Incomplete Seating of a Metal-backed Alumina Liner in Ceramic-on-Ceramic Total Hip Arthroplasty

Jaime A. Carvajal Alba, MD; Eric D. Schiffman, MD; Sean P. Scully, MD, PhD; Hari K. Parvataneni, MD

abstract

Full article available online at OrthoSuperSite.com/view.asp?rID=59371

Metal-backed modular ceramic bearing systems using a recessed alumina liner in a titanium sleeve were developed to decrease ceramic chipping or fracture due to femoral neck impingement after total hip arthroplasty (THA). However, malseating of the metal-backed ceramic liner has recently been described. The goal of this study was to assess the prevalence, etiology, and clinical relevance of this event.

Between 2005 and 2008, 51 consecutive patients (61 hips) underwent THA with a metal-backed alumina liner housed in a titanium shell. The metal-backed ceramic liner was aligned, seated, and impacted into the shell, and satisfaction in terms of liner stability and seating was confirmed intraoperatively. Postoperative assessment of seating was assessed with standard radiographs. Liner seating was classified as well seated, suspicious, or malseated.

Seven liners (11.5%) were found to be malseated and 4 (6.5%) were considered suspicious. Radiographically, there was a gap between the liner and the shell located inferomedially in 4 patients and superolaterally in 3 patients. Two liners subsequently seated at 1 and 3 months postoperatively, respectively. No dislodgement, failures, or adverse events were identified. There were no revision surgeries. The significant percentage of malseated liners were potentially attributed to poor exposure, bony/soft tissue interposition, and surgeon learning curve.

Drs Alba, Schiffman, Scully, and Parvataneni are from the Department of Orthopedic Surgery, Miller School of Medicine, University of Miami, Florida.

Drs Alba, Schiffman, Scully, and Parvataneni have no relevant financial relationships to disclose.

Correspondence should be addressed to: Jaime A. Carvajal Alba, MD, Department of Orthopedic Surgery, Miller School of Medicine, University of Miami, PO Box 016960 (D-27), Miami, FL 33101 (jcarvajal@med.miami.edu).

doi: 10.3928/01477447-20091124-11

Wear and osteolysis are major concerns and leading causes of aseptic failure in young patients undergoing total hip arthroplasty (THA). Ceramic bearing surfaces have gained popularity as alternate bearing surfaces since they are biocompatible, chemically inert, and hard materials that offer lower wear rates, minimal osteolysis, and improved implant longevity.[1-5] Encouraging results of this bearing surface are described in younger and more active patients after THA.[6-11]

Previous ceramic THA implants had an incidence of catastrophic failure as high as 3.5%.[10-14] The reasons for this included component malseating and impingement. Metal-backed modular systems using a recessed alumina liner in a titanium sleeve (Figure 1) were developed to decrease ceramic chipping and component fracture due to femoral neck impingement. D'Antonio et al[9] described the success of the preassembled titanium sleeve in preventing this complication and reported no ceramic chips or fractures in 328 alumina bearings followed over 4.2 years.

Nevertheless, increasing concern has arisen from various reports that describe a significant prevalence of malseating of the metal-backed alumina liner. Based on a retrospective radiographic review, Langdown et al[15] demonstrated that 16.8% of the liners from 117 ceramic-on-ceramic primary THAs were improperly seated. In their series, a malseated liner disengaged from the shell and required revision surgery. Miller et al[16] reported an incidence of liner malseating of 7.2% of 694 metal-backed ceramic liners, but no clinical significance could be associated with this event. Two additional published abstracts have also commented on the occurrence of this event.[17,18] The clinical relevance of this finding and a reasonable approach for this problem has not been reported. The goal of this study was to assess the prevalence, potential etiology, and progression of ceramic liner malseating in cementless primary THA.

Figure 1: Photograph of an acetabular modular ceramic bearing system showing a peripheral self-locking titanium shell and a recessed metal-backed alumina liner. Anti-rotation and Morse-taper locking mechanisms are also shown.

Materials and Methods

Between 2005 and 2008, 51 consecutive patients (61 hips) underwent THA with a metal-backed alumina liner housed in a titanium shell (Trident system; Stryker Orthopaedics, Mahwah, New Jersey) and were included in the study. The study group comprised 19 women (37%) and 32 men (63%), 35 right hips (57%) and 26 left hips (43%). Mean patient age at the time of the surgery was 44.78 years (range, 14-69 years). The most common preoperative diagnosis was osteoarthritis in 28 patients (46%), followed by avascular necrosis in 25 (41%) and other diagnosis in 8 (13%), which included failed hip resurfacing, failed hemiarthroplasty, painful THA, femoral neck nonunion, status post hip resection, developmental dysplasia of the hip, and posttraumatic arthritis.

All surgeries were performed by 2 surgeons (S.P.S., H.K.P.) using a posterolateral approach with the patient placed in the lateral decubitus position over the operating table. Either a hemispherical expanded or a peripheral self-locking titanium shell was implanted during surgery. The acetabulum was prepared and underreamed by 2 mm when using a hemispherical cup or line-to-line for a peripheral self-locking cup. Cementless acetabular shells were press-fit and adjuvant fixation was obtained by using 1 or 2 titanium alloy screws as needed. After removing the trial components, the metal-backed ceramic liner was aligned, seated, and impacted into the shell, and satisfaction in terms of liner stability and seating was confirmed intraoperatively. The evaluation of the liner/cup interface in terms of the presence of gaps was performed with the aid of a nerve hook, and adequate seating was tested provocatively for disengagement or displacement of the liner using a clamp.

Radiographic criteria for the inclusion of patients were: (1) appropriate views of the implant obtained by standardized anteroposterior (AP) views of the pelvis and AP and cross table lateral views of the hip; (2) weight-bearing radiographs; and (3) the presence of sequential radiographs for progression assessment. This was defined as having immediate postoperative radiographs and at least 2 of the following radiographs: 1-, 3-, or 6-month follow up. The authors reviewed the radiographs independently and a consensus of opinion was reached in terms of liner seating. No patients were excluded based on radiographic criteria.

Liners were considered malseated if a gap between the metal shell and the ceramic liner was observed in at least 1 of the 3 radiographic views of the hip in postoperative radiographs. Liners were then classified as well seated, suspicious (lack of consensus between the reviewers), and unseated. Malseating was classified as superolateral or inferomedial depending on the location of the gap (Figure 2). Subsequent radiographs were evaluated to assess the progression of the finding. A retrospective chart review was performed on those patients who had a malseated or suspicious liner with the aim of identifying possible causes and adverse events associated to this finding.

Results

Fifty-one patients (61 hips) were included in the study. Radiographically, the metal-backed ceramic liner was found to be malseated in 7 hips (11.5%), complete-

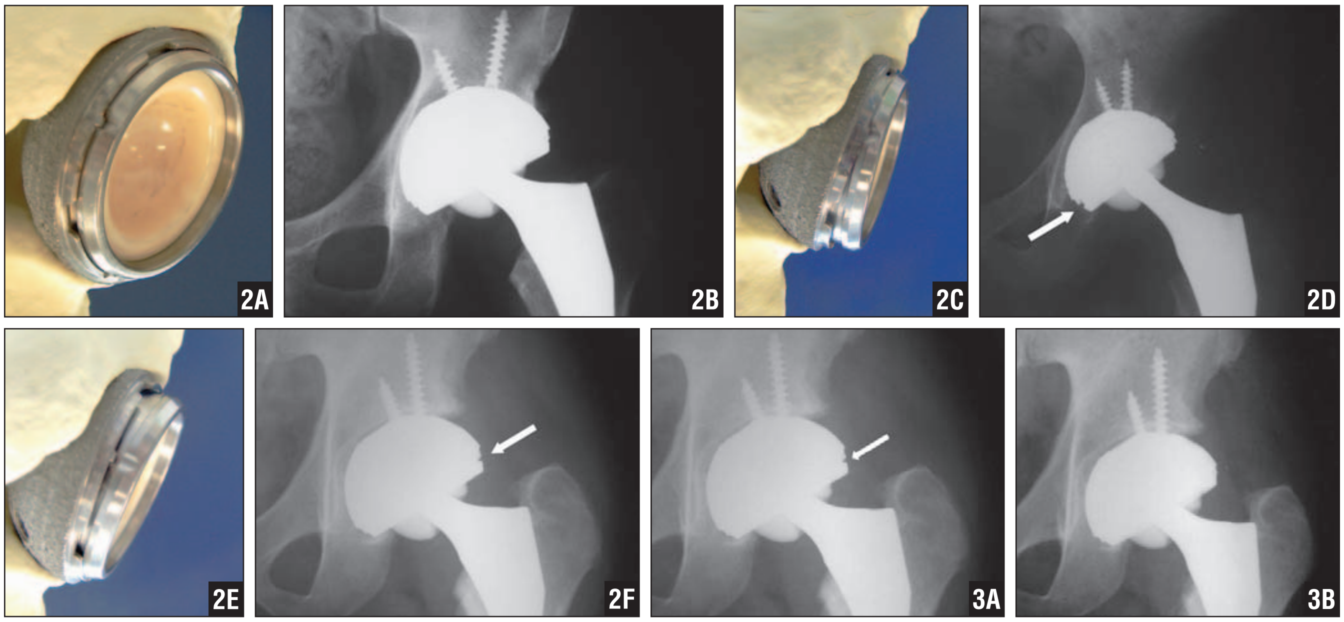

Figure 2: Representation of ceramic liner malseating based on the location of the gap in the liner–shell junction: complete seating (A, B); inferomedial malseating of the liner (C, D); superolateral malseating of the liner (E, F). **Figure 3:** Radiographic views of a patient who underwent primary THA with a metal-backed alumina liner housed in a titanium shell. Immediate postoperative radiograph showing superolateral malseating of the liner (A). Radiograph at 2-month follow-up showing subsequent seating of the ceramic liner (B).

ly seated in 50 hips (82%), and suspicious in 4 hips (6.5%). From the unseated liners, 4 were impacted in a peripheral self-locking cup and 3 in a hemispherical cup. The gap between the liner and the cup was located inferomedially in 4 cases and superolaterally in 3, independently of the type of shell.

Two liners became spontaneously seated at 1 and 2 months postoperatively, respectively. In both liners, superolateral gaps were seen (Figure 3). None of the liners that were unseated inferomedially have demonstrated subsequent seating in follow-up radiographs. Neither intraoperative insertional chips nor fractures of the ceramic liner were identified in any of the patients in this series. No clinical detriment attributed to the malseating of the ceramic liner could be identified. There were no dislodgements, failures, or revision surgeries in this series.

All liners that were considered unseated were implanted during the surgeon's first year of experience using this system, which may suggest that there is a learning curve with the insertion of this device that may have an impact on the incidence of this event.

Discussion

Patient age plays an important role in THA. Different studies have reported on the improved performance of alternative bearing surfaces, especially ceramic materials, when used in younger patients with higher physical demands. Better longevity of these implants is expected due to the lower wear rates associated with lower incidence of osteolysis and aseptic loosening.[5-7] Average patient age in our study was 44 years, reflecting the trend to use alternate bearing surfaces in patients younger than 50 years.

Squeaking and ceramic fracture are causes of concern when considering ceramic-on-ceramic couples in THA. Squeaking appears to be related to implant design, femoral neck impingement, and a sliding motion of the ceramic head against the liner during specific movements of the operated hip. Impingement of the femoral neck on the ceramic liner increases edge loading on the material, which has been also associated with an increased likelihood of liner fracture.[11,19,20] A metal-backed ceramic liner recessed in a preassembled titanium sleeve was designed. D'Antonio et al[9] reported on the success of this system in preventing liner fractures during a prospective, randomized multicenter study. They reported no liner fractures in a series of 328 patients followed over 4.2 years.[9] In our series, no ceramic liner fractures were identified during the radiographic evaluation of these patients; however, the use of computed tomography (CT) scans would increase the sensitivity to identify this complication.

A significant percentage of malseated ceramic liners were identified in our series. Liners were considered malseated by both reviewers in 7 cases (11.5%) and by only 1 reviewer in 4 (6.5%). In the worst case scenario, the incidence of liner malseating would be 18% if the liners considered malseated by at least 1 reviewer were added to the overall incidence of this event. According to previous reports, the incidence of ceramic liner malseating ranges from 7.2% to 16.8%.[15,16] Miller et al[16] reported an incidence of 7.2% liner malseating in a series of 694 patients who underwent ceramic-on-ceramic THA. Langdown et al[15] reported 19 malseated liners (16.8%) among 117 THAs using this device. Two preliminary reports presented at national orthopedic meetings also reported a similar incidence of this event.[17,18] The metal encasing of the liner makes it feasible to detect the gap in the liner–shell junction when malseating occurs. It is conceivable that nonmetal-backed liners may have a similar incidence of malseating, but this event may not be detected by standard postoperative radiographs.

The radiographic evaluation in our series suggests that liner malseating tends to occur intraoperatively. In agreement with previous reports,[15,16] all cases of liner malseating were identified in the immediate postoperative radiographic evaluation (radiographs obtained in the recovery room immediately postoperatively). All the liners showing radiographic signs of complete seating in this first radiographic evaluation have remained unchanged in subsequent radiographic follow-up.

The clinical significance of liner malseating appears to be related to the poorly distributed forces applied over the liner during impaction. Various reports[9,20] have shown that a forced impaction of a malpositioned ceramic liner could result in chipping or fracture of the material.[3,21,22] Disengagement of a malseated liner requiring revision surgery has been also reported.[15] Malseating may cause suboptimal function of the taper-locking mechanism. Proper alignment of the liner during impaction is evidently altered in malseated liners. A critical evaluation of the liner–cup interface in terms of the presence of gaps during impaction and intraoperative removal/realignment of the ceramic liner in case of malseating is strongly recommended.

Most polyethylene or nonmetal-backed ceramic liners are completely recessed within the cup or are flush with the periphery of the cup when inserted, which reduces soft tissue interposition or bony impingement that could lead to liner malseating. In contrast, the metallic component of the metal-backed ceramic liner overlaps with the external opening of the cup, creating a virtual space in which surrounding structures could potentially interfere with liner seating.

Malseated liners may become spontaneously seated postoperatively. Among the malseated liners identified in our study, 2 liners showed consequent seating at 1 and 2 months postoperatively, respectively. This event was also noted by Langdown et al,[15] who reported that 2 of 19 malseated liners in their series became spontaneously seated during the early postoperative period. Closer radiographic evaluation of the progression of the seating may be required in patients with unseated liners recognized postoperatively. A paucity of cases precludes the judgment of the risk/benefit ratio of revising the acetabular component in these cases.

Ceramic liner malseating is a consequence of poor visualization of the entire circumference of the shell, bony or soft tissue interposition between the liner and the cup, and the learning curve when using this specific implant. This fact should be taken into account during the insertion of the metal-backed ceramic liner intraoperatively. An adequate exposure with proper retraction of the surrounding tissue is required to prevent malseating. The evaluation of the liner–shell junction using a nerve hook may serve to expose the presence of gaps, implying liner malseating. The use of a liner removal tool to actively evaluate the stability of the component would increment the likelihood of detecting this event intraoperatively, given the chance of disengagement of improperly seated liners.

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