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Squeaking in Total Hip Replacement: No Cause for Concern

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raditional total hip arthroplasty (THA) using metalon-polyethylene bearings has been established as a reliable procedure, but polyethylene wear and wear debris-associated osteolysis are among the most frequent reasons for revision.1 Hard-bearing-surface THAs with improved tribological properties have been introduced to decrease wear and wear debris-induced osteolysis. Among the hardbearing alternatives, alumina ceramic-on-ceramic bearings have consistently shown low wear and biological reactivity to wear particles. Clinically, ceramic-on-ceramic hip

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"Orthopaedic Crossfire" is a registered trademark of A. Seth Greenwald, DPhil(Oxon).

Correspondence should be addressed to: S.B. Murphy. arthroplasties with modern metal-backed alumina cups have demonstrated excellent clinical outcomes with low revision rates,^{2,3} with complications such as acetabular liner, femoral head fractures, or chipping occurring rarely.⁴

Curiously, after more than 30 years of clinical experience with alumina ceramic-on-ceramic bearings worldwide and with 2 closely studied longterm FDA studies in the United States,^{2,3} a new phenomenon of frequent, clinically reproducible squeaking was reported, primarily beginning in 2006. Further, these reports were authored by surgeons who had little, if any, experience with alumina ceramic-on-ceramic bearings during the IDE study period from 1997 to 2003. Inevitably, many theories were proposed to explain this phenomen, including mismatched ceramic bearings diameters,5 edge loading due to acetabular component malpositioning,6 disruption of fluid film lubrication with stripe wear,7 microseparation and subluxation of the femoral head,⁷ the use of short necks,8 and wear debris from metal-on-metal impingement in implants.9 Ultimately though, one fundamental question has remained: Why, after years of successfully using ceramic-on-ceramic THA, did this phenomenon of squeaking suddenly become frequently noted by a subset of surgeons, particularly practicing in the Unitied States? The goal of this study was to use our clinical experience with two FDA IDE studies^{2,3} during a period of more than 10 years to improve our understanding of this squeaking phenomenon.

MATERIALS AND METHODS

The current study involved two parts. One part investigated the findings at surgery in hips that were revised in patients who had reported noise prior to surgery, and the second part investigated the incidence of squeaking in primary alumina ceramic-on-ceramic THA as a function of implant design.

In the first part, we evaluated the implant information on 1275 consecutive revision THAs performed at the New England Baptist Hospital between 2002 and 2007 to identify revisions of ceramicon-ceramic hips performed in patients who had reported squeaking. The clinical history, radiographs, and intraoperative findings in these revisions were reviewed.

In the second part, we identified 2778 primary ceramicon-ceramic hip arthroplasties that had been performed at the New England Baptist Hospital between 1996 and 2007 and at Beth Israel-Deaconess Medical Center between 1997 and 2003. Of these, we reviewed the clinical records of 1139 patients to date. Any patient reports of squeaking at the time of an office visit or by phone interview were recorded. To investigate the influence of implant design on squeaking, we divided the hips into different groups. Group 1 included all hips that incorporated a conventional titanium alloy shell with an alumina ceramic liner that was seated

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Figure 1: To investigate the influence of the rim design on the incidence of squeaking the reviewed hips were divided into two groups, one with flush (left) and one with recessed mounted ceramic liners (right). Figure 2: Squeaking hip with metal-onmetal impingement. Top left: The recessed liner of the cup (Trident cup) shows notching from the impingement (small arrow) with a corresponding impairment (big arrow) on the neck (Omnifit stem). Top right and bottom left: Same cup with notching from impingement. Bottom right: Beta titanium alloy stem (Accolade stem) with notching signs from metal-on-metal impingement.

evenly with the metal shell (so-called flush-mounted designs; Figure 1). This group included implants manufactured by Wright Medical Technology, Johnson & Johnson, and Biomet. Group 2 represented hip implants where the alumina ceramic acetabular liner was protected by a shroud of titanium at the rim (so-called recessed liners; Figure 1). Group 2 was then divided into 2 groups, with group 2A describing hip implants with a recessed liner mated with a stem made of conventional titanium alloy (TiAl6V4; Omnifit or Securfit stem with Trident Cup; Stryker, Mahwah, New Jersey) and group 2B describing hip implants with a recessed liner combined with stems made out of a beta titanium alloy comprised of 12% molybdenum, 6% zirconium, and 2% iron (Accolade stem with Trident Cup, Stryker).



Of the 1275 revision hip arthroplasties, 5 (0.4%) were in patients who had reported squeaking or grinding of alumina ceramic-on-ceramic bearings prior to revision. All 5 hips had a recessed metal-backed ceramic liner and evidence of metallosis.

In the primary hip arthroplasties, group 2B had significantly more squeaking (9 [7.6%] of 118) than group 2A (10 [3.1%] of 321; P=.002), which had significantly more squeaking than group 1 (4 [0.6%] of 700; P=.04). Even more noteworthy than the statistically significant difference in the incidence of squeaking as a function of implant design was the qualitative frequency of squeaking. For example, all 6 surgeons who had used the group 2B implant combination (recessed liner combined with a stem made of a beta titanium alloy) have heard squeaking on physical examination in their offices. In contrast, none of the 9 surgeons who used the group 1 implant combination (flush-mounted liner with a stem of conventional titanium alloy) have heard squeaking on physical examination in their offices with the exception of 1 hip where the acetabular and femoral bearing diameters were mismatched. This finding is particularly notable because the group 1 experience includes >1100 hips and >10 years of clinical assessments.

DISCUSSION

The current study demonstrates that all revisions of alumina ceramic-on-ceramic hips that generated noise preoperatively were associated with recessed liners with an elevated titanium alloy rim and metal contamination of the bearing. Similarly, the incidence of squeaking in hips with recessed metal liners and an elevated metal rim mated with a stem composed of a beta-titanium alloy was statistically significantly more frequent than with other implant combinations. These findings suggest that the most common primary mechanism for squeaking is not microseparation, stripe wear, or disruption of fluid film lubrication; rather, metal contamination of the bearing occurs primarily, with stripe wear and disruption of fluid film lubrication occurring as a consequence. In addition, metallosis is primarily the consequence of impingement at the extremes of motion, whereas squeaking typically occurs in mid-ranges of motion, such as stair climbing, after the bearing has been compromised. These findings are similar to those of Eichmann¹⁰ who reported squeaking in association with metallosis and neck-rim im-

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pingement in 2003. Similary, Mangla¹¹ found that squeaking occurs less frequently when the cup is medialized, as in group 2B implant combinations, because medialization reduces prosthetic impingement and promotes bony and soft tissue impingement in its place.12 Finally, this squeaking phenomenon arose after FDA clearance of the alumina ceramic-on-ceramic bearings in the United States, allowing surgeons to combine these bearings with any femoral component.

While prosthetic neck geometries in both group 2A and 2B implants varied in terms of offset, neck angle, neck geometry, and neck thickness, group 2B implants generally have thinner femoral necks than group 2A implants do. With all other factors being equal, it would be anticipated that group 2B implants would be associated with a lower incidence of neck-rim impingement than group 2A implants. The finding that squeaking is significantly more frequent in group 2B hips then suggests that impingement of a beta

titanium alloy femoral component against a conventional titanium alloy acetabular rim is more adverse to the alumina ceramic bearing than is impingement of conventional titanium alloy femoral component against a conventional titanium alloy acetabular rim. This finding raises questions concerning the nature of the metal debris that is generated. It is possible that oxides of molybdenum, zirconium, and iron may affect the alumina ceramic bearing more adversely than other types of wear debris or that impingement of a beta titanium neck is more adverse to the conventional titanium rim than a conventional titanium neck is. These questions remain unanswered.

CONCLUSION

Clinical outcomes following THA using alumina ceramicon-ceramic THA have been excellent, with little, if any, incidence of osteolysis being noted at 10-year follow-up. It is clear that this new phenomenon of squeaking is not primarily due to the alumina ceramic bearings themselves, but due to the materials and designs surrounding these bearings. Care should therefore be taken, not only in the bearing surfaces chosen, but in the implant designs and materials supporting the bearing technology.

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