Clin Orthop Relat Res (2016) 474:456–458 / DOI 10.1007/s11999-015-4487-3

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

CrossMark

Published online: 20 August 2015
© The Association of Bone and Joint Surgeons® 2015

CORR Insights

CORR Insights®: No Difference in Reoperations at 2 Years Between Ceramic-on-metal and Metal-on-metal THA: A Randomized Trial

John P. Collier DE

Where Are We Now?

When Engh Jr. and colleagues began studying metal-on-metal (MoM) versus ceramic-on-metal (CoM) bearings, determining the articulation of choice was an important question—at the time (between August 2005 and October 2006) MoM bearings were gaining in popularity. Therefore, a study that compares two different hard surfaces articulating with the same design of metal acetabular components promised to shed light on the relative performance of metal versus ceramic heads in this articulation. Nearly a decade later, MoM components have suffered a number of failures, as well as the recall of one design followed by lawsuits. All of this has dramatically reduced the interest in, and use of, hard bearings with a metal acetabular components. Today, the comparison might considered less relevant than it otherwise would have been.

While there is decreased enthusiasm for these devices in the marketplace, it is important that we continue to follow and report on as many of the patients with hard-on-hard bearings as possible. The paper by Engh Jr. and colleagues provides short-term results of a well-designed and closely studied group of patients, which suggests that, against metal acetabula, ceramic heads may do somewhat better than metal heads in terms of survivorship. An important question still remains: Why do articulations with a ceramic head result in fewer revisions?

Where Do We Need To Go?

One can hypothesize that ceramic heads have less articular wear, or that there is important corrosion and ion release at the metal head/stem interface. Either determination would require accurate and challenging measurement of the cups and heads or the bores and stems, neither of which was a focus of the current study. If carried out, these measurements may shed some light on the difference in performance of the two systems, but it is unlikely to provide conclusive results. Patient responses to MoM (and potentially to CoM) articulations are more-complex interactions than can be

This CORR Insights® *is a commentary on the article* "No Difference in Reoperations at 2 Years Between Ceramic-on-metal and Metal-on-metal THA: A Randomized Trial" *by Engh Jr. and colleagues available at:* DOI: 10.1007/s11999-015-4424-5.
The author certifies that he, or any member of his immediate family, has no funding or commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.
All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.
The opinions expressed are those of the writers, and do not reflect the opinion or policy of *CORR*® or The Association of Bone and Joint Surgeons®.
This *CORR* Insights® comment refers to the article available at DOI: 10.1007/s11999-015-4424-5.

J. P. Collier DE (✉)
Thayer School of Engineering, Dartmouth College, 8000 Cummings Hall, Hanover, NH 03755, USA
e-mail: john.p.collier@dartmouth.edu

CORR Insights

summarized by wear measurements alone.

Future studies might be divided into those with cobalt-chromium stems and those with titanium stems in order to determine whether there is any influence in stem type on the performance. If any are revised, the interface between stem and head can be measured and studied. Metal ions are produced at the articulating surfaces, and potentially from the crevices between metal shell and liner and the head/neck interface. The titanium ions seem well-tolerated, but cobalt and chromium ions are less so. Typically, there is less head/neck corrosion and metal ion release in ceramic heads compared with mixed metal combinations with cobalt-on-cobalt falling somewhere in the middle. The role of cup orientation and coverage, head size, and type (metal versus ceramic) may all play a role in patient outcomes, but this research will require extensive followup of many patients in order to separate out the individual factors.

Perhaps just as importantly, there is considerable variation in patient sensitivity to the ions released by these components, and currently, there does not appear to be any reliable method to test for it. Patient activity could also influence the wear of the components. Activities that focus on articulation at the extremes of the ROM may increase the loads on the rim of the cup thereby initiating wear that becomes more pronounced over time. This has not historically attracted much attention, possibly because metal-on-polyethylene (MoP) articulations tend to occur near the apex of the cup and rim articulation of properly aligned components are rare. MoM components often roll to the rim of the cup before sliding, and may therefore be more sensitive to high ROM activities. This hypothesis can only be tested by following the patients with the devices and asking about their activities, or in a small active series, perhaps instrumenting them and recording their ROM.

How Do We Get There?

It would be wonderful to better predict the outcome of a new technology before providing it to large numbers of patients. The recent experience with MoM hips is an example of a new variation of an existing technology that was predicted to perform better than the earlier designs, but that did not achieve its promise. The failure of many more MoM hips than were anticipated suggests that laboratory techniques for determining wear rates lacked the ability to simulate a sufficient number of the variables that patients provide to predict outcomes. Many of the simulator studies articulated the femoral head against the apex of the acetabular component and provided continuous motion for hundreds of thousands of cycles between examinations [1, 2, 4, 5]. The examination of the cups revealed that there is rarely any wear of the apex of the metal cup, and that maximum wear of the cups occur at the rim. This is quite different than what we observed with MoP articulations, where maximum wear generally occurs below the rim of the cup, within the hemisphere. Also, the human gait produces a stop in the motion for every cycle, so the potential for a continuous "hydrodynamic fluid layer" generated by motion in the simulator fails in every step of the patient. Simulator tests that produce components with wear in the same locations observed in retrievals and with the same patterns of damage that occurs on all MoM retrievals would be a good start.

There remains much to learn about the patient's ability to tolerate the ions shed by the MoM or CoM articulations. While most of the hard-on-hard bearings that have been implanted continue to function, scratching and motion without a fluid layer do not produce the amount of ion release that appear to cause a reaction in all patients. Improved simulator studies might provide more insight into the amount of ion generation a given

CORR Insights

design, size, orientation and patient activity will generate.

Anticipating the individual patient response to this dose rate of the metal ions will require new techniques for in vitro cellular response assessments. Decades ago, Mayor and colleagues [3] focused on a "migratory inhibition factor" determination made from the response of patient cells to different types of stimuli including metal ions. The results were promising, but incomplete. Perhaps a significant percentage of those patients whose MoM (and perhaps CoM) hips required revision had either a high wear rate or an increased metal sensitivity. Developing an understanding of why the hard-on-hard metal systems articulate near the rims of the cups may lead to improved designs that are more wear resistant and forgiving of slight malalignment or large angle patient articulations. Preoperative sensitivity assessment would identify patients who may not be suitable for metal articulation, therefore saving them the challenge of handling the potentially larger ion loads.

While the results with crosslinked polyethylene in the hip are promising and 15-year outcomes are good, it is likely that we will be revisiting variations of hard-on-hard bearings. If so, a better understanding of what has occurred in this round would be critical.

References

1. Fisher J. Bioengineering reasons for the failure of metal-on-metal hip prostheses: an engineer's perspective. *J Bone Joint Surg Br.* 2011;93:1001–1004.
2. Matthies A, Underwood R, Cann P, Ilo K, Nawaz Z, Skinner J, Hart AJ. Retrieval analysis of 240 metal-on-metal hip components, comparing modular total hip replacement with hip resurfacing. *J Bone Joint Surg Br.* 2011;93:307–314.
3. Mayor MB, Merritt K, Brown SA. Metal allergy and the surgical patient. *Am J Surg.* 1980;139:477–479.
4. Morris B, Zou L, Royle M, Simpson D, Shelton JC. Quantifying the wear of acetabular cups using coordinate metrology. *Wear.* 2011;271:1086–1092.
5. Underwood R, Matthies A, Cann P, Skinner JA, Hart AJ. A comparison of explanted Articular Surface Replacement and Birmingham Hip Resurfacing components. *J Bone Joint Surg Br.* 2011;93:1169–1177.