

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.

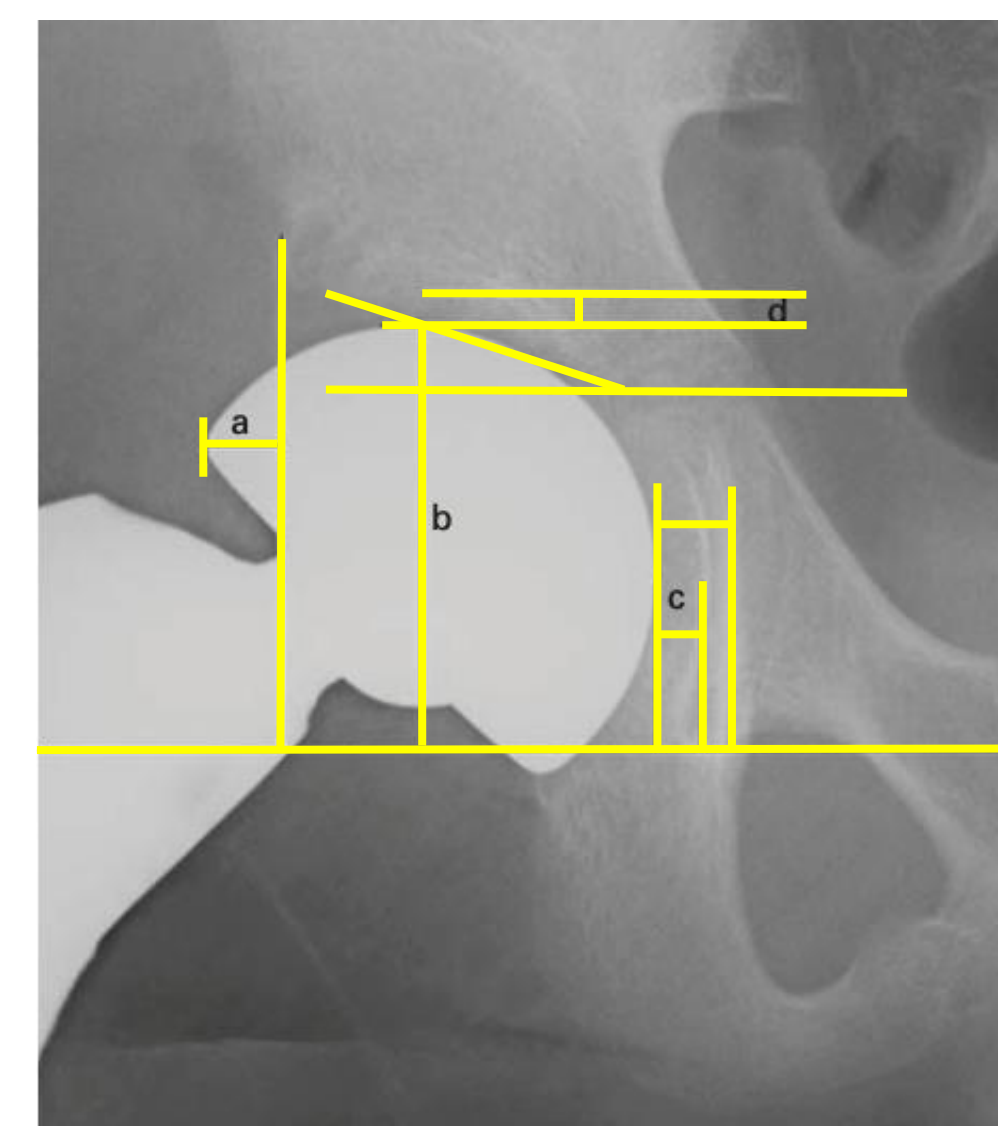
It has previously been shown that acetabular development, specifically acetabular depth and the hemispherical shape, is dependent upon appositional growth which requires the presence of a spherical femoral head. Manoso² et al demonstrated pediatric patients develop lateral translation, decreased superior coverage, elevation of the hip center of rotation, and shallow acetabuli. 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

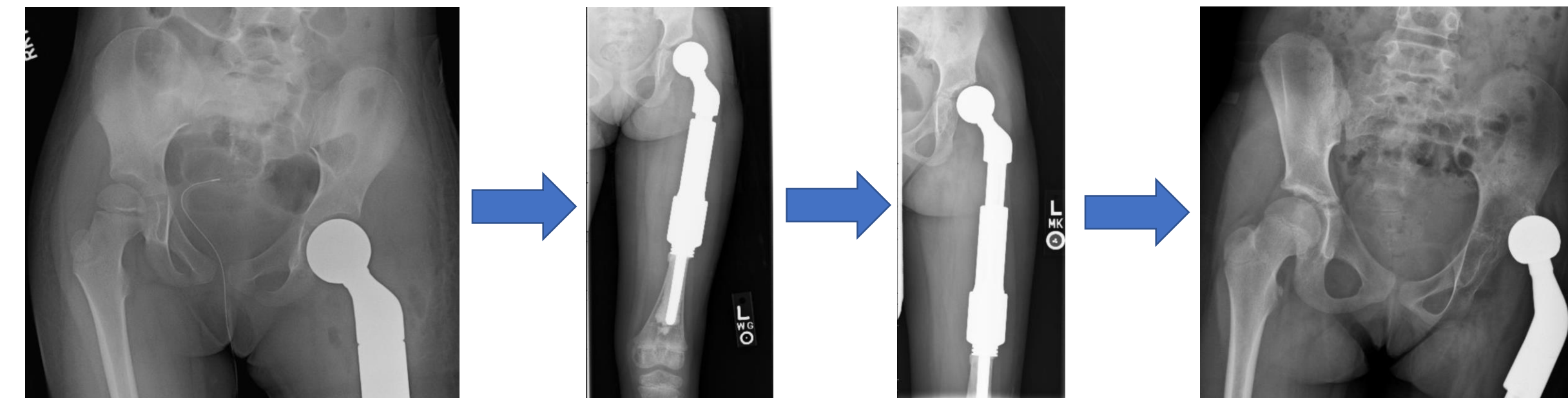
Pediatric patients who underwent a proximal or total femoral resection and endoprosthetic replacement with a hemiarthroplasty for primary bone sarcomas between 2007 and 2018 at our institution (N = 8) were reviewed after receiving IRB approval. Patient demographics, tumor characteristics, and implant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



Measured radiographic parameters, adapted from Manoso et al², additional measures include the ilioischial to prosthesis distance and the acetabular index.

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

Patient & Surgical Factors	Hemiarthroplasty	Converted to THA	Wilcoxon p-value
Age	10.5 (7.2 to 14.8)	5.7 (4.4 to 7.0)	0.037
Femoral Head Size (mm)	37.8 (32 to 45)	32	0.16
Implant Neck-Shaft Angle (NSA)	131.4 (126 to 135)	132	1
Difference between Implant and Native NSA	-5.7 (-16.9 to 4.1)	-9.7 (-11.65 to -7.7)	0.56
Implant Offset (mm)	32.6 (28 to 45)	29.7 (25 to 34)	1
Difference between Implant and Native Offset	0.95 (-3.65 to 6.45)	2.0 (0.5 to 3.45)	0.56
Resection Length	207 (165 to 330)	190 (170 to 220)	0.65

- Among patient, implant, and surgical factors, only **YOUNGER AGE** was associated with a higher risk of requiring conversion to a total hip arthroplasty due to symptomatic hip subluxation

Change in Radiographic Measures	Hemiarthroplasty	Converted to THA	Wilcoxon p-value
Acetabular Index (degrees)	2.58 (0.45 to 5.4)	3.55 (-1.05 to 7.05)	0.77
Center Edge Angle (degrees)	1.55 (-11.95 to 16.5)	0.10 (-29.75 to 29.85)	1
Medial Joint Space (mm)	-0.12 (-3.5 to 1.75)	-2.95 (-8.0 to 5.00)	0.55
Superior Joint Space (mm)	-2.74 (-5.3 to -1.25)	-10.02 (-17.4 to -6.1)	0.037
Teardrop to Superior Prosthesis (mm)	4.64 (-2.5 to 11.2)	10.4 (6.3 to 15.25)	0.37
% Uncovered Femoral Head	6.12% (-4.7 to 14.6)	1.57% (-16.7 to 25.45)	0.77
Ilioischial to Prosthesis (mm)	4.14 (0.05 to 6.9)	12.52 (4.75 to 18.9)	0.23

- There were no statistically significant differences among radiographic parameters between groups, except the superior joint space
- There were trends towards significance for teardrop to superior prosthesis and the ilioischial to prosthesis distances

Change in Radiographic Parameters

Line graphs for THA and No THA groups demonstrating the change in the mean value for each measurement during follow-up.



Outcomes

Complications

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

Patient Survival

- Mean survival of 81.0 (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

- 37.5% (3/8) patients required conversion to total hip arthroplasty at a mean 57.3 (range 31.2-80.9) 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 are required clearly identify additional implant or patient related factors as well as radiographic markers that can be predictive of failure