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Squeaking in Large Diameter Ceramic-on-Ceramic Bearings in Total Hip Arthroplasty

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ABSTRACT

We analyzed the results of 206 consecutive total hip arthroplasties performed using large diameter ceramic-on-ceramic bearings. At an average follow-up of 28 months, the mean Harris Hip Score improved from 54 to 92. Fifteen (7.3%) hips were noted to squeak. There was no significant difference between silent and squeaking hips with regards to age, weight, height, BMI, range of movement, femoral head diameter, leg length, and offset or center of rotation. No correlation was present between incidence of squeaking and increasing cup inclination and anteversion. 5.2% of cups orientated within Lewinnek's safe zone squeaked. No hips required revision for squeaking. While large diameter ceramic bearings may produce squeaking, our early results of surgery using large head ceramic bearings are encouraging. However, long-term follow-up is required.

In the quest to achieve better long-term clinical and functional outcome after total hip arthroplasty (THA), prosthesis and bearing designs is continually evolving. Increasing demands are being placed on THAs by higher levels of patient activity and longer life expectancy. Therefore, the ideal bearing surface would allow for recreation of natural hip motion, while displaying excellent wear properties. Large diameter femoral head bearings were designed with these needs in mind.

Conventional polyethylene is associated with wear debris-induced osteolysis [1] and hence the last decade has seen an increase in the use of hard-on-hard bearings in THA [2]. However, concerns now exist regarding the use of metal-on-metal bearings as they have associations with elevated metal ion levels and pseudotumor formation [3]. In contrast, ceramic-on-ceramic bearings have been shown to demonstrate excellent wear properties [4]. Ceramic liners are now commonly used in combination with a rough or porous coated titanium shell, with excellent rates of survival and patient satisfaction results reported [5,6]. However, some difficulties in assembling the acetabular component intra-operatively have been reported in a small number of cases [7,8].

Ceramic bearings have a number of very appealing properties, however, they can be associated with the unusual phenomenon of squeaking. The incidence of squeaking has been reported as ranging from <1 to 21% depending on how the sound is defined [9]. Squeaking has been reported as affecting the quality of life after THA, occasionally requiring revision surgery [10–12].

The DeltaMotion (developed by Finsbury Orthopaedics, Leatherhead, UK, now manufactured by DePuy, Leeds, UK) is a large diameter acetabular cup consisting of a titanium alloy shell with a pre-assembled fourth generation Ceram Tec BIOLOX delta ceramic liner. The thin ceramic liner of this component permits the use of a large femoral head, even in relatively small diameter acetabulae, thus optimizing the head–neck ratio. Potential advantages of large femoral heads over smaller diameter components include reduced risk of dislocation and impingement after THA [13]. However, unlike thin modular liners, the Delta motion does not permit the use of supplementary screws to achieve primary stability and this may be considered a potential drawback of the pre-assembled design. The aim of the study was to report the short-term clinical and radiological results of the DELTAMOTION cup, together with the incidence of post-operative squeaking.

Patient and Methods

We examined the results of 206 consecutive primary cementless THAs which were performed in 195 patients, using the DELTAMOTION ceramic bearing. Patient demographics are summarized in Table 1. The commonest indication for surgery was osteoarthritis (98.1%), followed by inflammatory arthropathy (1.5%) and acute fracture (0.5%). The data from all operations, clinical and radiological examinations were prospectively collected and stored in a database. Consent was obtained from all patients for the use of anonymous information for ongoing research projects.

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2014.09.010.

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Table 1
Summary of Cohort Demographics.

Hips	206
Patients	195
Male	77
Female	118
Mean age at surgery (years) (range)	69 (38.1–93)
Mean weight (kg) (range)	77 (46–136)
Mean height (cm) (range)	168 (152–198)

Operative Information

All the procedures took place in a single institution. The joint arthroplasty surgery was performed within a high air-flow environment, utilizing a posterior approach to the hip joint, by one of two experienced surgeons (WLW, WKW). All components were implanted utilizing a press-fit technique. The desired position of the component was 45° of abduction and 20° of anteversion. The size of femoral head used in the DELTAMOTION is dictated by the diameter of the acetabular component: a 32 mm head is used with 42 and 44 mm cups, a 36 mm head is used with 46 and 48 mm cups, a 40 mm head is used with 50 and 52 mm cups, a 44 mm head is used with 54 and 56 mm cups, and a 48 mm head is used with cups 56 mm and larger. All patients had a Securfit (Stryker Orthopaedics, Mahwah, New Jersey) cementless femoral component inserted. This stem is manufactured from a titanium alloy (Ti–6Al–4 V) with a proximal porous hydroxyapatite coating. A 12/14 titanium alloy (Ti–6Al–4 V) taper sleeve adapter was inserted onto the 12/14 trunnion of the femoral stem with the ceramic head impacted onto the taper sleeve. Prior to implantation, the company manufacturing the femoral heads agreed that all engineering tolerances and geometries of the head–neck taper interface were suitable for use together with the chosen stem and sleeve adaptor. The head-liner clearance and surface finish of hard-on-hard bearings are important considerations relating to surface wear and the impact on frictional forces, consequently, the senior authors were assured by the manufacturing company engineers that the surface finish and clearance between the acetabular component and femoral head were compatible. Postoperatively, patients had a standardized protocol, that included both mechanical and chemical thromboprophylactic measures, 48 hours of intravenous antibiotics, and mobilization fully weight bearing as tolerated under the supervision of physiotherapists.

Clinical Assessment

Clinical information was prospectively collected pre-operatively and post-operatively at out-patient follow-up (6 weeks, 6 months and 2 years). Assessment included an examination of range of movement together with a Harris hip score (HHS) [14]—a valid and reliable test for determining the outcome of total hip arthroplasty [15]. Each patient was asked a binary question to determine if any audible squeaking had occurred since the time of operation and if so, whether this noise was reproducible. Clunks, clicks or any other noises were not considered as "true squeakers", but the prevalence of these other noises was recorded. Known complications specifically relating to the prostheses (periprosthetic fracture and dislocation) were recorded in the database regardless of time after surgery and whether or not the complications were treated at our institution. Pulmonary embolism was detected by CT pulmonary angiography on the basis of clinical symptoms.

Radiological Assessment

Radiological assessment of the hip prostheses was performed utilizing anteroposterior (AP) pelvic and lateral radiographs using a standardized protocol. The AP film was obtained with a tube-to-film distance of 1000 mm with the tube orientated parallel to the floor. The resultant magnification of the radiograph created was 1.1. All pelvic radiographs were taken with the beam centered at the pubis symphysis with the patient standing. A low dose GE Definium machine was used to take all radiographs in this study. The images were scored by arthroplasty fellows, none of whom had been involved in the initial surgery or subsequent clinical follow-up. The radiological assessment of the acetabular component included evaluation for the presence or absence of radiolucent lines and osteolysis [16] according to the three zones described by DeLee and Charnley [17]. Components that exhibited no radiolucent lines or migration were considered well-fixed [18]. Cup inclination and anteversion were measured on the AP radiographs using the Ein-Bild-Roentgen-Analyse (EBRA) software [19]. EBRA is a validated method of determining cup orientation [20]. Component inclination and anteversion were measured blinded to the clinical outcome score or complication incidence. Femoral components were examined for evidence of subsidence by comparing serial radiographs. Using previously described techniques, pre and post-operative radiographs of squeaking hips were analyzed in order to assess the restoration of leg length [21], offset [22] and center of rotation [23], as these factors have been reported as influencing the incidence of squeaking [24]. The results were then compared with those for non-squeaking patients who were closely matched for gender, BMI (±2u), femoral head size, and cup inclination (±3°).

Statistical Analysis

The results of the analyses were compared using the paired and unpaired two-tailed t-tests. Statistical analysis of the presence or absence of squeaking was done with chi-squared and Fisher's exact tests. Correlation between squeaking and cup inclination and anteversion was determined with Pearson's coefficient. Statistical significance was set at $P < 0.05$.

Results

There were 189 hips in 178 patients available for clinical review, with a mean follow up of 28 months (15–41). Nine patients (5.1%) were lost to follow up and eight patients died (4.5%) from causes unrelated to the original surgery. EBRA analysis was performed on digital radiographs of 202 hips (98.1%).

Harris Hip Score

The mean HHS improved from a pre-operative score of 54 (16–95) to 92 (44–100) points post-operatively, with results rated as excellent in 175 hips (92.3%), fair in 5 hips (2.6%), and poor in 9 hips (4.7%).

Squeaking Hips

Fifteen hips (7.3%) (10 female:5 male) were recorded as squeaking. All occurrences of squeaking occurred during deep flexion of the hip. Mean post-operative time to onset of squeaking was 1.4 years (0.4–3). No significant difference was observed in age ($P = 0.187$), gender ($P = 0.785$), weight ($P = 0.195$), height ($P = 0.351$), BMI ($P = 0.919$), flexion/extension ($P = 0.695$), adduction ($P = 0.465$), abduction ($P = 0.987$), internal rotation ($P = 0.137$) or external rotation ($P = 0.629$) between squeaking and non-squeaking hips. The median femoral component size for squeaking hips was 44 mm. The median femoral component size for non-squeaking hips was 40 mm. The frequency of squeaking according to component size is reported in Table 2. Patients with a head size of 48 mm had the highest incidence of squeaking (11.1%). However, there was no statistically significant difference in the incidence of squeaking in the various head sizes ($P = 0.531$). In the squeaking hips, the mean acetabular component inclination and anteversion were 45.1° and 15.6° respectively. In the non-squeaking hips, the mean acetabular component inclination and anteversion were 45.5° and 16.2° respectively. There was no statistical