5.8 Squeaking in a Ceramic on Ceramic Total Hip

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Introduction

Three causes of squeaking have been described in the literature. In one case squeaking was thought to be due to a mismatch material wear couple, zirconia on alumina [1]. Another case involved a Biolox ceramic head which had worn through a 3 millimeter (mm) ultra high molecular weight polyethylene (UHMWPE) liner [2]. Three squeaking cases were reported in a retrieval study of ˝AML Plus˝ stems and ˝ACS˝ polyethylene liners. The metal heads were found to be articulating with the acetabular metal backings [3]. Garino has observed squeaking in a case where a 28 mm ceramic head was paired with a 32 mm inner diameter ceramic liner (J. Garino, personal communication 2002). Heros reported squeaking in two cases where a 32 mm ceramic head was paired with a 28 mm inner diameter ceramic liner (R. Heros, personal communication, 2002). The common finding in all cases was two hard surfaces coming into contact. We were unable to find a case in the literature implicating polyethylene as a source of squeaking.

We encountered squeaking in a patient with an alumina ceramic on ceramic hip arthroplasty. The squeaking was audible from across the room and caused her to seek treatment. In this report we present indications for revision surgery, findings at surgery, and discuss ways to minimize impingement and squeaking.

Case Report

A 54 year old female with rheumatoid arthritis underwent primary cementless total hip arthroplasty in March 1999. The stem and 50 mm O.D. cup were made of Ti-6A1-4V (Encore, Austin, Texas). The head and liner were alumina Biolox forte (Ceramtec Inc). The alumina head diameter was 28 mm with a -3.5 mm neck length.

Painless squeaking was noted six months postoperatively with normal ambulation. Two years after primary surgery radiographs demonstrated a notch on the posterior aspect of the neck of the femoral component (Fig. 1). This finding coupled with persistent squeaking were the indications for revision in April 2002.

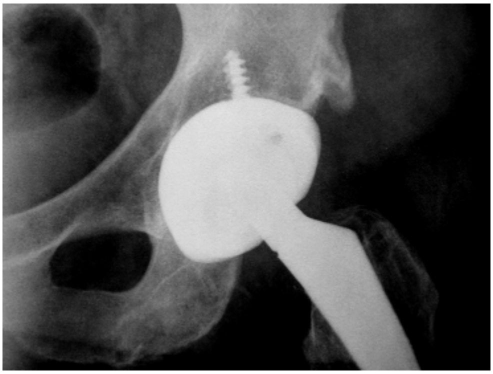

Figure 1:
Preoperative radiographs showing notching of the femoral neck.

At revision surgery, metal staining was noted in the surrounding soft tissues. The femoral neck had two distinct notches about 1 mm wide and deep, extending 10 mm and 14 mm transversely around the femoral neck (Fig. 2). The elevated posterior-rim of the metal-backed cup had also been partially destroyed by impingement and abrasion with the femoral neck. The cup and stem appeared to be in acceptable position and were well fixed. The metal shell and stem were retained and a CoCr head with a longer neck and UHMWPE liner were placed.

Figure 2:
Posterior aspect of titanium femoral neck with two notches. Titanium acetabular shell with a portion of the elevated metal rim worn away.

To avoid continued impingement, the elevated metal "protective" rim was removed along 30 percent of the circumference of the metal shell with a high-speed burr. The hip was stable without impingement after the modifications to the metal-backing and postoperatively the squeaking had resolved.

Six weeks postoperatively the patient dislocated her hip while stretching in bed. She underwent closed reduction and was given a hip abduction brace. One week later she again dislocated her hip, this time while climbing into the bathtub without her brace. Computerized tomography was obtained for component positioning, the inclination of the cup was 55 degrees, the planar anteversion was 30 degrees, and the femoral anteversion was 16 degrees (Fig. 3, Table 1). Open reduction of her anterior hip dislocation was performed and the components were again judged to be in acceptable position. The patient was taken through a full range of motion without impingement or dislocation and then placed in a cast postoperatively.

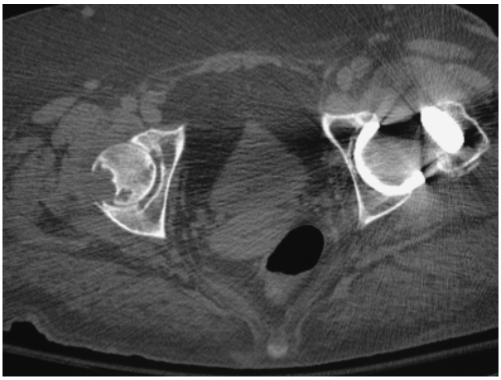

Figure 3:
Computerized tomography showing cup anteversion

	Left THA Side (Degrees)	Right Side (Degrees)
Cup Inclination	55	47
Cup Anteversion	35	28
Planar Anteversion	30	21
Femoral Anteversion	16	2

Table 1:
Comparison of Component Positioning to Patient Anatomy

Discussion

Squeaking has been reported in a case of mismatch wear couple, with zirconia on alumina [1]. Squeaking was also reported by Bono in three metal on polyethylene hips. The femoral head had penetrated the polyethylene liner and was articulating with the metal shell [3]. Simon reports squeaking in a ceramic on poly hip which was found to have articulation of the ceramic head on the metal backing [2]. The last two scenarios result in a low contact area. Pitto says that squeaking is a joint tolerance issue [4]. Garino and Heros cases of squeaking, in which the ceramic head and liner were incorrectly paired, support Pitto's statement. In this case neck-socket impingement found at revision was an obvious explanation for the squeaking. Another possibility is metal acting as a third body in ceramic articulations may cause squeaking by the same mechanism as the ceramic head that wore through the liner and articulated with the metal shell. In this mechanism impingement which creates metal wear debris is still the problem. Willmann reports the bearing surfaces were not responsible in the cases of squeaking he has encountered. Squeaking has not been seen in the Peterson Tribology Lab in ceramic articulations. Squeaking was due to cup design, positioning, or a combination of both (G. Willmann, personal communication 2002).

In this cup design an elevated metal rim was incorporated on the metal backing to "protect" the ceramic [5]. With this cup design, size of the cup (50 mm) and neck length (-3.5 mm) determine whether the neck impinges with the liner or metal backing (Table 2).

Cup Size	Range of Motion Prior to Component Impingement			
	-3.5 mm neck		+3.5 mm neck	
	Impingement on Cup	Impingement on Liner	Impingement on Cup	Impingement on Liner
48 to 50 mm	116	122	118	118
52 to 54 mm	120	124	126	122
56 to 58 mm	124	124	125	119
60 to 62 mm	127	123	129	119

Table 2:
The effect of cup size and neck length on range of motion prior to component impingement.

The metal rim decreases the range of motion 6 degrees in this case. The elevated rim on the metal-backing of cups puts the neck at risk in cases of neck-socket impingement [6, 7]. The metal rim also creates a fulcrum for subluxation and dislocation in our case (Fig. 4).

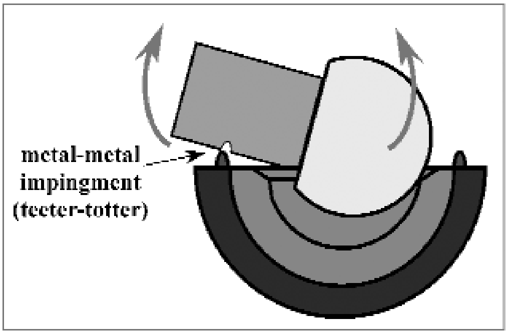

Figure 4:
Impingement teeter-tooter creates notching of the neck with subluxation

Concerns have been raised about chipping of the ceramic liner in cup designs where the metal backing does not fully cover the ceramic liner [5, 8, 9]. The clinical relevance of chipping is uncertain. Sedel reports it has not been a problem in 3,500 ceramic hip arthroplasties (L. Sedel, personal communication, 2002). Hamadouche reports no liner fractures in 18.5 years follow up using designs like the Ceraver in which the femoral neck comes in contact with the ceramic liner in cases of component impingement [10].
Rigid on rigid bearings eliminated the soft polyethylene "bumper" between the stem and cup (Fig. 5). Impingement with notching of the femoral neck has been reported with metal on metal articulations [11, 12]. In this case neck-socket

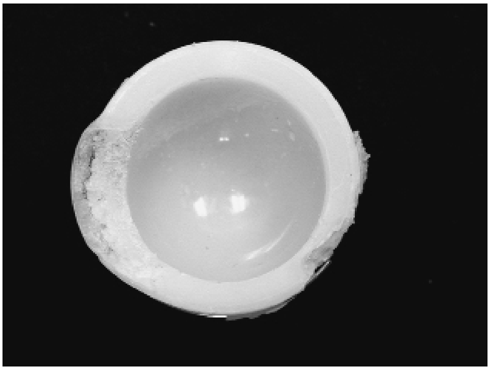

Figure 5:
Polyethylene liner acting as a bumper in cases of component impingement

impingement resulted in notching of the femoral neck, abrasion of the "protective" metal rim, and metal contamination of the ceramic bearing surfaces. At revision, the porous stem was well fixed and was left in situ. The notches on the neck pose a risk for fatigue fracture of the neck. The cup was not revised because intraoperatively the cup appeared to be in good position and the hip was stable.

Many optimal orientations have been described for cup placement [13, 14, 15, 16]. Garino suggests that more horizontal cup positioning (< 45 degrees) may be ideal and additional anteversion (20-30 degrees) may be needed in ceramic on ceramic articulations [17, 18,19]. Bader recommends 45 degrees inclination and 15 degrees of anteversion [20]. If the cup is too vertical the risk of ceramic fracture and dislocation increases [21]. The cup position by CT scan was 55 degrees of inclination and 30 degrees of planar anteversion. The cup in this case is positioned out of the "safe zone" for dislocation of 30 to 50 degrees inclination and 5 to 25 degrees of planar anteversion described by Lewinnek [16]. Experienced surgeons placed the cup out of the "safe zone" in 78 percent of the cases when positioning was determined by a navigational system [22]. This suggests that a surgeon cannot be expected to consistently place the cup in an ideal position.

In this case both the cup and stem were more anteverted then the unoperated side, which put her at risk for component impingement [23, 24]. Without the protective bumper effect of a polyethylene liner, positioning of rigid on rigid bearings may be less forgiving [7, 19]. Patients with activities and hobbies requiring the extremes of range of motion may not be good candidates for hard on hard bearing systems. These patients increase there odds of impingement especially if component positioning is suboptimal. In cases of hard on hard bearings would the need for precise positioning offset the $ 250,000 cost of a navigational system?

Conclusion

Squeaking occurred as a result of neck-socket impingement. Impingement can be minimized by component design and positioning. Omitting the elevated metal rim on the metal backing in this cup design would allow greater range of motion prior to component impingement. Rigid on rigid bearings are less forgiving then metal on polyethylene. Optimal component positioning is crucial when hard on hard bearings are used.

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