




Available online at
 ScienceDirect
www.sciencedirect.com

Elsevier Masson France

www.em-consulte.com/en



CLINICAL REPORT

Occurrence of noise in alumina-on-alumina total hip arthroplasty. A survey on 284 consecutive hips

A. Cogan*, R. Nizard, L. Sedel

Department of Orthopaedics and Traumatology, Lariboisière Hospital, 2, rue Ambroise-Paré, 75010 Paris, France

Accepted: 30 November 2010

KEYWORDS

Total hip replacement;
Squeaking;
Noise;
Alumina bearings

Summary

Background: Alumina-on-alumina bearings have been accepted as a valuable alternative for young and active patients. Alumina fractures, and socket loosening were the main complications reported. But, with the increasing number of prostheses implanted, noise occurrence appeared as a new concern. The primary aim of the present study was to quantify the prevalence of noticing noise in a population having received alumina-on-alumina total hip arthroplasty as well as its eventual impact on outcome.

Patients and methods: Two hundred and eighty-four ceramic-on-ceramic hips were performed in 238 patients from January 2003 to December 2004. The average age was 52.4 ± 13.4 years (range, 13 to 74 years). All the hips received the same prosthesis (Ceraver-Osteal™) with alumina bearing components (Ceraver-Osteal™): 32 mm liners were used for cups of 50 mm or larger and 28 mm liners for cups smaller than 48 mm; the minimal alumina thickness was 6 mm. The acetabular component (Cerafit™) was hemispherical, coated with a hydroxyapatite layer and press-fit fixed. The stem (Cerafit™) was a straight tapered cementless stem, fully coated with a hydroxyapatite layer. Clearance between femoral head and liner was between 20 and 50 microns. A retrospective survey was conducted by an independent surgeon who did not participate to surgery in 2007. He conducted phone interviews of patients using a standard questionnaire. No suggestion was offered on how they could describe the noise and they felt free to use the word that they considered to be the most adapted. Satisfaction was evaluated. When the noise was present, X-rays were taken to assess if sign of bearings fracture was present.

Results: Four patients (six hips) died of unrelated causes during the follow-up period. Three patients (three hips) live outside France and could not be followed (1.3%). Nine patients (10 hips) could not be traced and were considered lost to follow-up (3.8%). Two hundred and twenty-two patients with 265 hips, therefore, were included (nine using bearing components in 28 mm diameter and 265 in 32 mm). Twenty-eight hips experienced noise generation (10.6%).

* Corresponding author. 48, Chaussée de l'Etang, 94160 Saint-Mandé, France. Fax: +00 33 143 658 231.
E-mail address: cog20002002@yahoo.fr (A. Cogan).

It was defined as a snap for six patients, as a cracking sound by six, as rustling by six patients, as a squeaking by seven patients (2.6%), a tinkling by two patients, one patient was unable to define the sound she felt. No factor related to the patient influenced the occurrence of noise. Twelve patients were dissatisfied with the result of their hip prosthesis, five of them experienced noise (41.7%); 210 were satisfied or very satisfied, 23 of them experiencing noise (11%); this difference was significant ($P=0.002$).

Conclusion: The origins of noise occurrence are unknown. Squeaking may be related to generation of stripe wear and absence of sufficient lubrication. Other types of noise can be due to microseparation, occult dislocation, impingement between the femoral neck and the acetabular rim.

Level of evidence: Level IV. Retrospective study.

© 2011 Elsevier Masson SAS. All rights reserved.

Introduction

Hard-on-hard bearing surface have been accepted as a valuable alternative for young and active patients needing a hip replacement because these combinations are resistant to wear [1–3]. The main advantage of alumina-on-alumina bearing is its chemical inertness in massive and in particulate form [4]. From a clinical point of view, it has been demonstrated in short and long-term series that alumina-on-alumina combination led to minimal osteolysis on the femoral as well as on the acetabular side [5] This feature is due to material properties and to outstanding tribological behavior if design and manufacturing process are adequately controlled.

Initial development of alumina-on-alumina bearings faced complications. Fractures of ceramic components (femoral balls and liners) [6], difficulty to achieve fixation of the acetabular component have been the major complications that have been reported in literature [2]. Fracture rate was variable but improved in the most recent series except for so-called sandwich liners [7]. Fixation of the acetabular component also improved and reached at least the results of the standard polyethylene-metal combination especially in young patients, but noise occurrence has been noted with alumina-on-alumina bearings [8] as it was also observed with metal-on-metal bearings but at a lower frequency [9]. However, the rate of occurrence and the cause of this phenomenon are not well-known despite some factors such as stripe wear and lubrication seemed to appear critical in ceramic-on-ceramic bearing.

Having an exact evaluation of the risk of the occurrence of having hip noise and of its impact on patient function is necessary in order to guide patient counselling, before the operation to forewarn them of the possibility of hip noise and afterwards to take this phenomenon properly into account without unduly alarming the patient. Therefore, the aim of the present survey was to quantify the prevalence of having noise in a population receiving alumina-on-alumina hip arthroplasty, as well as its impact on the patient's satisfaction.

Patients and methods

Patients

Two hundred and eighty-four consecutive ceramic-on-ceramic hips were performed in 238 patients (126 males

and 112 females) from January 2003 to December 2004. Forty-six patients had a one staged bilateral hip arthroplasty, 104 were operated on the right side and 88 on the left side. The average age at the index operation was 52.4 ± 13.4 years (range, 13 to 74 years). The average weight was 75.5 ± 12.6 kilos (range, 41 to 135), the average height was 168.6 ± 8.4 cm (range, 147 to 198). Eighty-seven patients (36.6%) were overweight ($BMI > 25$), and 48 (20.2%) were obese ($BMI > 30$). The etiology for hip replacement was primary osteoarthritis for 166 hips, secondary osteoarthritis for 39 hips, osteonecrosis for 64 hips, inflammatory disease for 10 hips, a giant cell tumor of the femoral head and neck for one hip, a femoral neck fracture for one hip. Three hips had an uncertain diagnosis. A standard posterior approach was used for all patients. Senior surgeons performed 235 hips (82.7%) and less experienced surgeons 49 (17.3%).

We used the same type of prosthesis for all patients (CeraVer-Osteal™). The alumina (CeraVer-Osteal™) was a surgical grade alumina with an average grain size of less than 2 microns. The socket (Cerafit™) was hemispherical, coated with an 80 microns thick hydroxyapatite layer and implanted press-fit. The alumina insert was fixed inside the metal-back with an inverted Morse-taper cone (slope $5^\circ 42'$, depth 10 mm); the insert has an inner chamfer to lessen clearance with the femoral head and a very small outer chamfer to avoid having a sharp edge. The stem (Cerafit™) was a straight tapered rough cementless stem (made of TiAl6V4 alloy), fully coated with an 80 microns hydroxyapatite layer; the neck diameter is 13,3 mm. The modular femoral head was fixed to the cone with a Morse taper, it was 32 mm for sizes of sockets of 50 mm or more and 28 mm for sockets of 48 mm; the minimal thickness of alumina was 6 mm. Distribution of socket size is indicated in Table 1. Clearance between femoral and insert was between 20 and 50 microns.

Postoperative complications included five hips dislocations (1,46%), four of them were isolated and one recurred (0.35%). One patient had an early infection that was successfully treated with debridement and lavage (0.35%).

Method of assessment

The survey was retrospectively conducted during the last 6 months of 2007 by an independent surgeon who did not participated in patients care. He interviewed the patients by phone with a standardized questionnaire (Appendix) that

Table 1 Noise emission according to acetabular component diameter.

Acetabular component diameter	Total	Noise	%
48	9	0	0
50	78	9	11.5
52	70	8	11.4
54	55	6	10.9
56	32	3	9.4
58	11	1	9.1
60	7	0	0
62	3	1	33.3
Total	265	28	100

aimed to assess if noise was present and the characteristics of this noise if present. No suggestions were made to patients about how they would describe the noise and they used their own terminology for noise descriptions. Satisfaction was evaluated asking if the patient was very satisfied, satisfied or dissatisfied with its prosthesis. When the noise was present, the radiograph was evaluated to assess whether component fracture was present. The data were analyzed for statistical significance using a Chi² test for categorical variables and a Student *t*-test for continuous variables. A *p*-value of less than 0.05 was considered as significant.

Results

Four patients (six hips) died of unrelated causes during the follow-up period. Three patients (three hips) live outside France and could not be followed (1.3%). Nine patients (10 hips) could not be traced and were considered lost to follow-up (3.8%). Two hundred and twenty-two patients with 265 hips therefore were surveyed.

Among these 265 hips, 28 experienced noise generation (10.6%). It was defined as a snap by six patients, as a cracking sound by six, as rustling by six patients, as a squeaking by seven patients (2.6%), a tinkling by two patients, one patient was unable to define the sound she felt. The circumstances were clear for 26 patients, two patients were unable to describe it precisely. Seventeen patients described noise during a specific movement, for 15, it was during bending forward, for two during trunk rotation and for one during the both types of movements. Seventeen patients were able to describe one specific activity that triggered noise, for nine, it was during walking, for four during stair climbing, for two after an important effort such as rapid walking or sport, for one during dancing, for one during sudden movement of the hip and for one during stretching. Four patients spontaneously complained of noise (two of squeaking and two of cracking), before the question was asked. One of these patients (a squeaker) made noise loud enough to be heard around him, this noise being permanent. No bilateral cases had bilateral noisy hips. Noise production was once a day or more for five patients, once a week or less for 11 patients, and once a month or less for 12 patients. The noise was

Table 2 Influence of demographic factors on noise emission.

	Noise (28)	No noise (237)	
Age	51.0 ± 12.4	53.6 ± 1.4	NS
Weight	72.1 ± 15.9	75.9 ± 16.5	NS
Height	167.1 ± 8.4	168.7 ± 9.7	NS
BMI	25.8 ± 5.1	26.6 ± 4.8	NS

never considered by the patients sufficiently troublesome to indicate a revision operation but the four patients with a spontaneous complaint were nonetheless troubled, the two crackers by the noise itself, the two squeakers more by a feeling of play in the hip. No fracture was detected on radiographs for any of these patients. No patient demographic factors (age, weight, height and body mass index) were associated with the occurrence of noise. The characteristics of the two groups are indicated in Table 2. The two senior surgeons had non-significantly different rates of noise occurrence (respectively 13 and 10.9% of hips). The thickness of the alumina insert had no influence on noise occurrence (Table 1).

Twelve patients were dissatisfied with the result of the hip prosthesis, five of them experienced noise (41.7%); 210 were satisfied or very satisfied, 23 of them experienced noise (11%); this difference was significant ($P=0.002$). If we pooled the hips into three groups (no noise, squeakers and other noise), we observe that 2.95% of silent hips did not satisfy the patient, versus 42.9% of squeakers and 9.5% of other noises. This difference was significant ($P<0.0001$). Among hips with dissatisfaction, 25% are squeakers and 16.7% emit other noises. This difference was significant ($P<0.0001$).

Discussion

Noise generation after hip arthroplasty seldom has been reported before the end of the 2000s decade. Most of the recent reports focus on hard-on-hard bearings [10]. The current series demonstrated that 10.6% of the hips generated some sort of noise with alumina-on-alumina hip arthroplasty. The strengths of the present work are that it was a systematic survey that was specifically constructed to answer the question of noise occurrence, the rate of hips lost to follow-up remain within an acceptable range (6.7%), a single model of hip arthroplasty delivered by a single manufacturer was used, the characteristics of the material were well understood and controlled. However, there are some limitations: generalization of these results to other model of ceramic-on-ceramic arthroplasty may not be possible, and some of the factors that may be related to noise occurrence were not explored such as three dimensional implant positioning.

Most of the previous series of hip replacements centered their attention only on squeaking. Large variations of incidence have been reported. For alumina-on-alumina bearing surfaces, Walter et al. [11] and Capello et al. [12] found incidence rates less than 1%; but more worrying incidence were reported by Restrepo et al. [13] who found a

2.7% incidence, Ranawat and Ranawat [14] who found a 7% incidence, Baek and Kim [15] who found a 20% incidence and Keurentjes et al. [8] who found a 21% incidence. For metal-on-metal bearing surfaces, Back et al. [9] found a 3.9% incidence with the Birmingham resurfacing hips. In the current series, the incidence of squeaking hips was 2.6%. We thus see a wide variation in the reported incidence of squeaking; high incidences might be due to a lumping together of different types of noise under the umbrella "squeaking", to problems with specific implants, to sub-optimal implant positioning that can lead to impingement between neck and insert (Keurentjes et al. [8] did not antevert their hips) or to culturally specific practices (Koreans-Baek and Kim [15] are Korean – often squat, which can lead to neck – insert impingement); low incidences might mirror the previous hypotheses or might be due to less proactive research of noise. The questionnaire that was constructed in this series deliberately asked the patient experience because all categories of noise were considered as interesting enough to be reported. Surprisingly, other sort of noises, such as cracking, rustling and others, that were not evaluated or even searched in other series; appeared more frequent than squeaking. This finding is of interest because they can also worry patients as much as squeaking. The weaknesses of previous series were that none evaluated the incidence of all sorts of noise and none was specifically designed to address this issue. Moreover, unlike the current series, no structured questionnaire was used to evaluate conditions and effect of noise generation on patient life.

The impact of noise generation in patient life was minimal in this series because only five patients had a daily noise; it appeared in specific conditions such as stair climbing and did not reported it as having a major influence on their day-to-day life, even among the two patients who considered themselves bothered. However, it must be observed that dissatisfaction was more often seen in patients having noise. Even among the noisy hips, it must be observed that the squeakers are significantly more numerous to be dissatisfied. Despite this finding, the causative effect of noise on inferior satisfaction cannot be proven in this study, and the finding remains an association at the present time.

The origins of noise occurrence are unknown [16] but several hypotheses may be proposed. Squeaking has recently been reproduced experimentally. Taylor et al. [17] demonstrated that squeaking was encountered in association with stripe wear and occurred during subluxation of the head across the insert edge once the stripe wear began to form. They suggested that lubrication conditions and contact stress might also play a role in squeaking [17]. However, squeaking may arise during normal concentric articulation if the right combination of load vector, translation vector, lubrication conditions and contact stress exist with respect to a wear stripe. Other mechanisms such as inclusion of a third body can also be involved. Chevillotte et al. [18] reported in an experimental study that squeaking occurred in dry conditions; it occurred quickly with high load, stripe wear and material transfer (titanium transfer to the femoral head); and once it occurred it didn't stop. The same authors observed that squeaking disappeared when a small amount of lubricant was added except for the case

of the material transfer condition. Walter et al. [19] suggested that squeaking may result from resonance of one or other or both of the metal components especially when uncoupling of the ceramic insert from the metal shell occur. Different designs or confusion between different kinds of noise that may be generated by different mechanisms may explain the large variation incidence of noise after THA. Other types of noise can be due to microseparation [20], occult subluxation and, impingement between the femoral neck and the acetabular rim [21], or impingement between psoas tendon and anterior surface of an oversized acetabular component [9]. Microseparation was experimentally produced by Nevelos et al. [20]; they showed that 4 mm wide wear stripes (similar to wear observed in vivo) could be produced by micro-separation and they suggested that microseparation was associated to clicking sound. Tateiwa et al. [22] demonstrated that the stripe wear was shallower with the Alumina Osteal™ head than with the Biolox™ head on retrieved implants; this difference may explain variability in rates of noise generation between the implants. The choice of implant is thus of crucial importance: short necks limit joint range of motion and can lead to impingement between neck and acetabular rim, as well as slacken the periarticular soft tissues, leading to microseparation; both impingement and microseparation can also lead to subluxation. Some implants, such as the ones used by Keurentjes and al. [8] and Restrepo and al. [13], may have problematic seating of the liner inside the cup [23], favouring resonance [24]. Some ceramics may be more prone than others to generate stripe wear. Finally, the stem composition also plays a role, as indicated by Restrepo et al. [16]: these authors had seven times more squeaking with the more flexible and thinner titanium-molybdenum-zirconium stems than with the titanium-aluminium-vanadium stems, the more flexible and thinner neck having a lower bending stiffness and resonant frequency enabling it to better amplify vibrations generated by the ceramic-on-ceramic articulation to cause an audible squeak. Keurentjes et al. [8], who reported a 21% incidence of squeaking, had incidentally implanted titanium-molybdenum-zirconium stems. But besides the implant, surgical technique is also crucial: suboptimal implant positioning favours impingement [25], insufficient excision of anterior capsule can leave thickened capsule that favours posterior subluxation [25]. As emphasized by Malik et al. [21], the exact prevalence of impingement has been difficult to evaluate. Because it is a dynamic process, there are no clinical signs or imaging examinations able to demonstrate its occurrence and its relationship to noise generation.

In conclusion, it appears that noise after ceramic-on-ceramic arthroplasty is a frequent phenomenon. Different sorts of noises may be identified and may have different explanations. In the current series, the patients did not consider this problem as a major one and it never needed revision. However, there is still a need for a better assessment and comprehension of this phenomenon.

Conflicts of interest statement

None.

Appendix A. Questionnaire used for the survey.

1) Noise

- Does your prosthesis make noise?
 What type? (let the patient answer without any suggestion)
 Causes?
 Walking (from the start or after some time?)
 Climbing/getting downstairs
 Bending over
 Rolling over

2) Favoured factors of noise occurrence

- Age
 Weight
 Height

3) Associated signs of loosening or dysfunction

- Dislocation episodes
 Pain (groin, thigh, buttock)

4) Patient satisfaction

- Regarding your prosthesis, do you regard yourself as
 Very satisfied
 Satisfied
 Dissatisfied

5) Additional remarks from the patient were also noted down

References

- [1] Yoo JJ, Kim YM, Yoon KS, Koo KH, Song WS, Kim HJ. Alumina-on-alumina total hip arthroplasty. A five-year minimum follow-up study. *J Bone Joint Surg (Am)* 2005;87:530–5.
- [2] Nizard R, Sedel L, Hannouche D, Hamadouche M, Bizot P. Alumina pairing in total hip replacement. *J Bone Joint Surg (Br)* 2005;87:755–8.
- [3] Migaud H, Jobin A, Chantelot C, Giraud F, Laffargue P, Duquennoy A. Cementless metal-on-metal hip arthroplasty in patients less than 50 years of age: comparison with a matched control group using ceramic-on-polyethylene after a minimum 5-year follow-up. *J Arthroplasty* 2004;19(8 Suppl. 3): 23–8.
- [4] Christel PS. Biocompatibility of surgical-grade dense polycrystalline alumina. *Clin Orthop Relat Res* 1992;282:10–8.
- [5] Hamadouche M, Boutin P, Daussange J, Bolander ME, Sedel L. Alumina-on-alumina total hip arthroplasty: a minimum 18. 5-year follow-up study. *J Bone Joint Surg (Am)* 2002;84: 69–77.
- [6] Hannouche D, Nich C, Bizot P, Meunier A, Nizard R, Sedel L. Fractures of ceramic bearings: history and present status. *Clin Orthop Relat Res* 2003;417:19–26.
- [7] Ha YC, Kim SY, Kim HJ, Yoo JJ, Koo KH. Ceramic liner fracture after cementless alumina-on-alumina total hip arthroplasty. *Clin Orthop Relat Res* 2007;458:106–10.
- [8] Keurentjes JC, Kuipers RM, Wever DJ, Schreurs BW. High incidence of squeaking in THAs with alumina ceramic-on-ceramic bearings. *Clin Orthop Relat Res* 2008;466:1438–43.
- [9] Back DL, Dalziel R, Young D, Shimmin A. Early results of primary Birmingham hip resurfacings. An independent prospective study of the first 230 hips. *J Bone Joint Surg (Br)* 2005;87:324–9.
- [10] Yang CC, Kim RH, Dennis DA. The squeaking hip: a cause for concern-disagrees. *Orthopedics* 2007;30:739–42.
- [11] Walter WL, O'Toole GC, Walter WK, Ellis A, Zicat BA. Squeaking in ceramic-on-ceramic hips: the importance of acetabular component orientation. *J Arthroplasty* 2007;22:496–503.
- [12] Capello WN, D'Antonio JA, Feinberg JR, Manley MT, Naughton M. Ceramic-on-ceramic total hip arthroplasty: update. *J Arthroplasty* 2008;23(7 Suppl.):39–43.
- [13] Restrepo C, Parvizi J, Kurtz SM, Sharkey PF, Hozack WJ, Rothman RH. The noisy ceramic hip: is component malpositioning the cause? *J Arthroplasty* 2008;23(5):643–9.
- [14] Ranawat AS, Ranawat CS. The squeaking hip: a cause for concern-agrees. *Orthopedics* 2007;30:738–43.
- [15] Baek SH, Kim SY. Cementless total hip arthroplasty with alumina bearings in patients younger than 50 with femoral head osteonecrosis. *J Bone Joint Surg (Am)* 2008;90:1314–20.
- [16] Restrepo C, Post ZD, Kai B, Hozack WJ. The effect of stem design on the prevalence of squeaking following ceramic-on-ceramic bearing total hip arthroplasty. *J Bone Joint Surg (Am)* 2010;92:550–7.
- [17] Taylor S, Manley MT, Sutton K. The role of stripe wear in causing acoustic emissions from alumina ceramic-on-ceramic bearings. *J Arthroplasty* 2007;22(7 Suppl. 3):47–51.
- [18] Chevillotte C, Trousdale RT, Chen Q, Guyen O, An KN. The 2009 Frank Stinchfield Award: "Hip squeaking": a biomechanical study of ceramic-on-ceramic bearing surfaces. *Clin Orthop Relat Res* 2010;468:345–50.
- [19] Walter W, Gillies R, Donohoo S, Hozack W, Ranawat A, editors. Acoustic Analysis of squeaking hips. AAOS 75th Annual Meeting; Podium presentation no. 021, 2008; San Francisco, CA, USA.
- [20] Nevelos J, Ingham E, Doyle C, et al. Microseparation of the centers of alumina-alumina artificial hip joints during simulator testing produces clinically relevant wear rates and patterns. *J Arthroplasty* 2000;15:793–5.
- [21] Malik A, Maheshwari A, Dorr LD. Impingement with total hip replacement. *J Bone Joint Surg (Am)* 2007;89:1832–42.
- [22] Tateiwa T, Clarke IC, Pezzotti G, Sedel L, Kumakura T, Shishido T, et al. Surface micro-analyses of long-term worn retrieved "Osteal" alumina ceramic total hip replacement. *J Biomed Mater Res B Appl Biomater* 2007;83:562–70.
- [23] Langdown AJ, Pickard RJ, Hobbs CM, Clarke HJ, Dalton DJ, Grover ML. Incomplete seating of the liner with the Trident acetabular system: a cause for concern? *J Bone Joint Surg (Br)* 2007;89:291–5.
- [24] Rodriguez JA, Gonzalez DelaValle A, McCook N. Squeaking in total hip replacement: a cause for concern. *Orthopedics* 2008;31:874, 877–8.
- [25] Walter WL, Waters TS, Gillies M, Donohoo S, Kurtz SM, Ranawat AS, et al. Squeaking hips. *J Bone Joint Surg (Am)* 2008;90(Suppl. 4):102–11.