Acetabular Development after Non-Invasive, Expandable Endoprosthetic Reconstruction with Hip Hemiarthroplasty

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Background

The proximal femur is a common anatomic location for malignant bone tumors, often necessitating resection and reconstruction with either allografts, allograft prosthetic composites, or endoprostheses. In pediatric patients, due to remaining acetabular growth, skeletally immature patients are susceptible to acetabular dysplasia and subsequent symptomatic subluxation of endoprosthetic replacements. In the largest series of expandable endoprostheses by Tsuda et al1, 77% of patients developed symptomatic subluxation of the hip. Unfortunately this complication often requires conversion to a total hip arthroplasty.

It has previously been shown that acetabular development, specifically acetabular depth and the hemispherical shape, is dependent upon appositional growth which requires the presence of a spherical femoral head. Manoso2 et al demonstrated pediatric patients develop lateral translation, decreased superior coverage, elevation of the hip center of rotation, and shallow acetabulum. Specific risk factors were shown to include young age and proximal femoral replacements in comparison to total femoral replacements. In addition, van Kampen3 et al showed that attempts to provide improved femoral head coverage with acetabular osteotomies were unsuccessful.

Unfortunately, these studies included a heterogeneous population with respect to reconstructive techniques and did not include non-invasive expandable prostheses. Thus acetabular development following endoprosthetic reconstruction with a non-invasive expandable prosthesis with a hip hemiarthroplasty has yet to be characterized. Although some risk factors for symptomatic hip subluxation have been identified, there is an overall paucity of data in the literature.

Methods

Pediatric patients who underwent a proximal or total femoral resection and endoprosthetic replacement with a hemiarthroplasty for primary bone sarcomas between 2007 and 2018 at our institution (N = 8) were reviewed after receiving IRB approval. Patient demographics, tumor characteristics, and implant designs were noted. Two reviewers (JA and ZB) performed independent imaging reviews.

- Six patients had Ewing sarcoma and two patients had osteosarcoma
- Proximal femoral anatomy and acetabular parameters were assessed on pre-operative radiographs
- Acetabular index, center-edge angle, medial and superior joint space, teardrop to superior prosthesis distance, femoral head coverage, and the ilioischial line to prosthesis distance were measured on post-operative XRs
- Presence or absence of neoacetabularization and pseudoacetabularization were noted
- Medical records were reviewed to determine the incidence of surgical complications and oncologic outcome, including survival
- Mean duration of follow-up was 47.6 (range 18.5-77.2) months, patients were censored at death or at the time of conversion to THA

Natural History of Symptomatic Subluxation

Statistical Analysis

- Patients were grouped based on whether or not they developed symptomatic subluxation of the hip requiring conversion to a total hip arthroplasty, THA (N = 3) and hemiarthroplasty (N=5)
- Patient age, implant design features, and change in radiographic parameters for acetabular development were compared between groups
- Due to the small sample size, Wilcoxon sign-rank (non-parametric) tests were performed even when data was normally distributed
- Bayesian Liner Mixed Models were utilized to determine intra- and interobserver reliability for each radiographic parameter

Results

Change in Radiographic Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hemiarthroplasty</th>
<th>Converted to THA</th>
<th>Wilcoxon p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetabular Index (degrees)</td>
<td>-0.70 (3.85 to 7.4)</td>
<td>-1.55 (1.05 to 2.75)</td>
<td>0.07</td>
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<tr>
<td>Center Edge Angle (degrees)</td>
<td>1.55 (-1.95 to 16.5)</td>
<td>2.92 (2.95 to 29.85)</td>
<td>1.00</td>
</tr>
<tr>
<td>Medial Joint Space (mm)</td>
<td>-0.12 (3.75 to 1.75)</td>
<td>-2.96 (8.00 to 5.00)</td>
<td>0.55</td>
</tr>
<tr>
<td>Superior Joint Space (mm)</td>
<td>-2.74 (5.33 to -1.25)</td>
<td>-10.02 (17.4 to -61)</td>
<td>0.037</td>
</tr>
<tr>
<td>Teardrop to Superior Prosthesis (mm)</td>
<td>4.64 (2.5 to 11.2)</td>
<td>10.4 (6.3 to 15.25)</td>
<td>0.37</td>
</tr>
<tr>
<td>% Uncovered Femoral Head</td>
<td>6.12% (-4.7 to 14.16)</td>
<td>1.57% (-16.7 to 25.45)</td>
<td>0.77</td>
</tr>
<tr>
<td>Ilioischial to Prosthesis (mm)</td>
<td>4.14 (0.05 to 6.9)</td>
<td>12.52 (4.75 to 18.9)</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Outcomes

- Complications
  - Wound Complications: 3 requiring return to OR for I&D and 1 treated with antibiotics
  - One flexion contracture requiring a quadriceps lengthening
  - One patient developed acetabular loosening after conversion to a THA

- Patient Survival
  - Mean survival of 61.0 (range 18.5-145) months; two patients died, one from secondary AML and another from metastatic osteosarcoma at 67.3 and 70.7 months, respectively
  - Implant Survival
    - 73.5% (145) patients required conversion to total hip arthroplasty at a mean 57.3 (range 51.2-80.9) months
    - 5 revisions for maximal expansion were performed at a mean 48.8 months

Conclusions

- Symptomatic subluxation of the hip is a common, but not universal outcome of hip hemiarthroplasty in pediatric patients
- Younger age is associated with a higher risk of symptomatic subluxation, likely due to remaining acetabular development in this population
- Larger studies a required clearly identify additional implant or patient related factors as well as radiographic markers that can be predictive of failure