Incidence of ‘Squeaking’ After Ceramic-on-Ceramic Total Hip Arthroplasty

Kenny Mai MD, Christopher Verioti DO,
Kace A. Ezzet MD, Steven N. Copp MD,
Richard H. Walker MD, Clifford W. Colwell Jr. MD

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Abstract The incidence of hip “squeak” associated with ceramic-on-ceramic bearings has been variably reported, ranging from 0.7% to 20.9%. We determined the patients’ perception of squeaking in 306 patients (336 hips) in whom ceramic-on-ceramic total hip arthroplasties (THAs) were performed between 1997 and 2005. A questionnaire regarding hip noise was obtained by telephone. With a minimum followup of 2 years (mean, 3.9 years; range, 2–10 years), 290 patients (320 or 95% of the THAs) completed the questionnaire. Patients reported hip noise in 55 of the 320 THAs (17%); noise was perceived as squeak in

32 of the 320 (10%). Most squeaking hips (29 of 32) were pain-free and symptom-free. One patient was unhappy with his squeaking hip without pain. Our data suggest a much higher incidence of squeak as perceived by patients than previously reported.

Level of Evidence: Level II, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Ceramic-on-ceramic (COC) has been an excellent alternative bearing surface for THA in young, high-demand patients with end-stage arthritis of the hip [7, 13]. Previous concerns related to COC THA such as fracture and impingement of metal trunion against the ceramic liner have decreased with improvements in the manufacturing process and designs [17]. Another criticism is the potential for increased instability resulting from intraoperative limitations of head and liner options, but a recent multicenter analysis has reduced this concern [3].

Ceramic material has been used for THA in Europe for more than 30 years with excellent success [13]. At a minimum of 18.5 years followup, Hamadouche et al. reported minimal wear, limited osteolysis, and a low rate of complication with COC THA [6]. The American experience at short- and midterm followup suggests similar outcomes [1, 4, 5, 10]. However, recently described hip noise (“squeak”) associated with COC bearings has been reported and has caused concern among clinicians and patients [12, 16].

In an Australian study reporting 0.7% squeaking COC hips, the authors reported the squeak phenomena occurred in patients who were taller, heavier, and younger [16]. The

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at Scripps Clinic, Division of Orthopaedic Surgery, La Jolla, CA, USA.

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K. Mai
Hanford Orthopaedics, Inc, Hanford, CA, USA

K. A. Ezzet, S. N. Copp, R. H. Walker, C. W. Colwell Jr. (✉)
Division of Orthopaedic Surgery, Scripps Clinic, 10666 North
Torrey Pines Road, MS116 La Jolla, CA 92037, USA
e-mail: cliffcolwellmd@yahoo.com;
Hardwick.mary@scrippshealth.org; colwell@scripps.edu

C. Verioti, C. W. Colwell Jr.
Shiley Center for Orthopaedic Research and Education at
Scripps Clinic, La Jolla, CA, USA

Australian study also reported a higher variance in acetabular anteversion and inclination in the hips that squeaked. A study from The Netherlands reported a 20.9% incidence of squeaking in 43 noncemented COC hips [9]. That study reported no difference in patient characteristics or acetabular placement between squeaking and non-squeaking hips, but found short necks on the implants in hips that squeaked. In three studies, squeaking reportedly developed an average of 14 to 26 months after surgery [9, 11, 16]. Although long-term clinical implications of squeak are unknown, the squeak phenomenon can have a psychological impact on patients, sometimes leading to decreased satisfaction or revision. Occurrence of squeak has been reported as ranging from 0.7% to as high as 20.9% [9, 16].

Based on our experience, we presumed the squeak phenomenon in one specific COC bearing has been underreported in previous literature. We (1) measured the cumulative rate of squeaking as perceived by patients after COC THA at 2 to 10 years of followup and when it initially occurred; (2) determined the presence of pain, reoperations, and progression of squeak among the patients who experienced squeaking; and (3) examined patient and implant variables that might be connected with squeaking.

Patients and Methods

We retrospectively reviewed 306 patients who had 336 COC THA from July 1997 to July 2005 and consented to participate in the study. All THA components were from a single manufacturer (Stryker Orthopaedics, Mahwah, NJ) and were noncemented. Minimum followup was 2 years (mean, 3.9 years; range, 2–10 years). Three deaths occurred unrelated to THA. Thirteen patients (13 THAs [4%]) were lost to followup. This left 290 patients (320 THAs), all of whom completed a specific questionnaire by telephone. Osteoarthritis was the most common diagnosis for THA (Table 1). From the medical records, we determined body mass index, age, height, gender, unilateral versus bilateral surgery, side of surgery, and prosthetic components, including the type of acetabular cup, the size of the femoral head, and the type and neck geometry of the femoral component. We had prior Institutional Review Board approval.

Three titanium alloy acetabular components were used during the study period, including one porous-coated PSL and 30 SecurFit-HA arc-deposited hydroxyapatite-coated cups (so-called ABC cups) and 289 Trident-HA arc-deposited hydroxyapatite-coated cups. The 303 Trident-HA cups had ceramic liners that were recessed within a metal-backed titanium sleeve; the combined 31 PSL and

Table 1. Patient demographics: THA with and without squeak

Variable	THA with squeak	THA without squeak	p Value
Age	56.1	56.3	0.871
Gender			
Male	22	134	0.072
Female	10	124	
Weight (lbs)	185.3	182.6	0.740
Height (inches)	69.6	68	0.046
Body mass index (kg/m ²)	26.8	27.6	0.398
Side of surgery			
Left	10	137	0.101
Right	22	151	
THA (number of patients)			
Bilateral	8	22	0.441
Unilateral	24	236	
Diagnosis			
Osteoarthritis	28	255	0.775
Other	4	33	

SecurFit-HA ceramic liners were not but the ceramic material was identical in all implants. Four titanium alloy femoral components with the same metallurgy were used, including 92 Omnifit stems with C-taper neck, 126 Primary SecurFit-Plus stems with C-taper neck, 99 Super Secure Fit-Plus stems with V40-taper neck, and three Accolade stems with V40-taper neck. The V40-taper necks are approximately 11% smaller in diameter than the C-taper necks. Thirty-two percent of all femoral components used in this study had the V40 neck geometry. Two neck sizes and two acetabular components used in our study resulted in three subsets of patients with different design combinations: C-taper/ABC (n = 30), C-taper/Trident (n = 188), and V40/Trident bearing couples (n = 102). There were no differences in patient characteristics (eg, age, gender, height) among articulation subsets. Alumina ceramic liner inner diameter was dictated by chosen cup outer diameter, thereby determining head component diameter. Different acetabular and femoral components used during this study period were attributed to the evolving improvement in prosthetic design initiated by the manufacturer, with Trident-HA cups and Super Secure Fit-Plus femoral components being the latest designs.

All 290 patients (320 THAs) available for followup were contacted by telephone and asked the following questions: “Since surgery, has your hip ever made any noise with activity? (A) If yes, describe the noise; (B) describe related activities that produce noise (eg, walking, bending, rising from chair); (C) When did you first hear the noise? (D) Is the noise painful? (E) Describe any treatment so far as the result of noise.” The questionnaire consisted

of open-ended questions relating to hip noise, time of onset, symptoms (painful or not), and any treatment as a result of noise and was designed to capture patients' perception of noise, if any, after having COC THA. Activities that reproduced noise were also identified. Patients were given the opportunity to describe the noise (eg, squeak) in their own words. All patients were contacted by one of two authors of this article (KM, CV).

Univariate analyses were used to assess differences in demographic and implant variables between squeakers and nonsqueakers. Chi square tests were used to assess group differences in categorical variables (gender, unilateral versus bilateral surgery, side of surgery, diagnosis, type of acetabular cup, femoral head size, femoral neck geometry) and separate independent t-tests were used to compare continuous variables (age, weight, height, body mass index). Variables that were different between groups at $p < 0.10$ were included in a logistic regression model to investigate their role as risk factors for squeaking. Statistical analyses were conducted using SPSS (Version 13.0 for Windows; SPSS Inc, Chicago, IL), and all tests were two-tailed.

Results

Fifty-five patients (64 THAs) reported an audible noise (click, clunk, grinding, scraping, and squeaking) in one THA (55 THAs; 17% of all THAs); 32 of these patients (32 THAs; 10% of all THAs) produced noise described by patients as squeaking. Eight of these patients ("squeakers") had bilateral THA, with one squeaking hip and one quiet hip. Assuming the 16 patients (16 THAs) lost to followup or deceased were all squeakers, the worst case incidence of squeaking would be 14%. The best case incidence of squeaking would be 10% if all missing hips were quiet. Most of the squeaking initially occurred between 12 and 30 months postoperatively but could occur as late as 4 years postoperatively (Fig. 1). Activities that reproduced squeaking were variable, ranging from rising from a sitting position to casual walking. For example, one patient first experienced a squeak while attempting to put on his socks

Fig. 1 This graph depicts the variation of the time after surgery to onset of squeaking in patients.

in a standing position and can now produce the squeak on demand (Video 1: supplemental material available with online version of CORR).

One patient underwent revision for painful clicking and recurrent subluxation in which the ceramic liner was changed to a highly crosslinked polyethylene insert with a larger head size and longer neck length to resolve component impingement observed at the time of revision. Pain resolved after revision and the patient was doing well at the latest followup. Revisions were planned for two additional patients at the time of our review, one for recurrent dislocation and one for the squeaking phenomenon. Another patient had unresolved generalized pain around the hip without audible noise with a negative workup for infection. One squeaker was dissatisfied with the COC THA as a result of social embarrassment but did not experience pain. Three additional squeakers described some pain associated with squeaking but did not require pain medications. These patients declined revision. Four patients stated that the squeaking had gotten louder, but their hips remained pain-free. Four squeaking THAs improved after 6 months of onset. All remaining squeaking and nonsqueaking patients were pain-free and doing well at the time of evaluation. Most squeakers (29 of 32 THAs; 29 patients [91%]) stated they were pain-free and were happy with the THA results despite the occasional noise. These patients were more concerned about the clinical implication, eg, impending failure or fracture, rather than the noise itself.

There were no differences between squeaking and nonsqueaking patients in terms of age, gender, weight, body mass index, side of surgery, unilateral versus bilateral surgery, or diagnosis (Table 1). However, patients who

Table 2. Implant differences: squeaking versus nonsqueaking components

Variable	Squeaking (N = 32 THAs)	Nonsqueaking (N = 288 THAs)	p Value
Femoral head size			
28 mm	1 (4.2%)	23 (95.8%)	0.358
32 mm	18 (9.2%)	178 (90.8%)	
36 mm	13 (13.0%)	87 (87.0%)	
Acetabular component			
Trident	32 (11.0%)	258 (89.0%)	0.056
ABC	0	30	
Femoral neck geometry			
C-Taper	16 (7.3%)	202 (92.7%)	0.020
V40	16 (15.7%)	86 (84.3%)	
Neck/cup combination			
C-Taper/ABC	0	30	0.024
C-Taper/Trident	16 (8.5%)	172 (91.5%)	
V40/Trident	16 (15.7%)	86 (84.3%)	

experienced squeaking were taller ($p = 0.046$) than non-squeaking patients. Squeaking occurred in a higher percentage ($p = 0.020$) of patients with femoral components having smaller neck geometry with 16 of 218 (7%) of the C-taper necks squeaking compared with 16 of 102 (16%) of all V40 necks squeaking. None of the 30 C-taper/ABC articulations squeaked, whereas 16 of 188 (9%) of C-taper/Trident and 16 of 102 (16%) V40/Trident combinations squeaked (Table 2). Acetabular component type and cup/neck combination were not associated with squeaking status in the regression analysis and were excluded from the final model. Femoral neck geometry was the only variable predicting squeaking. Compared with patients who received a C-taper neck, those who received a V40 neck had an increased risk of squeaking (adjusted odds ratio, 2.21; 95% confidence interval, 1.05–4.63) after controlling for gender and height.

Discussion

The COC THA bearing continues to show excellent wear rates, low amounts of osteolysis, and low complication rates. Previous concerns such as fracture, impingement, and instability have been addressed elsewhere. However, after observing a relatively high proportion of patients at our institution who experienced squeaking after COC THA, we believed the squeaking phenomenon was being underreported in the literature. We measured the cumulative incidence rate of squeaking as perceived by patients and determined the clinical outcomes related to the squeak (pain, reoperations, progression of the noise). We also examined patient and implant variables that might be connected with squeaking.

One limitation of our study was losing 16 patients (4% of the THAs) to followup or death. However, we provide a worst case analysis of incidence. Second, we did not measure radiographic alignment of prosthetic components in squeaking hips. Although squeaking may be related to prosthetic components orientation, Keurentjes et al. [9] and Restrepo et al. [11] reported no difference in component alignment between squeaking and nonsqueaking hips using computed tomographic scan analysis. Third, the questionnaire used has not been validated and depended on patient self-reporting. All noise types (clicking, grinding, clunk, scraping, and squeaking) presented in this study were perceived and subjectively reported by patients and were not validated. Some misinterpretation of hip noise by patients may have occurred, resulting in a higher incidence of squeaking. Nevertheless, patients' perception of hip noise after THA is an important determinant of satisfaction and outcome regardless of how accurate or valid their perception may be. Lastly, this COC implant was produced

by a single manufacturer and may not represent all COC implants.

Our data substantiate our presumption of underreporting of the squeak phenomenon following this design of COC articulation. Although the fracture risk has been reduced with modern ceramic, hip noise associated with COC THA has recently surfaced as a common concern among surgeons and patients. Our results are consistent with the findings of Jarrett et al. [8] and Keurentjes et al. [9], which stated the squeaking phenomenon has been underreported. We found the incidence rate of audible hip noise to be 17% (55 of 320 THAs) and squeaking to be 10% (32 of 320 hips) as reported by patients over 2 to 10 years of followup. Despite the high percentage of squeaking, our patient cohort reported most squeaking hips (29 of 32 THAs) were pain-free and functioning well, and patients were satisfied with the outcome despite the occasional noise.

The onset of squeaking reported by Walter et al. [16] occurred at an average of 14 months postoperatively in 17 patients with squeaking COC THA. In addition, the authors found a positive correlation of squeaking with younger, heavier, or taller patients. Similarly, we found most squeaking began between 12 and 30 months postoperatively, although initial squeaking did occur as late as 48 months postoperatively (Fig. 1).

Prior studies have focused on surgical technique as well as component orientation as the possible causes of squeak [2, 11, 12, 15, 16]. Keurentjes et al. [9] reported neck length of the prosthetic design was a possible cause of squeak. Thirty-two percent of the femoral components in this study had the V40 neck, which is 11% smaller overall compared with the C-taper neck. A smaller neck can theoretically lead to improved head-to-neck ratio and range of motion. In examining patients with different articulation combinations, our data showed patients with a smaller neck geometry (V40) were 2.2 times more likely to experience squeaking than patients with a larger neck (C-taper) after controlling for the effects of gender and height. All squeakers in our study had acetabular components with a preassembled liner with the ceramic recessed in a titanium sleeve (11% of all ceramic recessed acetabular components as compared with 0% of acetabular components without a recessed ceramic liner).

Although the association between prosthetic design and squeaking is currently unknown, increased range of motion may increase the probability of squeaking. Theoretically, improved range of motion as the result of smaller neck geometry may lead to bony impingement at the extreme range of motion whereby the femur is levering against the pelvis, causing subluxation of the femoral head and edge loading, leading to stripe wear and squeak. Walter et al. [15] found wear scars on retrieved articular liners always occurred on the edge of the insert but indicated they were

not aware of this as an association between the wear scars and the transient noise, although the onset of the “squeaking” was consistent with a 14-month mean time to onset of squeaking encountered clinically. Taylor et al. [14], in attempting to establish a potential cause of the squeak phenomenon, produced wear stripes on ceramic bearings in a laboratory setting and determined that under certain conditions, noise could occur during either edge loading or joint simulation. Squeaking was not observed with bearings in their pristine condition. They concluded “wear stripes caused by edge loading may be associated with bearing noise during either edge loading or during normal articulation” [14]. Other mechanisms that have been postulated are the violation of a lubrication layer as well as impingement.

COC THA can be an acceptable treatment for young, active patients and appears to have long-term survival [6]. However, patients must be counseled at the preoperative evaluation regarding the risk of squeaking that, although mostly painless, could negatively influence their quality of life.

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