Ceramic Liner Fractures Presenting as Squeaking After Primary Total Hip Arthroplasty

Matthew P. Abdel, MD, Thomas J. Heyse, MD, Marcella E. Elpers, BS, David J. Mayman, MD, Edwin P. Su, MD, Paul M. Pellicci, MD, Timothy M. Wright, PhD, and Douglas E. Padgett, MD

Investigation performed at the Hospital for Special Surgery, New York, NY

Background: Squeaking after ceramic-on-ceramic total hip arthroplasty is a relatively uncommon phenomenon. It usually does not require treatment in the absence of pain, mechanical symptoms, and/or relentless squeaking. The purpose of this investigation was to report on four patients who presented with hip pain and squeaking due to fractured ceramic liners after ceramic-on-ceramic total hip arthroplasty.

Methods: Four patients with painful squeaking after ceramic-on-ceramic total hip arthroplasty were seen at our institution. One patient had a revision for suspected loosening and excessive anteversion of the cup noted on radiographs and magnetic resonance imaging (MRI). The remaining three patients had a revision for audible squeaking with progressive pain.

Results: Intraoperatively, the ceramic liners of all four patients were fractured.

Conclusions: Squeaking after ceramic-on-ceramic total hip arthroplasty rarely is a functional issue. However, painful squeaking without notable trauma may indicate fracture of the ceramic liner. Painful squeaking is difficult to evaluate by conventional imaging. When painful squeaking occurs, exploration via surgical revision is recommended in selected patients, as ceramic liner fractures may go unnoticed on radiographs and/or MRI and thus their actual prevalence may be higher than estimated.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Bearing wear contributes to late failure of total hip replacements using conventional polymers, recognition of which led to the development of alternative bearing surfaces. This development took two forms: improvements in polyethylene processing and packaging and the use of alternate bearing couples, including ceramic-on-ceramic and metal-on-metal articulations. The interest in ceramic-on-ceramic couples dates back to the 1970s, and the long-term clinical results have been encouraging.

However, several issues that have been noted with ceramic bearings include chipping and fracture of the ceramic components, poor seating of the ceramic liner, and noise generation in the form of clicking or squeaking during a patient’s daily activities. While the exact etiology of squeaking is unknown, component position, loss of lubrication between the bearing surfaces, resonance properties of the stem, and metal transfer to the femoral head as a result of impingement have all been implicated as contributing factors.

The clinical signs and symptoms of ceramic fracture were described by Stea et al. and Traina et al. with patients usually reporting a painless clicking or squeaking. Those authors used computed tomography to evaluate for possible impingement in patients with noise generation, and they performed synovial fluid analysis to look for ceramic debris. The presence of large ceramic fragments correlated with the presence of rim fractures in their series. Indeed, the design of a ceramic bearing with a protruding rim was implicated in rim impingement leading to damage.

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.

Newer acetabular components have been specifically designed with a lower-profile rim to avoid impingement and fracture. We report the cases of four patients who had a newer-generation ceramic-on-ceramic bearing with a low-profile design, in which catastrophic fractures of the ceramic liners were responsible for the recurrent squeaking and hip pain.

**Materials and Methods**

Four patients were seen at our institution with painful squeaking after ceramic-on-ceramic total hip arthroplasty. One patient had a revision for suspected loosening and excessive anteversion of the cup noted on radiographs and magnetic resonance imaging (MRI). The remaining three patients had a revision for audible squeaking with progressive pain.

**Source of Funding**

There were no external sources of funding for this study.

**Results**

The first patient was a fifty-three-year-old man who underwent a primary total hip arthroplasty using an uncemented total hip system with a ceramic-on-ceramic bearing (a size 54-mm R3 cup with an R3 Forte ceramic liner [Smith & Nephew, Memphis, Tennessee]; a Biolox Forte 36 mm + 4 mm femoral head [CeramTec/...
Smith & Nephew, Laurens, South Carolina; and an un cemented Synergy stem (Smith & Nephew) (Fig. 1-A).

While initially pain free, the patient soon noted an abnormal sensation of "pistoning" during weight-bearing. Within six weeks, he noted daily squeaking as well as groin and thigh pain. Physical examination at one year after the index surgery revealed quadriceps atrophy on the left side, a gait indicative of pain in the left hip, and a 6-mm limb-length discrepancy with shortening of the left lower limb that had not been noted at an earlier examination. Hip flexion was 75° with a 15° flexion contracture.

Because continued pain was limiting the activities of daily living, the patient was evaluated with a bone scan and serologic studies. Since both the C-reactive protein level and erythrocyte sedimentation rate were normal, a hip aspiration was not performed. The bone scan indicated loosening of the acetabular and femoral components. Further evaluation by MRI demonstrated capsular hypertrophy and scarring, but there was no adverse tissue reaction or evidence of an active infection. Limited osseous integration of the acetabular component was noted with a predominance of fibrous fixation and apparent excessive anteversion of the cup. Because of increasing disability and pain, the patient elected to proceed with revision surgery for presumed failure of socket and femoral ingrowth.

During revision surgery, an elliptical fracture of the liner was noted around the pole, resulting in two distinct pieces of the ceramic liner (Fig. 1-B). After removal of the ceramic liner pieces and the screw, the metallic acetabular shell was easily removed. The femoral stem also had predominantly fibrous fixation and was removed. A new cementless hemispherical metallic shell with adjuvant screw fixation was placed, and a monolithic cementless stem was inserted with a ceramic-on-highly cross-linked polyethylene bearing. Histologic analysis revealed third-body debris from the ceramic with synovial lining hyperplasia.

The second patient was a forty-seven-year-old woman who underwent a right total hip arthroplasty for osteoarthritis. She received an uncemented total hip system with a ceramic-on-ceramic bearing (a size 52-mm R3 cup with an R3 Forte ceramic liner, a Biolox Forte 36 mm +0 mm femoral head, and an uncemented Synergy stem).

The patient developed an acute onset of squeaking with progressive pain. Physical examination of the patient revealed flexion of the right hip to 120° without a flexion contracture. She had a nonantalgic gait with equal limb lengths. At that time, radiographs revealed an abduction angle of 41° and anatomic anteversion on the cross-table lateral radiograph. The C-reactive protein level and erythrocyte sedimentation rate were normal.

The patient underwent revision surgery because of the squeaking and pain. At the time of surgery, the femoral stem was well fixed and well positioned. Inspection of the acetabular component revealed that the ceramic liner was fractured into two separate pieces. The fracture was of a smaller central piece punched through the outer anulus within the titanium ring. The acetabular component was well fixed and well positioned. As such, a 52 mm × 36-mm R3 highly cross-linked polyethylene liner (Smith & Nephew) was inserted with a 36 mm +0 mm Oxinium femoral head (Smith & Nephew). Histologic analysis also revealed third-body debris from the ceramic with synovial lining hyperplasia.

The third patient was a twenty-four-year-old man with osteonecrosis of the hip bilaterally. The left groin pain was severe enough that he required the use of crutches. He underwent an uncemented left total hip arthroplasty with a ceramic-on-ceramic bearing (a size 50-mm R3 cup with an R3 Forte ceramic liner, a Biolox Forte 32 mm +0 mm femoral head, and an uncemented Synergy stem).

Approximately three years postoperatively, the patient developed squeaking and progressive pain in the left hip. The squeaking was loud and occurred with every step. The hip flexion was to 120° with no flexion contracture. He had an antalgic gait, but equal limb lengths. At that time, radiographs revealed an abduction angle of 40° and anatomic anteversion on the cross-table lateral radiograph. The C-reactive protein level and erythrocyte sedimentation rate were normal.

The patient underwent revision surgery because of the squeaking and progressive pain. At the time of the revision surgery, the femoral stem was well fixed and well positioned. In the acetabular component, the ceramic liner was fractured into two major pieces, with four minor ring fragments (Fig. 2). As with the first two patients, the main fracture was located where the circumference of the femoral head articulated with the liner.
The acetabular component was well fixed and well positioned. A 50 mm × 32-mm R3 highly cross-linked polyethylene liner was inserted with a 32 mm +4 mm Oxinium femoral head. As with the previous two patients, histologic analysis revealed third-body debris from the ceramic with synovial lining hyperplasia.

The fourth patient was a twenty-six-year-old woman with osteonecrosis of the left hip secondary to multiple subchondral fractures. She underwent an uncemented total hip arthroplasty of the left hip with a ceramic-on-ceramic bearing (a size 50-mm R3 cup with an R3 Forte ceramic liner, a Biolox Forte 32 mm +0 mm femoral head, and an uncemented Synergy stem).

The patient developed squeaking and grinding in the left hip and notable pain approximately three years postoperatively. The hip flexion was to 120° with no flexion contracture. She had an antalgic gait. Radiographs revealed an abduction angle of 40° and anatomic anteversion on the cross-table lateral radiograph. The C-reactive protein level and erythrocyte sedimentation rate were normal.

The patient underwent revision surgery because of the squeaking, grinding, and substantial pain. At the time of revision surgery, the femoral stem was well fixed and well positioned. However, the ceramic liner was fractured into multiple fragments. As with the first three patients, the main fracture was around where the circumference of the femoral head articularized with the liner. The acetabular component was assessed and found to be well fixed and well positioned. As such, a 50 mm × 28-mm R3 highly cross-linked polyethylene liner was inserted with a 28 mm +0 mm Oxinium femoral head. The histological findings were similar to those for the previous patients.

**Discussion**

Squeaking after ceramic-on-ceramic total hip arthroplasty has been noted at the time of midterm follow-up. The development of squeaking seems to be time-dependent, appearing at an average of fourteen months after surgery. Schroder et al. reported that 1.9% of their patients presented with audible squeaking at an average of three years, with no association with component position. Overall, the reported prevalence of squeaking has been reported to range from 2% to 21%. Theoretically, the majority of the patients in the series by Schroder et al. had squeaking only occasionally as a benign phenomenon that was not associated with pain and did not adversely affect quality of life, satisfaction, or function.

The etiology of squeaking remains obscure. Component malposition has been suggested as a possible cause. Walter et al. reported that suboptimal anteversion and abduction of the acetabular shell was associated with squeaking. Schroder et al. were unable to show this association, and squeaking has been reported to occur with well-positioned components, as was noted in three of our patients. Other proposed mechanisms leading to squeaking include edge-loading, lubrication film breakdown, metal transfer to the femoral head, and resonance forming over the metallic components of the total hip arthroplasty, leading to frequencies in the audible range.

In two of our patients (first and third), evidence of impingement was noted on the rim of the ceramic acetabular liners. Both rims had a region of metallic transfer along them, which is consistent with contact against the femoral stem. These two patients also had areas of the articular surface that were dull and rough in appearance, indicating a worn ceramic surface due to edge-loading. Both impingement and edge-loading can cause wear debris that is released into the joint and may get trapped between the bearing surfaces. These two patients initially presented with squeaking but then had progression to grinding. The introduction of third-body wear particles could be a potential source for this phenomenon. While these components were in good position, hard-on-hard bearings such as ceramics are less forgiving with component orientation than traditional metal-on-polyethylene bearings. Fracture of a ceramic acetabular liner as a coincidental intraoperative finding is rare. Such a finding was documented in one other case report, in which revision of a ceramic-on-ceramic total hip replacement was undertaken for a confirmed infection. The patient had reported ongoing pain, beginning six weeks after the index total hip arthroplasty, without notable trauma and had no major mechanical or anatomical hip-related disorders until the revision surgery. Alumina ceramic has a high elastic modulus and good compression strength, but it is brittle and prone to failure in tension or bending, loads that may occur during dislocation, impingement, malpositioning, and microseparation of the components.

Ceramic fractures are typically traumatic, with symptoms, and are usually recognized on radiographs. Fracture of a ceramic liner may easily go unnoticed on radiographs or MRI scans, especially when the rim of the liner remains intact, and the ceramic particles remain entrapped within the articulation. As the fractured fragments displace minimally and remain well covered by the metallic shell, patients may not have mechanical symptoms or pain. The pain described in our first patient could be attributable to the fractured liner or could be due to the marginal osseous integration of the cup and excessive anteversion. The propagation lines (Figs. 1-B and 2) suggest that the fracture may have become larger with time, given that ceramics are known to have slow crack propagation. These large fracture fragments may have only been at an early stage of a more catastrophic failure that would have eventually led to complete disintegration of the liner. The third and fourth patients, who had additional minor fragments, may have had fracture propagation as symptoms progressed from squeaking to grinding.

Of note, all four patients in this series had an acetabular cup and liner from the same manufacturer (a Smith & Nephew R3 cup with an R3 ceramic liner). The acetabular component is titanium, while the femoral component is a titanium alloy. In March 2011, Smith & Nephew voluntarily recalled certain lots of the R3 Forte ceramic liners secondary to a manufacturing defect. A small number of the liners had titanium rings that were pressed with a higher force than manufacturing specifications allowed, potentially contributing to the failures. Two of the four liners in this series were from the recalled lots.

In treating a patient presenting with a squeaking ceramic-on-ceramic total hip replacement that is painless and without mechanical symptoms, and for which imaging is unremarkable, it is reasonable to reassure the patient and schedule routine follow-up visits. However, when squeaking is associated with increasing pain, we recommend a more thorough investigation.
of the ceramic components, as well as ruling out infection by serological tests and an aspiration if necessary.

In conclusion, painful squeaking following ceramic-on-ceramic total hip arthroplasty is difficult to evaluate by traditional imaging, including radiographs and MRI. A joint exploration during surgical revision is warranted in patients who are unresponsive to conservative treatment. While fractures of ceramic liners are rare, they should be considered in patients without trauma who have squeaking and pain. During revision of a ceramic-on-ceramic total hip replacement, the surgeon should be prepared to treat bearing fractures, as these may go unnoticed in preoperative imaging studies.

References