>
<td>48</td>
</tr>
</tbody>
</table>

| Age          | At index procedure | 12.9 years | SD ±3.8 |

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteosarcoma</td>
<td>133</td>
<td>88</td>
</tr>
<tr>
<td>Ewing sarcoma</td>
<td>18</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur</td>
<td>103</td>
<td>68</td>
</tr>
<tr>
<td>Tibia</td>
<td>48</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limb Salvage</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Rotationplasty</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Amputation</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>
MEASURING QUALITY OF LIFE IN PATIENTS WITH SOFT TISSUE SARCOMA WHO PRESENT WITH MULTIPLE LUNG METASTASES
Diana L. Marsilio-Apostoli, MS; William C. Eward, DVM, MD; Anthony M. Griffin, MS; Brian E. Brigman, MD, PhD; Jay S. Wunder, MD, FRCSC; Peter C. Ferguson, MD, FRCSC

Objective: Patients with soft tissue sarcoma of the extremities who present with >3 lung metastases have a dismal prognosis. Treatment for patients presenting with multiple lung metastases is generally considered palliative. Surgical resection of soft tissue sarcoma of the extremities is associated with variable periods of recovery. The role of palliative resection of the primary tumor, undertaken to improve quality of life by alleviating local symptoms, has not been well elucidated. We sought to investigate the role of palliative surgery in improving quality of life (QoL) for patients with soft tissue sarcoma presenting with multiple lung metastases.

Methods: We reviewed ten patients presenting with soft tissue sarcoma and >3 pulmonary metastases between 2011 and 2013 who were treated with either resection of the primary tumor for palliative purposes (±radiotherapy/chemotherapy) or did not receive surgical resection (±radiotherapy/chemotherapy). We prospectively collected patient responses to clinical Edmonton Symptom Assessment System – Sarcoma Modified (ESAS-SM) questionnaires at initial presentation and at three and six months post-presentation. Symptom distress scores (SDS) were calculated and means compared across treatment groups using student’s t-test for continuous variables.

Results: Mean patient age was 69 years (range 47-88 years). Mean follow-up was 9.8 months (range 2–23 months). There were four patients with undifferentiated pleomorphic sarcoma, two patients with extraskeletal osteosarcoma, and three patients with soft tissue sarcoma – not otherwise specified. All tumors were high-grade and located in the lower extremity. Eight tumors were located in the proximal thigh and one was located in the posterior leg. Four patients received palliative resection (PR) of their primary tumor while six did not undergo surgical treatment (NS).

In the PR group, all tumors were large and causing significant local symptoms while in the NS group, tumors were asymptomatic or causing minimal local symptoms at initial presentation. Mean SDS scores at initial presentation were 44.0 ± 13.9 (n=4) and 27.0 ± 14.9 (n=4) in the PR and NS groups, respectively (p=0.14) and 46.0 ± 36.0 (n=2) and 40.2 ± 15.5 (n=4) at three-month follow-up (p=0.80). SDS rose by a mean of 2 and 13.25 in the PR and NS groups, respectively between presentation and three-month follow-up.

Conclusions: Higher SDS scores reflect sub-optimal QoL. Mean SDS scores for PR patients were higher than the NS SDS scores at initial presentation, indicative of a trend towards significance. Between initial presentation and three-month follow-up, SDS scores tended to rise by a greater amount in the NS group compared to the PR group. Because resection of large soft tissue sarcomas has a high complication rate and a prolonged recovery time as shown previously, palliative resection to control local symptoms in patients who present with extensive lung metastases must be carefully considered. Preliminary SDS scores are suggestive that Stage IV STS patients receiving surgical treatment are those with sub-optimal QoL at initial presentation in whom there is relatively little additional increase following surgery. Lack of significance may be attributable to small sample size. Stage IV STS patients are faced with a bleak prognosis; as such, recruitment to complete ESAS is a sensitive yet, important issue. Continuing investigation within our centers is warranted.
QUALITY OF LIFE AFTER EN-BLOC RESECTION OF MALIGNANT TUMORS OF THE MOBILE SPINE
Matthew Colman, MD; Syed Mohammed Karim, BS; Kevin A. Raskin, MD; Francis J. Hornicek, MD, PhD; Joseph Hasbrouck Schwab, MD

Background: En-bloc resection for malignant tumors of the mobile spine (ES) is a developing technique that is thought to offer the best chance at long-term survival. However, morbidity is high, and little has been reported regarding patient-centered quality of life outcomes after this procedure.

Question: How does patient quality of life after ES as measured by validated instruments compare with a control group treated with definitive radiation or to the general population?

Methods: We retrospectively identified 40 consecutive patients treated at our center with a malignant tumor of the mobile spine who had completed quality-of-life metrics during their clinical follow-up. 32 patients underwent en-bloc resection of their tumor, while 8 patients received definitive radiation and no surgery beyond open biopsy. The predominant diagnosis was chordoma (78%). Minimum follow-up was 6 months (median 32 months). Main outcomes instruments were EQ5D, PROMIS, Neck Disability Index (NDI), and Oswestry Disability Index (ODI). We performed comparisons between the surgery and radiation groups, the general population, and within the study group to identify predictors of higher quality-of-life scores.

Results: We identified a difference in quality of life between the surgery and radiation groups in only one of seven instruments, the PROMIS pain interference domain, with surgery having more pain interference (17.0 vs 10.1, p=0.047). Mean raw scores for the entire study group at follow-up for EQ5D, PROMIS anxiety, depression, pain interference, pain behavior, NDI, and ODI were 0.670 (+/- 0.23), 12.6 (+/- 5.1), 11.5 (+/- 5.6), 15.7 (+/- 6.9), 22.8 (+/- 7.6), 16.2 (+/- 14.8), and 35.4 (+/- 23.1). Each of the seven metrics was worse than the corresponding mean score for the general population. Multivariable linear regression for each of the seven instruments demonstrated that preoperative factors such as tumor location in the cervical spine, low Charlson comorbidity index, fewer involved tumor levels, and shorter fusion span were independently predictive of better quality of life scores.

Conclusions: Patients may experience more pain interference after surgery as opposed to definitive XRT, but we did not identify a difference for most metrics. Quality of life in our population was worse than the general population for all metrics. Cervical tumors, better baseline health, and less extensive disease predict better quality of life.

Level of Evidence: II
FUNCTIONAL CHARACTERIZATION OF BONE MORPHOGENETIC PROTEINS (BMPS) AND ELUCIDATION OF THEIR ROLES IN THE PATHOGENESIS OF OSTEOSARCOMA

David S. Geller, MD; Mikhail Bekarev, MD; Sajida Piperdi, BS; Jonathan B. Gill, MD; Amy Park, BS; Richard Gorlick, MD

The work was performed at Montefiore Medical Center and the Children’s Hospital at Montefiore, Bronx, NY

Background: Bone morphogenetic proteins (BMPs) are a group of TGF-β superfamily-related cytokines, important in multiple systemic processes involving cell signaling and control of tissue architecture. BMP dysregulation has been shown to exist in multiple malignancies and has been proposed to contribute to their pathogenesis, however, little is known about the role of BMPs in the setting of osteosarcoma tumorigenesis. Controversy exists as to whether the BMP pathways are involved in tumorigenicity and cell proliferation or whether they are involved in tumor suppression.

Questions/Purposes: The purpose of this study was to elucidate the role of BMPs in osteosarcoma tumorigenesis by determining gene and protein expression of the most commonly implicated BMPs and their receptors. Additionally, we sought to compare intracellular and extracellular levels of BMPs.

Methods: To further characterize the function of BMPs in osteosarcoma, we attempted to assess the mRNA and protein expression levels of BMP-1 through BMP-7, as well as BMPR1A, BMPR1B, and BMPR2 receptors, across multiple patient-derived osteosarcoma cell lines (n=16), standard cell lines (n=3) and primary tumor samples (n=2). Expression levels were assessed using RT-PCR and ELISA quantification methods. Further, we compared the results to known high- and low-expressing cell lines serving as positive and negative controls. Finally, we compared intra- and extracellular protein levels of BMPs in both serum-rich and serum-starved conditions.

Results: Our results suggest that the gene and protein BMP expression patterns are quite variable across different cell lines. Furthermore, patient-derived cell lines exhibited distinctive patterns of BMP expression compared to standard osteosarcoma cell lines and primary tumors, with the latter appearing to disproportionally overexpress BMP2, BMP4, and BMP7. In addition, BMP2, BMP4, and BMP7 exhibited significant variance between their mRNA and protein expression, but serum starvation did not appear to significantly change the patterns of production of these proteins across different cell lines.

Conclusions/Clinical Relevance: To our knowledge, this is the first attempt to characterize BMP expression patterns in a variety of osteosarcoma cell lines utilizing concurrent gene and protein expression data. Our data suggest that either RNA stability or posttranslational modification of BMP2, BMP4, and BMP7 may play a significant role in modulating their function. These results will serve as a basis for further experiments evaluating functional relevance of BMP inhibitors applied in a tumor-specific fashion.
Introduction: Osteosarcoma (OS) is a clinically challenging primary malignant bone tumor affecting mostly children and young adults. Current treatment includes neoadjuvant systemic chemotherapy and surgical resection of the primary tumor for local control. The overall 5 year disease free survival rate for non-metastatic disease reaches 75% while for metastatic disease is only 25%. Wnt signaling is known to play a role in the pathogenesis of several cancers, including breast, colon, and osteosarcoma. Therefore it is a promising target for therapeutic intervention in OS. Secreted Frizzled Related Proteins (sFRPs) are Wnt inhibitor proteins secreted by native osteocytes, which regulate Wnt signaling in bone and have been found in low levels in osteosarcoma tissue. 2- Methoxyestradiol (2-ME) is a naturally occurring estrogen metabolite which has been shown to reduce cell proliferation, induce cell cycle arrest, apoptosis, and autophagy in osteosarcoma cells through various pathways, including the interferon pathway. To further understand the molecular actions of 2-ME on osteosarcoma, we have studied the effect of 2-ME on Wnt signaling pathways using human osteosarcoma cells in culture.

Methods: To evaluate the effect of 2-ME on Beta-catenin/Tcf gene promoter activity, MG63 OS cells were transiently transfected with the Tcf reporter plasmid (TOPflash) and then treated with a negative vehicle control (ethanol), 2-ME, and a positive control (lithium chloride, LiCl). The Luciferase assay was carried out 48 hours after transfection per manufacturer’s protocol. To confirm the role of sFRP3 in 2-ME Wnt pathway inhibition, siRNA-mediated inhibition of sFRP3 gene expression was carried out per the manufacturer’s protocol and then treated with 2-ME. Cell proliferation was then analyzed with an MTS assay. Finally, to determine if 2-ME induces increased sFRP3 protein levels, cytoplasmic extracts from the negative vehicle control and 2-ME treated cells were analyzed by western blot hybridization using anti-sFRP3 and anti-actin antibodies. Quantitation was performed by densitometry and analyzed using Quantity One software.

Results: We have examined the effect of 2-ME treatment on the Wnt pathway in osteosarcoma cells. Our results show that 2-ME treatment decreased TOPflash activity by one-fourth compared to the negative control and by four fold compared to LiCl treatment. Then, to confirm the role of sFRP3 involvement in 2-ME-mediated Wnt pathway inhibition, we observed the effect of 2-ME in osteosarcoma cells which had been depleted of sFRP3 with siRNAs directed against the sFRP3 gene. Our results show that 2-ME-mediated cell death was reduced by 34% (p=.0007) in transfected OS cells compared to non-transfected cells treated with 2-ME, and by 23% (p =0.01) compared to 2-ME treated OS cells transfected with non-specific siRNAs. Finally, protein analysis revealed increased sFRP3 protein levels following 2-ME treatment in various human osteosarcoma cell lines (MG63, 143B and KHOS). The sFRP3 levels were not increased by other estrogenic compounds, nor were they increased following 2-ME treatment in normal osteoblasts.

Conclusion: The Wnt pathway is active in osteosarcoma for a variety of reasons, including mutations in beta-catenin or decreased transcription of Wnt antagonists. Our findings suggest that osteosarcoma cell death induced by 2-ME treatment is in part mediated by increased levels of Wnt antagonist and could be independent of Beta-catenin mutations. Our results show that 2-ME affects osteosarcoma cells through the regulation of multiple pathways, and thus is an attractive molecule for further study as a potential treatment in osteosarcoma.
Axl IS A NOVEL THERAPEUTIC TARGET FOR OSTEOSARCOMA
Ashley Rettew, PhD; Christopher Manuszak; Dina Leu; Eugenie Kleinerman; Fadi W. Abdul-Karim; Robin Elliot; Patrick J. Getty, MD; Edward Greenfield

Despite aggressive chemotherapy protocols, the survival rate for osteosarcoma patients with metastases is only 25% and has not improved over the last 30 years. Therefore, novel therapeutic agents are needed. The receptor tyrosine kinase Axl contributes to the progression of many cancers but remains relatively unstudied in osteosarcoma. Previously, our phosphoproteomic screening showed that Axl was phosphorylated in all 5 human osteosarcoma cell lines tested. Moreover, screening of the metastatic 143B cell line showed that knockdown of Axl by four individual siRNA duplexes inhibited invasion, motility and colony formation in vitro. In this study, two cell lines stably expressing different Axl shRNAs (shAxl-2.5 and shAxl-3.5) were derived from the metastatic human 143B osteosarcoma cell line and had >88% Axl mRNA knockdown compared to 143B cells expressing a control Luciferase shRNA. Motility and colony formation were significantly inhibited in both of the shAxl cell lines in vitro (p<0.001). In a murine orthotopic model of osteosarcoma, tumorigenesis was significantly inhibited by 60% in the shAxl-2.5 group and by 75% in the shAxl-3.5 group (p<0.05). Importantly, metastasis was significantly inhibited by 88% in the shAxl-2.5 group and by 92% in the shAxl-3.5 group (p<0.05). Immunostaining for Axl activity using a tissue microarray demonstrated that 41 of 47 (88%) human osteosarcoma patients were positive for phospho-Axl expression. Sequencing of the entire coding region of Axl revealed no mutations in five metastatic human osteosarcoma cell lines (143B, LM7, H3, M112, M132) and three non-metastatic cell lines (TE85, Saos-2, Hu09). In an expression analysis, phospho-Axl levels correlated with Gas6 mRNA levels in osteosarcoma cell lines and human mesenchymal stem cells (hMSCs). These results indicate that receptor activation is likely due to autocrine signaling by Gas6. Activation of Akt, Erk and Ack1, potential downstream mediators of Axl signaling, were unaffected by Axl knockdown. In order to simultaneously assay a wider set of signal transduction pathways, the Cignal 45-Pathway Reporter Array was performed.

• Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
• FDA information not available at the time of printing. For full information, refer to inside back cover.
Soft-tissue sarcomas are a heterogeneous group of tumors arising from connective tissue. Recently, mutations in the neurofibromin 1 (NF1) tumor suppressor gene were identified in multiple subtypes of human soft-tissue sarcomas. To study the effect of NF1 inactivation in the initiation and progression of distinct sarcoma subtypes, we have developed a novel mouse model of temporally and spatially restricted NF1-deleted sarcoma. To generate primary sarcomas, we inject adenovirus containing Cre recombinase into NF1<sup>lox/lox</sup>; Ink4a/Arf<sup>lox/lox</sup> mice at two distinct orthotopic sites: intramuscularly or in the sciatic nerve. The mice develop either high-grade myogenic sarcomas or MPNST-like tumors, respectively. These tumors reflect the histological properties and spectrum of sarcomas found in patients. To explore the utility of this model for preclinical studies, we performed a study of MAPK pathway inhibition with the MEK inhibitor PD325901. Treatment with PD325901 delays growth of primary NF1-deleted myogenic sarcomas in this model. We also examined the effects of MEK inhibition on the native tumor stroma and find that PD325901 decreases microvessel density. Taken together, our results utilize a primary tumor model to demonstrate that sarcomas can be generated by loss of NF1 and Ink4a/Arf, and that these tumors are sensitive to MEK inhibition. These studies suggest that MEK inhibitors should be further explored as potential therapies in patients with myogenic sarcomas containing NF1 deletion.

Photographs of NF1-deleted tumors generated from injections into the sciatic nerve (top) or muscle (bottom). Histopathology of IM and SN tumors. IM tumors resemble high-grade myogenic sarcomas and stain focally for MyoD1 and Ki67, but not S100. SN tumors resemble MPNSTs and stain focally for S100, but not for MyoD1. SN tumors have mast cell infiltrates. Both tumors are positive for pERK and pS6 (not shown), indicating activity of the MAPK and mTOR pathways, respectively.

Figure 1. Characterization of a mouse model of NF1-deleted soft-tissue sarcoma.

Figure 2. Kaplan-Meier curve of tumor development based on site of orthotopic injection. The average time for tumor development is 4.1 months for mice injected in the sciatic nerve (SN) and 6.2 months for mice injected intramuscularly (IM).
Figure 3. Activity of a MEK inhibitor in sarcomas from NF1 flox/flox; Ink4a flox/flox mice. (A) Inhibition of cell growth by MEK inhibitor U120 in vitro. (B) Inhibition of allograft growth by rapamycin and PD0325901.

This work was supported by a Children’s Tumor Foundation Young Investigator Award to R.D.D.
EXTRA-ABDOMINAL SPONTANEOUS DESMOID TUMORS: IS SURGICAL MARGIN REALLY IMPORTANT? EXPERIENCE ON 23 CONSECUTIVE CASES

André Mathias Baptista; Olavo Pires de Camargo, MD

Objectives: treatment algorithm for extra-abdominal desmoid tumors remains undefined, mostly due to the rarity of these benign tumors and to their unpredictability clinical behavior. Whenever feasible, functionally acceptable surgery with negative margins is the objective of the treatment. Local recurrence is typically high, between 30% and 40%, and prognostic factors are controversial. The objective of this study is to present a single institution consecutive series of extra-abdominal spontaneous desmoid tumors with emphasis on identifying local recurrence prognostic factors.

Material and Methods: twenty-three consecutive patients with the diagnosis of extra-abdominal spontaneous desmoid tumors were enrolled in this study. The patients’ data were harvested from their charts, including age, gender, anatomic site, laterality, microscopic surgical margin and occurrence of local recurrence. Gardner syndrome cases were excluded, and all cases were submitted to surgical resection. Follow-up to the last consultation was noted. Among the 23 cases, there were 11 females and 12 males. Thirteen patients were over 20 years of age and 10 patients 20 years old or less. Tumor size was less than 5cm in only 5 cases, and 5cm or more in the remaining 18 cases (78%). The tumor was located in the lower extremity in 12 cases, in the trunk in 4 cases and in the upper extremity in 7 cases. The right side of the body was the site of the tumor in 12 cases, and the left side in 11 cases. The microscopic surgical margin was positive in 11 cases and negative in 12 cases. Local recurrence occurred in 10 cases (43%) and the median overall follow-up was 98 months. Local recurrence prognostic factors were tested: age (<20 years, 20 years or more), gender (male, female), tumor size (<5cm, 5cm or more), anatomic site (upper extremity, trunk, lower extremity), laterality (left, right) and microscopic surgical margin (positive, negative).

Results: The only prognostic factor identified in our study was the microscopic surgical margin: 10 of the 11 cases in which the margin was positive recurred (91%), and none of the negative margin 12 cases recurred (p<0,001). All others variables were not statistically significant.

Conclusions: microscopic surgical margin was the only prognostic factor in extra-abdominal spontaneous desmoid tumors.
PERIOPERATIVE OUTCOMES IN THE TREATMENT OF SOFT TISSUE SARCOMAS USING REDUCED DOSE PREOPERATIVE RADIATION COMBINED WITH A RADIOSENSITIZING AGENT

Shannon Puloski, BSc., MD, FRCSC; Norman S. Schachar, MD; Lloyd Mack, MD; Walley Temple, MD; Elizabeth Kurien, MD; Michael Kwan, MD

Objective: The positive impact of preoperative radiation on the reduction of local recurrence compared to surgery alone in the treatment of soft tissue sarcomas (STS) has been well established. However, major wound complication rates in excess of 30% have been associated with most preoperative protocols utilizing radiation alone. The purpose of the current prospective study was to assess both the perioperative complications and early functional outcomes when utilizing a modified preoperative radiation protocol in conjunction with an established radiosensitizing agent. The local recurrence outcomes (<10%) using this protocol have been previously reported.

Methods: Patients with a pathological diagnosis of STS deep to the muscular fascia were treated with three days of low dose intravenous doxorubicin (30 mg/day) used as a radiosensitizer, 10 days of external beam radiation (300 cGy/day) followed by limb-sparing surgery. Major wound complications were documented as those requiring re-operations, invasive procedures or deep wound packing. Wound infections requiring oral antibiotics and/or aspiration of seromas were documented as minor wound complications.

Results: 53 patients were accrued into the study between 2006 and 2011. Four patients dropped out of the study prior to operation and one required limb ablative surgery. Of the 48 remaining patients, the median age was 61 years, all had intermediate or high grade tumors, and 81% of were > 5cm. All patients were treated within 8 weeks of completing their radiotherapy. Tumor location included lower limb (proximal 39.6%, distal 29.2%), upper limb (proximal 16.7%, distal 8.3%) and trunk (6.3%). In terms of the primary outcome, 7 (14.6%) patients developed minor wound complications requiring home antibiotics or seroma drainage. Five (10.4%) patients developed major wound complications (4 re-operations, 1 deep wound packing). Median hospital stay was 5.0 days. Comprehensive two-year functional outcomes are pending.

Conclusion: The current neoadjuvant protocol utilizing low-dose doxorubicin as a radiosensitizer and reduced dose radiation suggests superior wound complications rates in the treatment of soft tissue sarcoma compared to standard preoperative radiotherapy regimes.
A COMPARISON OF BRACHYTHERAPY AND EXTERNAL-BEAM RADIATION IN TREATMENT OF SOFT TISSUE SARCOMA

Nathan Donaldson, DO; Paul Rothenberg, BS; Martin Keisch, MD; H. Thomas Temple, MD; Sheila Conway, MD

Background: Treatment of soft tissue sarcomas often includes surgery and radiotherapy. The optimal radiotherapy modality has not been established and there is limited data regarding sarcoma outcomes with the use of high-dose-rate brachytherapy (HDR-BT).

Questions/Purpose: The purpose of this study is to compare the rates of local recurrence and radiation morbidities between patients treated with external-beam radiotherapy (EBRT) and HDR-BT.

Patients and Methods: We retrospectively reviewed the records of 218 patients treated with HDR-BT (68 patients), EBRT (133 patients) or both (17 patients) with mean follow up of 50 months (range 3-268). These three groups were compared for oncologic outcomes (local recurrence rate) and functional outcome (major complication rate, pathologic fracture, and late radiation morbidity assessed with the RTOG Late Radiation Morbidity Scoring Schema).

Results: The incidence of return to surgery due to local complications and local recurrence were similar between the group treated with HDR-BT (17.6% and 14.7% respectively) and the group treated with EBRT (13.5% and 14.3% respectively). Return to surgery was much higher for those treated with both modalities (41.2%). Five patients developed pathologic fractures, 4 patients (3%) from the EBRT group and one patient (5.9%) from the group treated with both modalities. No patients in the HDR-BT group developed pathologic fracture. Comparison of the RTOG scores between groups demonstrated the lowest morbidity rating in the HDR-BT group.

Conclusion: Patients treated with either HDR-BT or EBRT had similar rates of local recurrence and major complications. Patients treated with HDB-RT alone had lower rates of pathologic fracture and superior late radiation morbidity scores.

Level of Evidence: Level III, therapeutic study.
TARGETING RANKL IN ANEURYSMAL BONE CYST: CASE PRESENTATION AND POST-HOC VALIDATION OF TARGET
Dominic W. Pelle, MD; Jonathan W. Ringler, MS; Jacqueline D. Peacock, PhD; Kevin Kampfschulte, BA; Donald J. Scholten II, BA; Mary M. Davis, MD; Deanna S. Mitchell, MD; Matthew R. Steensma, MD

Study Design: Laboratory study and clinical case report

Objective: To demonstrate that RANKL-mediated signal activation through its cognate receptor, RANK, is essential to aneurysmal bone cyst (ABC) progression, and that ABCs may be effectively targeted with Denosumab.

Summary of Background Data: Denosumab, a RANKL inhibitor, is increasingly being used to treat giant cell tumor of bone. Although ABC and GCTB are distinct entities, they both contain abundant multinucleated giant cells and are characteristically osteolytic. We hypothesize that ABC’s express both RANKL and RANK in a cell-type specific manner, and that targeting RANKL will mitigate ABC tumor progression.

Methods: We reviewed the case of a 5-year-old male with a large sacral aneurysmal bone cyst who presented with chronic cauda equina syndrome. We documented the details of his management and favorable therapeutic response to Denosumab. Next, we sought to confirm RANKL expression in freshly harvested ABC samples (n=4; qPCR) using GCTB as a positive control, and determine the cell type-specific expression patterns of RANKL and RANK by immunofluorescence laser confocal microscopy.

Results: Following 3 months of denosumab therapy, MRI demonstrated tumor shrinkage, bone reconstitution, and healing of a pathologic sacral fracture. At 6 months, bowel and bladder function was restored. Denosumab treatment was well tolerated. Post-hoc analysis demonstrated strong RANKL expression in the patient’s tumor. A consistent pattern of RANKL and RANK expression was observed: fibroblast-like stromal cells strongly expressed RANKL; monocyte/macrophage precursor and multinucleated giant cells expressed RANK. No difference in relative total expression of RANKL in ABCs compared to GCTB was found (p>0.05).

Conclusion: These findings demonstrate that RANKL-RANK signal activation is essential to ABC tumor progression. RANKL-targeted therapy may be an effective alternative to surgery in select ABC presentations. Further study is warranted.
Background: Primary bony tumors of the elbow account for approximately 1% of all osseous tumors. The delayed diagnosis is widely reported in the literature as a result of lack of clinician familiarity and as a result of their rarity. We present the largest case series of primary bone tumors of the elbow in the English literature.

Purpose: We sought to identify characteristics in the epidemiology, spectrum of disease and clinical course specific to all primary bone tumors affecting the elbow. In particular, we discuss the cases of misdiagnosis and reasons for any delay in diagnosis. The authors also recommend a collaborative protocol for the diagnosis and management of these rare tumors.

Methods: A prospectively collected national database of all bone tumors is maintained by an independent clerk. Each entry includes data concerning patient demographics, diagnosis, clinical course, radiological imaging, pathology, management, recurrence, mortality and follow-up. The registry and case notes were retrospectively reviewed from January 1954 until June 2012. Eighty cases of primary osseous tumors of the elbow were studied. Tumors were classified as benign or malignant and their grade according to the Enneking spectrum. All patients were followed up for a minimum of two years until discharge or death. No patients were lost to follow up.

Results: A delay in diagnosis was common, with a mean time from onset of symptoms to diagnosis of seven months. We identified more malignant tumors in the distal humerus and more benign tumors affecting the proximal ulna and radius. Patients presented at an older age (40 years) for malignant tumors. Only giant cell tumor (female) and Ewing’s sarcoma (male) showed a statistically significant gender trend. Pain was described as the most frequent presenting symptom (100%) in all tumors. Accordingly, this was more severe in malignant tumors. Swelling was also common with 70% of all cases having this as a presenting complaint. Cases of misdiagnosis were most often attributed to soft tissue injuries or simple bone cysts. There were forty-seven (59%) benign and thirty-three (41%) malignant primary bone tumors. The commonest benign tumors were fibrous dysplasia (30%), giant cell tumor (17%) and aneurysmal bone cyst (15%). With respect to the malignant bone elbow tumors, the majority were osteosarcoma (42%), chondrosarcoma (18%) and Ewing’s sarcoma (12%). The clinical course of each tumor is described and trends for each tumor are discussed with respect to the cohort studied. The multidisciplinary approach is discussed. The majority surgical treatments were intralesional curettage but endoprosthetic replacement was occasionally indicated. The evolution in treatment modalities is clearly demonstrated. Comparisons are made to the current literature. Cases of delay and misdiagnosis are evaluated.

Conclusions: Clinicians should be aware that elbow tumors can be initially misdiagnosed as soft tissue injuries or cysts. The suspicion of a tumor should be raised in the absence of trauma with pain and swelling. Lesions affecting the distal humerus are more likely to be malignant. Early diagnosis and adjuvant therapy are important. We identified the first case of osseous malignant fibrous histiocytoma of the elbow in the English literature. We suggest an investigatory and treatment protocol for patients with a suspected primary bone tumor of the elbow in order to avoid a delay to diagnosis. This protocol is now successfully being utilised in our centre.
A NEW APPROACH TO TERTIARY SARCOMA SERVICES: AN AUDIT OF A NOVEL SERVICE REDESIGN FOR A NATIONAL SERVICE

David Wallace, MD; Mike Jane; Helen Findlay

Bone and soft tissue sarcoma is an uncommon. Benign swelling are, however, common. An approach to tertiary referral is required to accommodate the need for specialist interpretation of all concerning referrals, while maintaining an acceptable time to diagnosis and management.

We aim to describe a new tertiary sarcoma service, utilising modern communication technology and the “virtual clinic” model through a multidisciplinary approach.

All suspected musculoskeletal sarcoma cases are discussed, with available history and imaging, in a virtual clinic by a multidisciplinary team within a week of referral. Clinic decisions allow either immediate discharge, progress to further investigation, or clinic appointment.

Data from the first thousand patients was prospectively collected for initial management decision, and final intervention, and in 625 for waiting time. Almost one third of patients were discharged from the virtual clinic without physical appointment. 45% were sent for further investigation prior to first clinic appointment. Of 625 patients with referral data, mean waiting time was 5.1 days to virtual clinic. For malignant bone and soft tissue tumours, not requiring neoadjuvant treatment, median time to surgery from virtual clinic review was 37 and 47 days respectively.

Through a virtual clinic approach to tertiary sarcoma care, almost a third of referrals have been managed quickly without need for an unnecessary appointment. For 45% of patients the first appointment will be after all necessary investigations have been performed to facilitate rapid decision making. This enables shorter clinic waiting times and rapid transition from first referral to definitive management.
THE OUTCOME OF LIMB SALVAGE SURGERY IN A DEVELOPING COUNTRY, KHCC EXPERIENCE

Ahmad M. Shehadeh, MD; Iyad Sultan; Abed latif Al Mosa; Sameer Yaser

Background: Limb salvage surgery (LSS) became the standard surgical treatment for bone sarcomas since the late 1970s; however, LSS has high cost and numerous complications that make it less applicable in developing countries.

Objectives: To show that LSS in developing countries, can be compared to developed countries, when; team work, expert surgeon and enough resources are available.

Methods: Since July 2006, a multidisciplinary team of sarcoma was established. This team consisted of pediatric and medical oncologists, radiation oncologists, radiologist, nurse coordinator and a full-time orthopedic oncology surgeon. The team was supported by a service for physical therapy. Clinical practice guidelines were established and a special protocol for rehabilitation following surgery was applied.

Results: Ninety five patients with malignant or benign aggressive bone tumors presented at the study period, 5 patients received primary amputation, 90 patients received LSS (95% of all patients) included in our analysis, with mean follow up of 34 months (range, 6-70 months). Tumors were located in the extremities (n=82), in the scapula (n=3) and the pelvis (n=5). Histological diagnosis was: Osteosarcoma (n=45), Ewing’s sarcoma (n=20), Chondrosarcoma (n=10), Giant Cell Tumor (n=5), Bone metastasis (n=5) and others (n=5). Endoprosthetic reconstruction used in 77 patients (67 modular, 7 expandable, 3 custom prosthesis), biological reconstruction in 7 patients, and no skeletal reconstruction in 6 patients. Local tumor control was achieved in 57 patients (88%). Among the complications encountered were: periprosthetic infection (n=8, 9%), traumatic dislocation (n=1, 1.6%), superficial skin necrosis (n=4, 3%), and radiation-induced stem loosening (n=1, 1.6%). Eleven patients (12%) developed local recurrence.

Limb survival was 95.4% at study end; four limbs had secondary amputation (two for local recurrence and 3 for persistent periprosthetic infection). All other types of complications were managed successfully. The average MSTS functional score for the 85 survived limbs was 87%.

Conclusions: Our early results are encouraging. Patients with sarcoma are managed better within a multidisciplinary team that is familiar with highly specialized procedures including LSS. The early outcomes of our cases are comparable to that in developed countries in term of local control and prosthesis related complications.

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* Indicate the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
• FDA information not available at the time of printing. For full information, refer to inside back cover.
DEMOGRAPHIC PROFILE OF OSTEOSARCOMA FROM A TERTIARY CARE CENTRE IN A DEVELOPING COUNTRY- RETROSPECTIVE ANALYSIS OF THE LAST EIGHT YEARS

Shah Alam Khan, MS, DNB, MRCS Ed, FRCS, MCh Orth

Aims and Objectives: It is known that the demographic profile of Osteosarcomas give etiological insights. Most demographic studies on Osteosarcomas are from the Developed countries with paucity of data on the epidemiology of these lesions in the developing world. The aim of the present study was to retrospectively study the demographic profile of Osteosarcomas from one of the largest centre for musculoskeletal oncology in the country. The aim of our study is to present the demographic characteristics of patients with Osteosarcoma and compare these with the available western literature so as to draw out factors which are exclusive for this part of the world.

Materials and Methods: Ours was a retrospective study with identification of cases of Osteosarcomas of the bone presenting to our tertiary centre between January 2004 and December 2011. Data was extracted from the hospital records. All demographic data including age, gender, site of involvement, histopathological subtype and metastasis at presentation were collected. Patients who underwent surgical treatment following neo-adjuvant chemotherapy were grouped and the type of surgery was noted.

Results: We identified a total of 408 cases of biopsy proven Osteosarcoma. The average age at presentation was 18.4 years. The male-female ratio was 2.1: 1. 52.3% of the patients in our study were in the age group of 15 to 24 years while 9 patients (2.2%) were aged 45 years or more at the time of presentation. No bimodal peak of tumor occurrence was noted as has been mentioned in literature from the West. Thirty nine patients (9.6%) were found to have metastasis at presentation. Data on primary site of involvement was not available for 52 patients. Among the remaining 356 patients, the most frequent site of origin was femur (49.2%), followed by tibia (21.6%) and humerus (9.3%). Following neo-adjuvant chemotherapy, 170 patients underwent surgical treatment. Limb salvage surgery was performed in 136 patients while 34 patients underwent radical or wide amputation. Tumor excision alone was performed in 7 patients, intercalary reconstruction using fibular graft was done in 33 patients.

Reconstruction using irradiated bone was done in 2 patients. Forty patients underwent arthrodesis while 54 patients had an endoprosthetic reconstruction after resection of juxta articular tumors. Survivorship analysis was done for patients who underwent limb salvage surgery or amputation.

Conclusion: Our study has the limitation of being a hospital based data. In the absence of population based data, intermediate term experience of a tertiary care centre from the second largest country throws some light on the epidemiology of Osteosarcoma in the developing world. The number of patients undergoing surgical treatment is comparatively low. The age of incidence of Osteosarcoma is slightly higher when compared to the Western data. No bimodal peak of occurrence of these tumors was identified in our data (as is commonly seen in the Western data). We also found that the metastasis at presentation is slightly higher (around 10 percent) in our study when compared to studies from the West. Socio-economic factors appear to play an important role in this. Our study had 40 joint arthrodesis which is infrequently encountered in most studies from the West. Our data can be helpful in identifying the need and working of a model of musculoskeletal oncology set up in a developing country like India.

Disclosures listed in handout
HUMANITARIAN AID AS A TEACHING TOOL
Audrey Goelz, MD

Disaster aid from the US to other countries is fairly common as seen in the aftermath of the Haitian earthquake as well as regular missions to third world countries where the infrastructure for complicated surgical interventions are simply not present (Knowlton, Gosney, Chackungal, Altschuler et al., 2011). Salvage after traumatic injury is problematic due to increased incidence of infection and sepsis ultimately requiring amputation (Korompilias, Beris, Lykissas, Vekris et al., 2009). Cost is typically cited as a barrier to reconstruction or salvage in the US though has been thoroughly researched with no real demonstrated difference where overall care is considered (Chung, Sassawi-Konefka, Hasse & Kaul, 2009). Patient outcomes differ widely as surgical skill, size of resection, nature of tumor or trauma and setting limits resources. Quality of life concerns have been addressed in this country though the implications of amputation versus salvage in other countries are poorly researched.

The primary population requiring reconstruction or salvage in this country are younger presenting factors such as quality of life, consideration of age at diagnosis and patient input determining the choice of procedure (Barr & Wunder, 2009; Henderson, Pepper, Marulanda, Millard, et al., 2010; Johnson, Singh, Evans, Drury et al., 1997; Nagarajan, Neglia, Clohisy & Robinson, 2002). The lack of available resources in poorer countries creates a barrier to provision of procedural options despite the best efforts of international interventions. Humanitarian missions with both surgical residents and experienced orthopaedic surgeons have been shown to improve the quality of care in third world countries and improve the surgical skills of native physicians. The medical missions seem to positively impact not only the surgical skills of the residents but provide cultural and ethical perspective (Leeds, Creighton, Wheatley, Srinivasan, et al., 2011). Due to the very nature of a short-term mission, the standard of care may differ from that seen in industrialized countries though would arguably still provide better patient outcomes.

Evidence has repeatedly shown the positive impact of real-world experience in the surgical realm; the hierarchical structure of residency programs has a tendency to limit this method of teaching (Leeds, et al., 2011; Richard, Lee, Richard, Shew Oo, et al., 2009). Appropriate supervision and opportunity provide a venue for teaching not easily acquired in traditional practical training. Use of this setting would provide desperately needed care to those less able to access necessary resources as well as provide a veritable wealth of personal and educational experience for surgical residents.

References
CHALLENGES IN DELIVERING SARCOMA CARE IN PORT-AU-PRINCE HAITI

Nadine Williams, MD; H. Thomas Temple, MD; David Pitcher, MD

Background: Port au Prince Haiti is estimated to be home to more than 3.5 million people. Most Haitians live in poverty and have difficulty accessing quality health care for various reasons such as geographic and economic barriers. This country relies heavily on traditional healers. The devastating earthquake in January 2010 compromised access even further. As a result, patients present with more advanced disease than that observed in the United States. Project Medishare at the University of Miami continues to provide care at Hospital Bernard Mevs in Port-au-Prince. We treated the three orthopaedic oncology patients recently.

Purpose: We review the logistical and economic challenges of delivering sarcoma care in Port-au-Prince Haiti and review the barriers and solutions to delivering sarcoma care in Haiti.

Patients and Methods: We received notification through project medishare regarding three patients, two young women and a male. One patient, a sixteen year old girl had a large giant cell tumor of the distal femur with extensive cortical destruction. The second patient was a fifteen year-old girl with a massive destructive fungating metastatic osteosarcoma of the right femur. The third was a 42 year-old male with a huge giant cell tumor of the right radius. In February and March 2013, we performed two separate medical relief trips to Bernard Mevs Hospital. Most of the work was preparatory; we communicated preoperatively with the OR staff regarding the necessary instruments. Equipment donations were obtained from the University of Miami Hospital, an osteoarticular allograft from the University of Miami Tissue Bank, and hardware from a major orthopaedic trauma company.

Results: We performed a distal femoral osteoarticular reconstruction after resecting the giant cell tumor which had a large soft tissue component and pathologic fracture. A palliative disarticulation was done on the patient with the fungating sarcoma. We also resected the radius and performed a single bone forearm in the man with a distal radius giant cell tumor. During the procedures we dealt with infrastructure problems such as electricity outages, as well as natural sources of potential contamination such as insects, particulate debris and obvious language barriers. Despite these obstacles the patients were successfully treated.

Conclusions: Sarcoma patients in Port-au-Prince Haiti face many obstacles in accessing quality health care, including cultural beliefs, geographic barriers, infrastructure, and health system challenges that significantly delay diagnosis, treatment and adversely affect outcome. Increasing the presence of orthopaedic oncologists in Port-au-Prince may address some of these issues in sarcoma care in Port-au-Prince, Haiti.

Level of evidence: Level IV, Case series
RACIAL DISPARITIES IN EXTREMITY SOFT TISSUE SARCOMA OUTCOMES – A NATIONWIDE ANALYSIS
Ginger E. Holt, MD; Vignesh K. Alamanda; Nicole Behnke, MD; Gadini Delisca, MS; Yanna Song, MS; Herbert S. Schwartz, MD

Background: Racial disparities in access and survival have been reported in a variety of cancers. These issues, however, have yet to be explored in detail in patients with soft tissue sarcomas (STS). The purpose of this paper was to investigate the independent role of race with respect to survival outcomes in STS.

Methods: A total of 7,601 patients were evaluated in this study. A SEER registry query for patients over 20 years old with extremity STS diagnosed between 2004–2009 (n=7, 225) was performed. Patients over 18 years old from a major sarcoma center presenting with an extremity STS between 2000 and 2008 were also analyzed (n=376). Survival outcomes and the role of frequently seen comorbidities were analyzed after patients were stratified by race. Multivariable survival models were used to identify independent predictors of sarcoma specific death. Wilcoxon rank sum test was used to compare continuous variables. Statistical significance was maintained at p<0.05.

Results: This study showed that African American patients were more likely to die of their STS. They were younger at presentation (p=0.001), had larger tumors (<0.001), had less surgery (p=0.002), received radiotherapy less frequently (p=0.024), had higher family income (p<0.001) and were less likely to be married (p<0.001). African American race by itself was not an independent predictor of death. No differences in distant metastasis and local recurrence were found between the two races. Comorbidities such as hypertension, diabetes mellitus, hyperlipidemia, obesity and post-operative wound issues were not independent predictors of survival.

Conclusion: African Americans encounter death due to STS at a much larger proportion and faster rate than their respective Caucasian counterparts. African Americans frequently present with a larger size tumor, do not undergo surgical resection or receive radiation therapy as frequently as compared to their Caucasian peers. Barriers to timely and appropriate care should be further investigated in this group of at-risk patients.

LEVEL III study

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DOES HISTOLOGIC DIAGNOSIS REALLY DETERMINE PROGNOSIS? AN NCDB ANALYSIS OF OSTEOSARCOMA CHONDROSARCOMA AND EWINGS SARCOMA
William G. Ward, MD; Robert M. Corey, MD; Katrina R. Swett, MS

Introduction: It is commonly accepted that the prognosis of chondrosarcoma is significantly better than that of osteosarcoma. It is generally accepted that the prognosis of osteosarcoma is a bit better than that of Ewings Sarcoma. However, it is possible that the histologic diagnosis is not the controlling factor but rather simply the stage and grade of the underlying neoplasm. Accordingly, an analysis of the National Cancer Database (NCDB) of the American College of Surgeons was queried to determine, after correcting for stage and grade, if there was truly a difference based on the underlying histology.

Materials and Methods: An analysis of the NCDB data collected from the years 1998 through 2010 was performed to determine, based on the three histologic diagnoses, if there was a difference in the survivorship curves for each of the three entities when grouped and compared within the same stage and grade (features regularly recorded in the NCDB).

Results: For the majority of the grades and stages, the survivorship curves are remarkably similar. In stage 4 disease, the five-year survivorship for all three entities is identical and dismal. The modest differences seen in some grades or stages can likely be accounted for by the difficulty in accurately grading tumors of different histology in a similar fashion. Sensitivity to chemotherapy may account for the slightly better early survivorship seen in the 1-2 year range in Ewings sarcoma and Osteosarcoma compared to that of chondrosarcoma, however, the ultimate 5-year survival is equally dismal for all three entities in advanced stage disease. Multiple survivorship curves will be presented to illustrate these stage and grade similarities across diagnostic categories.

Conclusions: The role of histologic diagnosis and categorization may have been previously overemphasized. Underlying basic oncogenic biologic factors may have greater prognostic significance than previously appreciated. Enhanced efforts to determine the biologic mechanisms underlying tumor grade and metastasis may prove more fruitful than efforts to elucidate the causes of the differences in histologic differentiation. * Chief of Musculoskeletal Service Line, Guthrie Healthcare System, Sayre PA, Professor Emeritus, Wake Forest Baptist Health, Winston Salem, NC William_Ward@guthrie.org ** Surgical Resident, Robert Packer Hospital/Guthrie Healthcare System, Sayre, PA **Statistician, Division of Public Health Sciences, Wake Forest Baptist Health, Winston Salem, NC

Disclosures listed in handout
Background: Pre-operative external beam radiotherapy (XRT), post-operative XRT, and brachytherapy have all demonstrated benefit when added to wide surgical excision for the local control of soft tissue sarcoma (STS). However, each method has its own disadvantages. Pre-operative XRT is associated with higher wound complication rates, whereas post-operative XRT requires higher radiation dosages and thus carries greater incidences on edema, fibrosis, and joint contracture.

Purposes: Here we describe a modified post-operative brachytherapy delivery technique termed Brachy-VAC therapy.

Patients and Methods: Patients were selected based on the diagnosis of high-grade STS sarcomas that were felt to require both radiation therapy and a soft tissue reconstruction. After sarcoma excision, brachytherapy catheters were placed at 1 cm intervals along the entire tumor bed. A vacuum-assisted closure (VAC) sponge was then placed over the catheters and the wound was sealed according to standard VAC protocol. Following the completion of brachytherapy (typically 1 week), patients were taken back to the operating room by the reconstructive surgery team for removal of the VAC device and brachytherapy catheters, and management of the soft tissue defect.

Results: During the study period of 2010-2013, seven patients underwent the procedure, ages 34 to 73, each with a high-grade soft-tissue sarcoma. In this group there were three wound complications. One skin graft breakdown, one abdominal incision infection requiring hospitalization, and one instance of bleeding from a free flap harvest site. There were three instances of local recurrence requiring additional surgery. Two of the patients with local recurrence also developed pulmonary metastatic disease.

Conclusion: Brachytherapy is an effective method for the local control of STS following wide resection when a soft tissue reconstruction is anticipated. By combining brachytherapy with vacuum-assisted closure, it is possible to avoid many of the known complications of both pre- and post-operative XRT. Additional research with greater numbers is required to compare Brachy-VAC therapy with more standard radiotherapy strategies.

Level of Evidence: IV, Case Series
PSEUDOMYOGENIC HEMANGIOENDOTHELIOMA OF BONE: A CASE REPORT AND LITERATURE REVIEW OF A RARE TUMOR

Kurt R. Weiss, MD; Uma Rao, MD

Case: The patient is a 9-year-old girl who presented to a tertiary pediatric orthopaedic practice with a chief complaint of right hip pain and a recent fall. She was felt to have a slipped capital femoral epiphysis (SCFE) and a percutaneous screw was placed. Endocrinologic evaluation was negative. Unfortunately her pain persisted and a permeative, lytic process was appreciated. At this point an infectious work-up was performed and was found to be negative. She was referred to a musculoskeletal oncologist.

CT-guided biopsy was inconclusive so she was taken for an open biopsy. This was consistent with pseudomyogenic hemangioendothelioma of bone. Staging studies showed that she had localized disease. A wide resection and endoprosthetic reconstruction was performed with negative margins.

Discussion: Pseudomyogenic hemangioendothelioma of bone is an extremely rare disease entity. Histologically, the tumor is characterized by “…loose fascicles and sheets of plump spindle cells with vesicular nuclei, variably prominent nucleoli, and abundant brightly eosinophilic cytoplasm, some with a strikingly rhabdomyoblast-like appearance” [1]. Its behavior is characterized by a high incidence of local recurrence and a limited but real metastatic potential. There may be an associated genetic translocation [2].

Conclusion: Pseudomyogenic hemangioendothelioma of bone is a rare tumor and the literature is not replete with guidance on how to optimally manage this disease. The disease appears to have a limited metastatic potential but a high propensity for infiltrative growth and local recurrence.

References:

SARCOMA ARISING IN A PREVIOUSLY REPLANTED LIMB
Kurt R. Weiss, MD; Richard L. McGough III, MD; Michael Gimbel, MD; Stephen Burton, MD; Hussein Tawbi, MD, PhD; Uma Rao MD

Background: MM is a 32 year-old male with a history of a right arm replantation performed when he was 8 years old secondary to trauma. The arm was replanted just proximal to the elbow joint. The patient subsequently developed a grade 3 leiomyosarcoma in the replanted arm 24 years after the injury.

Treatment: The patient was treated at the University of Pittsburgh Cancer Institute (UPCI) in a multidisciplinary fashion. After confirmation of the sarcoma by a musculoskeletal pathologist, he underwent a margin-negative resection by a Musculoskeletal Oncologist. He then received brachytherapy treatments under the care of the UPCI Radiation Oncology service. After this, he underwent a microvascular free soft tissue transfer with the Plastic and Reconstructive Surgery service. Finally, he received adjuvant chemotherapy from the UPCI Hematology/Oncology service.

Resolution: The patient is presently 1 year from the cessation of his chemotherapy treatments and free of any measurable disease. He is back to work in construction and manual labor.

Conclusion: Multidisciplinary sarcoma care is potentially successful, even in extremely complicated cases. We know of no other cases in the literature of sarcoma in a replanted extremity.
ACCURACY AND PRECISION OF A BIDIRECTIONAL INFRARED SURGICAL NAVIGATION SYSTEM

Kenneth R. Gundle, MD; Jed K White, MD; Ernest Conrad III, MD; Randal Ching, MD

Objectives: Surgical navigation technology has the potential to guide tumor excision and facilitate limb salvage. However, in the process of utilizing these systems, there are numerous opportunities for error that may impact surgical margins and reconstruction. This study aimed to examine sources of error in an idealized scenario, using a bidirectional infrared surgical navigation system (Stryker Navigation System II).

Methods: Accuracy and precision was assessed using a calibrated artifact with known distances between machined indentations while varying: 1) the distance from the artifact to the navigation camera (range 150 to 247cm), 2) the distance from the artifact to the patient tracker device (range 20 to 40cm), and 3) whether the minimum or maximum number of bidirectional infrared markers were actively functioning. Distances were selected to represent clinically meaningful scenarios and were within manufacturer guidelines.

For each scenario, distances were measured between 10 and 120mm using the OrthoMap 3D software, with twelve measurements for each distance. The accuracy outcome was root mean square (RMS) error between the navigation-determined distance and the actual distance. To assess precision, four indentations were recorded six times for each scenario, while varying the angle of the pointer. The outcome for precision testing was the standard deviation of the distance from each point to the mean three-dimensional coordinate.

Results: Multiple linear regression revealed that as the distance from the navigation camera to the artifact increased, the error increased (p<0.001). The error also increased when not all infrared markers were actively tracking (p=0.047). These factors accounted for 30% of the overall variance in RMS error. Precision also worsened when not all infrared markers were active (p<0.001), and as the distance between navigation camera and physical space increased (p<0.001).

Conclusions: This study suggests that the navigation system is more accurate and precise when the distance from the navigation camera to the physical (working) space is minimized. Also, in order to minimize these errors, the patient tracker and pointer must be positioned so that all bidirectional markers are active and visible. These findings may require alterations in operating room setup and software changes to improve the accuracy and precision of the navigation system.

Disclosures listed in handout

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CLINICAL OUTCOMES OF A COMPOSITE BONE GRAFT SUBSTITUTE TO TREAT BENIGN BONE LESION DEFECTS

William B. Payne, MD; Judd E. Cummings, MD; Matthew J. Seidel, MD

Background: A composite injectable bone graft substitute composed of calcium sulfate and calcium phosphate has been approved by the FDA for filling bone defects. This composite is marketed under the trade name Prodense. To date there have been few studies evaluating its use as a bone void filler in the treatment of benign bone lesions.

Questions/Purposes: We studied the amount of time to radiographic incorporation of the graft, time to weight bearing, time to full activity and postoperative complications encountered when this material was used in the treatment of benign bone lesions.

Methods: We retrospectively reviewed the charts of 82 patients (48 males, 34 females) with benign bone lesions treated with Prodense from 2008 to 2011. These patients had an average age of 20 years (range 3-71) at the time of surgery and were treated primarily for the following diagnoses: unicameral bone cyst (14), nonossifying fibroma (14), giant cell tumor (11), aneurysmal bone cyst (10), chondroblastoma (five), fibrous dysplasia (four), osteoid osteoma (four), osteoblastoma (three), Langhans Cell Histiocytosis (two), enchondroma (two), and chondromyxoid fibroma (two). Previous reports of Prodense show a consistent pattern of peripheral resorption around the graft followed by ossification. Therefore, postoperative radiographs were reviewed to determine the time to first evidence of resorption, time to complete incorporation of the bone graft, time limited/protected weight bearing and release to full activity. The average follow-up was 463 days (range 15-1301 days).

Results: Overall, the bone graft successfully incorporated in 72 of the 82 patients (88%). In patients without a local recurrence or infection (73 patients), the graft successfully incorporated in 98%. The average time to first evidence of resorption was 40 days (range 8-85), while the average time to complete incorporation of the graft was 243 days (range 20-1243). Average time to weight bearing was 60 days (range 0-222) and average time to full activity was 120 days (range 15-316). Postoperative complications included eight local recurrences, pathologic fracture at the recurrence site in two patients, and one wound infection requiring graft removal with irrigation and debridement. We did not observe any bone graft specific complications such as absorption without incorporation, heterotopic bone formation or sterile drainage. No patients without local recurrence required additional bone grafting and all patients were considered to be fully radiographically incorporated at last follow up. All patients considered completely incorporated were released to full activity without restrictions and none have had complications or required further surgery at most recent follow up.

Conclusion: Patients treated with Prodense experienced reliable incorporation of the graft into bone defects secondary to treatment for benign bone lesions. In our series, when tumor control was achieved the graft was universally successful and we did not see graft specific complications such as sterile drainage as seen with some other bone void fillers. We believe that this composite bone graft substitute is a reasonable filler to use in the operative treatment of bone defects created in the treatment of benign bone lesions.

Level of evidence: III, retrospective review.

* Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).

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LEIOMYOSARCOMA SURVIVAL IS INDEPENDENT OF ANATOMIC LOCATION
Srikanth Divi, MD; Richard L. McGough III, MD; Kurt R. Weiss, MD

Background: Leiomyosarcoma (LMS) is a malignancy that can occur anywhere in the body and accounts for approximately 10% of soft tissue sarcomas. It commonly originates in the uterus, retroperitoneum and abdominal cavity. Sarcomas account for only 7% of uterine malignancies, and the most common subtypes are LMS and endometrial stromal sarcoma [1]. LMS also arises in non-visceral locations such as the dermis, the extremities, the trunk, and head and neck tissues [2]. The purpose of this study was to evaluate possible differences in outcomes between patients with uterine and extra-uterine LMS. It is popularly held that uterine LMS behaves differently than extra-uterine disease, and we hypothesized that patients with uterine LMS would have worse outcomes [3].

Methods: Surgical pathology reports from the University of Pittsburgh Medical Center were electronically searched and filtered to identify patients with the diagnosis of LMS. Over a period from 1981-2012, 639 patients were identified, including 129 patients diagnosed with uterine LMS and 510 patients diagnosed with extra-uterine LMS.

Results: Median survival for patients with uterine LMS was 5.05 years with a 95% CI of [2.64, 7.46]. Median survival for patients with extra-uterine LMS was 4.52 years with a 95% CI of [3.76, 5.28]. A log-rank test was used to compare survival differences, and no significant differences were found (p=0.81, Figure 1). The hazard ratio with a 95% CI was 1.042 [0.815, 1.333], indicating no significant difference between the two groups. Stratifying for gender, tumor grade, tumor size, adjuvant therapy, and margin status failed to uncover any survival differences between the two groups.

Conclusion: These data from a large series of patients suggest that uterine and extra-uterine LMS carry similar prognoses, thus proving our hypothesis incorrect. Further studies are required to investigate the biological similarities and differences between uterine and extra-uterine LMS that might explain these findings.

References:

Figure 1

Disclosures listed in handout
ALDEHYDE DEHYDROGENASE (ALDH) IS A MARKER FOR METASTATIC DISEASE IN MUSCULOSKELETAL TUMORS ORIGINATING IN BONE
Kurt Weiss, MD; Xiaodong Mu; Adel Majoub; Trevor Schott, MD

Introduction: Musculoskeletal bone tumors complicated by metastatic disease continue to have high rates of mortality that have remained unchanged despite advancements in surgical and oncologic care [1]. The problem of metastatic disease remains unsolved, and novel approaches are required. Aldehyde Dehydrogenase (ALDH) is an enzyme which has been associated with a poor clinical prognosis in a variety of malignancies [1,2]. The purpose of this study was to establish whether ALDH could be a molecular marker of metastatic potential in various musculoskeletal tumors originating in bone.

Method: After IRB approval, musculoskeletal tumor tissue samples were obtained from patients diagnosed with a variety of tumors originating in bone at the time of diagnostic biopsy or operative procedure. Diagnoses included Osteosarcoma, Chondrosarcoma, and Ewing’s sarcoma. Flow cytometry was performed on the cell population isolated from each tissue sample in order to identify the percentage of cells that demonstrated high ALDH activity.

Results: Tissue samples were attained from 10 patients. Diagnoses included Chondrosarcoma (n=5), Osteosarcoma (n=3), and Ewing’s Sarcoma (n=2). Metastatic disease was evident in 8 patients at the time that the sample was acquired, and in each case, metastases were pulmonary. The patients with metastatic disease were found to have high ALDH activity ranging from 3.9% to 39.4% in the examined tumor tissue samples as demonstrated in Table 1 and Figure 1. The two patients without metastatic disease had high ALDH activity less than 1.2%. In this limited patient population, employing 3.9% as a threshold value, the high ALDH activity assay was both 100% sensitive and specific at differentiating patients with metastatic disease from those without metastatic disease.

Conclusion: Musculoskeletal tumors continue to have high rates of mortality due to pulmonary metastatic disease. ALDH is an enzymatic marker that could portend metastatic potential and represent a potential therapeutic target for high-risk bone sarcomas. Further studies are required to evaluate greater numbers of bone tumors, examine the relationship between ALDH and soft tissue sarcomas, and explore the feasibility of anti-ALDH therapy in sarcoma patients.

References
Figure 1. ALDH assay performed on tissue from 63-yr Female diagnosed with right foot dedifferentiated chondrosarcoma. The patient underwent a below knee amputation for local control of the disease and was noted to have lung metastasis based on imaging at the time of the operative procedure. High ALDH activity was present in 20.3% of the cells from the tumor tissue sample. (Number of cells with ALDH activity indicated in green. Number of cells with low ALDH activity indicated in purple. Total number of cells in the tissue sample indicated in gray.)

Table 1. Patient information from obtained musculoskeletal tumor samples

<table>
<thead>
<tr>
<th>Patient Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>Metastatic Disease</th>
<th>% ALDH-High Cells</th>
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<tbody>
<tr>
<td>19</td>
<td>M</td>
<td>Osteosarcoma</td>
<td>Lung</td>
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</tr>
<tr>
<td>27</td>
<td>M</td>
<td>Ewing’s Sarcoma</td>
<td>Lung, Bone</td>
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<tr>
<td>70</td>
<td>M</td>
<td>Dedifferentiated Chondrosarcoma</td>
<td>Lung</td>
<td>23.3</td>
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<tr>
<td>63</td>
<td>F</td>
<td>Dedifferentiated Chondrosarcoma</td>
<td>Lung</td>
<td>20.3</td>
</tr>
<tr>
<td>35</td>
<td>M</td>
<td>Ewing’s Sarcoma</td>
<td>Lung, Brain</td>
<td>7.1</td>
</tr>
<tr>
<td>84</td>
<td>F</td>
<td>Surface osteoblastic Osteosarcoma</td>
<td>Lung</td>
<td>5.5</td>
</tr>
<tr>
<td>60</td>
<td>F</td>
<td>Dedifferentiated Osteosarcoma</td>
<td>Lung</td>
<td>3.9</td>
</tr>
<tr>
<td>86</td>
<td>M</td>
<td>Myxoid Chondrosarcoma</td>
<td>None</td>
<td>1.2</td>
</tr>
<tr>
<td>80</td>
<td>M</td>
<td>Dedifferentiated Chondrosarcoma</td>
<td>None</td>
<td>0.2</td>
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</tbody>
</table>
MULTI-VITAMIN USE MAY DECREASE THE RISK OF METASTASIS IN PATIENTS WITH SOFT TISSUE SARCOMAS
Meena Bedi, MD; David M. King, MD; John A. Charlson, MD; Donald A. Hackbarth, MD; Dian Wang, MD, PhD; John C. Neilson, MD

Introduction: Supplements and minerals are used for their potential benefits by many patients diagnosed with cancer. The aim of this retrospective study was to assess the correlation between supplement and multivitamin (MVT) use with outcomes in patients with soft tissue sarcomas (STS).

Materials And Methods: Between 2000 and 2012, 185 patients with stage I-III primary STS of the extremity and chest-wall underwent treatment at the authors’ institution. We retrospectively analyzed various factors relating to overall survival (OS), disease-free survival (DFS), and distant-metastasis free survival (DMFS). Numerous variables, including patient, tumor and treatment characteristics were analyzed (Table 1). This included medications and supplements that were taken by patients prior to, during and after the diagnosis and treatment of STS. Univariate analysis (UVA) was done using the log-rank test and multivariate analysis (MVA) was performed using the Cox proportional hazards model. Binary logistic regression was used to describe associations between predictive factors.

Results: Median follow-up was 3.6 years. All patients underwent wide local excision for their primary STS. Fifty-five (29.7%) patients underwent neoadjuvant chemotherapy. Sixty of the 178 patients (34%) had record of taking a MVT at the time of sarcoma diagnosis. Of these patients 6 (10%) developed metastasis compared to 46 of 118 (39%) who did not take a MVT at the time of their diagnosis.

On UVA, MVT use predicted for an improved DFS (p=0.001) and DMFS (p=0.001) (Figure IA and IB). Median DFS and DMFS was not reached in patients taking MVT, compared to 63 and 63 months for those not taking MVT, respectively. On MVA of OS, aspirin (p=0.03, HR 1.5), and calcium-channel blockers (p=0.004, HR 2.1) were both predictors for poorer overall survival. On MVA of DFS, smoking (p=0.008, HR 2.0), stage III tumors (p=0.003, HR 5.9), and HMG-COA reductase inhibitor use (p=0.02, HR 2.10) were negative predictors, however MVT use (p=0.0004, HR 0.25) led to improved DFS. On MVA for DMFS, smoking (p=0.002, HR 2.4) stage III disease (p=0.004, HR 5.7), and HMG-COA reductase inhibitor use (p=0.006, HR 2.5) led to decreased DMFS and MVT use (p=0.0004, HR 0.23) led to improved DMFS. On post-hoc analysis for OS, DFS and DMFS, aspirin, CCB and HMG-COA reductase inhibitors were strongly correlated with age, however, this association was not present with MVT use.

Fifty-five patients (29.7%) developed distant metastasis in this cohort. On UVA and MVA, MVT use (14.1 vs 13.9 mo, p=0.59) nor use of any other supplement predicted for metastatic survival (time from metastasis to death).

Conclusions: Patients who were taking a MVT at the time of diagnosis and during and after their treatment for their STS had improved DFS and DMFS in our patient cohort. Patients who developed metastasis and were on an MVT at the time of their initial diagnosis did not have improved metastatic survival compared to those who were not on an MVT. This may suggest that MVT use prevents distant metastasis, but does not prolong survival once one develops metastasis. Further studies are needed to corroborate these findings.
Table 1: Patient, Tumor and Treatment Characteristics

<table>
<thead>
<tr>
<th>Patient and Tumor Variables</th>
<th>Tumor Variables</th>
<th>Treatment Factors</th>
<th>Medication</th>
<th>Supplements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Size</td>
<td>Chemotherapy</td>
<td>Metformin</td>
<td>Multivitamin</td>
</tr>
<tr>
<td>Performance Status</td>
<td>Location</td>
<td>Timing of Radiation</td>
<td>Aspirin</td>
<td>Vitamin B</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Stage</td>
<td></td>
<td>Prednisone</td>
<td>Vitamin C</td>
</tr>
<tr>
<td>Gender</td>
<td>Grade</td>
<td></td>
<td>Calcium Channel Blocker</td>
<td>Vitamin D</td>
</tr>
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<td>Cardiovascular Disease</td>
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<td></td>
<td>HMG-COA Reductase Inhibitor</td>
<td>Folate</td>
</tr>
<tr>
<td>Diabetes</td>
<td></td>
<td></td>
<td>COX-2 Inhibitor</td>
<td>Chromium</td>
</tr>
</tbody>
</table>

**Figure IA. Multivitamin Use and Disease-Free Survival**

**Figure IB. Multivitamin Use and Distant-Metastases Free Survival**
EVALUATING THE READABILITY OF ONLINE PATIENT EDUCATION MATERIALS RELATED TO BONE AND SOFT TISSUE SARCOMAS
Herrick J. Siegel, MD; Shaan Patel, BA, Brent Ponce, MD; Evan Sheppard, BS

Background: Cancer patients need adequate health information to cope with their diagnosis and to take advantage of the positive health outcomes that come from understanding medical procedures and treatment options. With more cancer and orthopaedic patients searching the Internet for health information, it is important for the reading level of online patient education materials (PEMs) to match the health literacy level of cancer and orthopaedic patients. The National Institutes of Health (NIH) recommends PEMs to be written at a 6th to 7th grade reading level. No present study has thoroughly evaluated the readability of PEMs related to multiple bone and soft-tissue sarcomas and conditions that mimic bone sarcoma, nor have any used ten readability instruments. We hypothesize that the reading level of PEMs related to bone and soft-tissue sarcomas and mimics of bone sarcoma is higher than the NIH’s recommendation.

Materials and Methods: Relevant online PEMs were identified from the following websites: American Academy of Orthopaedic Surgeons, academic training centers, sarcoma specialists, Google search hits, bonetumor.org, Sarcoma Alliance, Sarcoma Foundation of America, and Medscape. Ten separate readability instruments were used to evaluate the reading level of each websites’ PEMs.

Results: 72 websites and 774 articles were evaluated. No websites had a mean readability score at or below 7 (seventh grade). Collectively, all websites had a mean readability score of 11.4 and the range of scores was grade level 8.9 to 15.5.

Conclusion: All PEMs in this study related to bone and soft-tissue sarcomas and conditions that mimic bone sarcoma did not meet the NIH’s recommendation for the reading levels of PEMs. Concerted effort to improve the reading level of orthopaedic oncologic PEMs is necessary.
The antifibrinolytic effect of tranexamic acid (TXA) has been reported to reduce blood loss in total joint and spinal procedures; however the impact on hemostasis has not been reported in orthopaedic oncology. This study evaluates the safety and efficacy of TXA in patients undergoing oncologic resections in procedures with significant anticipated blood loss. The study group consists of 48 patients treated perioperatively with TXA. The procedures included 21 distal femur replacements, 18 proximal femur replacements and 9 soft tissue sarcomas (>20 cm in diameter). Pathology included 18 patients with metastatic disease, 9 osteosarcoma, 4 Ewing sarcoma, 2 chondrosarcoma, 9 high grade soft tissue sarcomas, 2 myeloma, 2 lymphoma of bone, 1 angiosarcoma of bone, 1 leiomyosarcoma of bone. Each patient was administered 1 gram of intravenous TXA 10 minutes prior to surgical incision, 1 gram at the beginning of closing and 1 gram 3 hours post operatively.

A patient matched historical control group of 56 patients treated by the same surgeon during a period that TXA was not used was used for comparison. The study evaluates intraoperative blood loss, post operative complications, incidence of transfusion and hospital stay of the study group compared to the control group. We analyzed group differences in the study demographic and operative parameters using one-way ANOVA; Analyses were performed using Stata1 8.2 software. Infection incidence, thromboembolic events, cardiac related problems were not significantly different between the study and control groups (p=0.20, 0.07, 0.15, respectively). Blood loss, incidence blood transfusion, and hospital stay were all reduced with statistical significance (p value =.010, .033 and 0.044, respectively). Hospital stay for the controlled averaged 6.3 days and the study group averaged 4.1 days. Post operative blood loss as determined by drain output was also significantly reduced (average 420 cc vs 714 cc). Tranexamic acid appears to be safe and effective in reducing blood orthopaedic oncologic procedures. Randomized, prospective studies are needed to further validate this study’s findings.
OSTEOPOROTIC DISTAL FEMUR FRACTURES TREATED WITH MODULAR ONCOLOGIC REPLACEMENT PROSTHESES
Herrick J. Siegel, MD; Brian Etier, MD; Jason Gay, CRNFA

Comminuted distal femur fractures in the elderly remain a complex problem to manage. Non-union and prolonged immobilization in this patient population results in significant disability. While internal fixation remains the mainstay for non-comminuted distal femur injuries, when extensive comminution or bone loss is present, distal femur replacement may provide optimal management. This study evaluates the treatment of osteoporotic comminuted fractures of the distal femur in patients undergoing replacement with a modular oncologic hinge system. The study group includes 52 patients ranging in age from 65-91 years of age who have undergone distal femur replacement by a single surgeon. The patients were divided into 3 subgroups: 1) 18 acute distal femur fractures 2) 12 non-union or failed fixation of a distal femur fracture, 3) 22 periprosthetic femur fracture. Perioperative complications, blood loss, length of hospitalization and functional/ambulatory outcome were recorded and evaluated. The Stryker GMRS distal femur replacement was used in all cases. All components were cemented. Patients were full weightbearing without restrictions immediately post-operative.

The average blood loss was 450 cc (200-850 cc) and the length of hospitalization ranged from 3-14 days (average stay 5.1 days). Thirty nine of 52 patients presented with other injuries that were treated surgically and may have contributed to the length of hospitalization. Twenty-four perioperative complications were noted in 21 patients. This included pneumonia, DVT, myocardial infarction, renal insufficiency, cellulitis, deep infections, and PTE. All deep and superficial infections occurred in non-union patient subgroup with prior internal fixation. Forty six of 52 patients returned to independent ambulation at final follow. All thromboembolic events occurred in the acute fracture group while on anticoagulation treatment. Distal femur replacement is an acceptable option in the elderly patient population with a comminuted fracture that would benefit from immediate weightbearing. Caution should be used in non-union patients with prior internal fixation and all should be cultured intraoperatively.
THE ROLE OF SPINOPELVIC RECONSTRUCTION AFTER AMPUTATIVE SACRECTOMY
Grigoriy G. Arutyunyan, MD; Peter S. Rose, MD; Franklin H. Sim, MD; Michael J. Yaszemski, MD, PhD

Background: Concurrent hemipelvectomy and partial or total sacrectomy (amputative sacrectomy) may be necessary for curative treatment of advanced spinopelvic malignancies. No prior studies have reported this technique and when instrumented lumbopelvic fusion is necessary following these resections.

Methods: We reviewed all patients undergoing amputative sacrectomy between 1998-2012 to analyze surgical and oncologic outcomes as well as reconstructive techniques and results. Twenty-two patients underwent amputative sacrectomy for sarcoma (n=20) and locally advanced visceral malignancy without metastases (n=2). Seventeen patients underwent partial sacrectomy hemipelvectomy and five underwent total sacrectomy hemipelvectomy. Average follow-up was 44 months on surviving patients.

Results: All patients with total amputative sacrectomy and eight of seventeen patients with partial amputative sacrectomy underwent planned (n=7) or delayed unplanned reconstruction (n=1 at 23 months). Patients were selected empirically for planned reconstruction if >50% of the lumbosacral junction was resected.

Eight patients died of disease, four patients died of other causes including two in the perioperative period and one in the intraoperative period. Major complications were seen in fifteen patients (n=14 unplanned re-operation; n=1 renal failure requiring hemodialysis). Seven of ten surviving patients have no evidence of disease, three are alive with disease. All surviving patients are independent in their activities of daily living (with appropriate assistive devices).

Conclusions: Amputative sacrectomy can be pursued with high complication rates but reasonable long-term outcome for advanced spinopelvic malignancy. Most patients with ≥ 50% of the lumbosacral junction remaining do not require reconstruction. In patients with more extensive partial or total sacrectomies, spinopelvic reconstruction can be successfully performed.

Level of Evidence: IV, Therapeutic

Key Words: Hemipelvectomy, Sacrectomy, Sarcoma, Reconstruction
EPIPHYSEAL AND GROWTH PLATE SPARING IN CHILDREN WITH MALIGNANT BONE TUMOR ABOUT THE KNEE: THE BIOLOGICAL SOLUTION
Samuel Kenan, MD; Adam Levin, MD

Introduction: Limb length discrepancy following wide resection of distal femur or proximal tibia in young children presents a major challenge. Attempt to overcome this problem using the expandable prosthesis has been associated with high morbidity related to multiple lengthening and revisions procedures. In an attempt to spare the knee joint and growth plate, in selected patients in whom the tumor is away from the growth plate, transmetaphyseal or transepiphysseal resection has been performed successfully. The outcome in twelve patients is presented.

Material and Methods: From 1990–2012, twelve selected patients with malignant bone tumors were treated. 10- osteosarcoma, 2-Ewing’s sarcoma. Age: 5 to 18 years. 7-male, 5-female. All received chemotherapy. 8-distal femur, 4-proximal tibia. In ten patient’s transmetaphyseal resection and in two, transepiphysseal resection was performed. Intercalary fresh frozen allograft was used in all cases. In four distal femur, combined allograft vascularized fibula was used.

Results: Follow-up period was from one year to 22 years. In four patients, follow-up was 18 to 22 years. All patients are disease free. There were no immediate complications. Late Allograft fracture in two proximal tibia treated successfully by autogenous bone graft and improved fixation. One patient with distal femur allograft at three years revised successfully using vascularized fibular graft. One patient with distal femur, failure in bone healing required resection and replacement with endoprosthesis. The growth plate was preserved in ten patients, all continued growth without significant limb length discrepancy. One patient with distal femur transepiphysseal resection will require future bone lengthening. All patients regained full active range of motion of the knee and returned to normal lifestyle activity.

Discussion: In the last decade better understanding of the biological behavior and improved radiographic imaging and at the same time effective chemotherapy treatment has enabled us to be more conservative with respect to the extent of the surgical margin. How close margin is too close is still to be determined. With the help of MRI tumor extension could be better determined. These advances made it possible to come closer to the tumor with adequate oncological surgical margins. In patients in whom the tumor is away from the growth plate, transmetaphyseal or transepiphysseal resection could be performed successfully spring the knee joint and growth plate allowing continues growth and minimizing limb length discrepancy. In the proximal tibia the surgical effect could be restored successfully by an allograft. For distal femur the best result could be obtained by combined allograft vascularized fibular graft. In eleven out of twelve selected patients with malignant bone tumor about the knee joint such procedure was performed successfully. This Biological solution proven to be effective, all patients continued growth without significant limb length discrepancy. All patients regained full active range of motion of the knee and returned to normal lifestyle activity.
INTERRAMEDULLARY NAILING OF FEMORAL DIAPHYSEAL METASTASES: IS IT REALLY NECESSARY TO PROTECT THE FEMORAL NECK?
Bryan Moon, MD; Patrick P. Lin, MD; Robert L. Satcher, MD; Justin E. Bird, MD; Valerae O. Lewis, MD

Introduction: Intramedullary nailing is the accepted form of treatment for impending or pathologic fractures of the femoral diaphysis. Traditional teaching promotes the use of a cephalomedullary nail so that stabilization is provided for the femoral neck in the event that a future femoral neck metastasis develops. However, there is no evidence in the literature that supports this practice. The purpose of this study is to evaluate the incidence of femoral neck metastases in patients who underwent femoral nailing of diaphyseal metastases.

Methods: Retrospective analysis of our Musculoskeletal Oncology database identified 146 femoral nailings performed for metastatic disease, myeloma, or lymphoma of the femoral diaphysis between 2001 and 2011. Average age was 59 years old. 145 of the nails were cephalomedullary implants and 1 was flexible nails. 84 cases received either preoperative or postoperative radiation therapy.

Results: Average radiographic follow-up was 13 months and average postoperative survival was 14 months. No (0%) cases of femoral neck metastases developed postoperatively.

Conclusion: Despite traditional teaching, that supports the use of cephalomedullary implants when treating metastatic disease of the femur, we were unable to identify a single case of femoral neck metastases developing after surgery. Our findings do not support the ubiquitous use of cephalomedullary implants in this patient population for the sole purpose of prophylactic femoral neck stabilization.
ESTABLISHING CRITICAL STEPS IN OPEN BIOPSY: A DELPHI CONSENSUS STUDY
Brian L. Seeto, MD; Peter C. Ferguson, MD

Background: Traditional post-graduate medical education techniques have been recently challenged. Surgical training programs are feeling increasing pressure from certifying bodies and licensing authorities to achieve and objectively demonstrate competencies throughout orthopaedic surgery. Open biopsy of suspected musculoskeletal tumours is one such competency that is expected of all orthopaedic surgery graduates. Despite it’s importance, there is no consensus on the critical skills or steps that an orthopaedic trainee must demonstrate in order to competently perform an open biopsy.

Objective: Using Delphi methodology, this study aims to investigate if expert consensus could be reached to establish the critical technical skills required for an orthopaedic trainee to competently perform an open biopsy of a suspected musculoskeletal tumour.

Design: A preliminary list of items was generated by the staff orthopaedic oncologists at a single tertiary care centre. One hundred and forty-five North American members of the Musculoskeletal Tumor Society (MSTS) were then invited to rate the list of items on a five-point scale based on importance as an indicator of competence. Participants were asked to suggest additional items or make amendments to existing items. These suggestions were incorporated into subsequent rounds. After each round, responses were analyzed and resent to the experts for further ratings until consensus was reached. Consensus was defined a priori as ≥ 80% of experts scoring ≥ 4 on all remaining items.

Results: Of the one hundred and forty-five members of the MSTS who were invited to participate, seventy-two responded to the first round. A preliminary twenty-three item list was generated by the authors. An additional ten items were added by the Delphi panel for rating. Only two total rounds were needed to reach consensus, with 57 respondents in the final round. Twenty-four items reached consensus as critical steps necessary for an orthopaedic trainee to perform an open biopsy of a musculoskeletal tumour competently.

Discussion: Delphi methodology established a consensus of the critical steps required for an orthopaedic trainee to demonstrate competency in performing open biopsies of musculoskeletal tumours. In future studies, this data will be incorporated into a novel evaluation tool that will a trainee’s technical and non-technical skills when performing open biopsies.
THE SURGICAL MANAGEMENT OF LOWER EXTREMITY BONE TUMORS: LEVELS OF EVIDENCE AND QUALITY OF REPORTING

Nathan Evaniew, MD; James Nuttall, MBB Ch BAO, Forough Farrokhyar, MPhil, PhD; Mohit Bhandari, MD, PhD, FRCSC; Michelle Ghert, MD, FRCSC

Background: The objectives of this study were: (1) to characterize the overall levels of evidence in the published literature on the surgical management of lower extremity bone tumors, (2) to evaluate the quality of reporting, and (3) to identify common deficiencies in reporting.

Methods: We conducted a systematic review of all studies reporting on the surgical management of lower extremity primary bone tumors from 2002 to 2012. Two authors independently assigned levels of evidence and appraised the included studies. For observational studies, we assessed reporting quality with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist.

Results: A total of 1387 studies were identified in our initial search. Of these, 607 met the eligibility criteria and were assessed for level of evidence. There were no level I studies, 2 level II studies, 47 level III three studies, 308 level IV studies, and 250 level V studies (Figure 1). The most common pitfalls in reporting of observational studies were failures to justify sample size (2.2% reported), examine sensitivity (2.2% reported), account for missing data or losses to follow-up (9.8% reported), and discuss potential sources of bias (14.1% reported). Duration of follow-up (66.3%), precision of outcomes (64.1%), eligibility criteria (55.4%), and methodological limitations (53.3%) were variably reported.

Conclusions: Observational studies are the dominant form of evidence for the surgical management of primary lower extremity bone tumors. However, numerous deficiencies in the quality of reporting decrease the value of the information when making clinical practice decisions. Authors may use the results of this study to inform future work and improve reporting in observational studies.
INTRODUCTION: Stabilization of impending or pathological fractures improves quality of life in the patient with metastatic disease. While this is typically accomplished with metal implants, this can lead to difficulty in visualizing and monitoring the fracture sight with radiographic modalities. Carbon Fiber technology offers the strength, durability, and ease of placement as standard stainless steel or titanium implants, but with the added benefit of being invisible on radiographs and providing minimal artifact on MRI. This allows the clinician to monitor the area of concern for healing and recurrence far better than that possible with conventional metallic implants.

This report provides the preliminary results of the use of Carbon Fiber plates and nails in the treatment of impending and pathological fractures due to neoplasia. Patient selection, surgical techniques and outcomes, as well as short term follow-up is presented to provide the clinician with additional and possibly improved avenues of treatment and monitoring.

MATERIALS AND METHODS: Fourteen non-randomized patients (ages 20 -88) underwent stabilization of impending (8) or pathological (6) fractures of long bones treated by intra-medullary nailing (7) or plate (7) fixation using carbon fiber implants. (Table 1). Diagnoses included both benign and malignant bone tumors as well as metastatic disease. The surgical techniques, including methodology of interlocking screws through an invisible implant are discussed. Mechanical stability, durability, patient and implant outcomes, as well as monitoring modalities are discussed. Additionally, the implant design and clinical implications of an invisible nail is reported.

RESULTS: Successful stabilization was achieved in all patients in that all patients were fully weight bearing or using their extremity for desired purposes in the usual amount of time for a metallic implant. (Typically by 12 weeks). Post-operative restrictions and activity levels were identical as well. Surgical time ranged from 42 minutes to 118 minutes with fluoroscopy time averaging slightly less than two minutes. There were no intra-operative or peri-operative complications. EBL ranged from 25 –150 cc and hospital length of stay ranged from 1 – 3 days. All pathological fractures demonstrated early signs of healing by six weeks and union by 12 weeks. No impending fracture progressed to fracture. Postoperative radiographs enabled the visualization of the fracture site or tumor site far more clearly due to the invisibility of the implant. Better visualization of healing was also noted. There were no obstructed views based on implant position as would commonly be seen with metallic implants.

CONCLUSIONS: The surgical and medical management of patients treated with carbon fiber fixation devices for impending or pathological fractures was very similar if not identical to the management of patients treated with metallic implants. The design of the implant enables the surgeon to accurately place the device in the appropriate position to secure fixation. The benefits however are quite significant in that the invisibility allows the clinician to more clearly monitor the most important area of concern, that being the fracture site, or impending fracture site, as well as the tumor location itself. The carbon fiber implant is MRI compatible and mechanically equivalent to similar implants of metallic design of the same sizes and shapes. The use of carbon fiber implants in the patients with metastatic and primary neoplasia of bone plays an improved role in our ability to monitor and therefore care for these patients.
<table>
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<th>Location</th>
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<th>Fx/Imp Fx</th>
<th>F/U (Mos)</th>
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<td>Union</td>
<td>Met Cholangio</td>
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Table 1.
ADVANCED IMAGING IS OVERUSED PRIOR TO REFERRAL TO A MUSCULOSKELETAL ONCOLOGIST: A PROSPECTIVE, MULTI-CENTER INVESTIGATION
Benjamin J. Miller, MD, MS; Raffi S. Avedian, MD; Judd Cummings, MD; Tessa Balach, MD; Kevin MacDonald, MD on behalf of the Musculoskeletal Oncology Research Initiative

Background: Patients often receive advanced imaging before referral to a musculoskeletal oncologist.

Questions/Purposes: To determine if there is regional variation in the use of advanced imaging or common factors predictive of excessive studies.

Patients and Methods: We performed an 8-center prospective analysis of patients referred for evaluation by a fellowship-trained musculoskeletal oncologist. Each surgeon collected 50 consecutive, or 6 months of, new tumor referrals. We recorded patient factors (age, sex, race, insurance status), referral details (specialty of referring physician, distance traveled), advanced imaging performed (MRI, CT, bone scan, ultrasound, PET scan), and presumptive diagnosis. The specialist at each institution reviewed the studies using predefined criteria to assess their utility. We analyzed the data using bivariate methods and logistic regression to determine regional variation and risk factors predictive of excessive advanced imaging.

Results: Of the 371 subjects were included for analysis, 301 (81.1%) were referred with some form of advanced imaging and 113 (30.4%) had at least one excessive study. There were no significant regional differences in the use of advanced imaging (Table 1). 17% of MRIs, 74% of CT scans, 62% of bone scans, 76% of ultrasounds, and 50% of PET scans were determined to be excessive (Table 2). Orthopaedic surgeons were as likely as non-orthopaedic surgeons to order excessive studies (p=0.940). In a univariate logistic regression, benign bone lesions had an increased odds of referral with an excessive study (OR 2.18, 95% CI 1.39-3.43).

Conclusions: We found no evidence that the proportion of patients referred with advanced imaging varied dramatically by region. Studies other than MRI were likely to be considered excessive and should not be routinely performed by referring physicians. Diligent education of orthopaedic surgeons and primary care physicians in the judicious use of investigations in benign bone tumors may help mitigate unnecessary imaging.
POSTER #18 (cont.)

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<th>Number with CT scan (%)</th>
<th>Number with bone scan (%)</th>
<th>Number with ultrasound (%)</th>
<th>Number with PET scan (%)</th>
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<td>54 (15)</td>
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<tr>
<td>PET scan</td>
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<td>7 (50)</td>
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Table 1. Incidence of prereferral imaging at participating centers

Table 2. Total number of excessive and repeated scans

Disclosures listed in handout
CONDITIONAL SURVIVAL IS GREATER THAN OVERALL SURVIVAL AT DIAGNOSIS IN PATIENTS WITH OSTEOSARCOMA AND EWING’S SARCOMA

Benjamin J. Miller, MD, MS; Charles F. Lynch, MD, MS, PhD; Joseph A. Buckwalter, MD, MS

Background: Conditional survival is a measure of the risk of mortality given survival of a defined period of time. These estimates are clinically helpful and have not been previously reported for osteosarcoma or Ewing’s sarcoma.

Questions/Purposes: We determined the conditional survival of osteosarcoma and Ewing’s sarcoma given survival of one or more years.

Patients and Methods: We utilized the Surveillance, Epidemiology, and End Results Program database to investigate all cases of osteosarcoma and Ewing’s sarcoma in patients younger than 40 years from 1973-2009. We used an actuarial life-table analysis to determine any cancer cause-specific 5-year survival estimates conditional upon 1-5 years of survival after diagnosis. We performed a similar analysis to determine 20-year survival from the time of diagnosis.

Results: The estimated 5-year survival improved each year after diagnosis (Table 1). The likelihood of 20-year cause-specific survival from the time of diagnosis was greater than 94% after 10 years of survival in localized disease and greater than 89% in metastatic disease, suggesting that while most patients will remain disease-free indefinitely, some experience cancer-related complications years after presumed eradication (Figure 1).

Conclusions: The 5-year survival estimates of osteosarcoma and Ewing’s sarcoma improve with each additional year of patient survival. Knowledge of a changing risk profile may be useful in counseling patients over time. The presence of cause-specific mortality decades after treatment supports lifelong monitoring in this population.

<table>
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<th>Osteosarcoma (metastatic)</th>
<th>Ewing’s sarcoma (local/regional)</th>
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<td>35.5</td>
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<td>85.4</td>
<td>92.5</td>
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Table 1. Cause-specific 5-year conditional survival for osteosarcoma and Ewing’s sarcoma in the SEER database, 1990–2009.
Background: The surgical practice patterns of early-career musculoskeletal oncologists have not been previously explored.

Questions/Purposes: To describe the types of surgical procedures performed, individual variations in case load, and sources of challenges and satisfaction in the first years following fellowship training in orthopaedic tumor surgery.

Patients and Methods: Fifteen fellowship-trained musculoskeletal oncologists in their first years of practice (range 1-4 years) submitted complete operative case lists from September 1, 2010 through August 31, 2012. We recorded the type of procedure (tumor, trauma, adult reconstruction, or other). We then determined associations between the annual number of tumor surgeries and annual total operative case load, years in practice, and individual details of practice (metro population, time dedicated to research, practice size, and number of tumor surgeons in area). Each participant completed a survey regarding sources of stress and satisfaction and the results were compared to an identical survey previously given to the general membership of the Musculoskeletal Tumor Society (MSTS).

Results: 5,611 surgical cases were available for review. For the entire cohort, there were 3,303 (58.9%) tumor surgeries, 973 (17.3%) trauma, 890 (15.9%) adult reconstruction, and 445 (7.9%) other. We treated 1,407 (42.6%) benign tumors, 748 (22.6%) sarcomas, 591 (17.9%) metastatic lesions, and 557 (16.9%) non-neoplastic conditions. The annual number of tumor procedures varied by individual (median 135, range 47-216.5) and correlated with the total annual number of procedures (r=0.73, p<0.001). Individuals in practice for three or more years performed a higher annual number of tumor cases (p=0.026). There was substantial variability between individuals in the annual number of subspecialty cases (Fig 1) and percent of subspecialty cases (median 55.6% tumor, range 43.1-94.2%). Sources of stress and satisfaction were similar to the general membership of the MSTS, with early-career surgeons placing more importance on case volume (p<0.001).

Conclusions: Early-career orthopaedic tumor surgeons should anticipate that less than 60% of their operative cases will be directly related to their fellowship training in musculoskeletal oncology. Overall, the challenges and rewards of medical practice are similar to surgeons later in their career.
CARBON FIBER FIXATION IN ONCOLOGIC BONE SURGERY
Daniel C. Allison MD, MBA, FACS; Lawrence R. Menendez MD, FACS

This research was conducted at the Cedars-Sinai Medical Center and the University of Southern California Medical Center

Background: Compared with conventional metal bone fixation devices, carbon fiber provides improved fatigue strength, complete imaging compatibility, and a modulus of elasticity closer to that of cortical bone. These characteristics make carbon fiber a potentially ideal fixation choice for joint sparing oncologic procedures.

Questions / Purposes: We ask if carbon fiber represents a safe and effective alternative to current metallic long bone fixation devices used in oncologic bone tumor surgery.

Patients & Methods: We retrospectively reviewed our experience with carbon fiber in the treatment of tumors and tumor-like conditions of the long bones over an 18-month period of time at two academic institutions. Five cases met the inclusion criteria: one myeloma pathologic nonunion of the proximal femoral shaft, one metastatic bronchogenic adenocarcinoma impending pathologic fracture of the tibia, two infected nonunions of the tibial shaft, and one femoral nonunion with extensive bone loss. Follow up ranged from 6 to 24 months.

Results: No adverse tissue reactions or complications were seen among the cases. All patients were allowed to weight bear immediately. Radiographic fracture and bone lesion imaging remained optimal in all cases. All nonunions healed, based on radiographic and clinical evaluation. No cases of subsequent fracture or hardware failure occurred. All cases of infection achieved remission.

Conclusions: Because of its material and imaging properties, carbon fiber provides an ideal solution for long bone fixation in tumor cases. At short term follow-up, carbon fiber is a safe and effective alternative and well tolerated without increased rate of complications when compared to conventional metal fixation devices.

Level of Evidence IV – retrospective study without control

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This research was conducted at the University of Southern California Medical Center.

**Background:** Scant literature exists regarding malignant ulceration of sarcomas, with only 1 previously published study on the condition, which found a higher rate of amputation, decreased survival, and higher rate of metastases at presentation.

**Question / Purposes:** We ask if fungating soft tissue sarcomas are associated with worse outcomes or prognosis when compared to their non-fungating counterparts.

**Patients and Methods:** We retrospectively reviewed our institution's pelvic and extremity soft tissue sarcomas over a 7 year period, comparing fungating sarcomas (n = 17) to non-fungating sarcomas (n = 201) with regard to limb salvage, local recurrence, metastases, and overall survival.

**Results:** The fungating tumors demonstrated statistically increased size (12.6cm vs 8.9cm), rate of primary amputation (29.4% vs 8.5%), metastatic disease (58.8% vs 36.8%), and flap soft tissue coverage (35.3% vs 0%) when compared to controls. No statistically significant differences in age, location, local recurrence, or resection type were seen. The fungating tumor group showed trends toward significance with regard to increased two-year survival (50% vs 68%), tumor necrosis (53.0% vs 40.5%), time to recurrence (10.5 vs 18.9 months), and time to metastasis (12.6 vs 18.5 months).

**Conclusions:** Expounding upon the only previously published study on the subject, fungating soft tissue sarcomas of the extremities demonstrate statistical increased size, rates of primary amputation, need for flap soft tissue coverage, local recurrence, and development of metastatic disease when compared to non-fungating controls. These tumors show statistical trends toward increased tumor necrosis, decreased 2-year overall survival, time to recurrence, and time to metastasis.

**Level of Evidence III** – retrospective comparative study
DISTRIBUTION AND CHARACTERIZATION OF HEMANGIOMAS IN THE SPINE
Alexandria Starks, BA; Brandon Shallop, BS; Diane Deely, MD; Adam Zoga, MD; Suzanne Long, MD; William Morrison, MD; David S. Geller, MD; John A. Abraham, MD

**Introduction:** Hemangiomas are the most common benign tumor of the vertebral column; 90% of which are found incidentally through imaging. Vertebral hemangiomas (VHs) are typically described in the vertebral body, but may occur anywhere in the cross section of the vertebra. When discovered in a location other than the common thoracolumbar vertebral body location, the diagnosis is sometimes doubted, in spite of classic imaging. Location in the pedicle or posterior elements, based on an assumption that hemangiomas do not exist in these locations, may lead to unnecessary referral or biopsy. The purpose of this study is to determine the distribution and characterization of VHs within the spine, both axially and in cross-section. A thorough understanding of the distribution of these lesions may help prevent unnecessary procedures or referral for these benign lesions.

**Methods:** Retrospective review of radiology database identified spine images with VHs. Two independent musculoskeletal radiologists then confirmed the diagnosis of hemangioma using established imaging criteria. The axial and cross sectional location of the lesion is recorded. Volume is estimated by imaging.

**Results:** 998 VHs were identified. In the preliminary analysis, the mean patient age is 59.1 years with a male to female ratio of 1 to 3. 36.8% of patients present with multiple VHs. 22.7% of VHs have an atypical appearance. Lesions were seen in all regions of the spine, with the highest incidence in the lumbar spine followed by the upper thoracic spine. The location of VHs within the vertebral body varies widely, with 202 (20.2%) showing location in or some extension into the posterior elements, including pedicle, lamina, and spinous process. In this series, however, none of the lesions were located solely in the transverse process. The average volume of a VH increases as its location moves caudally within the spine, ranging from 0.67cm³ in the cervical region to 2.62cm³ in the lumbosacral region.

**Conclusion:** VH is a commonly found vertebral lesion. While the prevalence of VHs is highest in the thoracolumbar spine, they can frequently be seen in the cervical spine and sacrum as well. In our preliminary analysis of this series, up to 20% of hemangiomas in this series involved the posterior elements, supporting the hypothesis that location in the posterior elements alone should not exclude the diagnosis. It is our hope that the detailed characterization of these common tumors can help guide reporting and ultimately management of these common benign tumors.
**Objectives:** The goals of prophylactic surgical fixation for impending pathological fracture are to reduce pain, prevent fracture, and provide rapid recovery and weight bearing. It has been suggested that curettage and cementation of the lesion was an important adjunct to intramedullary (IM) nailing, to achieve these goals and prevent failure. To date, no study has proven the need for cementation in addition to IM nailing. However, with current surgical hardware and technique, adjuvant radiation, improved systemic therapies for many cancers, and bisphosphonate and anti-RANKL therapies, curettage and cementation may not be necessary. The purpose of this paper is to describe outcomes of IM nail stabilization without intra-lesional curettage and cementation for impending pathological fracture.

**Materials and Methods:** Retrospective review of surgical database identified patients with impending pathological long bone fractures stabilized with IM nails, without curettage and cementation, between February 2001 and April 2013. In all cases, the treating orthopaedic oncologist determined risk of pathologic fracture. Adjuvant therapies include radiation, bisphosphonates, and chemotherapy. Outcomes include postoperative complications such as infection and deep venous thrombosis, pain, time to weight bearing, and implant failure defined as: completion of fracture, fracture around implant, need for revision to a more extensive implant, or reoperation for any mechanical problem.

**Results:** We identified 361 patients with impending or completed pathological fracture stabilized with IM nail fixation. We have completed analysis of 119 patients with 117 impending fractures stabilized with IM nail fixation without intra-lesional curettage and cementation. In preliminary analysis, 82.9% were femoral, 15.4% humeral, and 1.7% tibial. Mean follow-up was 8.5 months (range 7 days-11.9 years). 26.5% were treated postoperatively with adjuvant radiation and bisphosphonate therapy, 30.8% were treated with neither radiation nor bisphosphonate therapy, and the remaining 43.0% were treated with either radiation or bisphosphonate therapy alone. We observed 5 (4.3%) minor postoperative complications including: 2 wound infections successfully treated with antibiotics alone, 2 hematomas, and 1 intraoperative fracture. 8 (6.8%) major postoperative complications were observed, including: 4 deep venous thromboses, 1 pulmonary embolism, and 2 deaths. We also observed the following failures: 3 (2.6%) fractures around the implant and 1 (0.9%) implant failure. Approximately 92 (78.6%) patients were free of pain in the operated limb at their last follow-up, and only 11 (9.4%) were unable to bear weight on the operated limb 6 weeks post-operatively.

**Conclusions:** We present a series of patients treated with IM nailing without curettage or cementation for impending fractures from metastatic cancer to bone. The practice of curettage and cementation of metastatic bone lesions remains a current practice without convincing evidence. Newer therapies may obviate the need for curettage in many cases. Our preliminary data suggests a failure rate of 3.42% in this population. Other authors have described a local failure rate of 11% in stabilization of metastatic lesions to long bones. If borne out in final analysis, these results suggest that including curettage and cementation may be unnecessary with current adjuvant treatment in the vast majority of cases.
POSTER #25

TUMOR INDUCED OSTEOMALACIA: CASE REPORT AND REVIEW OF THE LITERATURE
Geoffrey Siegel, MD; David H. Wesorick, MD; Aaron Berg, MD; May P. Chan, MD; Craig Jaffe, MD; J. Sybil Biermann, MD

The authors report a case of tumor-induced osteomalacia diagnosed after a pathologic subtrochanteric femur fracture.

A 58 year-old male presented with a left femoral neck lesion and associated nondisplaced subtrochanteric femur fracture found on MRI at an outside institution. He complained of severe progressive diffuse muscle and joint pain and weakness of proximal muscles, as well as painful range of motion of his left hip. Laboratory studies were within normal range except for hypophosphatemia (1.3 mg/dL), elevated alkaline phosphatase (203 IU/L) and elevated urinary phosphate (1936 mg, normal 400-1200 mg) in a 24-hour collection. CT Scan demonstrated a lytic lesion in the proximal femur with cortical erosion. Metastatic workup was negative. CT-guided needle biopsy was consistent with a benign spindle cell and lipomatous neoplasm. The patient underwent resection of the tumor and endoprosthetic reconstruction with rapid resolution of the hypophosphatemia.

Tumor-Induced Osteomalacia (TIO) is a rare paraneoplastic syndrome affecting phosphate and vitamin D metabolism leading to hypophosphatemia and osteomalacia. TIO is caused by inappropriate secretion of Fibroblast Growth Factor-23 (FGF-23), a phosphatonin hormone, by a tumor. FGF-23 is secreted by osteocytes in response to elevated serum phosphate to decrease the expression of sodium-phosphate co-transporters in the proximal renal tubular cells resulting in increased phosphate wasting. FGF-23 has also been shown to decrease renal expression of 1-alpha-hydroxylase and increase expression of 24-hydroxylase leading to a net decrease in 1,25-dihydroxyvitamin D levels. Clinically this syndrome presents similarly to genetically associated hypophosphatemic rickets. TIO is curable with complete excision of the tumor.

Conclusion: Tumor-induced osteomalacia is a rare cause of hypophosphatemia, but should be considered in cases of patients presenting with bone tumors and unexplained hypophosphatemia. Resolution of the metabolic abnormalities ensues soon following tumor resection.

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TUMOR BED RE-EXCISION FOLLOWING UNPLANNED SARCOMA EXCISION RESULTS IN DECREASED FUNCTIONAL OUTCOME COMPARED TO PRIMARY RESECTION

Emily E. Carmody Soni, MD; Mark T. Scarborough, MD; C. Parker Gibbs, MD

**Background:** It has been well documented that tumor bed re-excision following unplanned resection of a soft tissue sarcoma results in more morbid surgical procedures than if the sarcoma had been excised primarily with a wide margin. Fortunately, this has little impact on oncologic outcome for patients. Little is known however as to how this increase in morbidity affects patients’ functional outcome. The purpose of this study was to compare surgical procedures, oncologic outcomes, and functional outcomes in a group of patients who underwent tumor bed re-excision compared to a control group that was matched in terms of patient age, tumor grade, location and size whom had undergone primary wide excision.

**Methods:** After obtaining IRB approval, we conducted a retrospective review of our orthopaedic oncology database, from 1990 through 2007, to identify patients who underwent an unplanned excision of a soft tissue sarcoma and were then subsequently referred to our institution for further management. We then identified a group of patients, whose initial tumor was managed at our institution. These patients were matched in terms of age (+/- 5 years), tumor location, size, and grade. We then compared incidence of coverage procedures, oncologic outcomes as well as functional outcomes between the two groups. MSTS and TESS scores were used to evaluate functional outcome.

**Results:** Patients having undergone an unplanned excision required more surgery when compared to optimally managed controls. The use of skin grafts was increased from 11% to 56% and flaps from 4% to 26%, between the two groups. There was a significant difference in functional outcome between the two treatment groups as measured by TESS. Patients who had a primary wide excision had a higher average TESS score of 89% than those who had an unplanned prior excision at 82%. There was no significant difference noted between the two groups when functional outcome was measured by MSTS score. In our re-resection group a total of 6 out of 46 (13.0%) patients developed a local recurrence. In patients who had undergone primary excision 6 out of 52 (11.5%) developed a local recurrence. We observed no difference in overall survival between the two groups.

**Conclusion:** The definitive management of a contaminated tumor bed after an unplanned excision of a soft tissue sarcoma is complex, and increased morbidity associated with an unplanned excision of a soft tissue sarcoma should not be unexpected. We have confirmed that muscle flap and skin graft use is markedly increased in our tumor bed-re-excision when compared to a matched control group of optimally managed patients. We are the first, to our knowledge, to show that this increase in surgical morbidity results in decreased functional outcome for these patients. Survival outcome was not adversely affected in our series of patients, in keeping with other reports addressing soft tissue sarcoma management. Our data suggests that we, as surgeons, should respect the small but real malignant potential in all extremity soft tissue tumors and the morbidity to our patients associated with their mismanagement. Each warrants a careful and thorough evaluation to include a complete history, physical examination and cross sectional imaging when appropriate. Excisional biopsy for all but the most determinate masses should be discouraged and referral to a surgeon experienced in the management of musculoskeletal tumors should be considered.
HISTOLOGIC SUBTYPES OF LIPOSARCOMA AND CORRELATION WITH SURVIVAL- AN NCDB NATIONAL REPORT

Robert M. Corey, MD; Katrina R. Swett, MS; William G. Ward, MD

Introduction: It is generally accepted that primitive and less well differentiated tumors have a less favorable prognosis than more differentiated tumors. Within the family of sarcomas diagnosed as liposarcomas, exact prognostic relationships are unclear from prior series that may have been subject to selection bias and other biases, therefore we chose to query the American College of Surgeons Commission on Cancer’s National Cancer Database (NCDB) determine if there was a prognostic difference based on histology as well as on other demographic and staging data.

Materials and Methods: The NCDB was queried to examine the records of all patients with Liposarcoma entered from the years 1998 through 2010. The records of a total of 12,367 patients were analyzed to determine what factors, including histologic subtype, staging, grading and demographic data had statistically significant associations with survival. Estimates of survival were calculated by using the Kaplan-Meier method. Cox Proportional Hazard regression was used to estimate survival adjusting for various demographic and clinical covariates.

Results: Both the two year and five year survivorship data was calculated for the following five histological subtypes. The results are shown in the following table.

<table>
<thead>
<tr>
<th>Histologic Subtype</th>
<th>2 year survival (%)</th>
<th>5 year survival (%)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipsarcoma, Well Diff</td>
<td>92</td>
<td>89</td>
<td>3,791</td>
</tr>
<tr>
<td>Myxoid Liposarcoma</td>
<td>88</td>
<td>77</td>
<td>3,994</td>
</tr>
<tr>
<td>Liposarcoma, NOS</td>
<td>83</td>
<td>69</td>
<td>2,622</td>
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<tr>
<td>Round Cell</td>
<td>78</td>
<td>58</td>
<td>409</td>
</tr>
<tr>
<td>Pleomorphic</td>
<td>70</td>
<td>50</td>
<td>1,551</td>
</tr>
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A number of tumor characteristics exhibited statistically significant associations with long-term survivorship. These included the factors that are listed below, along with their p values and the hazard ratios. The histologies are analyzed relative to Liposarcoma NOS.

**Conclusions:** This demonstrates the largest report of the histologic subtypes of liposarcoma. It confirms previous reports that mixoid liposarcoma has a better prognosis than pleomorphic liposarcoma. This report also provides previously unreported survival data based upon various histological subtypes. This data confirms prior observations that soft tissue sarcomas have worse prognosis with increasing grade and increasing size. It also demonstrated worse prognosis for advancing age, hispanic race, and male gender. These types of prognostic factors require a national database such as this to detect these statistically significant associations. It is beyond the capability of this database to determine what affect various therapies might have had on prognosis.

<table>
<thead>
<tr>
<th>Factor</th>
<th>p value</th>
<th>Hazard Ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>&lt;.0001</td>
<td>0.77</td>
</tr>
<tr>
<td>Hispanic</td>
<td>.0046</td>
<td>1.31</td>
</tr>
<tr>
<td>Size (&gt;5cm)</td>
<td>&lt;.0001</td>
<td>1.43</td>
</tr>
<tr>
<td>Grade (mod/mod well/int diff)</td>
<td>&lt;.0001</td>
<td>1.51</td>
</tr>
<tr>
<td>Age (increasing 10 yr brackets)</td>
<td>&lt;.0001</td>
<td>1.54</td>
</tr>
<tr>
<td>Grade (poorly diff)</td>
<td>&lt;.0001</td>
<td>2.75</td>
</tr>
<tr>
<td>Grade (undiff, anaplastic)</td>
<td>&lt;.0001</td>
<td>3.02</td>
</tr>
</tbody>
</table>
**Objectives:** Intramedullary nailing is the standard procedure indicated for impending fractures of long bones. Due to metastatic cancer, patients undergoing this procedure are at higher risk for Deep Venous thrombosis (DVT) and pulmonary embolism (PE) than patients undergoing the same procedure in a fracture setting without metastatic cancer. Currently, there is no clear standard for the best method of anticoagulation after this type of procedure. The purpose of this study is to define the risk of DVT in a series of intramedullary nails performed for metastatic lesions to long bones, and determine the optimal postoperative anticoagulation protocol.

**Materials and Methods:** Retrospective review of surgical databases at participating institutions identified patients with impending pathological long bone fractures stabilized with IM nails, between February 2001 and April 2013. In all cases, the treating orthopedic oncologist determined risk of pathologic fracture. Adjuvant therapies include radiation, bisphosphonates, and chemotherapy. Postoperative anticoagulation prophylaxis methods were recorded. Outcomes include DVT or PE, wound infection or dehiscence, hematoma formation at the surgical site.

**Results:** We identified 361 patients with impending or completed pathological fractures stabilized with IM nail fixation. At the current time, we have completed analysis on 119 patients with 141 impending (126) or completed pathological (15) fractures stabilized with IM nail fixation. In this preliminary analysis, 75.9% were femoral, 21.2% humeral, and 2.8% tibial. Mean follow-up was 7.8 months (range 7 days-11.9 years). Post-operatively we observed 6 (4.2%) minor complications, including 3 minor wound infections treated with antibiotics only, and 9 (6.4%) major complications, including severe hypotension, deep venous thrombosis (DVT), pulmonary embolism (PE), myocardial infarction, and any complication leading to death. We excluded 11 patients with incidence of DVT or PE with a history of DVT, PE or stroke who were on therapeutic anticoagulation prior to surgery. DVT prophylaxis included a variety of agents, including heparin 5000U SC q8hrs, Enoxaparin 30g-80mg SC daily (24% of patients), Aspirin 325mg PO daily, and warfarin to a target INR of 1.8-2.3 (37% of patients). 5 patients did not receive any chemical DVT/PE prophylaxis, however, no DVT or PE was observed in these patients. At preliminary analysis, we observed 5 (3.6%) DVTs, and 1 (0.7%) PE. These thromboembolic events occurred following repair of 5 impending femur fractures and 1 completed humeral fracture. Primary pathology was lung cancer in 3 patients, breast cancer in 2 patients, and multiple myeloma in 1 patient. Thromboembolic complications followed prophylactic use of warfarin with a target INR of 1.8-2.3 in 5 of the 6 cases and enoxaparin 60mg SC every 12 hours in 1 patient. The wound complication rate was 3.36%, with 5 patients having either hematoma or wound infection treated successfully with antibiotics only. Of note, one patient, with a history of atrial fibrillation treated with warfarin, had both a hematoma and wound infection. Only one of these patients received enoxaparin anticoagulation post operatively, and none of the patients with wound complications required removal of the implant.
Conclusions: Our preliminary data suggests a DVT/PE rate of 4.3% in the 119 patients analyzed to date. The remainder of the patient records are currently being analyzed. The majority (5/6) of the patients who developed DVT or PE received warfarin prophylaxis. Literature examining outcomes of metastatic bone lesion stabilization describe a rate of 4.2% with heparin only prophylaxis (Nilsson 2008) & 8.9% (Katzer 2002, method of prophylaxis not described). One concern about anticoagulation with enoxaparin in lower extremity post-operative patients is wound complication. Our rate was comparable to published literature at 4%. One of the wound complications was in a patient receiving enoxaparin, however none of the patients required removal of the implant. We conclude that the risk of DVT and PE is high in this population, and the risk is higher in patients not receiving enoxaparin anticoagulation postoperatively. Final analysis of the entire cohort will be needed to support these findings and is underway, but the preliminary evidence presented here suggests that postoperative anticoagulation with at least enoxaparin is necessary, and that warfarin and subcutaneous heparin are not adequate for preventing thromboembolic complications.
SACRAL FORAMINAL OSTEOCHONDROMA CAUSING RADICULOPATHY
Brandon Shallop, BS; Michael Maceroli, MD; Ravi Ponnappan, MD; Alex Vaccaro, MD; John Abraham, MD

Introduction: Osteochondromas are the most common benign tumor of bone. Less than 0.5% of all spinal osteochondromas originate in the sacrum, but they have not been reported to extend through the neural foramen. We present an unusual case of a sacral osteochondroma extending into the neural foramen, causing radiculopathy.

Methods: A twenty-year-old male soccer player presented with a complaint of six months of tingling and stabbing pain in the right buttock, posterior thigh, calf, and lateral foot as well as new onset “pins and needles” sensation in the lateral right foot. Physical exam demonstrated increased sensitivity in the S1 nerve root distribution on pinprick exam and a diminished right ankle reflex. Imaging showed an osteochondroma arising from the inferomedial aspect of the right hemisacrum, extending into and through the S1 neural foramen.

Given the anterior, posterior, and foraminal extent of the tumor, a staged approach to excise the mass and decompress the nerve root was planned. The anterior resection was conducted through a modified pfannenstiel incision. A posterior decompression laminectomy and further excision of compressive posterior tumor remnants in the neural foramen was performed to complete the excision.

Results: Postoperatively the patient reported resolution of symptoms. At two years follow-up the patient had no further complaints and reported that he had been able to resume playing soccer. Neurologic exam of bilateral lower extremities showed full strength and intact sensation to light touch in the distribution of the S1 nerve root.

Conclusion: We describe a case of a primary sacral foraminal osteochondroma presenting as S1 radiculopathy in a 20-year-old male. Excision through a staged, combined anterior-posterior approach allowed for complete removal of the tumor and resolution of symptoms at two-year follow up.
DOES WOUND INFECTION AFTER SOFT TISSUE SARCOMA RESECTION AFFECT PROGNOSIS?
Nicole M.K. Behnke, MD; Vignesh K. Alamanda, BS; Yanna Song, MS; Kristin R. Archer, PhD;
Herbert S. Schwartz, MD; Ginger E. Holt, MD

All work was performed at Vanderbilt University Medical Center, Nashville, TN.

Background: Prior studies have demonstrated postoperative infection to potentially confer a protective effect on overall survival after osteosarcoma resection. There are no studies that explore this relationship in soft tissue sarcoma.

Purpose: To determine whether wound infection after soft tissue sarcoma resection has a protective effect on metastasis, recurrence or survival.

Patients and Methods: A retrospective chart review was conducted and 397 patients treated surgically for a soft tissue sarcoma between 2000 and 2008 were identified. Relevant oncologic data, including tumor size, grade, AJCC stage, metastasis, recurrence and death were collected. 56 patients with evidence of a postoperative infection were identified, and their clinicopathologic characteristics were compared with 341 patients without infection. Wilcoxon rank sum test, Pearson test and either $\chi^2$ or Fisher’s exact test were used to compare variables. Kaplan-Meier analysis and Gray’s test were performed to evaluate cumulative risk; hazard ratios for metastasis and recurrence were generated from a Cox model.

Results: There was no difference in survival, local recurrence or metastasis between patients with and without postoperative infection.

Conclusion: The presence of a postoperative infection did not confer any protective effect, nor did it increase the risk of adverse oncologic outcomes after soft tissue sarcoma resection. This finding further reinforces our lack of definitive knowledge about the interplay between infection and sarcoma.

Level of Evidence: Level II – Prognostic Study, Retrospective analysis. See the Guidelines for Authors for a complete description of levels of evidence.
DEVELOPMENT AND USE OF A NOVEL ONLINE MULTI-INSTITUTIONAL SARCOMA BOARD
Felix H. Cheung, MD; Brock A. Lindsey, MD; Shawn Price, MD

Background: A significant number of musculoskeletal oncologists practice as the only surgeon specializing in their field in their practice group. Discussion of their difficult cases in a general tumor board often times is not fruitful due to the lack of experience in this field by the other participants. We present a novel way of developing an online Multi-Institutional Sarcoma Board for the discussion of difficult cases.

Methods: Three medical centers (Marshall University, Huntington, WV; West Virginia University, Morgantown, WV; Norton Health Care, Louisville, KY) chose to participate. Each center had only one fellowship trained musculoskeletal oncologist and each one was at least 150 miles away from each other. Each surgeon had participated in different MSK fellowships (MGH/BIDMC; UMPC; Univ of Utah). Using Webex with HIPPA compliant encryption, all three Sarcoma teams (consisting of the musculoskeletal oncologist, medical and pediatric oncologists, radiation oncologists, musculoskeletal radiologists, and pathologists) at each institution met online once a month using web cams, phone conferencing, and desktop sharing. Shared images were previously scrubbed of patient identifiers according to each institution’s requirements. Each institution selected 1-2 of their most difficult cases to discuss per month. A survey of 10 questions was filled out by the surgeon for each patient retrospectively, and the results for 6 months were compiled.

Results: A total of 19 patients were discussed between July 2012 and Dec 2012 (6 meetings). Diseases included 9 STS, 3 EWS, 2 CSA, 3 OSA, 1 Desmoid, 1 Fibrosarcoma of bone. Comparison of pre-discussion “aggressiveness of treatment” to post-discussion went from 2.42 to 3.05 out of 5 (p < 0.1) (1 being most aggressive). Confidence of treatment plan post discussion was rated 2.17 / 5 (1 = Much more confident) Comfort level with discussing treatments with the patients was rated 1.84 / 5 (1 = Much more comfortable). Likelihood of telling patients that they discussed their case with colleagues was rated 1.00 / 5 (1 = Very likely). Finally, surgeon impression of whether the discussion improved the overall management of the patient was rated 1.95 / 5 (1 = Significantly improved)

Conclusion: Multi-Institutional Sarcoma Boards are possible using modern web meeting technology, eliminating geography as a reason for lack of appropriate discussion of cases. The use of this board trended to less aggressive treatment, higher surgeon confidence in treatment plan, and an impression of improvement in patient care. We recommend the consideration of an online multi-institutional sarcoma board for other centers with solo musculoskeletal oncologists to maximize patient care.
Purpose: Evidence in unicameral bone cyst (UBC) treatment remains to be clearly demonstrated and the optimal treatment is controversial. The aim of this quantitative systematic review was to assess the effectiveness of different treatment modalities for UBC.

Method: Pubmed was utilized to identify studies published until 2012 on patients with UBC who received any sort of treatment based on the search terms: “unicameral bone cyst”, “simple bone cyst” and “solitary bone cyst”. The eligibility criteria included non-experimental retrospective design, sample size larger than 15 patients, follow-up more than 6 months and radiographic data on UBC healing. Two groups of patients were identified based on final UBC healing; success - good outcome included healed and partially healed UBCs and failure - poor outcome included persistence and recurrent UBCs. Eligible studies were examined for quality and heterogeneity test was performed prior to the meta-analysis. The random effect meta-analytic method was used for the summary estimates due to significant heterogeneity (p < 0.05).

Results: A total of 467 studies were identified from the literature related to UBC, 62 studies were selected for the meta-analysis based on the inclusion criteria. The cumulative sample size was 3211 patients with 3217 UBC, and male to female ratio (2.2:1). The most common location of the UBC was in the humerus (59.2%), followed by the femur (25.9%). Based on healing outcome, 2448 UBCs (76.1%) were classified as healed or partially healed (success), while 769 cysts (23.9%) were classified as persistent or recurrent (failure). The outcome of different treatment modalities was comparable in the humerus and the femur. Surgical curettage (autograft or allograft) provided 96% success rate in the calcaneus. The summary estimate after observational management was 64.2%, 95% CI (26.7-101.8), and after active treatment 85.7, 95% CI (83.6 – 87.8). The summary estimate after Methylprednisolone (MPA) injection was 77.4%, 95% CI (72.7 – 82.2), which was comparable to bone marrow injection 77.9%, 95% CI (65.9 – 89.9). Healing rate after MPA injection when inner wall disruption was performed was 86.6%, 95% CI (59.6 – 113.7). The healing rate after bone marrow with demineralized bone matrix (DBM) injection was high 98.7%, 95% CI (95.7 – 101.7). UBC healing rate after surgical curettage was comparable whether autograft or allograft was utilized (90%), and was higher with calcium phosphate or sulfate pellets (96.5%). UBC treatment with flexible intramedullary nails without curettage provided almost 100% healing rate while continuous decompression with cannulated screws provided 89% healing rate.

Conclusion: The healing rate after MPA or bone marrow injection was higher in this meta-analysis compared to a published randomized clinical trial (Wright et al, JBJS-Am 2008). The healing rate after surgical curettage was relatively higher compared to injection (MPA or bone marrow).

Significance: Active treatment for UBC provided variable healing rates and favorable relative to conservative treatment.
UNICAMERAL BONE CYSTS IN THE HUMERUS: TREATMENT OUTCOMES
Muayad Kadhim, MD; Samir Sethi, MD; Mihir Thacker, MD

Background: Several treatment modalities have been described for the treatment of unicameral bone cyst (UBC). The aim of this study was to examine the outcome of various treatment modalities of UBC in a specific anatomic location, the humerus.

Methods: This is a retrospective case-only study of patients with humeral UBC with minimum follow up of one year. Outcome of interest is UBC healing status based on last follow up x-ray. Healing was classified into three groups (healed, partially healed and not-healed). Humerus length on the affected side and the contralateral side were performed to examine the possibility of humeral length discrepancy.

Results: Sixty-eight patients (54 boys and 14 girls) with humeral UBC consisted the study population. Sixty-four cases (94.1%) presented with a pathologic fracture. Fifty-one cases were in the proximal metaphysis and 17 were in the diaphysis. Mean age at diagnosis was 9.2±3.7 years, and mean follow-up was 4.0±2.6 years. Twenty-five patients were treated with observation, 38 by injection (27 with steroids and 11 with bone marrow), and 5 by open surgery (Curettage, allograft and flexible intramedullary nailing). Most frequent treatment in diaphyseal UBCs was observation (12 cysts out of 17), while in metaphyseal UBCs the most frequent treatment was injection (34 cysts out of 51). Eight out of these 25 cases treated with observation showed no healing (persistence) and were older with shorter follow up compared to patients with healed and partially healed UBCs. Patients who underwent open surgery had relatively larger cyst measurements (length, width and index), and all healed or partially healed at last follow up. In MPA injection group, 15 patients received one injection (3 failed to heal), and 12 patients received more than one intervention (6 UBCs did not heal).

In bone marrow injection group, 3 patients received one injection, while the 8 received more than one intervention (2 UBCs did not heal). Inner wall disruption was performed in 17 patients (24% did not heal) while 21 patients did not have inner wall disruption (33% did not heal). UBC persistence was observed in 29% of diaphyseal and 27.5% of metaphyseal cysts. Of the 19 patients with persistence, 8 were treated with observation 9 with steroid injection and 2 with bone marrow injection. Eleven patients complained of pain at the last visit (8 had a persistent, 2 partially healed and one healed UBCs). Length discrepancy between the normal and the affected humerus ranged from 2 cm (the normal humerus is longer) to -1 cm (the UBC side is longer) and the mean was 0.5 cm.

Conclusion: Complete healing of humeral UBC is challenging to achieve irrespective of treatment modality. Healing rate of humerus UBC after observation was more in younger children, but long follow up seems to be needed. The need of an extra intervention was observed more in bone marrow group, but failure to heal was observed more after multiple MPA injections. Failure to heal did not vary whether inner wall disruption was performed or not. Pain, limited function and refracture were the common reason to perform further management (injection or open surgery). Although the number of patients with adequate humerus length measurements was small, we did not observe apparent humerus length discrepancy. UBC measurements and activity did not vary between healing groups. UBCs treated with open surgery tended to heal better. Unhealed cysts were more likely to be associated with pain.
CHROMOSOME 6 (RUNX2) ABNORMALITIES IN A PATIENT WITH MULTIPLE BONE CYSTS AND PATHOLOGIC FRACTURES
Mihir M. Thacker, MD; Michael Bober, MD; Katrina Conard, MD; Mary Harty, MD; Jane B. Lian, PhD

We report a case of a Caucasian male with a history of multiple pathologic fractures, starting at age 3 years. His mother also had a history of fracturing her bones rather easily and died in a trivial motor vehicular accident. Examination revealed minor dysmorphic features. He was initially thought to have osteogenesis imperfecta and was treated with IV pamidronate. He continued to have pathologic fractures through lesions that radiographically and histologically resembled unicameral bone cysts. He had multiple such lesions throughout his appendicular as well as axial skeleton. The histologic findings from a biopsy of one of his lesions revealed a fibrous cyst wall, incorporating attenuated woven bone, surrounding trabecular bone, and hematopoietic cellular elements. Vascular markers were negative. Cytogenetic studies demonstrated a complex genotype 47,XY+r[17]/48,XY,+r2[3]. Further analysis of this material demonstrated abnormalities of chromosome 6 (6p12.3->6q12) resulting in overexpression of RUNX2.

He later presented with a pathologic compression fracture in the thoracic spine with cord compression and was treated with urgent decompression along with cement augmented pedicle screw fixation and posterior spinal fusion with full neurologic recovery. This, to the best of our knowledge, is the first reported case of abnormalities in chromosome 6 and RUNX2 expression resulting in multiple bone cysts and pathologic fractures. This association is discussed as is the technique of the cement augmented pedicle screw fixation in this difficult clinical situation with extremely soft bone.
Purpose: Benign osseous lesions are amenable to curettage of the lesion with grafting of the osseous defect for definitive management. Grafting materials include autogenous bone graft, allograft, or commercially available bone graft substitutes. Commonly used synthetic fillers are comprised of either an ultraporous beta-tricalcium phosphate (TCP) paste, or a calcium sulfate/calcium phosphate (CSCP) composite paste. These materials are intended to form an osteoconductive structure through which normal osseous ingrowth can occur. Recently we reported that a commonly used TCP can persist up to a year on radiographs. CSCP composites should mitigate this effect by dissolution of the calcium sulfate, allowing osseous ingrowth into the remaining calcium phosphate scaffold. Currently we are prospectively comparing the results of these two synthetic bone graft substitutes in benign lesions. This report is intended to describe an unexpected outcome related to a subset of patients treated with the CSCP composite.

Methods: Plain radiographs of all 110 patients treated with curettage and CSCP composite paste during a five year period from 12/2007 to 12/2012 were retrospectively reviewed. The typical pattern of integration was one of concentric centripetal incorporation. Patients were identified with radiographic failure of the graft as defined by non-concentric resorption of the CSCP cement on plain film. The patient charts of subjects exhibiting this radiographic failure pattern were then reviewed for age, type, location, and size of lesion, prophylactic plate fixation, time to radiographic failure by plain film imaging, reoperations, and fracture. Computed tomography of the lesion after failure was also reviewed if available to confirm graft failure.

Results: Twelve patients with average age of 24 (6-64) were identified with early failure of CSCP cement. Lesions treated were identified by the university pathologists as aneurysmal bone cyst (3), unicameral bone cyst (2), fibrous dysplasia (2), and one each of intraosseous ganglion, non-ossifying fibroma, chondromyxoid fibroma, chondroblastoma, fibrosis and chronic inflammation. Four lesions were located in the tibia, two in metatarsal, and one each in the femur, fibula, talus, humerus, ulna, and clavicle. Average size of the lesions preoperatively was 12.3 cubic centimeters (1.2–37.5). Prophylactic plate fixation was placed in one femur and one ulna. Average time to radiographic failure of the graft was 23 weeks (6-41). One reoperation is currently planned for graft failure in a metatarsal. Currently no perilesional fractures have been detected.

Conclusions: The vast majority (89%) of patients treated with CSCP cementing after curettage of benign bone lesions go on to uneventful healing in our series. There does exist, however, a minority of patients in whom the calcium phosphate scaffolding collapses prior to osseous ingrowth and filling of the lesion. These lesions tend to be larger with an average size of 12 cubic centimeters. The failure also tends to be later, with one as late as 41 weeks. CSCP is not intended for structural support in weight bearing bones, and it is our policy to prophylactically stabilize at risk regions with plate fixation. It is likely due to this practice that no perilesional fractures have occurred. Given our results, we recommend close follow up of lesions treated with CSCP for signs of graft failure.
The work was performed at the Montefiore Medical Center and the Children’s Hospital at Montefiore, Bronx, NY

**Background:** The Capanna technique, combining a bulk allograft bone with a free vascularized fibular flap for reconstruction following bone loss, has been well described. The success of this technique rests upon the marriage of the allograft’s immediate structural support with the vascularized flap’s biologic potential, including its capacity for healing, hypertrophy, and most importantly union. Although originally described for femoral defects, subsequent reports have illustrated its success in other long bone reconstructions, such as the tibia and the humerus as well as with modifications that include the ipsilateral rotational vascularized fibula, the only technique and the inlay technique.

**Questions/Purposes:** The purpose of this report is to illustrate a novel variation on the Capanna technique termed the “canoe modification,” designed to address the size mismatch between the humeral and tibial isthmus and the diameter of the vascularized fibula.

**Methods:** The canoe modification initial involves routine preparation of the allograft, including widened of the intramedullary canal with reamers to allow for the vascularized fibula. Thereafter, two longitudinal osteotomies are created along the length of the allograft, effectively unroofing the intramedullary canal and allowing the free vascularized fibula to be lowered rather than telescoped into the allograft. This allows for accommodation of a slightly larger fibula, allows for a size mismatch that frequently exists between the fibula and either the humeral or tibial diaphysis, and avoids excessive pressure on the fibular vascular pedicle, essential for healing and remodeling.

**Results:** Case 1: A 19 year-old female presented with a diaphyseal lesion of the tibia, histologically consistent with an adamantinoma. She underwent conventional resection and reconstruction with an intercalary allograft and internal fixation and healed both host-allograft sites without incident. Subsequently, she sustained a twisting injury resulting in a non-displaced fracture of the allograft, which failed to unite despite both conservative and minor operative intervention. Ultimately she was revised, using the canoe modification of the Capanna technique and realized uncomplicated union at both sites.

Case 2: A 9 year-old male presented with a diaphyseal lesion of his humerus, ultimately diagnosed as a high-grade osteosarcoma. Following neoadjuvant chemotherapy, he underwent wide excision and reconstruction using an intercalary allograft bone and internal fixation. He healed his distal allograft-host bone junction site, but failed to unite at the more proximal site. He subsequently underwent revision using the canoe modification of the Capanna technique. Thereafter he healed both sites uneventfully.

**Conclusions/Clinical Relevance:** The canoe modification of the Capanna technique is technically simple, requires minimal additional time, and no additional cost. Our results with the technique have been very encouraging to date. The technique should be considered an important addition to the reconstructive armamentarium in the case of segmental bone loss.
REQUIRED SURGICAL MARGINS FOR LOCAL CONTROL IN A XENOGRAFT OSTEOSARCOMA MURINE MODEL WITH AND WITHOUT SINGLE OR DUAL-AGENT CHEMOTHERAPY

David S. Geller, MD; Michael Singh, BA, Wendong Zhang, BA; Esperanza Villanueva-Siles, MD; Sajida Piperdi, BS; Amy Park, BA; Richard Gorlick, MD

The work was performed at the Montefiore Medical Center and the Children's Hospital at Montefiore, Bronx, NY

Background: In addition to systemic therapy, complete surgical excision is essential for successful treatment of osteosarcoma. Currently, the gold standard is to perform a “wide excision,” however the definition of a wide excision is descriptive only. There is no current clear consensus on what constitutes an adequate “wide excision.”

Questions/Purposes: The purpose of this project is to quantify an adequate “wide excision,” defined by lack of local and/or distant recurrence using a xenograft murine model both with and without single agent chemotherapy.

Methods: Patient-derived osteosarcoma tumor cells (OS17 and 187) were cultured and surgically implanted into the proximal metaphyseal tibia of female SCID mice. Once tumors were palpable, amputations were performed under general anesthesia in either an intralesional, marginal, or wide manner. Histological sectioning was conducted in a standardized fashion to obtain measurements of bone and soft tissue margins. Mice were followed for six weeks, after which amputation stumps were evaluated for local recurrence while both the lungs and livers were assessed for metastatic dissemination. Thereafter, a second group of mice underwent implantation and amputation as previously described. They were thereafter treated with either cisplatin or doxorubicin over a course 4 weeks and followed for an additional 6 weeks to identify local and distant recurrence. Finally, a third group of mice were treated with implantation, amputation and thereafter dual-agent chemotherapy, using both doxorubicin and cisplatin. They were similarly followed for 6 weeks.

Results: In mice implanted with either OS17 or 187 and treated without chemotherapy, surgical bone margins lower than 100µm reliably resulted in local recurrence while margins greater than 700µm showed no recurrence. A variable recurrence rate was found between margins of 100µm and 700 µm. Similarly, soft-tissue margins below 50µm reliably resulted in local recurrence while margins greater then 600µm showed no recurrence. In mice implanted with OS17 and thereafter treated with single-agent chemotherapy, no recurrence was seen above bone or soft-tissue margins of 14µm while mice implanted with 187 showed no recurrence above bone margins of 25µm or soft tissue margins above 10µm. In mice implanted with OS17 and thereafter treated with dual-agent chemotherapy, no recurrence was seen above bone or soft-tissue margins of 9µm while mice implanted with 187 showed no recurrence above bone or soft tissue margins of 8µm. Metastatic disease did not overtly develop in any case and may require a longer period of observation.

Conclusions/Clinical Relevance: In conclusion, chemotherapy appears to reliably decrease the surgical margin required to obtain adequate local control in this xenograft model, with dual-agent chemotherapy decreasing necessary margins more so than single-agent. These findings may contribute to surgical decision-making and in turn, may have ramifications on surgical morbidity and long-term reconstructive and functional outcome for patients with localized high-grade osteosarcoma.
CASE REPORT: USE OF CARBON FIBER INTRAMEDULLARY NAIL FOR TREATMENT OF OSTEOID OSTEOMA

Daniel E. Prince, MD, MPH

This is a case presentation on the novel use of a carbon fiber intramedullary femoral nail for stabilization after resection of a posterior femoral cortical osteoid osteoma. A 36-year-old male presented with symptoms and radiographic studies consistent with an osteoid osteoma of the posterior cortex of the midshaft of the femur. The patient preferred surgical resection to radiofrequency ablation and underwent a marginal resection of the osteoid osteoma and fixation with a carbon fiber intramedullary nail for stabilization (Carbofix, Herzeliya, Israel). The patient went on to heal without incident while radiographic studies could be obtained visualizing callus healing and facilitating the potential need for follow up studies during the healing phase at the site of the osteoid osteoma with the radiolucent intramedullary nail in place. The symptoms of the osteoid osteoma were eliminated and pathology was consistent with osteoid osteoma. The nail was extracted 1 year postoperatively without incident and the patient had full return to function. This case presentation shows the potential utility of radiolucent carbon fiber fixation in oncological surgery to facilitate postoperative diagnostic studies for tumor pathology and healing, without compromising osseous fixation.
ARE ‘SMART-PHONE’ CAMERAS EFFICIENT AND SAFE FOR INTRAOPERATIVE PHOTOGRAPHY IN ORTHOPAEDIC ONCOLOGY?
Aditya V. Maheshwari, MD; Qais Naziri, MD; Gregory Parnes, BS; Robert Pivec, MD

Background: Digital technology has contributed to marked advances in medicine including the improved ability to record, analyze, and communicate patient information. The use of ‘digital-cameras’ has become increasingly popular in recent years for perioperative documentation, including intra-operative findings. The newer generation of ‘smart-phones’ with in-built cameras now offers another compact, portable and user-friendly attractive option for intra-operative photography. Although documented in other medical specialties, the use of intraoperative ‘digital-camera’ photography has not been well established in the orthopaedic literature. Further, the safety of ‘smart-phone’ cameras in the operating room is also unknown. We hypothesized that smart-phone camera is safe to use in the operating room, does not increase the rate of postoperative wound infection and enhances the overall education in an academic program.

Material and methods: All consecutive orthopaedic oncology and related cases (group-I) were compared prospectively to a consecutive cohort of all non-oncology orthopaedic cases (group-II and included joint replacement and trauma cases) operated by the same surgeon between March-2011 to Feb 2013 in a single academic program. The perioperative setting was similar for both groups, except that intraoperative photography using a same ‘smart-phone-camera’ was done in all cases in only group-I. All photographs were taken by the same ‘smart-phone-camera’ (XXX) with a 5 megapixel capacity and in a sterile fashion which included using a new set of sterile gloves each time and cleaning the phone with antiseptic wipes before each case. No special casing/cover was used for the phone. Postoperative infection was defined as per the Centers for Disease Control guidelines. The role of obtained digital photographs in enhancing education was surveyed by the residents and the patients through a questionnaire.

Results: There were 225 procedures (210 patients) in group-I and 155 procedures (148 patients) in group-II. Both groups were similar demographically, except for younger patients in group-I (median 48 vs 64 years). A mean of 3.1 (range 1-12) photographs were taken per procedure. There was no significant difference (p=0.2) in the post-operative infection rate between the two groups (1 deep and 1 superficial in group-II, and 2 superficial in group-I). However, 3 additional patients in group-I had a primary negative pressure wound dressing (and a subsequent flap procedure) and 1 patient developed a postoperative seroma requiring drainage. But these 4 patients were never diagnosed/treated as ‘infection’. There was no interference of the ‘smart-phone’ with the operating-room machinery and there was no technical difficulty in obtaining/transferring photographs in any case. Both the patients and the residents reported an improved education regarding the disease process and surgical technique through the photographs.

Conclusions: Although the numbers are limited, our preliminary results suggest that ‘smart-phone-camera’ can be safely used for intraoperative photography without any added risk of infection. In addition, it offers convenience in accessibility and portability, and allows images to be transferred easily and immediately. Moreover it enhances the education for the residents and the patients. Further larger studies are needed to confirm our findings.
OSTEOSARCOMA: A META-ANALYSIS AND RETROSPECTIVE REVIEW

Jill C. Wilmoth, MD; Jeffrey Peck, MD; Xueliang Pan, MD; Mahmoud Abdel-Rasoul, MD; Joel Mayerson, MD

Background: Over the years, advances in treatment and the addition of neoadjuvant chemotherapy has led to improved 5 year survival in patients with osteosarcoma. Tumor necrosis has been found to be an important predictor of patient prognosis, and necrosis of greater than 90% correlates with an overall good prognosis. With modern therapies, research has shown that 45% of patients are expected to achieve >90% tumor necrosis. However, more recent literature suggests the overall prognosis remains highly variable with little improvement over the past several decades. It also seems that patients at the author’s center have increasingly been experiencing inferior necrosis responses.

Questions/Purposes:
1) Overall survival of patients with osteosarcoma has not improved over the past several decades
2) Fewer patients are achieving 90% necrosis than previously thought
3) These phenomena are represented at OSUWMC

Patients and Methods: We performed a meta-analysis of the current literature and a retrospective review of patients with primary osteosarcoma treated at The Ohio State University Wexner Medical Center (OSUWMC) from 2000 to 2011.

Data and Results: Forty articles met the inclusion criteria and were included in the study. We performed separate analyses on articles that included patients with both metastatic and non-metastatic disease as well as analyses on articles including patients with non-metastatic disease alone. Analysis was performed in order to determine the 5-year overall survival for all studies based on the weight given to each study by using a random-effects model for this analysis (heterogeneity test: Q=656.23; P<=0.001; I2=93.4%). For the combined data set, the 5-year overall survival ranged from 19% to 94% with an average of 63% (95% CI, 60% to 66%). The 5 year overall survival for studies including only patients with non-metastatic disease was 71% (95% CI 67% to 76%). Studies of patients with non-metastatic osteosarcoma had 50% of patients achieve 90% necrosis on histology. Review of patients at OSUWMC revealed 53% of patients achieved >90% necrosis on pathology with an overall survival of 72%.

Conclusions: The overall 5 year survival and the number of patients achieving 90% necrosis is consistent with previous reports, however emphasizes that these numbers have remained constant over the past several decades. This study stresses the importance of rigorous retrospective reviews in order to continually evaluate the effectiveness of treatment regimens and patient’s outcomes. It also identifies those areas needing improvement in order to increase patient prognosis.

Level of Evidence: Level II, Retrospective study and meta-analysis. See the Guidelines for Authors for a complete description of levels of evidence.
Study performed at the University of Miami Hospital, Miami, FL.

**Background:** In very young patients with primary bone sarcomas arising near the physis, the optimal method of resection and reconstruction remains controversial. While surgical resection with negative margins is the standard of care, what constitutes an adequate surgical margin poorly defined.

**Questions/Purpose:** We present a case series of skeletally immature patients with primary bone sarcomas in which close surgical margins were utilized to preserve the adjacent physis and reconstruction was accomplished with intercalary grafts.

**Patients and Methods:** We retrospectively reviewed the records of three patients with bone sarcomas (age 2 - 8 years) treated with chemotherapy and physeal sparing surgical resection. Patients were followed for a minimum of 13 months (range 13-51), and monitored for local recurrence, distant metastasis, functional outcomes, leg length discrepancy, physeal arrest and avascular necrosis (AVN) of the femoral head. The closest surgical margin ranged from 1.5 to 15mm.

**Results:** All patients were alive at last follow up. There were no instances of local recurrence, one patient developed lung metastasis. All achieved union of their host-graft junction sites, and there was no physeal arrest or AVN of the femoral head. Two patients had leg length discrepancies, one in which the operated leg was shorter and the other who had overgrowth of the operated leg. All patients had good or excellent function.

**Conclusion:** In this series, by utilizing close surgical margins, the physis was spared allowing longitudinal growth and good to excellent function of the extremity. At early follow up there has been no evidence of local recurrence.

**Level of Evidence:** Level IV, Case Series.
Study performed at the University of Miami Hospital, Miami, FL.

**Background:** Collision lesions (the concurrent development of a neoplasm in the same location as a second unrelated neoplasm) are rare, particularly in the long bones of the skeleton.

**Questions/Purpose:** The purpose of this study was to present two cases of collision lesions and to review the literature regarding these unusual lesions.

**Patients and methods:** We performed a retrospective review of two patients, focusing on imaging studies and of the histopathologic evaluation of the biopsy specimens. A literature review was also preformed in search of other reports of collision lesions.

**Results:** The first case was that of a 60 y/o male with a left femoral neck lesion that on imaging appeared to be a cartilaginous lesion. A biopsy was performed and the final histologic diagnosis was a plasma cell neoplasm present in association with an enchondroma. The second case was that of a 61 year old male with chronic lymphocytic leukemia with a lytic lesion of the left proximal fibula. A biopsy of the lesion demonstrated the presence of a Richter transformation in association with an epithelioid hemangioma.

**Conclusion:** Collision lesions occurring in the long bones are rare. Often in those cases reported in the literature, the authors are uncertain whether or not the lesions truly represent a collision or if one tumor has arisen as a result of dedifferentiation of the initial lesion. In both of the cases presented, the lesions represent a collision of two distinct neoplasms of bone.

**Level of Evidence:** Level IV, Case Series.
30 YEAR SINGLE INSTITUTION REVIEW OF OSTEOSARCOMA SURVIVAL AND r GCSF IMPACT

Joseph Kuechle, MD, PhD; Denise Rokitka, MD; Martin Brecher, MD; Brian McGrath, MD

This work was performed at Roswell Park Cancer institute with collaboration with the University at Buffalo department of Orthopedics

**Background/Purpose:** With the advent of chemotherapy osteosarcoma survival improved significantly with further development of novel agents, and protocols survival continues to improve. R GCSF is one agent which has been used to support intensification regimens. This proposed mechanism of survival advantage of r GCSF is by decreasing the duration of neutropenia and prevention of a delay in of chemotherapy. We sought to review our experience with this agent in osteosarcoma and in the context of intensification regimens.

**Methods:** 155 patients were identified through the Roswell Park tumor registry as being diagnosed with osteosarcoma between 1980 and 2010. Exclusion included extra skeletal tumors, patients treated elsewhere, and patients with previous bony pathology. Since at our institution r GCSF use began in 1994 with the application of dose intensification protocols we examined the survival of those patients who had therapy before and after this date. For this we used Kaplan Meier analysis.

**Results:** Using survival analysis we demonstrated a statistically significant increase in survival of the groups consisting of all patients when comparing the patients diagnosed either before or after 1994. The 5 year survival for those before 1994 was 56% and after 1994 was 71% p=0.05.

**Conclusion:** Progress continues to be made in advancing survival rates in patients with osteosarcoma. Here we demonstrate a significant improvement in all patient outcomes after 1994 when r GCSF is used as a support to dose intensification regimens.

**Level of Evidence:** Level IV, Retrospective Review
Background: Musculoskeletal sarcomas are a heterogeneous group of rare malignant tumors involving bone and soft tissue. The exact incidence and survival of many subtypes in the United States have not been reported recently.

Purpose: The purpose of this study was to analyze the incidence and survival of all sarcomas based on year of diagnosis, anatomic site, grade, stage, and age of patient.

Methods: The Surveillance, Epidemiology, and End Results (SEER) database was queried for the years 1975 to 2009 and included 18 registries across the United States representing 28% of the national population. Incidence rates for 2005-2009 and 5-yr survival rates for 2000-2004 were calculated for all categories of sarcomas for multiple key variables.

Results: Sarcomas are rare, with most occurring in less than 0.5 per 100,000. The most common were leiomyosarcoma, Kaposi sarcoma, malignant fibrous histiocytoma, liposarcoma and fibrosarcoma. Some sarcomas demonstrated higher incidences in certain populations such as leiomyosarcoma (white females), Kaposi sarcoma (black males), gastrointestinal (black males), chordoma (elderly adults), fibrosarcoma (middle aged adults), and Ewing sarcoma (young adults). Survival was poorer for more advanced grade, stage, and age at diagnosis. Most sarcomas affected the lower extremities, followed by the upper extremities and torso. Pelvic tumors were less common, but generally had lower survival than extremity lesions.

Conclusions: The epidemiology of sarcomas varied widely by type and other variables. The incidence and survival are valuable information for patient counseling and may have implications in understanding the natural history of sarcoma. This study represents the most recently updated comprehensive report on musculoskeletal sarcomas in the United States.
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<tr>
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<td>75% (60-90)</td>
<td>(unstacked)</td>
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<tr>
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1Indicating malignancy histiocytic, Langerhan cell sarcoma, dedifferentiated sarcoma, disseminated Langerhan cell histiocytosis, including myeloid sarcoma and malignant nodulizing fibrous tissu;2including hematoptiocytomas;3including malignant giant cell tumor of soft part;4including myxoid nodulizing giant cell tumor and malignant giant cell tumor of bone;5All cases were recorded as unstaged.

Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).

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Background: Metal prostheses are frequently used for limb salvage following distal femur resection and provide good functional outcomes. However, their failure to preserve bone stock and need for revision may be problematic for most younger patients who outlive these implants. Osteoarticular allografts provide an alternative reconstruction option that allows for bone preservation and growth plate conservation though their long-term functional outcomes are not well described. We sought to describe long-term allograft survival, complications, and function compared to a cohort of similar patients with metal reconstruction for a single reconstructive site.

Methods: Review of 37 patients receiving allografts and 35 receiving metal following distal femur resections at a single institution with mean follow-up of 4.5 years. Survivals were estimated using Kaplan-Meier curves and compared by logrank test. Associations with patient characteristics were tested using logrank and Fisher's exact tests. Musculoskeletal Tumor Society (MSTS) scores at last follow-up were compared using t-tests.

Results: Allograft survival was 52% at 5, 10, and 15 years; not different than that of metal, trending towards mortality for osteosarcoma (P=.06), and not associated with sex or age.

Allograft complications included nonunion (22%), fracture (32%), and infection (14%), accounting for 93% of allograft failures, were more common for osteosarcoma (65 vs. 29%, p<.05), and resulted in only one amputation. Metal complications included aseptic loosening (17%) and infection (16%) without prosthetic dysfunction. Mean MSTS scores did not differ between allograft and metal (21.7 vs. 22.6, P=.39).

Discussion: Allograft reconstruction allows for bone stock preservation and growth plate conservation while providing similar implant survival and functioning compared to metal. When allografts fail, salvage with metal implants or joint resurfacing can still be employed which may provide great benefit to younger patients who would be likely to need revisions during their expected lifetimes.

Level of Evidence: Therapeutic study, Level III (Retrospective review)
Background: Unplanned excisions of high-grade subcutaneous soft tissue sarcomas of the trunk and extremities are common referrals to tertiary centers. Traditionally, these patients are treated with tumor bed re-excision with immediate soft tissue reconstruction followed by adjuvant radiation. Evidence suggests that a subset of patients may not need radiation and may be eligible for less morbid soft tissue reconstruction. Some information necessary to decide on radiation can only be obtained after re-excision. We have utilized a vacuum dressing to temporize between resection and reconstruction to obtain this information.

Purpose: We set out to 1) identify criteria for patients that do not require adjuvant radiation and 2) assess the safety of a vacuum dressing to temporize the wound bed after re-excision.

Methods: A comprehensive review of current literature is used to develop criteria for which high-grade subcutaneous sarcomas after unplanned excision will and will not require radiation. A small case series of nine patients from 2005-2011 at our institution is used to assess the impact of the criteria and safety of the vacuum dressing.

Results: Oncologic outcomes are most influenced by the initial size of the mass, presence of residual disease, and extent of negative margins. Myxofibrosarcoma subtype is more infiltrative and at greater risk of local recurrence. Our case series demonstrates the criteria would influence traditional patient care. Use of a vacuum dressing was not associated with any infections or tumor recurrence.

Conclusions: High-grade subcutaneous sarcomas after unplanned excision ≤ 5 cm at the time of initial excision do not need radiation in the absence of residual disease at re-excision or, in the presence of residual disease if radial histologic margins are ≥ 1 cm. Myxofibrosarcoma subtypes likely require wider surgical margins to obtain radial histologic margins ≥ 1 cm. Use of a vacuum dressing temporizes until the final pathology report is available. This measure appears safe and does not seem to influence oncologic, infectious, or wound outcomes.
VENOUS THROMBOEMBOLISM IN SOFT TISSUE SARCOMA PATIENTS TREATED WITHOUT CHEMOPROPHYLAXIS

Brock Adams, MD; Mathew Wallace, MD; Morteza Meftah, MD; Robert Henshaw, MD

Investigation Performed at Medstar Washington Hospital Center, Washington, DC.

Background: Cancer has classically been associated with an increased risk of venous thromboembolism. Common prophylactic regimens use chemical and mechanic agents in an attempt to minimize this risk. Chemoprophylactic agents, however, are known to increase rates of bleeding and wound complications.

Purpose: The purpose of this study was to determine the rate of postoperative venous thromboembolic events in soft tissue sarcoma patients treated with a standard regimen of mechanical prophylaxis and no chemoprophylactic agents.

Methods: We retrospectively reviewed 199 consecutive patients who underwent surgery for soft tissue sarcoma of the lower extremity. Data was taken from the medical records of 154 patients with adequate follow up from the immediate perioperative period to 3 months post operatively. All patients received postoperative mechanical prophylaxis while in the hospital; selected high risk patients underwent preoperative IVC filter placement. No patient received anticoagulants except 7 patients who were taking them for preexisting conditions. Primary data collected were thromboembolic events within 3 months postoperatively. We also collected basic demographic information, adjuvant treatment, and complications.

Results: In the 154 patients reviewed, there were 6 thromboembolic events (3.9%). Of these, there were 5 cases of symptomatic deep venous thrombosis confirmed by imaging (3.2%) and 1 case of intraoperative pulmonary embolism while undergoing hemipelvectomy, despite prior IVC filter placement, resulting in death (0.6%).

Conclusion: The rate of thromboembolism in this series is comparable to others published in the literature. This suggests that patients undergoing surgery for soft tissue sarcomas of the lower extremity can be safely managed without chemical prophylaxis.

Level of evidence: Therapeutic Level IV. See the Guidelines for Authors for a complete description of levels of evidence.
This research work was conducted in St Jude Children’s Research Hospital, Memphis TN.

**Background:** Factors influencing outcome of locally recurrent osteosarcoma are not well established, especially in the context of prior limb-sparing surgery. The optimal management of tumor recurrence in a previously reconstructed limb is not known.

**Questions/Purposes:** What factors influence post-recurrence survival after prior limb-sparing surgery for extremity osteosarcoma? How to best manage local tumor recurrence in this scenario?

**Patients and Methods:** Between Oct 1989 and Jan 2012, 21 osteosarcoma patients developed local recurrences following limb-sparing surgery; 18 had histologically confirmed recurrence and were included in the analysis. Patient, disease and treatment factors were correlated with post-recurrence survival using Cox regression analysis.

**Results:** Ten patients (55.6%) underwent proximal amputations, six (33.3%) had a second limb-sparing wide resection, and two (11.1%) had no further surgery. Median time to local recurrence was 1.4 years (range: 0.6 - 10.4 years). Median post-recurrence survival was 11.8 months (range: 3.7 months–12.1 years). Post-recurrence survival was significantly associated with resection margins of ≥1 cm, compared to subcentimeter or positive margins, or no resection of the recurrent tumor (p=0.04). Post-recurrence survival was longer with amputations compared with second limb-sparing surgeries (2.44 versus 0.86 years), and in with patients who had distant metastases completely resected compared to those who did not (2.70 versus 0.85 years) but was not statistically significant.

**Conclusions:** Wide resection margins are important for control of locally recurrent osteosarcoma, independent of the type of surgery performed. Further limb salvage may be attempted only if margins of ≥1 cm can be achieved. Maintaining complete control of distant metastases also likely contributes to improved survival.

**Level of Evidence:** Level II, Prognostic study.
HEMICONDYLYAR AND HEMI-INTECAlARY ALLOGRAFT RECONSTRUCTION IN INTERMEDIATE AND HIGH GRADE PRIMARY SARCOMAS OF BONE

Santiago A. Lozano-Calderon, MD, PhD; Megan E. Anderson, MD; Mark C. Gebhardt, MD

Introduction: With the advent of new chemotherapy protocols and better imaging tools for early detection of malignancies, limb salvage is becoming standard treatment for primary sarcomas of bone. A balance between oncologic (wide resection for local control) and functional goals is difficult to achieve and changes on a case by case basis. We present oncologic and functional outcomes for 13 patients with close wide-resection with hemicondylar or hemi-intercalary allograft reconstruction for the treatment of primary sarcomas of bone.

Materials and Methods: Under IRB approved protocol, 11 patients (7 males, 4 females), average age 22 years (range 11-37) who underwent 11 hemicondylar or hemi-intercalary allograft reconstructions of the tibia or femur were evaluated for outcomes oncologically (recurrence), surgically (complications) and functionally (MSTS score).

Results: Four patients had a diagnosis of conventional osteosarcoma, 2 of periosteal osteosarcoma, 3 of recurrent locally aggressive osteofibrous dysplasia, 1 of metastatic Ewing’s sarcoma, and one of recurrent phosphaturic tibia tumor. Three patients received hemicondylar allografts (2 medial tibia, 1 medial femur); and 8 received hemi-intercalary allografts (3 anterior tibia, 2 medial tibia, 1 lateral tibia, and 2 lateral femur). Average follow up was 56 months (range 2-202). Average MSTS score was 28 points (24-30). There were no recurrences. Only one complication was identified: one patient had a post-operative peroneal nerve palsy. There were no soft-tissue complications, infections, or fractures.

Conclusion: Hemicondylar and hemi-intercalary allografts are a safe technique for reconstruction in primary sarcoma of bone. The increased area of contact between host bone and allograft substantially decreases the risk of non-union and allograft fracture. Excellent function can be obtained with this type of reconstruction.
SKELETAL METASTASIS FROM HEPATOCELLULAR CARCINOMA, A REVIEW OF A CASE SERIES AND PROPOSED TREATMENT ALGORITHM

Leslie A. Donnelly, MD; Jeffrey Moore; Kathleen S. Beebe, MD; Francis R. Patterson, MD; Joseph Benevenia, MD

Skeletal metastases from hepatocellular carcinoma (HCC) have been infrequently reported in the literature outside of Asian populations. At this institution, the authors’ attention has been drawn to a greater prevalence of patients with HCC skeletal metastasis than is currently represented in the literature. The purpose of the current review is to evaluate these patients’ patterns of presentation, treatment modalities, and treatment effectiveness to determine the best orthopedic treatment algorithm to HCC patients with skeletal metastasis. Recent progress in HCC, including advancements in diagnostic imaging, has led to an increased survival time of patients, and with that, an increased potential to develop secondary skeletal metastasis. We anticipate this increased prevalence will be reflected in HCC populations within other North American institutions, and therefore feel this review will be a relevant addition to the literature.

We conducted a retrospective review of patients from 1985 to 2013 who presented with pathologically confirmed skeletal metastasis from HCC. Presentation of metastasis, progression of disease, survival rate, and utilization of interventions and their effect on morbidity and mortality were all identified from patients’ medical records.

We identified a total of 8 HCC patients with skeletal metastasis within this timeframe. Of these 8 patients, 4 (50%) had no prior diagnosis of HCC, and their symptomatic skeletal metastasis was their initial cause for presentation. Surgical intervention was indicated for two of these patients, and two were treated conservatively with external beam radiation and/or chemotherapy. Average survival time after initial presentation for these patients was 30 days, and all have died of disease.

Four other patients (50%) had preexisting diagnosis of HCC before presenting with a skeletal lesion. Average time from diagnosis to skeletal metastasis was 3.7 years (range 2.5-4.4). Surgical intervention was indicated in 1 patient, while the remaining 3 were treated exclusively with conservative measures, either external beam radiation or chemotherapy. Average follow up for these patients was 78 days, with two patients dead of disease at 104 and 120 days following their initial presentation of a skeletal metastasis. Of note, 2 patients in our series were diagnosed with HCC and secondary skeletal metastasis after receiving liver transplantation for end stage liver disease.

Within this review of cases, we have found skeletal metastasis from HCC to consistently be a late manifestation of the disease. Treatment modalities of skeletal metastasis appear to have been appropriately implemented solely as palliative measures. Utilization of Mirel’s criteria and more temporizing means of fixation are relevant in determining the manner and means of surgical intervention. It is important to note that prior liver transplantation does not necessarily protect a patient from a later diagnosis of hepatocellular carcinoma or a secondary skeletal metastasis. As advances in the diagnosis and treatment of HCC continue, we encourage clinicians to consider an HCC primary origin for skeletal metastasis in patients with known liver pathology.
Giant cell tumor and chondroblastoma are benign epiphyseal (periarticular) aggressive bone tumors. When sufficient periarticular bone and cartilage can be preserved, treatment is resection-curettage with adjuvant therapy. This treatment may have a deleterious effect on the subchondral plate. Bone grafting may be used to enhance healing by maximizing the biologic potential. Our hypothesis was that supplemental subchondral bone graft would result in fewer periarticular complications including fractures and osteoarthritis.

Forty-seven patients with giant cell tumors (39) and chondroblastomas (8) were treated primarily with resection-curettage and adjuvant treatment from 1996 to 2013. Reconstruction was done with polymethylmethacrylate (PMMA) -alone in 23 patients and bone graft with/without PMMA in 24 patients. Complications were recorded including reoperation, recurrence, fracture, and osteoarthritis, and then compared between the two treatment methods.

Of the 23 patients treated with PMMA-alone, twelve (52%) patients experienced at least one complication. There were ten (43%) non-oncologic complications, five periarticular fractures and five progressions to osteoarthritis. Average time to non-oncologic complication was 16 months (range 2-30). Seven (30%) patients had local recurrence requiring reoperation which included two total knee endoprosthesis and one ankle arthrodesis. Average time to recurrence was 17 months (range 8-32).

Of the 24 patients treated with bone graft with/without PMMA, six (21%) patients experienced at least one complication. There were three (13%) non-oncologic complications of osteoarthritis. Average time to osteoarthritis was 45 months (range 7-112). There were three (13%) local recurrences requiring re-operative procedures which included two patients with total knee endoprosthesis.

The difference in overall complication rates between the two methods, PMMA vs. supplemental bone graft, was statistically significant (52% vs 21%, p=0.002). The difference in rates of non-oncologic complications (fracture and osteoarthritis) between the two methods was also statistically significant (43% vs. 13%, p=0.009). The difference in local recurrences was not statistically significant (7 vs. 3, p=0.07).

Compared to PMMA constructs, the use of bone graft constructs with/without PMMA following tumor resection significantly reduces the rates of post-operative fracture and osteoarthritis in patients without increasing tumor recurrence rates. Therefore, the addition of periarticular bone graft may provide a biologic solution without increasing the risks.
A CASE REPORT OF FOOT ROUND CELL LIPOSARCOMA
Mamdoh Mokhtar Alhowsawi, MD; Mohammad Dursi Alfawareh, MD

Introduction: Liopsarcoma is the second most commonly diagnosed soft tissue sarcoma found in humans. It is a tumor of adipose tissue of mesenchymal cell origin.

Liposarcoma is the diagnosis in approximately 15% of soft tissue tumors, and usually it is deep seated mass located proximally in the extremities, with distant metastases have ranged between 21% to 86%. Histological Subtypes include: well differentiated, myxoid/round cell, pleomorphic and dedifferentiated.

Round cell liposarcoma is the rarest subtype of liposarcoma which may arise in the upper and lower extremities, mainly the thigh, and rarely arise in the foot.

Purpose: A few studies discussed primary round cell liopsarcoma, arising in the foot.

We are reporting primary round cell liposarcoma arising in the foot of 17 years old girl which is rarely diagnosed and rarely develop in the foot.

Result: A 17 years old girl, presented with right foot mass treated previously as infection and / or ganglion. Recent biopsy was done and the pathological diagnoses were made based on the excisional biopsy. The patient treated surgically by local wide tumor excision followed by free flap reconstruction by plastic surgery with adjuvant chemotherapy administration. Postoperatively the patient involved in intensive rehabilitation system with no local recurrence or distant metastases after 2 years follow up.

Conclusion: The incidence of foot liposarcoma is very low. However, a high index of suspicion with good evaluation required for early diagnosis which may have better outcome.

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AGE AS A FACTOR OF OUTCOME IN SURGICAL RECONSTRUCTIONS UTILIZING AN EXPANDABLE MEGAPROSTHESIS AFTER BONE TUMOR RESECTION

John S. Groundland, MD; Leon Anajar, BS; Odion Binitie, MD; Gabriele Drago, MD; Elisa Pala, MD; David Cheong, MD; Pietro Ruggieri, MD, PhD; G. Douglas Letson, MD

Objectives: The use of expandable megaprostheses during tumor surgery for the skeletally immature patient has gained acceptance. High surgical complication and failure rates have been reported in the literature, but few studies have investigated which factors may lead to favorable or adverse outcomes. The purpose of this study was to describe the outcomes of expandable megaprostheses surgery and to investigate the role that age may play as a predictor of success.

Materials and Methods: A retrospective chart review was performed at two major cancer hospitals. Patients were included if they underwent surgery for bone tumor excision, were skeletally immature at the time of surgery, and they received an expandable metallic megaprostheses. Patients were excluded if the surgery was for non-oncologic purpose, or if the prosthesis was not metallic. Data were collected for demographics, oncologic diagnosis, surgical complications, modes of failure requiring revision, number and length of expansions, and functional outcomes as measured by the Musculoskeletal Tumor Society (MSTS) survey rating. Data were divided into a group of patients under the age of ten years old and a group over the age of ten years old, in order to investigate the contribution that age may have on the outcome of the surgery.

Results: Ninety patients met inclusion criteria. Forty-six patients were under the age of 10, while forty-four patients were over the age of 10. The average follow-up of the under 10 group was 59.4 months (range, 1-186 months); the average follow-up time for the group over 10 years old was 49.3 months (range, 3-177 months). Frequency of anatomic location of the resection and reconstruction was: 6 proximal femur, 4 total femur, 69 distal femur, 6 proximal tibia, 1 distal tibia, 1 total humerus. The average number of expansions for the group under 10 years of age was 5.3 (range, 0-25) with the total length expanded averaging 32 mm (range, 0-165). The average number of expansions for the group over 10 years of age was 3 (range, 0-17) with the total length expanded averaging 22.5 mm (range, 0-68).

Seventeen of forty-six (37.0%) of patients under 10 years of age required at least on additional surgery for an adverse event; twelve of forty-four (27.3%) of patients over the age of 10 had a failure. Non-failure complications occurred in 43.5% of the patients in the under 10-year-old group and in 43.2% of the over 10-year-old group. The MSTS scores of the two groups averaged 81% and 87% for the under 10 and over 10 year old groups, respectively. Differences in the complications and failures between the two groups studied did not reach statistical significance.

Conclusions: The use of expandable metallic megaprostheses has gained acceptance in the field of orthopedic oncology. Complication and failure rates remain high, but clinically relevant expansion has been achieved in many patients. Patient satisfaction and functional outcomes, as measured by the MSTS functional questionnaire, are satisfactory. In the present study, young age did not associate with higher rates of complications or failure.

Level of Evidence: Level III, Retrospective study. See the Guidelines for Authors for a complete description of levels of evidence.
SURGICAL AND FUNCTIONAL OUTCOMES IN PROXIMAL HUMERUS RECONSTRUCTION USING METALLIC ENDOPROSTHESIS – DOES THE USE OF SYNTHETIC GRAFT AUGMENTATION IMPROVE RESULTS?

John S. Groundland, MD; Daniel Houskamp, BS; David Cheong, MD; G. Douglas Letson, MD

Objectives: The use of a metallic endoprosthesis to reconstruct the osseous defects created in bone tumor surgery of the proximal humerus has been well described. Historically, one of the main complications of this construct has been subsequent dislocation of the glenohumeral joint. The purpose of this study was to assess the surgical and functional outcomes of a metallic endoprosthesis following proximal humerus reconstruction when a vascular graft material was used to create an artificial joint capsule versus when no such augmentation was utilized.

Materials and Methods: A retrospective chart review was performed at a National Cancer Institute Facility. Inclusion criteria comprised the use of a metallic endoprosthesis to reconstruct an osseous defect created during tumor excision surgery of the proximal humerus. Patients were divided into two groups: one group had augmentation of the soft tissue repair with a vascular graft that was anchored to the glenoid and encircled the proximal humerus (graft group) while a second group had no such augmentation (no-graft group). Statistical analysis was utilized to determine if significant differences between the two groups existed in regards to demographics, oncologic diagnosis, surgical techniques, complications, failures and functional outcomes.

Results: Sixty patients met inclusion criteria. The first twenty-six patients had a metallic endoprosthesis placed without a vascular graft used to augment the soft tissue reconstruction (no graft group); the subsequent thirty-four patients received the vascular graft, which was anchored to the glenoid and encircled the proximal humerus (graft group). Five of the twenty-six patients (19.2%) in the no-graft group experienced a soft tissue failure requiring surgical correction, while two of the thirty-four patients (5.9%) in the graft group had a soft tissue failure (p=0.20). There were no other failures for either group. The no-graft group had 7 complications that did not require surgical correction (26.9%); the graft group had 9 complications (26.5%).

Musculoskeletal Tumor Society scores for the no-graft group versus the graft group was 61% and 54%, respectively. The active range of motion in flexion for the no-graft group was 47 degrees; active flexion for the graft group was 35 degrees. Active abduction in the no-graft group was 45 degrees while the graft group demonstrated an active abduction of 27 degrees (p=0.03). Fifty percent of the no-graft group reported having “no or minimal” pain, while 74.2% of the graft group expressed “no or minimal” pain (p=0.08).

Conclusions: The use of a metallic endoprosthesis in proximal humerus reconstruction following tumor excision remains a viable option. The overall failure rate in this series was 15% (9 of 60 patients); the use of a vascular graft material to augment the soft tissue repair and to attempt to secure the proximal humerus to the glenoid decreased the rate of failure to 5.9%, but this difference was not found to be statistically significant. Further research and innovation is needed to successfully reconstruct the osseous and associated soft tissue defects in proximal humerus reconstructions.

Level of Evidence: Level III, Retrospective study. See the Guidelines for Authors for a complete description of levels of evidence.
Background/Objective: For the musculoskeletal oncologist, there are times when tumors are not readily localized either by palpitation or because of change in the anatomy of the surgical field. There are times when frozen section provides little information to distinguish tumor bed from non-tumor bed. Unfortunately, this occurs in the setting of recurrences in a prior irradiated, surgically resected tumor bed. While navigation can be used to guide resection with a “fused” CT/MRI scan, margins can only be confirmed with frozen section and final pathology of tissue that is amenable to these modalities (normal non-irradiated/non-resected tissue). Navigation does not allow real time confirmation of tumor resection. A number of major medical centers have purchased intraoperative MRI capability for their neurosurgeons for intracranial procedures. Although these yield small fields for the typical musculoskeletal case, the field is adequate for the typical musculoskeletal tumor case in which MRI localization is most helpful. Intraoperative MRI may allow the surgeon to perform relatively real-time tumor margin resection confirmations with the aid of imaging. With major cooperation, flexibility, creativity and financial support, a medical center’s current intraoperative neurosurgical MRI suite can be modified to accommodate musculoskeletal tumor resections. We report our first experience with intraoperative MRI assisted sarcoma resection with the purpose showing the oncology community the benefit of intraoperative MRI.

Methods: A neurosurgical MRI (Siemens 1.5Tesla magnet on mobile track) surgical suite was used and modified in order to perform an intraoperative MRI assisted sarcoma resection of the extremity. Table modifications were accomplished with hospital engineers with the use of MRI compatible material. In this manner the patient can be positioned such that the musculoskeletal field (extremity, pelvis) can be visualized with the mobile scanner being moved around the surgical field in one plane. Cost was $15,000 and a change in the table may void the prior warranty for the table. The surgical team is required to obtain special training regarding parameters of MRI safety. Specific protocols are used as to surgical instruments/count to avoid harm to the patient and the operative team as to metal instruments becoming missiles under magnetic field influence. Moving the MRI in and out of the room on tracks takes approximately 30 minutes with a 10–15 minute scan time. Prior to a patient’s surgery, a current MRI is obtained for intraoperative comparison. There is a significant learning experience in set-up modification.
Results: ME was a 58 year old female had two procedures (index 2/2006 and recurrence 9/2007) at outside institution for myxoid liposarcoma, and with each time having positive margins in the proximal right anterior thigh near the femoral vasculature. She was subsequently treated with radiation therapy of 63Gy at another musculoskeletal tumor center where she was managed. In early and late 2010 at our institution, two local recurrences were resected and coverage was obtained with a turn down rectus abdominis flap. In 2012 after 4 previous surgeries and significant radiation, she had two additional recurrences in different areas approximately 2 cm each. The surgical field suffered from significant fibrosis and radiation changes, the femoral artery was only localized with Doppler with prior resection and the anatomy was quite distorted. Intraoperative MRI (principally axial STIR sequence) was used to confirm location of both tumor recurrences prior to incision. After incision and approach to the tumor recurrence, the surgical field was scanned to gauge an appropriate margin around each recurrence. After resection, both specimens were placed away from the surgical field but within the intraoperative MRI scanning field to confirm adequate resection of the field as well as to confirm the specimen with appropriate tissue margins. Postoperatively the two specimens were confirmed to have negative margins histologically.

Conclusion: With mutual cooperation among interdepartmental members of an institution and creativity, the neurosurgical intraoperative MRI suite can be modified with effort to accomplish a musculoskeletal case that can benefit from intraoperative MRI localization for a unique sarcoma resection. Intraoperative MRI offers a way to address local soft tissue sarcoma recurrence in a prior field of radiation and distorted anatomy due to prior resection. Intraoperative MRI can benefit both the surgeon and patient by being able to assure that appropriate margins are being obtained without sacrificing vital structures. The learning experience of MRI suite modification was the most important aspect in accomplishing the surgical endeavor and the stepwise approach to the modification can be shared with other academic centers.
OUTCOMES OF THE QUADRICEPS-SPARING LATERAL APPROACH TO THE DISTAL FEMUR FOR TUMOR RESECTION AND ENDOPROSTHETIC RECONSTRUCTION

Shaun I. Accardo, MD; Scott Sabo, BS; Odion T. Binitie, MD; David Cheong, MD; G. Douglas Letson, MD

Background: The majority of malignant bone tumors occur in the distal femur. The most typically reported surgical approach for tumors in this location is an anteromedial parapatellar approach. The lateral approach to the distal femur is a quadriceps-sparing technique, allowing for improved postoperative recovery without any compromise to implant function or longevity.

Questions/Purposes: The purpose of this study is to review the surgical and functional results of patients treated with the quadriceps-sparing lateral approach to the distal femur.

Patients and Methods: One hundred and twenty-eight consecutive patients who underwent distal femoral resection and reconstruction between 2000 and 2012 at a single institution were reviewed. Of these, 52 patients had a primary procedure performed through the lateral approach and had greater than 6 months of follow-up. Demographic, surgical, and oncologic data were retrospectively reviewed on all patients. Functional outcomes were assessed by knee range of motion and the Musculoskeletal Tumor Society Lower Extremity Scoring System.

Results: The mean age of the patients was 45 years (range 14-82 years). There were 35 males and 17 females. Forty-three patients underwent distal femoral reconstruction due to primary tumors, while the other 9 patients had metastatic lesions. Mean estimated blood loss was 375 ml, mean operative time was 216 minutes and median length of hospital stay was 4 days. Follow-up was an average of 33 months (range 6-99). The average knee flexion was 107 degrees and average loss of knee extension was 3 degrees. There were a total of 14 failures: 5 due to infection (type IV), 4 due to tumor recurrence (type V), 3 due to aseptic loosening (type II), and 2 due to periprosthetic/prosthetic fracture (type III). Of the 14 failures, 10 had successful endoprosthesis revision. There were 4 amputations. The average time to failure was 18 months (range 2-62). At last follow-up, 39 patients were alive and the mean MSTS score was 24.4 (81.2%). Among the patients with primary sarcomas, overall survival was 79%.

Conclusions: The lateral approach to the distal femur for oncologic resection and reconstruction provides appropriate exposure utilizing a quadriceps-sparing technique. Postoperatively, patients have very good range of motion and functional outcome scores. Failure rates are comparable to previously reported series of distal femoral replacements. This approach also minimizes vascular exposure medially, allows for proximal extension to expose the entire femur if necessary, and potentially allows for faster functional recovery by sparing the quadriceps.

Level of Evidence: Level IV, Case series

Disclosures listed in handout
This research was performed at Memorial Sloan-Kettering Cancer Center, approved by its Institutional Review Board, and supported by a grant from the Rosalind Pearlman Research Fund.

Précis: Preoperative TAE minimizes bleeding during surgical interventions for osseous bone metastases. Embolization safely and effectively reduces blood loss in patients with larger, hypervascular bone metastases, and particularly in those undergoing open femoral surgery and intramedullary nailing.

Background: Small case series suggest that preoperative transcatheter arterial embolization (TAE) minimizes bleeding and facilitates surgery for hypervascular metastatic bone tumors. In this case-control study, we evaluated the effect of preoperative TAE on intraoperative blood loss in patients treated for osseous metastatic lesions.

Methods: We retrospectively reviewed records of patients with hypervascular bone metastases treated at our institution between 1998 and 2008. Twenty-seven patients with renal cell carcinoma and 12 with thyroid carcinoma who underwent TAE prior to 41 surgical procedures were matched to 41 non-embolized patients. In univariate and multivariate analyses, age, tumor size, degree of vascularity, TAE use, surgery type/risk, embolization-to-surgery interval, and degree of devascularization were evaluated for correlations with estimated blood loss (EBL), packed red blood cell (PRBC) transfusion volume, operative time, and post-TAE renal function.

Results: Embolization was associated with significantly lower mean EBL (0.90 vs 1.77 L), PRBC transfusion volume (2.15 vs 3.56 U), and operative time (3.13 vs 3.91 h). Larger tumor size was significantly correlated with higher EBL, PRBC transfusion volume, and operative time. Higher-risk surgery was weakly correlated with greater EBL and operative time. Neither embolization-to-surgery interval nor degree of devascularization correlated with EBL or transfusion volume. In open femoral surgery and intramedullary nailing, TAE conferred greater benefit in terms of reduced EBL, transfusion volume, and operative time. Among embolized patients with normal preoperative renal function, creatinine levels remained normal.

Conclusion: Preoperative TAE is safe and effective for significantly reducing EBL. PRBC transfusion volume, however, was not significantly reduced by embolization.

Key Words: Pathological fractures; Surgical blood loss; Embolization, therapeutic; Metastasectomy; Orthopedic procedures; Radiology, interventional; Carcinoma, renal cell; Carcinoma, thyroid.
Hypothesis: The risk of pathologic fracture for enchondromas of the hand can be determined using reproducible radiographic measurements and clinical observations.

Methods: 76 surgical cases of enchondromas involving the hand were retrospectively reviewed to determine if radiographic and clinical criteria could be used to determine the likelihood of a patient having a pathologic fracture. The presence or absence of fracture for each case was determined based on preoperative radiographs and intraoperative findings. Cases without preoperative radiographs and syndromic cases of enchondromatosis were excluded. Criteria examined in this study included the hand involved (left vs right), bone involved (distal phalanx, middle phalanx, proximal phalanx, metacarpal), the digit involved (small, ring, long, index, thumb), and longitudinal percentage of the occupied up by the lesion on AP radiographs. Preoperative radiographs and clinical criteria were evaluated independently by two physicians. Odds ratios were calculated for each clinical criterion, statistical significance was evaluated using the chi-squared test.

Results: There was a statistically significant difference between the fracture and non-fracture group in regards to age (p=0.0271), the digit involved (p = 0.0075), bone involved (p = 0.0307), and percentage of the bone invaded by the lesion on AP radiographs (p = 0.0168). The small finger was the most common finger associated with fracture (19 of 20 cases). The distal phalanx and proximal phalanx were the bones most likely to present with a fracture (distal phalanx 10 of 11 cases, proximal phalanx 18 of 23 cases). There was a direct relationship between percentage of longitudinal bone involvement on AP radiographs and presence of fracture.

Summary Points: Enchondromas are the most common primary bone tumor of the hand, often found incidentally at presentation. Conservative treatment with observation and serial radiographs is often successful, but a subset of patients exist who will go on to develop a pathologic fracture. Objective criteria to predict the likelihood of fracture in these patients is currently lacking, making it difficult for clinicians and patients to make appropriate treatment decisions. This investigation provides evidence that age, the affected finger, the affected bone, and the percentage of the bone occupied by the pathologic lesion on AP radiographs can be used as objective criteria to predict fracture risk and guide clinical decision making.
A PROGNOSTIC MICRO-RNA SIGNATURE FOR CHONDROSARCOMA
Scott Riester, MD; Andre Oliveira; Maran Avudaippan; Kris Shogren; Robert Brown; Michael Yaszemski, MD; Sanjeev Kakar, MD; Andre van Wijnen, MD

Background: Chondrosarcoma is a malignant cartilage tumor that requires surgical resection for cure. Histologic grading is used to categorize tumors into benign and aggressive tumor types. Unfortunately histologic analysis is limited in its ability to accurately predict the clinical behavior of specific chondrosarcomas. As such the majority of these tumors are treated with wide resection often in the form of an amputation. Alternative diagnostic techniques that can more accurately predict the clinical behavior of chondrosarcomas have the potential to improve clinical outcomes for patients.

Question: Can microRNA profiles be used to distinguish between benign and malignant chondrosarcomas?

Methods: MicroRNA sequencing was performed on 18 fresh frozen cartilage tumor specimens obtained from various anatomic sites including the pelvis, spine, sternum, femur, and proximal humerus. Osteochondromas, enchondromas, grade 1, grade 2, grade 3, and de-differentiated chondrosarcoma specimens were included. All specimens used in this investigation were collected under institutional review board approved protocols.

Results: MicroRNA profiling of chondrosarcoma specimens revealed three distinct microRNA profiles representing grade 1, grade 2–3, and de-differentiated chondrosarcomas respectively.

Conclusion: MicroRNA profiling is able to accurately categorize chondrosarcomas as grade 1, grade 2-3, or de-differentiated chondrosarcoma use fresh tissue specimens.

Clinical Relevance: MicroRNA profiling can serve as an adjunct to traditional histologic analysis to clinically categorize chondrosarcomas. This has the potential to guide surgical management identifying more benign tumors that may be amenable to curettage, rather than amputation.
SYNOVIAL SARCOMA HISTOLOGY EFFECT ON PROGNOSIS: AN NCDB ANALYSIS OF 3,755 CASES
William G. Ward Sr., MD; Katrina R. Swett, MS; Robert M. Corey, MD

Introduction: It is generally accepted that primitive and less well differentiated tumors have a less favorable prognosis than more differentiated tumors. Within the family of sarcomas diagnosed as synovial cell sarcomas, it is unclear from the literature if there is a prognostic difference based on histologic subtype. We explored the survival prognosis for synovial sarcoma subtypes utilizing the American College of Surgeons Commission on Cancer’s National Cancer Database (NCDB) to determine if there was a prognostic difference based on histology as well as on other demographic and staging data.

Materials and methods
The National Cancer Database for the years 1998 through 2010, containing records on 3755 patients with synovial sarcomas, was queried with survivorship analyses to determine what factors, including histologic subtype, staging, grading and demographic data had statistically significant associations with survival.

Results: Biphasic synovial sarcoma histology cases demonstrated improved survival compared to spindle cell or NOS histology (p<0.001, n=3755).

A number of tumor characteristics exhibited statistically significant associations with long-term survivorship. These included the factors that are listed below, along with their p values and the hazard ratios. The histologies are analyzed relative to biphasic synovial cell sarcoma.

<table>
<thead>
<tr>
<th>Factor</th>
<th>p Value</th>
<th>Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histology synovial sarcoma *NOS</td>
<td>p&lt;0.001</td>
<td>1.47</td>
</tr>
<tr>
<td>Histology synovial sarcoma spindle cell</td>
<td>p= 0.031</td>
<td>1.31</td>
</tr>
<tr>
<td>Increasing age</td>
<td>p&lt;0.001</td>
<td>1.25</td>
</tr>
<tr>
<td>Black race</td>
<td>p=0.013</td>
<td>1.33</td>
</tr>
<tr>
<td>Female gender</td>
<td>p&lt;0.001</td>
<td>0.75</td>
</tr>
<tr>
<td>Grade moderately differentiated</td>
<td>p=0.70</td>
<td>0.91</td>
</tr>
<tr>
<td>Grade poorly differentiated</td>
<td>p=0.019</td>
<td>1.64</td>
</tr>
<tr>
<td>Grade equals undifferentiated or anaplastic</td>
<td>p= 0.003</td>
<td>1.90</td>
</tr>
<tr>
<td>Radiation treatment</td>
<td>p&lt;0.001</td>
<td>0.62</td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>p=0.001</td>
<td>1.33</td>
</tr>
<tr>
<td>Tumor size greater than 5 cm</td>
<td>p&lt;0.001</td>
<td>2.30</td>
</tr>
</tbody>
</table>

*Not Otherwise Specified

Conclusion: These data confirm prior observations that soft tissue sarcomas have worse prognosis with increasing grade and increasing size. It also demonstrated worse prognosis for advancing age, black race and male gender. It is difficult to explain the improved survival noted with radiation and the worsened survival noted with the use of chemotherapy other than to note it was likely related to selection bias. The worse prognosis observed with spindle cell sarcoma not otherwise specified and synovial sarcoma spindle cell histology compared to synovial sarcoma with biphasic histology is a new observation. Further studies will be required to determine the basis for this difference, however it is likely related to the degree of differentiation required for biphasic histology compared to spindle cell synovial sarcoma or synovial cell sarcoma NOS.
HISTOLOGIC SUBTYPES OF LIPOSARCOMA AND CORRELATION WITH SURVIVAL- AN NCDB NATIONAL REPORT

Robert M. Corey MD; Katrina R. Swett, MS; William G. Ward MD

Introduction: It is generally accepted that primitive and less well differentiated tumors have a less favorable prognosis than more differentiated tumors. Within the family of sarcomas diagnosed as liposarcomas, exact prognostic relationships are unclear from prior series that may have been subject to selection bias and other biases, therefore we chose to query the American College of Surgeons Commission on Cancer’s National Cancer Database (NCDB) determine if there was a prognostic difference based on histology as well as on other demographic and staging data.

Materials and Methods: The NCDB was queried to examine the records of all patients with Liposarcoma entered from the years 1998 through 2010. The records of a total of 12,367 patients were analyzed to determine what factors, including histologic subtype, staging, grading and demographic data had statistically significant associations with survival. Estimates of survival were calculated by using the Kaplan-Meier method. Cox Proportional Hazard regression was used to estimate survival adjusting for various demographic and clinical covariates.

Results: Both the two year and five year survivorship data was calculated for the following five histological subtypes. The results are shown in the following table.

A number of tumor characteristics exhibited statistically significant associations with long-term survivorship. These included the factors that are listed below, along with their p values and the hazard ratios. The histologies are analyzed relative to Liposarcoma NOS.

<table>
<thead>
<tr>
<th>Factor</th>
<th>p value</th>
<th>Hazard Ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>&lt;.0001</td>
<td>0.77</td>
</tr>
<tr>
<td>Hispanic</td>
<td>.0046</td>
<td>1.31</td>
</tr>
<tr>
<td>Size (&gt;5cm)</td>
<td>&lt;.0001</td>
<td>.43</td>
</tr>
<tr>
<td>Grade (mod/mod well/int diff)</td>
<td>&lt;.0001</td>
<td>1.51</td>
</tr>
<tr>
<td>Age (increasing 10 yr brackets)</td>
<td>&lt;.0001</td>
<td>1.54</td>
</tr>
<tr>
<td>Grade (poorly diff)</td>
<td>&lt;.0001</td>
<td>2.75</td>
</tr>
<tr>
<td>Grade (undiff, anaplastic)</td>
<td>&lt;.0001</td>
<td>3.02</td>
</tr>
</tbody>
</table>

Conclusions: This demonstrates the largest report of the histologic subtypes of liposarcoma. It confirms previous reports that mixoid liposarcoma has a better prognosis than pleomorphic liposarcoma. This report also provides previously unreported survival data based upon various histological subtypes. This data confirms prior observations that soft tissue sarcomas have worse prognosis with increasing grade and increasing size. It also demonstrated worse prognosis for advancing age, hispanic race, and male gender. These types of prognostic factors require a national database such as this to detect these statistically significant associations. It is beyond the capability of this database to determine what affect various therapies might have had on prognosis.
HISTOLOGIC SUBTYPES OF OSTEOSARCOMA AND CORRELATION WITH SURVIVAL – AN NCDB NATIONAL REPORT
William G. Ward, MD; Katrina R. Swett, MS; Robert M. Corey, MD

Introduction: A prognostic variation based on the histologic subtypes of osteosarcoma has been reported in the past. Is well-known that Parosteal Osteosarcoma has a much better prognosis and Paget’s osteosarcoma has a much worse prognosis. However it remains unclear if there is a prognostic effect from possessing a chondroblastic or fibroblastic histologic subtype differentiation. Therefore an analysis of the American College of Surgeons’ Commission on Cancer’s National Cancer Database (NCDB) was performed to determine the prognostic effect, if any, of a number of patient and tumor characteristics including the histologic subtype.

Materials and Methods: The NCDB was queried to examine the records of all patients with Osteosarcoma entered from the years 1998 through 2010. The records of a total of 5392 patients were analyzed by survivorship analysis and the PHREG procedure to determine statistically significant associations with survival and also to determine the relative risks associated with these factors.

Results: Compared to Osteosarcoma not otherwise specified (NOS), the following six histological subtypes had statistically significant differences in survival prognosis. These are shown in the following table in ascending order of hazard ratio along with the hazard ratio.

<table>
<thead>
<tr>
<th>Histologic Subtype</th>
<th>p value</th>
<th>Hazard ratio</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parosteal</td>
<td>p&lt;0.0001</td>
<td>0.174</td>
<td>299</td>
</tr>
<tr>
<td>Periosteal</td>
<td>p&lt;0.0002</td>
<td>0.404</td>
<td>66</td>
</tr>
<tr>
<td>Fibroblastic</td>
<td>p&lt;0.0001</td>
<td>0.689</td>
<td>393</td>
</tr>
<tr>
<td>Telangiectatic</td>
<td>p&lt;0.0367</td>
<td>0.764</td>
<td>140</td>
</tr>
<tr>
<td>Chondroblastic</td>
<td>p&lt;0.0110</td>
<td>0.866</td>
<td>831</td>
</tr>
<tr>
<td>Osteosarcoma (NOS)</td>
<td>N.A.</td>
<td>1.000</td>
<td>3532</td>
</tr>
<tr>
<td>Pagets</td>
<td>p&lt;0.0001</td>
<td>2.427</td>
<td>131</td>
</tr>
</tbody>
</table>

The following factors (based on an analysis of a subset of 1275 patients (patients in which there were no missing values) were also found to have a statistically significant association with prognosis:

<table>
<thead>
<tr>
<th>Factor</th>
<th>p value</th>
<th>Hazard ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (10 year brackets)</td>
<td>p&lt;0.0001</td>
<td>1.348</td>
</tr>
<tr>
<td>Black race</td>
<td>p&lt;0.0015</td>
<td>1.305</td>
</tr>
<tr>
<td>Grade poorly differentiated</td>
<td>p&lt;0.0001</td>
<td>3.020</td>
</tr>
<tr>
<td>Grade undifferentiated, anaplastic</td>
<td>p=0.0003</td>
<td>2.810</td>
</tr>
<tr>
<td>Stage III</td>
<td>p=0.0061</td>
<td>2.060</td>
</tr>
<tr>
<td>Stage IV</td>
<td>p&lt;0.0001</td>
<td>4.243</td>
</tr>
</tbody>
</table>

Conclusions: In addition to the commonly accepted prognostic significance of Parosteal, Periosteal, Telangiectatic and Paget’s Osteosarcoma subtype, this database demonstrated prognostic significance based on fibroblastic or chondroplastic differentiation. In addition to the expected prognostic effect of grade and stage, this database also revealed the statistically significant effect of race and age. These types of prognostic factors require a national database such as this to detect these statistically significant associations. It is beyond the capability of this database to determine what affect various therapies might have had on prognosis.

Disclosures listed in handout
NOVEL TECHNIQUE FOR TREATING AN INFECTED TOTAL FEMUR REPLACEMENT

Lance C. Smith, MD; Eric R. Beaver, BS; Jeremy R. White, MD

Background: Total femoral replacement is utilized for treatment of oncologic resection of the femur or failed arthroplasty of the hip or knee. Total femur replacements are known to be accompanied by a high post-operative infection rate. Treatment of these infections is very problematic and can be complicated by joint stiffness and limb length loss.

Question / Purpose: To investigate whether a novel technique for constructing a total femur spacer with an articulating component at the hip and knee can be utilized for treatment of an infected total femur replacement with acceptable outcomes and occurrence of complications.

Description of Technique: The infected total femur prosthesis was removed and an appropriate debridement of the surrounding soft tissue was performed. A custom antibiotic cement spacer was constructed by combining a mono-polar femoral head, modular revision femoral body, a femoral intramedullary nail, and an articulating knee component fabricated with cement molds. The entire construct was coated with PMMA impregnated with vancomycin and tobramycin. The dual-articulating spacer is made to replicate the mega total femur prosthesis, theoretically preserving femoral length, alignment, and joint mechanics during two-staged infection eradication.

Patients and Methods: A 19 year old male presented with a low grade osteosarcoma of the femur that was treated with a distal femur-replacing rotating hinge arthroplasty. Recalcitrant infectious complications required removal of his entire femur. After apparent clearance of the infection a total femur arthroplasty was performed. Four months post-operatively, the patient developed a recurrent MRSA periprosthetic infection and was subsequently treated with a two-stage treatment including initial implant removal and spacer placement. A dual-articulating antibiotic delivery system as described above was constructed and implanted.

Results: Total femur arthroplasty was performed three months after placement of the dual-articulating spacer. The patient maintained his leg length, alignment and stability post-operatively. Active range of motion was 0 to 90 degrees. The patient has remained infection free for greater than 8 months and is able to ambulate without assistive devices. No major complications were encountered.

Conclusions: A dual-articulating, custom-built antibiotic femoral spacer may offer a viable solution for maintaining lower extremity length, alignment and range of motion during treatment of total femur arthroplasty infections.
A SIMPLE TECHNIQUE FOR ESTIMATING THE VOLUME OF NEEDED BONE GRAFT MATERIAL

April Hamm, MD; James A. Hurst, MD; Jeremy R. White, MD

Location: Investigation performed at the University of Oklahoma Health Sciences Center, Department of Orthopedic Surgery and Rehabilitation.

Background: Bone graft material is often used to address the bony defects created by the treatment of bone tumors, trauma, and failed arthroplasties. It is also commonly used in arthrodesis procedures performed by spine, hand, and foot and ankle surgeons. Therefore, the use of bone graft material is pervasive through most orthopedic surgical subspecialties. Bone graft material is utilized in approximately 600,000 procedures in the United States and 2.2 million procedures worldwide each year. The annual cost of these procedures in the United States is estimated to be $2.5 billion. Estimating the volume of needed bone graft can be difficult. Commonly used techniques include estimating the volume from preoperative imaging or simply using intraoperative clinical judgment. It is the opinion of the authors that these techniques are prone to significant error. Commercial bone graft material is very expensive and opening too much material or having to open several smaller packages can significantly increase the cost of a procedure. Some of the graft materials available in our institution cost more than $100 per cubic centimeter. In our ever-increasing fiscally conscious healthcare system, every dollar counts.

Purpose: To describe a technique of estimating the volume of needed bone graft to fill an osseous defect.

Technique: Our technique for estimating bone graft need is a simple one. It involves a graduated syringe and sterile normal saline, both of which are relatively inexpensive and are opened during almost all operative cases. After exposing and creation of the final defect, an appropriately sized syringe is filled with saline. The saline is then injected into the defect until the desired volume is reached. Finally, a corresponding sized amount of the graft product is chosen.

Case Examples: Case #1. Eight year old male presented with an aneurismal bone cyst of the tibia. This was treated with an extended curettage. Using the described technique the defect was estimated at 25 cc. 22 cc of graft material was used to completely fill the defect. Case #2. Fourteen year old male presented with a recurrent aneurismal bone cysts of the calcaneus. The defect was estimated at 45 cc and it required 45 cc of graft material to fill the defect.

Discussion: This technique has been very helpful in cutting down waste at our institution. It is quick, simple, and inexpensive. It also is based on the actual defect after treatment, which is the principle limitation of the technique based on preoperative imaging. It does, however, have limitations. First, the defect must be contained enough to hold a liquid and it must be dry. Secondly, it can underestimate the amount needed if the graft is pressurized. In conclusion, our technique is an inexpensive and novel way to measure for the appropriate amount of bone graft material needed. This can help conserve financial resources in our modern healthcare system.

Disclosures listed in handout
RISK FACTORS FOR UNPLANNED EXCISION OF DERMATOFIBROSARCOMA PROTUBERANS

Nadine Williams, MD; Michael Mijares, MD; Michael Schoor; Sheila Conway, MD; H. Thomas Temple, MD

Background: Dermatofibrosarcoma protuberans (dfsp) is a rare cutaneous locally aggressive tumor that is characterized by high local recurrence rates. Wide surgical excision is traditionally recommended but recent dermatologic data has supported Mohs surgical excision. We have treated several patients with local recurrence secondary to either incomplete excision or after failed Mohs microscopic resection and recommend wide surgical excision.

Purpose: We reviewed treatment outcomes of 28 patients with dfsp treated at our institution between 2001 and 2013. Many presented after incomplete or unplanned excisions. What are the risk factors for unplanned excisions of dermatofibrosarcoma protuberans? How does incomplete excision affect local recurrence and treatment outcomes?

Patients and Methods: We retrospectively reviewed twenty eight cases treated by our group between 2001 and 2013. All patients were diagnosed with primary dfsp. We recorded disease presentation and outcomes as it relates to race, ethnicity, and healthcare access.

Results: Between the planned and unplanned groups, there was a significant association between African Americans and increased rates of unplanned excisions (4 vs. 36%, respectively P= .05). Between African American and Caucasian patients there was a significant association between local recurrence and unplanned excisions in blacks (57 vs. 43%, P=.03). Among racial groups, African Americans and Caucasians accounted for most of the unplanned excision (41 vs. 32 vs. 27%, P= .05, .695, .18 respectively). Among patients with unplanned excisions, African Americans were probably more likely to develop post-operative complications (63 vs. 25 vs. 13%, P= 0.07). The three observed cases of fibrosarcomatous degeneration were in African Americans, but this was not significant (P= .12). There was no significant association between race and amputation (50 vs. 33 vs. 17%, P=.23).

Conclusions: African Americans suffer a disproportionate rate of unplanned excisions of DFSP and locally recur more frequently. This is most likely due to the subcutaneous location of DFSP lesions which increases the risk of misdiagnosis and mismanagement. The subspecialty of the initial treating physician also increases the risk of incomplete excisions.
**UNPLANNED SURGICAL EXCISIONS OF SOFT TISSUE SARCOMAS, IDENTIFYING PATIENT CHARACTERISTICS**

*Nadine Williams, MD; David Landy, PhD; Michael Mijares, MD; Sheila Conway, MD; H. Thomas Temple, MD*

**Background:** Soft tissue sarcomas are rare. Limited data exists on the effects of healthcare access, unplanned excisions and oncological outcome.

**Purpose:** We evaluated the relationship between health care access - charity / medicaid (indigent) vs. private / medicare (insured) and the risk of unplanned excision. Risk factors were identified.

**Patients and Methods:** Records were retrospectively reviewed for 356 patients with high-grade soft tissue sarcomas (torso, pelvis, extremities) treated operatively between 1989 and 2013. Charts were reviewed for: demographics, insurance, race, ethnicity, complications, and oncologic outcomes (local recurrence, metastasis, survival). Disease-free survival was analyzed (Kaplan-Meier).

**Results:** Planned and unplanned groups did not differ with respect to gender (55 vs. 54% male, \(P=0.90\)), age (mean 55 yrs for both groups, \(P=0.06\)), race/ethnicity (54% vs. 58% white non-Hispanic, \(P=0.60\)), and insurance (8 vs. 11% insured vs. indigent \(P=0.39\)). Both groups differed with respect to diagnosis: Liposarcoma (20% vs. 14%), pleomorphic sarcoma (4% vs. 23%), osteosarcoma (10% vs. 1%) and fibrosarcoma (5% vs. 10%), but not stage (59 vs. 61% with Stage 2B disease, \(P=0.37\)), tumor size (11 vs. 7 cm, \(P<0.01\)), and symptom duration (mean 11 vs. 22 months, \(P=0.01\)). Both groups differed with respect to chemotherapy (87% vs. 45%, \(P<0.01\)) but not radiotherapy (79 vs. 84%, \(P=0.49\)). The groups were similarly likely to need amputations (19% vs. 17%, \(P=0.76\)). The unplanned group was more likely to require a flap (26% vs. 8%, \(P<0.001\)), with a trend toward developing an infection (18% vs. 10%, \(P=0.07\)). These associations were unchanged adjusting for tumor size and chemotherapy.

Adjusting for tumor size and chemotherapy using Cox proportional hazards models, the unplanned group was still more likely to recur locally (HR=2.45, 95% CI=1.17-5.15), to develop metastases (HR=0.92, 95% CI=0.49-1.73) and improved survival (HR=0.57, 95% CI=0.33-0.98).

**Conclusion:** Patients with smaller lesions of longer duration with an indolent course were more likely to undergo unplanned excision. After presentation, these patients had treatment outcomes similar to patients with planned procedures.

**Level of Evidence:** Level II, Prognostic
HEALTHCARE ACCESS, COMBINATION THERAPY, AND SYNOVIAL SARCOMA OUTCOME

Nadine Williams, MD; Michael Mijares, MD; Jason Klein, MD; Sheila Conway, MD; H. Thomas Temple, MD

Study performed at the University of Miami Hospital, Miami, FL.

Background: Synovial cell sarcoma is rarely diagnosed. Most cases are treated with resection and radiotherapy. There is limited data on the role chemotherapy in the treatment of this sarcoma.

Purpose: To determine how healthcare access affects survival and oncological outcomes of patients treated with combination therapy. What risk factors are associated with adverse outcomes?

Patients and Methods: We performed a retrospective review of all synovial sarcomas treated at our institution between 1987 and 2010 that had been followed for a minimum of five months or until patient death. The study group contained 52 patients, and the control group (planned) had 35, the experimental group (unplanned) had 17 patients respectively. The cohorts were compared with regard to disease presentation, treatment, oncologic outcomes, healthcare access, race, and ethnicity.

Results: There was a significant relationship between advanced age and increased local recurrence (P=0.01). There was a trend towards significance with female gender and local recurrence (P=0.09). The development of postoperative complications was increasingly associated with race and significantly associated with stage at presentation. Hispanics had decreased risk vs. whites who had increased risk of complications (P=0.06). Stage III disease was significantly associated with increased complications (P=0.03). Younger patients and decreased tumor size were significantly associated with improved survival (P=.01, P=.05 respectively). Regarding treatment outcomes, patients with advanced age were significantly associated with increased amputations (P=0.001). African Americans had an increased likelihood of receiving an amputation (P=.07). Larger lesions were significantly more likely to metastasize and more likely to be amputated (P=.03, P=.06). Stage III disease was significantly associated with developing metastasis (P < .001).

Conclusions: There was a significant association between advanced age and disease stage at presentation, race, and tumor size on oncological outcome and survival. Patients with female gender, advanced age, white race, stage III disease and larger tumor size are more likely to have local recurrence, develop post operative complications, and have worst survival. They are also most likely to develop metastasis and receive an amputation. The generalizability of our results are limited by a small sample size but suggest an overall trend of association between the above variables, treatment outcomes and survival in synovial sarcoma patients.

* Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
• FDA information not available at the time of printing. For full information, refer to inside back cover.
Background: Bony voids are often formed during the surgical excision of tumors. These voids reduce the structural integrity of the bone and may lead to delayed healing and fractures. There are various bone void fillers used including calcium phosphate.

Purposes: The purpose of this study was to analyze rate of absorption and complications with calcium phosphates (Hydroset and BSM).

Methods: A retrospective charts review was conducted of patients who had undergone excision of a bony tumor with placement of Hydroset or BSM from 2009 to 2012. Outcomes including complications and graft absorption were reviewed at 6 month. Absorption was graded as 0%, 25%, 50%, 75%, and 100%. Fisher’s exact test was used.

Results: 36 patients were identified: 20 in BSM group, and 16 in Hydroset group. The groups were similar in regards to age (p=0.23), amount used (p=0.69), and benign tumors (p=1.0).

X-rays were available for 10 in Hydroset group and 17 in BSM group. BSM had 5 with no absorption, 9 with 25%, and 3 with 50%. Hydroset had 9 with no absorption and 1 with 100%. These values were statistically significant (p=0.001). 10% of BSM group had a complication. 31% of Hydroset group had a complication (p = 0.2036).

Conclusion: The rate of absorption was different, with the BSM remodeled faster than the Hydroset. There were a high number of complications with Hydroset. This was not significantly different. This is most likely due to the lack the power to show the difference that would be indicated with the higher number of complications.

Level of Evidence: Level III, Therapeutic study.
INTRODUCTION: The best method of proximal humerus reconstruction in young children after oncologic resection has not been elucidated. The claviculo pro humeri (CPH) procedure was originally described as a treatment for congenital upper limb deficiency and was later modified for the treatment of shoulder girdle defects resulting from the oncologic resection of sarcomas. We report the first North American CPH case series for the treatment of sarcomas.

METHODS: The CPH procedure is a biologic reconstruction of the proximal humerus using the patient’s ipsilateral clavicle. CPH does not require microsurgical anastomoses or the need for distant donor tissue. The CPH procedure maintains inherent stability of the transposed bone fragment through retention of the acromioclavicular ligaments and native blood supply to the lateral portion of the clavicle through the thoracoacromial trunk. We reviewed the first four CPH cases performed at a single institution. Demographics, diagnoses, surgical complications, functional outcomes, limb salvage rate, and oncologic outcomes were all assessed.

RESULTS: Four children underwent CPH, 3 for osteosarcoma and one for Ewing sarcoma. Patient age at surgery ranged from 4 years and 5 months to 8 years and 9 months. Mean age at surgery was 5 years and 11 months. All patients are alive without local or distant recurrence at 29-56 months (mean = 40.8 months) after surgery. There were no post-operative infectious complications. Two patients experienced non-union requiring onlay vascularized free fibula grafting with revision internal fixation. All patients ultimately achieved union, and hypertrophy of the transposed bone is noted in all cases. Limited shoulder range of motion comparable to other forms of pediatric proximal humerus reconstruction was observed in all cases. Full elbow range of motion and distal nerve function were preserved in all patients. No patient requires pain medication, and functional results were good or excellent in all cases.

DISCUSSION: This is the first reported North American series of claviculo pro humeri cases. Functional limb salvage was achieved in all four patients. All four have a painless, stable neo-humeri and excellent hand, wrist, and elbow function. Prior claviculo pro humeri series reported similar results with high rates of limb salvage and good function but a frequent need for re-operation due to non-unions and other complications. The largest series by Rodl et al. reported 15 cases with 10 patients requiring a total of 15 re-operations. The Rodl study found that CPH patients had better function than other proximal humerus reconstructions performed at the same institution despite the CPH patients having more re-operations and a higher percentage of extra-articular resections. We remain enthusiastic of this technique because of its potential to provide a painless, stable limb salvage in this challenging population. We believe the risks of early complications are outweighed by the advantages of a durable biologic reconstruction.

CAl VICUlO PrO HUMErI FOR lIMB SALVAGE OF PEDIATrIC PrOXIMAl HUMErUS SARCOMAS
Jennifer Wright, MD; George Calvert, MD; Holly Spraker-Perlman, MD, MS; Kevin B. Jones, MD; R. Lor Randall, MD, FACS
ALLOGRAFT RECONSTRUCTION OF THE PELVIC RING FOLLOWING TYPE III INTERNAL HEMIPelveCTOMy

Matthew Colman, MD; Syed Mohammed Karim, MD; Vini Shah, MD; Joshua Hirsch, MD; Albert Yoo, MD; Joseph Hasbrouck Schwab, MD; Francis Hornicek, MD, PhD; Kevin A. Raskin, MD

Background: Type III internal hemipelvectomy is performed for local control of pelvic tumors which occur medial to the acetabulum. Classically, these resections are not reconstructed given the preserved continuity of the weight-bearing axis from femur to axial spine. However, allograft reconstruction of the pelvic ring may have benefits in terms of soft tissue reconstruction of the pelvic floor and for hip stability.

Question: What is the postoperative functional status after allograft reconstruction of type III pelvic defects, and what are the rates of hernia, hip instability, and infection?

Methods: We retrospectively reviewed all consecutive type III pelvic resections over a recent 10-year period (N=17). Partial anterior acetabular wall resections along with the medial pelvis were included. Patient demographics, disease status, functional status, and complications were recorded. Median follow-up was 19 months. For a portion of the cohort, we used a novel technique for anterior acetabular wall reconstruction employing the concave cartilaginous surface of a proximal fibula allograft.

Results: We analyzed 8 type III and 9 type III with partial anterior acetabular resections. Disease-related mortality was 35% at median 19.8 months. We found local recurrence in 2 patients (12%), both of whom succumbed to disease. 14 patients were reconstructed using allograft bone and soft tissue augments, and 3 were left unreconstructed. Eleven required surgical hip dislocation at the time of resection. All patients remained ambulatory with or without assistive device at follow-up. Pain at six months after surgery was reported as none in three, mild in five, moderate in three, and severe in one. Complications included infection in 4 patients (24%; 2 in the non-reconstructed group), symptomatic hernia in 1 patient (5.9%), and hip instability in 2 patients (11.8%; 1 in the non-reconstructed group).

Conclusions: Allograft reconstruction after type III pelvic resections provides a stable, functional reconstruction with low rates of hernia and hip instability, and infection rates in line with published observations. Allograft assists in pelvic floor anchoring and reconstruction, and using a whole fibula allograft helps restore the concave cartilaginous surface of the anterior acetabulum.

Level of Evidence: IV

Disclosures listed in handout
PERCUTANEOUS ACETABULOPLASTY COMPARED WITH SURGERY FOR HIGH GRADE PERIACETABULAR CARCINOMA METASTASES
Matthew Colman, MD; Syed Mohammed Karim, MD; Vini Shah, MD; Joshua Hirsch, MD; Albert Yoo, MD; Joseph Hasbrouck Schwab, MD; Francis Hornicek, MD, PhD; Kevin A. Raskin, MD

Background: Most patients with metastatic carcinoma to bone have short life expectancies. In the presence of destructive periacetabular disease, goals of treatment are palliation of pain and restoration of ambulatory capacity. Although open complex acetabular reconstruction is one option, more limited percutaneous cement acetabuloplasty (PA) may also be effective in the short term.

Question: Is percutaneous cement acetabuloplasty at least as good as open complex reconstruction for providing short term pain relief and ambulation in high grade metastatic carcinoma lesions around the acetabulum?

Methods: We retrospectively identified 17 consecutive patients who underwent open Harrington-type or anti-protrusio reconstruction and cemented total-hip arthroplasty, and compared them to 11 consecutive patients who underwent PA. The inclusion criterion was a Harrington grade 2 or higher (Surgery 2.59 vs. 2.09 for PA, p=0.06) periacetabular lesion from metastatic carcinoma. Median follow-up was 21 months. Main outcome measures were change in pre-procedure performance status (PS), ambulatory status (AS, 0= unassisted ambulation, 1 = assisted ambulation, 2= nonambulatory), and 10-point visual-analogue pain scale score. A secondary outcome measure was survival time from index procedure.

Results: The surgery group had better pain reduction than the PA group at 3 months (-3.6 vs. -1.5 points, p=0.04), and a trend towards the same at final follow-up of 20 and 13 months, respectively (-3.8 vs. -1.4 points, p=0.06). Improvement in ambulatory status was better in the surgery group at 3 months only (-0.53 vs +0.14, p=0.03). There was no statistical difference between the two groups in reduction of PS at any time point. Kaplan-Meier log-rank survival analysis showed no difference in overall survival between the two groups (median survival 23 vs. 35 months, p=0.7). Cox regression analysis of the entire study group identified only preoperative calcium level as a predictor of poor survival (p=0.01, HR 3.4, 95% CI 1.3-8.9). There were three deep infections requiring reoperation in the surgery group. Although there were no procedure-related complications in the PA group, two patients required reoperation for persistent pain.

Conclusions: Cement acetabuloplasty remains an option for palliation of periacetabular metastases, with low procedural complication rates. However, more definitive structural reconstruction may provide improved pain relief and ambulation in the short term, especially for more extensive lesions.

Level of Evidence: III

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Purpose: To evaluate clinical efficacy and outcomes of percutaneous image directed therapy of juxtaphyseal aneurysmal bone cyst (ABC) in children with doxycycline as a multimodal antineoplastic therapy.

Methods: Using our institutional database, a retrospective analysis was performed on sixteen children with juxtaphyseal ABC ages 2-15Y (Mean = 7.1Y). Doxycycline microfoam was percutaneously injected under image guidance (Mean dose = 300 mg/session). The primary endpoints were boney healing and stability during surveillance. We analyzed the morphology of the growth plate, physeal growth, presence/absence of physeal bars, juxtaphyseal deformity, and movement of the healing ABC scar away from the physis.

Results: ABCs of the humerus (9), tibia (3), fibula (2), ulna (1), and femur (1) were treated in 102 percutaneous sessions (Mean = 6.4 sessions per patient). All patients were treated using our percutaneous ABC protocol; follow-up 12-62 months (Mean = 39 months). We found boney healing response; remodeling to normal or near-normal morphology; visible boney scar migrating away from the physis, and symmetrical physeal growth without deformity in 16/16 patients. 3/16 patients demonstrated focal physeal bars in locations with previous transphyseal ABC invasion. One case of focal skin necrosis was noted; no other complications. Localized recurrence was noted in 1/16 patients, treated successfully with localized doxycycline injection.

Conclusion: Directed therapy with doxycycline microfoam is feasible, safe, and effective for percutaneous treatment of juxtaphyseal ABC in the long bones of children.

Significance: Literature references show up to 71% recurrence following open surgical treatment of juxtaphyseal ABC. Percutaneous doxycycline therapy offers a promising new treatment for juxtaphyseal ABC, as well as other sites of ABC.
“ROBOTIC LEG” - WHO NEEDS IT, AND HOW DOES IT IMPROVE QUALITY OF LIFE?

Munjed Al Muderis, MD; Guy Raz, MD; Brendan Burkeet, MD; Belinda Bosley, MD

Introduction: The Integral Limb Prosthesis (ILP) has been used to treat lower limb amputees since 1999. Prior to its advent all prosthesis were consisting of stump and socket mechanisms which didn’t changed dramatically within the last decade, and failed to address a few major requirements of normal gait.

Methods: Since 2009 ILP has been performed in Australia. Patients can access the Australian Osseointegration Group, directly by a web link, and begin the screening process to validate their compatibility. As part of the pre-operative assessment, patients are functionally tested with: Time Up an Go (TUG), Six Minutes Waling Test (6MWT), K-scale, and surgeon subjective functional scale of 1-10. These assessments are repeated following completion of the two-staged robotic leg implantation.

Results: Since 2009 thirty-six patients were implanted with ILP in Australia, two cases of bilateral implantation, summing to thirty-four cases in our center, and four by other surgeon. In 28 cases (75%) the amputation was performed due to trauma, in 12% (5) due to infection, 10% (4) due to neoplasia, and a single case due to congenital deformity.

The average K-scale pre-surgery was 2.0 and improved to 2.8 with the higher rise in individual cases such as improvement of 3 points from level 0 to level 3 post-surgery. Pre-op TUG was average of 13.3 seconds (40% of patient were not able to perform this test). Pre-op 6MWT average of 279.5 meters (40% unable to perform test) compared to average of healthy adults ages 60-69 of 550 meters.

Discussion: The term Robotic leg was assigned in the past to prosthesis that utilizes sensory input, such as biosensors. One of the most striking advantage of ILP is the regaining of leg / prosthesis Osseo perception. It is so profound that several ILP recipients expressed their regained ability to feel small details such as the texture of the ground, or small obstacles with less than 1 cm diameter. As a result of this new regain ability, ILP patients are able to walk in the dark, or walk without constantly looking at the ground in order to avoid obstacles. Additional advantage of ILP is the ability to control rotation of the prosthesis, which improves ambulation; it helps in particular with changing position or directions, while walking. This improvement is evident in the dramatically improved functional test such as TUG and 6MWT, as well as K scale, where for instance we observed improvement of wheel chair bound patient (K0) to fully competent community walker (K3). The use of ILP negates numerous impediments that affect the use of stump and socket prosthesis, such as skin irritation, feeling of extra weight of the prosthesis, stump pain, and leg falling off when rising from sitting position.

Conclusion: ILP may benefit any lower leg amputee, whether he is in the lower end of functional scale, or whether he is a young, active, and highly functional individual.

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A COMPREHENSIVE ONLINE ORTHOPAEDIC ONCOLOGIC SURGERY TEXTBOOK
J. David Pitcher Jr., MD; H. Thomas Temple, MD; Sheila Conway, MD; Christian Veillette, MD

Background: Electronic media have gained widespread use by patients and physicians over the last decade.

Purpose: We report a comprehensive online orthopaedic oncologic surgery textbook in outline format updated daily available as downloadable PDF files for free for individual topics, and for individual chapters or entire text for a small fee. The concept is to include the entire English literature available on PubMed for each subject.

Methods: Numerous physicians have added to chapters within the text:

- Staging, Biopsy, Terminology, and Surveillance
- Clinicoradiologic and Pathological Interpretation
- Osseous Tumors and Lesions of Bone and Soft Tissue
- Cartilage Tumors of Bone and Soft Tissue
- Fibrous and Epithelioid Tumors of Bone and Soft Tissue
- Round Cell Tumors of Bone and Soft Tissue
- Vascular and Lipomatous Tumors of Bone and Soft Tissue
- Giant Cell Tumors, Cysts, and Cyst-like Lesions of Bone and Soft Tissue
- Muscular and Neurogenic Tumors of Bone and Soft Tissue
- Metastatic Bone and Soft Tissue Disease
- Bone and Soft Tissue Metabolism and Disease
- Resection and Reconstruction after Tumor Resection with Limb Salvage

Results: The work is often found on online searches when typing in a physician’s name and disease because of the more than 25,000 references cited to date in the text. Illustrative cases in over 6000 gray scale and color images in over 4000 pages have been added to date.

Conclusions: The text provides up-to-date information for patients, students, oncologic surgeons, radiologists, and pathologists, including individual review and review type courses.

Disclosures listed in handout
ACETABULAR RECONSTRUCTION FOR METASTATIC DISEASE WITH POSTERIOR COLUMN SCREWS AND TOTAL HIP ARTHROPLASTY

Andrew S. Fang, MD; James O. Johnston, MD

Background: Quality of life for patients with metastatic disease of the acetabulum is often poor secondary to pain and loss of mobility. Patients may present with extensive pelvic bone loss, poor bone quality and pathologic fractures. Secure fixation of total hip arthroplasty can be challenging and various techniques exist.

Purpose: Determine whether screws placed into the posterior column in conjunction with total hip arthroplasty provides a reliable and uniform means of reconstructing metastatic acetabular defects. Review of patient demographics, intra-operative data, and analysis of outcomes.

Methods: Sixteen cases of metastatic disease involving the acetabulum were treated with placement of long posterior column screws in conjunction with cement to support total hip arthroplasty. Procedures were performed between 2001 and 2011. Medical records were reviewed for demographics, patient survival, revision rates, complications, and functional status. A standard posterior approach to the hip was used to perform the entire procedure. The basis of the reconstruction was two to four long 6.5 mm cancellous screws placed through the metastatic defect into the posterior column of the pelvis. This created a foundation to secure a metal backed acetabular component. The construct was completed with a standard cemented femoral component.

Results: 10 out of 16 patients presented with pathologic acetabular fractures including two with protrusio acetabulae. Median follow up was 12 months (1-127 months). All patients required assistive devices pre-operatively with two patients being bed-bound. At the time of follow up, 15 out 16 patients had died of their disease with a median survival of 11 months (1-122 months). Estimated blood loss averaged 1216 cc and the average operative time was 126 minutes. Two patients required re-operation (12.5%) and one patient was revised (6.25%) for acetabular failure. Early post-operative complications included one dislocation, one failed acetabular component, and superior migration of one construct. There was one late infection 97 months after the index surgery. All patients demonstrated improved pain following their surgery and the MSTS scores for the 12 patients surviving at least 6 months averaged 15.3 (5-27).

Conclusions: Acetabular reconstruction for metastatic disease can be performed with posterior column screws and cement to secure an acetabular component for total hip arthroplasty. The procedure can be done through a posterior hip approach familiar to most orthopaedic surgeons. A uniform technique of screw placement allows various size metastatic defects to be addressed. Intraoperative parameters and postop complications were comparable to previously published studies. All patients improved in terms of their pain following the procedure. In addition, function was improved in most cases, despite an often limited patient lifespan.

Level of Evidence: Level IV, Case Series

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PERSISTENT WOUND DRAINAGE AFTER TUMOR RESECTION AND ENDOPROSTHETIC RECONSTRUCTION OF THE PROXIMAL FEMUR

Werner H. Hettwer, MD; Peter Horstmann, MD; Peter Horstmann; Tomas A. Grum-Schwensen, MD; Michael M. Petersen, MD

Background: An association of persistent surgical wound drainage with a higher incidence of superficial and deep periprosthetic infection, as well as the relevant risk factors have been clearly established in several studies on conventional total hip arthroplasty. Reported infection rates after tumor resection and subsequent endoprosthetic reconstruction of the proximal femur are substantially higher than in conventional hip arthroplasty, however more detailed data on the prevalence of persistent surgical wound drainage in this patient subset and the effect of the use of skin adhesives as an adjunct to wound closure have not been published.

Material and methods: To establish the duration of postoperative surgical wound drainage, duration of administration of antibiotics and the date of discharge, we performed a retrospective review of all adult patients who underwent endoprosthetic reconstruction of the proximal femur after tumor resection for primary or metastatic bone disease in our department in 2012. Prospective assessment of similar patients operated in the current year, in whom routine wound closure with staples was substituted with intradermal suture, application of Steristrips and an occlusive skin adhesive, is currently being completed.

Results: Of 42 patients operated in 2012, complete data on duration on post operative wound drainage, duration of administration of antibiotics and discharge date were available in 41. Mean duration of post operative wound drainage was 8 days (range 2–45), mean duration of administration of post operative antibiotics was 8,2 days (range 1–45) and mean hospital stay was 9,4 days (range 3–45). 19 patients (45%) had prolonged wound drainage (7 days or longer), prolonged hospital stay and antibiotic administration. One patient developed persistant deep periprosthetic infection with multirestistant e. coli, despite all therapeutic efforts and was discharged to palliative care with a draining sinus on post op day 45 on permanent oral antibiotics.

The preliminary first 10 patients, who underwent skin closure with subcuticular suture, Steristrips and topical skin adhesive, all had dry wounds at the first scheduled post operative dressing change (mean 2,9 days, range 2–4), mean duration of post operative administration of antibiotics was reduced to 3,6 days (range 2–7) and mean hospital stay was reduced to mean 6,5 days (range 3–10).

Discussion: Our small sample showed a surprising prevalence of prolonged drainage from the surgical site after endoprosthetic reconstruction of the hip in tumor patients, probably reflecting multiple factors: the extent of the procedure, prolonged surgical time, often significant perioperative blood loss and the burden of primary disease with its associated comorbidities and often present recognised risk factors, such as previous radiation, chemotherapy and malnutrition, all predisposing these patients to wound healing complications. Simple change in the wound closure routine with intradermal suture, maintenance of wound apposition with Steristrips and application of a topical skin adhesive as a sealant, appears to show a promising reduction in wound drainage, post operative antibiotic administration and hospital stay and warrants further study.

Disclosures listed in handout
Introduction: Squamous Cell Carcinoma (SCC) is the most common primary malignancy of the hand. It is known to be more aggressive and pertain to a worse prognosis when located on the hand compared to other locations. It is crucial to perform wide excision so as to prevent recurrence and metastasis. There can be significant loss of hand function as a result of surgery. Dupuytren's disease is a relatively common disorder affecting approximately of 5% of Caucasians and can cause significant contractures which limit use of the hand if severe. It has frequent recurrence despite surgical intervention. There are no current published reports of treatment for patients with concurrent SCC and Dupuytren's. This case presents a coverage option for preservation of a digit in the setting of a SCC involving two rays, one of which was also effected by Dupuytren’s disease.

Case Description: A 91 year old male who lived independently was referred to orthopaedic oncology for biopsy confirmed invasive SCC located at the 3rd web space and involving both the ring and long fingers of the left hand. The wound was necrotic, chronically draining and had repeated infections. Concurrently, the patient had a 40 degree flexion contracture of the left ring finger metacarpal phalangeal joint with notable cord formation from Dupuytren's disease. He had significant disability affecting his activities of daily living due to the chronic wound, pain and lack of hand mobility. The SCC was primarily dorsally located and involved the radial aspect of the skin over the proximal phalanx of the long finger. It extended past the commissure and slightly onto the palmar aspect of the hand. On Magnetic Resonance Imaging the SCC was noted to center at the level of the proximal aspect of the proximal 3rd and 4th phalanges and was measured 2.9x2.0x2.2cm, but there was no involvement of bone. The patient was started on oral cephalexin for the infection and showed response. Systemic workup for metastatic disease showed a metastatic lesion in his lung so treatment of his hand would be palliative.

The goals of treatment were to eliminate the chronically infected wound, preserve as much tissue as possible and provide a sensate and functional hand. Treatment options considered included chemoradiation, radiation treatment, and surgical options including amputation of the 3rd and 4th rays. Radical chemoradiation was felt to expose this patient to excessive morbidity given his age. Radical radiation therapy would entail high risk of bone necrosis and finger contracture and still may require surgery. Palliative radiation treatment would likely not provide local control or improve hand function. Amputation of both the 3rd and 4th rays, while technically an easier option, was an unacceptable option to the patient. In conjunction with orthopaedic hand surgery, it was opted to perform a 4th ray amputation with the use of a fillet flap for soft tissue coverage for the long finger and web space. This would also eliminate his Dupuytren’s contracture. A fillet flap is a well described technique when amputating a digit. It is a technique where the bone and tendons can be filleted from the soft tissues and skin. The remaining tissues can then be used for local soft tissue coverage. A particular advantage is the transfer of native finger tissue allows for optimal sensory preservation of the hand. The surgery was performed without complication under conscious sedation and regional block. Frozen sections were utilized during the case to ensure negative margins. He was discharged home on post-operative day #1. Final pathology interpretation showed negative margins.

Discussion: This case illustrates a way to balance adequate treatment of SCC while optimizing function in a 91 year old patient with concurrent invasive and metastatic SCC involving two rays and Dupuytren’s contracture of an involved finger. The goals were palliative with overall improvement in hand function. Similar treatment can be considered for patients with primary carcinomas of the hand in the setting of an already functionally compromised digit.

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THE RELATIONSHIP BETWEEN SOLITARY PULMONARY MICRONODULES AT PRESENTATION AND SURVIVAL IN YOUNG SARCOMA PATIENTS

Cara Cipriano, MD; Lauren Brockman, BS; Jeff Ording, BS; Jason Romancik, BS; Curt Ginder, BS; Robert Hartemaer, BS; Joel Krier, MD; Steven Gitelis, MD; Paul Kent, MD

Introduction: Differentiation between localized and metastatic sarcoma is critical for determining both management and prognosis; therefore, patients typically undergo chest Computed Tomography (CT) to screen for pulmonary metastases at the time of initial diagnosis. While there is agreement that multiple and/or large pulmonary nodules >1cm warrant biopsy, the significance of isolated micronodules identified on high resolution CT remains unclear. Our purpose, therefore, was to evaluate the clinical course and 4 year survival of young sarcoma patients with subcentimeter pulmonary nodules at time of diagnosis.

Methods: The study population included 203 consecutive patients <50 years of age treated for bone or soft-tissue sarcoma at our institution over a 10 year period. 69 were excluded for missing CT data and 13 for non-pulmonary metastatic disease at presentation, leaving 121 available for study. Reports from chest CT scans performed at time of diagnosis were reviewed to identify patients with subcentimeter pulmonary nodules but no other indication of metastatic disease; this population was then further divided into patients with no nodules (Group 1); a single nodule <5mm (Group 2); >1 nodules <5mm (Group 3); and 1 or more nodules ≥5mm (Group 4). All patients were treated according to standard chemotherapeutic and surgical protocols, and 15 (12 Group 1-3, 3 Group 4) had biopsies of suspicious nodules at diagnosis. All patients were followed for pulmonary and/or systemic oncologic progression and survival.

Results: 121 patients had complete data sets with a mean follow up of 47.2 months (range 0-110 months). 45 patients presented with no nodules on CT (Group 1); 25 had a single nodule <5mm (Group 2); 37 had >1 nodules <5mm (Group 3); and 14 had 1 or more nodules ≥5mm (Group 4). There was no statistically significant difference between Groups 1-4 with respect to age or histology. At both mean follow-up and end of the study, the overall survival among Groups 1-3 was not significantly different; however, there was a significant difference between survival of Groups 1-3 compared to Group 4 at both time points. In addition, those with histologically proven malignant nodules in Groups 1-3 demonstrated statistically better survival than those with malignant nodules in Group 4 (Figure 1).

Conclusions: The data from our cohort of young sarcoma patients suggests that solitary <5mm pulmonary micronodules detected on high resolution CT, even with malignant histology, do not adversely affect survival at mean 47.2 month follow up.
RECONSTRUCTION OF THE DIGIT AFTER LOW GRADE CHONDROSARCOMA IS A Viable ALTERNATIVE WITH GOOD FUNCTIONAL OUTCOMES: A SALVAGE PROCEDURE AFTER RESECTION OF MIDDLE PHALANX OF FIFTH DIGIT IN LIEU OF RAY AMPUTATION

Anna A. Kulidjian, MD; Reid Abrams

Background: Ray resections in a setting of a pathologic fracture from low grade chondrosarcoma in digits are a mainstay of treatment. These are well tolerated and have excellent functional outcomes. In some cases, however, patients may prefer to salvage the digit. In contrast to developments in endoprosthetic reconstruction for long bones, options for hand surgery are limited. We present a case of a pianist with a pathologic fracture of a middle phalanx of the fifth digit from low grade chondrosarcoma, who had resection of the middle phalanx with iliac crest autograft reconstruction.

Methods: Eradication of the tumor is the main goal of the surgery. If the grade and imaging studies allow a surgeon to resect the involved tissues without sacrifice to oncologic outcomes, few options remain if the tumor involves the phalanges. Poor bone quality due to disuse osteopenia make it difficult to secure segmental defects in the digits to allow a meaningful functional recovery. Neurovascular preservation is the key, and hence meticulous and well planned surgical technique is paramount. We present a salvage technique utilizing a dorsal approach with bicortical iliac crest graft fashioned to allow fusion in a functional finger flexion. Surgical techniques for fusion to distal and proximal phalanx are presented in the setting of osteopenia. We believe this technique provides a reasonable alternative to ray amputation in the setting where preservation of the finger is important to the patient. The surgical technique and postoperative treatment are described.

Results: Intercalary defects in phalanges post tumor resection can be reconstructed with iliac crest autograft with meaningful functional results. This may be a preferred alternative in patient who would not tolerate a ray resection.
PERCUTAENOUS CRYOABLATION A NOVEL METHOD FOR RAPID PALLIATION FOR SEVERELY SYMPTOMATIC OSTEOID OSTEOMA PATIENTS

Thad J. Dean, DO; David K. Monson, MD; Roger S.H. Williams, DO; Douglas Yim, MD

Objectives: The purpose of this study was to evaluate the safety, efficacy and utility in rapid palliation following CT-guided percutaneous cryoablation in opioid requiring severely symptomatic osteoid osteoma patients.

Methods: Over a 12-month period (11/2011-11/2012), four patients mean age of 17.5 ± 8.2 years old underwent CT-guided percutaneous cryoablation for painful osteoid osteomas. Lesion locations included two mid shaft tibia, one lesser trochanter and one femoral neck. Three procedures were performed under general anesthesia and one patient with moderate sedation. Under CT guidance a 15-gauge bone drill was used to core the approach. Subsequently, a 17-gauge cryoablation probe was placed within the lesion and ablation performed. Each ablation included two 10-minute freezes interspaced by an 8-minute thaw cycle. Post ablation CT was performed for evaluation of hazy disruption of lesion nidus. Follow-up was performed to assess clinical outcome for a minimum of 1 month. A visual analog scale (VAS) and pain episodes requiring oral opioids per week (PEOA), 24-hour post-ablation and 1 month post-ablation pain scales were assessed.

Results: Cryoablation was clinically successful for all patients. No fractures or other adverse events were observed. Complete (100%) pain relief was observed in all patients at one month. Mean VAS were 6.25 ± 1.2 @ pre-procedure, 1.0 ± 0.82 @ 24-hours post procedure and 0.25 ± 0.50 @ 1 month follow-up. The PEOA pre procedure was 5.8± 1.71 and at 0 @ 1 month post procedure. All patients were allowed return to unrestricted activity within 10 days after the procedure without incident.

Conclusions: Percutaneous image-guided cryoablation is a safe, effective and rapidly palliating method for severely symptomatic patients with osteoid osteoma.

Figure 1.
16 year old male with severely symptomatic OO in the mid-tibia. Cryoablation probe was placed in the central aspect of the nidus.

Disclosures listed in handout
OUTCOMES FOLLOWING SURGICAL MANAGEMENT OF METASTATIC BONE DISEASE: A SYSTEMATIC REVIEW

Thomas J. Wood, MD; Antonella Racano, MSc; Herman Yeung, MD(c); Forough Farrokhyar, PhD; Michelle Ghert, MD, FRCSC; Benjamin Deheshi, MD, MSc, FRCSC

Background: Metastatic Bone Disease (MBD) is the most common malignant process affecting the skeleton. Surgery is typically reserved for lesions with the highest risk of fracture, or in patients with intractable pain and functional disability. However, MBD patients are generally deconditioned, potentially immunocompromised and at high risk of peri-operative complications. Therefore, the risks associated with surgery may outweigh the benefits of improved pain and/or function, which are not guaranteed.

Questions/Purpose: The purpose of this study was to conduct a systematic review of the literature to determine if patients exhibit improved pain or function following surgical management of metastases to the long bones and or pelvis/acetabulum.

Methods: MEDLINE®, EMBASE®, and all Evidence Based Medicine (EBM) reviews, including the Cochrane Library, were systematically searched for clinical studies that reported functional outcomes following the surgical management of metastases to the long bones or pelvis. The initial database search yielded 2314 studies. Eligibility of each study was assessed by two independent reviewers based on inclusion and exclusion criteria set a priori. Forty-eight studies were included in the final analysis. Methodological quality was assessed using the MINORS scale. Studies were categorized by anatomic location, including humerus, femur and pelvis/acetabulum.

Results: Following surgical management of metastatic lesions to the humerus, the weighted mean for pain improvement was 0.95 (95% CI, 0.90-0.98) (I² = 0%, p=.52) and functional improvement was 0.93 (95% CI, 0.88-0.97) (I² = 17.2%, p=.27). The weighted mean for pain improvement following surgical fixation of the femur was 0.93 (95% CI, 0.88-0.96) (I² = 57.5%, p=.0006) and functional improvement was 0.87 (95% CI, 0.80-0.93) (I² = 78%, p=<0.0001). Pain improvement following surgical fixation of the pelvis/acetabulum was 0.97 (95% CI, 0.93-0.99) (I² = 0%, p=.71) and functional improvement was 0.94 (95% CI, 0.86-0.99) (I² = 56.9%, p=.023).

Conclusions: Current evidence (Level IV) suggests a benefit for the surgical management of bone metastases in relieving pain and improving function, specifically in the humerus, femur and pelvis/acetabulum. Future studies should be directed at correctly identifying which patient characteristics are conducive to optimizing functional and quality of life outcomes following the surgical management of MBD.
Objectives: The treatment options for patients with Giant Cell Tumor of bone are varied. The goals of treatment are to obtain local control while maximizing function. For especially large tumors with inadequate bone stock for intralesional curettage-resection, joint resection with allograft or endoprosthetic reconstruction has been recommended. The objective of our study was to review our experience with performing a two-stage joint preserving intralesional surgery based on sound biological principles in lieu of joint resection and reconstruction for such tumors.

Materials and methods: From 2000 to 2011, four patients with large subchondral giant cell tumors, judged to have inadequate bone stock to be treated with conventional intralesional curettage-resection, were identified. Average patient age at initial evaluation was 41.5 years old (22 to 55 years). All patients were followed for a minimum of two years: (average 7 years; range 2-13 years). There were two tumors of the distal radius and one each in the distal femur and distal tibia. All patients were treated with a two-stage procedure. Stage one consisted of mini open biopsy and suction removal of tumor or minimal curettage without extended curettage. No attempt was made to remove all tumor. Between the first and second stage procedure new bone formation was observed creating a more manageable tumor that was amenable intralesional surgery without joint sacrifice. After a period of time in which new bone formation occurred a second stage procedure was performed including extended curettage, use of a high speed burr use of a physical or chemical adjuvant, bone grafting the subchondral bone and cementation. Patient outcomes were assessed using modified Hospital for Special Surgery (HSS) and Musculoskeletal Tumor Society (MSTS) scores for the distal femur, The Disabilities of Arm, Shoulder and Hand (DASH) scores for the distal radius and Foot and Ankle Outcomes Instrument (FAOI) for the distal tibia. Range of motion as well as strength was assessed in all patients. Follow up radiographs were attained at all visits to assess for recurrence.

Results: One patient required one additional procedure nine weeks after the second-stage consisting of manipulation under anesthesia, lysis of adhesions, quadricepsplasty and lateral retinacular release and removal of excess cement in the patellofemoral joint. At final follow up, active range of motion was noted to be 0-130 degrees. Strength with knee flexion and extension was full compared to the contralateral side. No recurrence was noted upon radiographic evaluation. For the two patients with lesions in the distal radius both patients maintained full pronation and supination. One maintained full flexion and extension while the other lacked 5 degrees of extension and 20 degrees of flexion. Both patients had full grip strength in comparison to the contralateral side. The patient with the distal tibial lesion remains free of disease and has maintained good function.

There was one local recurrence that was successfully treated with repeat second stage procedure.

Conclusion: Local control without joint sacrifice was achieved in all patients. A two stage approach to patients with GCT of bone with inadequate bone stock to undergo intralesional resection and in whom joint resection in considered, provided a mechanism to allow partial removal of the tumor and shifting the balance of bone destruction to favor bone production and allow joint preservation surgery at the time of the second stage surgery. While the ideal time between the first and second stage of surgery has not been defined, all patients were spared joint sacrificing procedures.
SYMPHYSIOTOMY: AN OLD TECHNIQUE APPLIED IN A NOVEL WAY FOR STAGED RESECTION OF MASSIVE INTRAPELVIC SACRAL TUMORS
Matthew Colman, MD; Kevin A. Raskin, MD; Joseph Schwab, MD; Francis J. Hornicek, MD; John Mullen, MD

Background: Symphysiotomy was described over two centuries ago and is still used in some non-western countries for pelvic volume expansion in obstetric cephalo-pelvic disproportion. Symphysiotomy may also be a useful maneuver when attempting en-bloc resection of large intrapelvic tumors which occupy nearly the entire transverse volume of the pelvis.

Question: Can symphysiotomy be used safely to facilitate margin-negative resections of massive intrapelvic sarcoma?

Methods: We describe a technique for staged resection of sacral tumors with large intrapelvic extension. This technique typically involves three stages. A complete symphysiotomy is performed with a Gigli saw or electrocautery during stage one, along with an anterior transperitoneal approach involving pelvic viscera mobilization, posterior iliac vessel ligation, and anterior sacral and iliac ostetomies. Stage two is performed prone from a posterior approach, where the anterior osteotomies are completed. During this stage, the pelvic volume is expanded using manual pressure or an AO distractor to facilitate tumor removal en bloc. A third stage involves anterior and posterior approaches for fixed-angle symphyseal plating, rectus abdominus flap harvest, and complex posterior closure.

Results: Two patients underwent this procedure in a recent five-year period. Histology of the tumor was malignant peripheral nerve sheath tumor (MPNST) for one patient and sacral chordoma for the other. The mean maximum coronal diameter of the intrapelvic tumor volume was 11.1 cm, compared to a mean interspinous distance of 9.1 cm. Margin status for both procedures was R0. The patient with MPNST recurred locally at 8 months and underwent revision resection. The patient with chordoma developed metastatic disease and succumbed at 8 months postoperatively.

Conclusions: This series describes a novel maneuver that may facilitate en-bloc removal of the largest intrapelvic sacral tumors with negative margins. These tumors are associated with high complication and local recurrence rates regardless of the technique employed.

Level of Evidence: IV
SCREW AND GLUE – PERCUTANEOUS STABILIZATION OF METASTATIC DISEASE OF THE ACETABULUM

J.C. Neilson, MD; David King, MD; Sean Tutton, MD

Traditional treatments for painful acetabular bone destruction from metastatic cancer primarily involve two general treatment options; 1) medical modalities (radiation, chemotherapy) and limited weight bearing creating limited mobility or 2) Complex acetabular reconstruction associated with a variety of surgical and medical complications. In an effort to mobilize patients earlier and improve pain control without major surgery we have developed a protocol involving a musculoskeletal oncologist and an interventional radiologist using a combination of fluoroscopic and computerized tomographic (CT) guidance to place cannulated screws percutaneously through standard and non-standard pelvic corridors. PMMA is used to augment fixation, fill contained and uncontained cavitary defects and provide increased strength to weakened sub-chondral acetabular bone.

This retrospective case series reviews the early results of nine patients treated with percutaneous screw fixation and polymethyl methacrylate (PMMA) augmentation for impending or non-displaced pathologic fractures of the acetabulum. Patients were identified from institutional databases. Inclusion criteria included; age greater than 18, metastatic cancer, painful acetabular lesions causing significant impairment in function or decreased quality of life. Patients were excluded if their fracture(s) were displaced or if they did not have a native acetabulum.

Nine patients were identified and reviewed. Metastatic cancers included lung, esophageal, renal, melanoma, leiomyosarcoma, malignant peripheral nerve sheath tumor, breast, and neuroendocrine. Eight patients had one or more supra-acetabular screws placed and three patients had a screw placed in the superior pubic ramus. Two patients had metastatic femoral lesions that were stabilized during the same admission. All but one patient were WBAT after the procedure. One patient developed a mild protrusio, but did not require conversion to open acetabular reconstruction. Length of follow-up averaged approximately one month. Average improvement in MSTS score was 11/30 points with an average 3/5 point improvement in pain.

All patients improved at least one level of independence by two weeks post op. All walker dependent patients ambulated short distances independently and all wheelchair depended patients were able to walk short distances with a walker. Due to the percutaneous nature of the procedure patients returned to radiation and chemotherapy as early as one day post op. Five patients underwent at least one other ablative procedure including; embolization, cryoablation or radio frequency ablation. Complications included; one elderly patient with post-procedure delirium, 2 patients with asymptomatic foveal cement extrusion, one patient with cement extrusion along the medial wall of the acetabulum, and two patients died within 3 months of the procedure due to progression of their metastatic cancer.

Percutaneous acetabular stabilization improves the quality of life in patients who often have a limited lifespan with a low risk of failure and symptomatic complications.
Soft-tissue sarcomas account for less than one percent of all primary cancer diagnoses. Most sarcomas are treated with surgical resection in which a margin of normal tissue is removed along with the tumor. Wide margins and radiation have been shown to decrease the risk of local recurrence. Definitive closure may entail complicated reconstructive procedures which may need to be revised or re-radiated in the setting of positive margins.

In some surgical situations such as re-excision of non-oncologically excised sarcomas, tumor adjacent to essential structures (ie. major vessels and nerves) and tumors with infiltrative margins on MRI are more likely to have positive margins. Therefore, there is a significant risk of contamination of a complex soft tissue reconstruction. In order to ensure adequate margin resection without the need for re-operation on a reconstructed extremity, musculoskeletal oncologists, pathologists, and plastic surgeons at our institution have developed a protocol for the staged reconstruction of the resected soft tissue bed. After wide excision or re-excision of a sarcoma believed to be at high risk for positive margins the resection bed is steriley covered using NPWT. During a 1-7 day period post-resection a musculoskeletal pathologist assesses the tumor margins from the resected specimen rather than perform a more limited analysis of intra-operative margins. If margins are positive the sarcoma is re-excised and re-temporization with NPWT. When margins are negative soft tissue coverage is performed by plastic surgery.

This retrospective review selected subjects from prospectively collected institutional database over a 10 year period and were screened for the following inclusion criteria: above the age of 18 years, histologic diagnosis of a soft tissue sarcoma, participation in a staged reconstruction with NPWT, and minimum follow up of 6 months. Outcome measures include; rate of re-resection, wound healing, local recurrence, infection rates, secondary surgeries, and complications.

The patient population contained at total of 36 patients, 19 male (53%) and 17 female (47%) with an average age of 59 years old and average follow up of 15 months. Twenty seven patients were non-oncologically excised at an outside institution. Of the 36 patients, four patients had positive margins after the first resection (11%). One patient had a false positive intraoperative margin. Two patients had instances of local recurrence (6%). Four patients had post-reconstructive debridement of the flap. Two patients also required flap debulkings within six months of surgery. There were no infections.

From this study it appears that staged reconstruction of soft tissue sarcoma resections provides an excellent procedure by which to temporize and evaluate the margins of the soft tissue bed, thereby limiting contamination of complex flap reconstruction or the need for additional post operative radiation, while potentially minimizing local recurrence. This method shows great promise as an effective approach to soft tissue sarcoma resections at higher risk for positive margins.
Patient Chart

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of patients</td>
<td>36</td>
</tr>
<tr>
<td>Male</td>
<td>19 (53%)</td>
</tr>
<tr>
<td>Female</td>
<td>17 (47%)</td>
</tr>
<tr>
<td>Average Age</td>
<td>59</td>
</tr>
<tr>
<td>Age (min)</td>
<td>20</td>
</tr>
<tr>
<td>Age (max)</td>
<td>87</td>
</tr>
<tr>
<td>Tumor Grade (AJCC 2010)</td>
<td></td>
</tr>
<tr>
<td>G1</td>
<td>8 (22%)</td>
</tr>
<tr>
<td>G2</td>
<td>2 (6%)</td>
</tr>
<tr>
<td>G3</td>
<td>26 (72%)</td>
</tr>
<tr>
<td>Tumor Stage</td>
<td></td>
</tr>
<tr>
<td>IA</td>
<td>6 (16%)</td>
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<tr>
<td>IB</td>
<td>2 (6%)</td>
</tr>
<tr>
<td>IIA</td>
<td>9 (25%)</td>
</tr>
<tr>
<td>IIB</td>
<td>1 (3%)</td>
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<tr>
<td>III</td>
<td>14 (39%)</td>
</tr>
<tr>
<td>IV</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>Patients with positive margins</td>
<td>4 (11%)</td>
</tr>
<tr>
<td>Number of patients with previous non-oncologic excisions</td>
<td>27 (75%)</td>
</tr>
<tr>
<td>Local Recurrence</td>
<td>2 (6%)</td>
</tr>
</tbody>
</table>
Innovations in Orthopaedic Oncologic Nursing and Allied Disciplines from A to Z

8:00 am  Welcome
Brandi Nunn, RN, BSN, Nurse Planner
Carol Stevenson, RN, Content Expert
Richard J. O’Donnell, MD, Physician Planner
Rosanna Wustrack, MD, Session Moderator

8:00 am  IPOP: And Other Advances in Prosthetic Care for Amputees Important for Partners in Care
Matthew Garibaldi, CPO

8:45 am  OPRA: Overview of Transdermal Osseointegration for Amputees
Örjan Berlin, MD

9:30 am  OPRA: Care of the Surgical Patient
Örjan Berlin, MD

10:15 am  Morning Break

10:30 am  ILP: Overview of Transdermal Osseointegration for Amputees
Horst Aschoff, MD

11:15 am  ILP: Care of the Surgical Patient
Munjed Al Muderis, MD

12:00 pm  Lunch

1:00 pm  CPS: Compressive Osseointegration for Endoprosthetic Reconstruction: Nursing and Allied Health Considerations
Rosanna L. Wustrack, MD

1:45 pm  RFA: And Other Advances in Musculoskeletal Radiology Relevant to Nursing and Allied Health Care
Thomas M. Link, MD

2:30 pm  IHC: Update on Musculoskeletal Pathology: What the Nurse and Health Care Team Needs to Know
Andrew E. Horvai, MD, PhD

3:15 pm  Afternoon Break

3:30 pm  IORT: And Other Advances in Radiation Therapy for Sarcomas for Health Care Team Members
Alexander R. Gottschalk, MD, PhD

4:15 pm  IA: Nursing and Allied Health Update on Chemotherapy for Sarcomas
Kristen N. Ganjoo, MD; Victor M. Villalobos, MD

5:00 pm  Conclusion
Rosanna L. Wustrack, MD, Session Moderator

* Indicates the FDA has not cleared this drug and/or medical device for the use described in this presentation (i.e., the drug or medical device is being discussed for an “off label” use).
* FDA information not available at the time of printing. For full information, refer to inside back cover.
Please print legibly.

Name (required for CME Credits)

Email address (optional)

This educational meeting (Check all that apply):

☐ Confirmed that my knowledge in this subject area is up to date
☐ Presented me with new knowledge on the topic
☐ Presented me with new knowledge directly applicable to my practice
☐ Will stimulate me to gain further information on the topic
☐ None of the above

What is your overall rating of the effectiveness of this meeting on your learning and application of knowledge to your practice?

Poor Marginal Fair Good Very Good Excellent

What suggestions do you have for improving this meeting?
EVALUATION (cont.)

Overall, how well did this session meet the following learning objectives?

- Evaluate treatment approaches and their application to your practice for current controversies
  - Aseptic, septic, and other complications
  - Basic and translational research
  - Osseointegration, prosthetics, and rehabilitation
  - Targeted therapy
  - Humanitarian and collaborative efforts
  - Differential diagnosis for bone and soft tissue tumors and tumor-like conditions

- Answer patient questions regarding different treatment options
  - Aseptic, septic, and other complications
  - Basic and translational research
  - Osseointegration, prosthetics, and rehabilitation
  - Targeted therapy
  - Humanitarian and collaborative efforts
  - Differential diagnosis for bone and soft tissue tumors and tumor-like conditions

- Identify your approach to treating …
  - Aseptic, septic, and other complications
  - Basic and translational research
  - Osseointegration, prosthetics, and rehabilitation
  - Targeted therapy
  - Humanitarian and collaborative efforts
  - Differential diagnosis for bone and soft tissue tumors and tumor-like conditions

- Describe potential complications and surgical approaches to avoid and treat …
  - Aseptic, septic, and other complications
  - Basic and translational research
  - Osseointegration, prosthetics, and rehabilitation
  - Targeted therapy
  - Humanitarian and collaborative efforts
  - Differential diagnosis for bone and soft tissue tumors and tumor-like conditions
**EVALUATION**

- How well did this session meet your current learning needs in this content area?

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<th>Met Objective</th>
<th>Exceeded Objective</th>
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<tr>
<td>Young Investigator Award Winners</td>
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- To what extent will you implement knowledge gained into your practice within the next year?

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<tr>
<th>Content Area</th>
<th>Not at All</th>
<th>Slight</th>
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EVALUATION (cont.)

Please Comment:

1. Which presentations were of most interest to you?

________________________________________________________________________

2. What topics or symposia were not addressed that you would like to have had presented?

________________________________________________________________________

3. Based on the 2013 program content, will you try to attend the 2014 MSTS Annual Meeting? 

☐ Yes  ☐ No

4. Additional comments and suggestions:

________________________________________________________________________

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Please return to the MSTS Registration Desk (Grand Ballroom Foyer) by Saturday, October 5, or mail to:

Musculoskeletal Tumor Society
6300 N. River Road, Suite 727
Rosemont, IL 60018 USA

or fax to: (847) 823–0536

THIS IS ESSENTIAL FOR CME CREDITS
Please critique the presentations taking into consideration the following items:

- Was the level of information appropriate to the audience?
- Were the presentations of interest and the information current?

Friday, October 4, 2013

8:00 am  IPOP: And Other Advances in Prosthetic Care for Amputees Important for Partners in Care  
Matthew Garibaldi, CPO

8:45 am  OPRA: Overview of Transdermal Osseointegration for Amputees  
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Kristen N. Ganjoo, MD; Victor M. Villalobos, MD
EVALUATION (cont.)

Please Comment:

1. Which presentations were of most interest to you?

2. The purpose of this session is to increase competence and improve nursing practice in orthopaedic oncologic care. Do you believe the session met this goal? Why or why not?

Additional comments and suggestions:

3. Based on the 2013 program content, will you try to attend the Future Sessions?  □ Yes  □ No

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Rosemont, IL 60018 USA

or fax to: (847) 823–0536
Please join us

2014 MSTS Annual Meeting

Omni Houston Hotel
Houston, Texas
October 9–11, 2014

MSTS Specialty Day
Morial Convention Center
New Orleans, Louisiana
March 15, 2014

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