Use of Oversized Highly Porous Cups in Acetabular Revision

AMAR S. RANAWAT, MD; MORTEZA MEFTAH, MD; ANIL O. THOMAS, MD; RAJSHEKAR K. THIPPAANNA, MD; CHITRANJAN S. RANAWAT, MD

Abstract

This study assessed the efficacy of highly porous cups in revision total hip arthroplasty for Paprosky types II and III acetabular bone loss. The authors identified 33 acetabular revisions in 29 patients from a prospective database (66% type III, 7 with pelvic dissociation). Initial stability was achieved with interference fit between the anterior inferior iliac spine, pubis, and ischium with cups that were 2 to 4 mm larger than the reamed acetabulum and augmented with multiple screw fixations without allograft or wedges. At mean follow-up of 6 years (range, 2.7-7.7 years) after revision surgery, no dislocation, infection, or reoperation was noted. Mean satisfaction score was 6±3.2. Mean anteversion and abduction angles were 43°±4.6° and 21.5°±4.4°, respectively. Complications included limp in 13% of patients, wound issues in 10%, and heterotopic ossification in 17%. Osteointegration was seen in all cups, without any migration. Mean overall osteointegration, based on the average percentage of the 3 zones in both views, was 55%±21% (range, 25%-95%). The most osteointegration was seen in zone I (superior) and zone VI (posterior), and the least osteointegration was seen in zone II (medial) and zone IV (anterior). This method can provide reproducible results in acetabular revision arthroplasty. [Orthopedics. 2016; 39(2):e301-e306.]

Current challenges in acetabular revision total hip arthroplasty (THA) include accurate assessment of bone loss and pelvic discontinuity, removal of the failed acetabular implant without causing additional bone loss, and achievement of stable socket fixation against bleeding bone. Severe acetabular bone loss affects mechanical stability at surgery and interferes with biologic osteointegration of the acetabular component. Highly porous implants, such as trabecular metal cups, were recently introduced to address this issue. Tritanium cups (Stryker, Mahwah, New Jersey) are hemispheric metal implants with a 3-dimensional pure titanium surface, designed to resemble cancellous bone. Compared with earlier implant designs, the surface of the Tritanium acetabular cup has intrinsic roughness and higher porosity to provide initial stability and ingrowth potential.

Tritanium cups have high midterm survivorship and low complication rates, comparable to other porous metal acetabular implants. The authors have used oversized Tritanium cups for revision THA, even in Paprosky type IIIa or IIIb acetabular defects with pelvic discontinuity. The goal is to obtain a 3-point interference fit as a wedge fixation as long as there is sufficient bone in the region of the anterior inferior iliac spine, pubis, and ischium, with cups that were 2 to 4 mm larger than the reamed acetabulum and augmented with multiple screw fixations without allograft or wedges. At mean follow-up of 6 years (range, 2.7-7.7 years) after revision surgery, no dislocation, infection, or reoperation was noted. Mean satisfaction score was 6±3.2. Mean anteversion and abduction angles were 43°±4.6° and 21.5°±4.4°, respectively. Complications included limp in 13% of patients, wound issues in 10%, and heterotopic ossification in 17%. Osteointegration was seen in all cups, without any migration. Mean overall osteointegration, based on the average percentage of the 3 zones in both views, was 55%±21% (range, 25%-95%). The most osteointegration was seen in zone I (superior) and zone VI (posterior), and the least osteointegration was seen in zone II (medial) and zone IV (anterior). This method can provide reproducible results in acetabular revision arthroplasty. [Orthopedics. 2016; 39(2):e301-e306.]

The authors are from the Hospital for Special Surgery (ASR, CSR), New York, and the Bronx-Lebanon Hospital Center and the Hospital for Joint Disease/NYU Langone Medical Center (MM), New York, New York; the Christian Medical College and Hospital (AOT), Tamil Nadu, India; and Ranawat Orthopaedics (RKT), New York, New York.

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Correspondence should be addressed to: Morteza Meftah, MD, Hospital for Joint Disease/NYU Langone Medical Center, 301 E 17th St, 11th Fl, New York, NY 10003 (MeftahM@hss.edu).

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Table 1

<table>
<thead>
<tr>
<th>Paprosky Type</th>
<th>No. of Hips</th>
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<tbody>
<tr>
<td>I</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>IIa</td>
<td>5 (15%)</td>
</tr>
<tr>
<td>IIb</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>IIc</td>
<td>3 (9%)</td>
</tr>
<tr>
<td>IIIa</td>
<td>12 (36%)</td>
</tr>
<tr>
<td>IIIb</td>
<td>10 (30%)</td>
</tr>
<tr>
<td>Pelvic dissociation</td>
<td>7 (21%)</td>
</tr>
<tr>
<td>Total</td>
<td>33 (100%)</td>
</tr>
</tbody>
</table>

Figure 1: Anteroposterior radiograph before revision in a patient with failed uncemented cup-cage and pelvic discontinuity (arrow) (A). Anteroposterior radiograph showing osteointegration at the superior dome and ischium (arrowheads) 5 years after revision (B).

ischiunm cups for Paprosky types II and III acetabular osteolysis. In addition, 26 patients (30 hips; 11 cemented cups and 19 uncemented cups) underwent revision for symptomatic osteolysis and/or aseptic loosening. Finally, 3 patients (3 hips) underwent revision for periprosthetic infection and were treated with 2-stage revision arthroplasty. Average time from index surgery to revision was 16.5±10.3 years (range, 1.4-32 years).

Acetabular defects were classified according to the Paprosky classification, which is based on the severity of bone loss and the pattern of migration of the implant. This classification is as follows: type I, the rim is intact, with minimal deformity; type II, the rim is distorted but intact, with superolateral migration and loss of the medial wall; type IIIA, the rim has bone loss and superolateral cup migration; and type IIIB, the rim has bone loss and superomedial cup migration. In patients with Paprosky type III acetabular defects or pelvic discontinuity, preoperative computerized tomography images were used to generate patient-specific, 3-dimensional models of the hip joint to accurately evaluate the extent of bone loss. Most acetabular defects (22 hips, 66%) were types IIIa and IIIb (Table 1). Seven hips in the type IIIB group (severe bone loss with lysis of the medial wall) had pelvic discontinuity (Figure 1). The cup size was 58 mm in 21% of hips, 60 to 68 mm in 50% of hips, and 70 to 74 mm in 29% of hips. All femoral heads were 32 mm or 36 mm. An average of 4 screws (range, 3-5 screws) were used as additional fixation.

Surgical Technique

The previous cup was carefully removed to minimize further bone loss. Thorough debridement of the cement (when present), hypertrophic scar, and hypertrophic interface membrane was performed. Progressive reaming with reamers of increasing diameter was performed to obtain bleeding bone in the reamed cavity, ischium, ilium, and pubis. Interference fit between the anterior inferior iliac spine, ischium, and pubis was assessed with a trial cup of the same size as the final reamer to test for stability. De-mineralized bone graft with morselized cancellous bone chips was impacted to fill the defects, especially the dome defects. Final press-fit was achieved with a Titanium cup that was 1 or 2 sizes (2-4 mm) larger than the trial cup, depending on bone quality, in appropriate abduction and anteversion. In pelvis dissociations, the distraction technique was used. The fixation was augmented with multiple screws. No cup-cage combination, structural allograft, or wedge was used. Total time of surgery was assessed as an indicator of the difficulty of the case.

Patients were prospectively followed with clinical and radiographic examination. Mean follow-up was 6±1.4 years (range, 2.7-7.7 years) after revision surgery. The patients included 16 men and 13 women, with mean age of 70±12 years.
Osteointegration was assessed in 82 patients. Radiolucent lines were defined as any demarcation of more than 2 mm in any of the 3 Charnley zones. The greatest amount of osteointegration (100%) was seen in zones II (medial) and IV (anterior), and the least osseointegration was seen in zones I (superior) and VI (posterior). The minimum amount of osteointegration was 20% in the anteroposterior view and 4% in the false profile view. In addition, 11% of hips in the anteroposterior view and 4% in the false profile view had no osseointegration in 2 zones. No hips showed circumferential demarcation, loosening, or cup migration. Mean overall osteointegration, based on the average percentage of overall osteointegration was more evident on the false profile view than on the anteroposterior view (Table 3). Eighty-two percent of false profile views and 71% of anteroposterior views showed more than 50% overall osteointegration (Figure 2).

### RESULTS

Mean WOMAC and HSS scores were significantly improved from 51 and 26.6 preoperatively, respectively, to 18.1 and 36.6 at final follow-up, respectively ($P<.01$, Table 2). Four patients (13%) had a mild limp that did not require intervention. One patient had a significant limp as a result of thorough debridement of soft tissue and necrotic bone for periprosthetic infection, and a constrained liner was used to prevent dislocation. Five patients (17%) used a walker to ambulate. Three patients (10%) had delayed wound healing, and 5 patients (17%) had heterotopic ossification on final radiographic evaluation. Mean satisfaction score was $6.2\pm3.2$ (range, 0-10). Mean surgical time was 2 hours and 38 minutes (range, 1:34-4:20) from skin incision to closure. No intraoperative fractures or postoperative dislocations occurred. There were no periprosthetic infections, re-revisions, or reoperations at final follow-up.

**Table 2** Clinical Results at Final Follow-up

<table>
<thead>
<tr>
<th>Time</th>
<th>Western Ontario and McMaster Universities Arthritis Index (WOMAC) Score</th>
<th>Hospital for Special Surgery Hip Score</th>
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<tbody>
<tr>
<td>Preoperative</td>
<td>$51\pm26$ (5-84)</td>
<td>$18.1\pm6$ (10-32)</td>
</tr>
<tr>
<td>Postoperative</td>
<td>$26.6\pm22$ (0-72)</td>
<td>$36.6\pm4.7$ (20-40)</td>
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*Range, 0-96, with lower scores indicating better outcomes. Higher scores (0-40) indicate better outcomes.

**Table 3** Osseointegration in Anteroposterior and False Profile Views in Each Charnley Zone

<table>
<thead>
<tr>
<th>Osseointegration</th>
<th>Anteroposterior View</th>
<th>False Profile View</th>
<th>Both Views</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% osseointegration in all 3 zones</td>
<td>14 (42%)</td>
<td>14 (42%)</td>
<td>12 (36%)</td>
</tr>
<tr>
<td>≥50% osseointegration overall</td>
<td>24 (72%)</td>
<td>27 (81%)</td>
<td>17 (52%)</td>
</tr>
<tr>
<td>&lt;50% osseointegration overall</td>
<td>10 (30%)</td>
<td>6 (18%)</td>
<td>4 (12%)</td>
</tr>
<tr>
<td>No osseointegration in 1 zone</td>
<td>7 (21%)</td>
<td>12 (36%)</td>
<td>5 (15%)</td>
</tr>
<tr>
<td>No osseointegration in 2 zones</td>
<td>4 (12%)</td>
<td>1 (3%)</td>
<td>1 (3%)</td>
</tr>
</tbody>
</table>

Mean anteversion and abduction angles were $43.0\pm4.6^\circ$ and $21.5\pm4.4^\circ$, respectively. No hips showed circumferential demarcation on radiographs. Further radiographic analysis showed osteointegration in at least 1 Charnley zone in all hips. No hips had circumferential demarcation, loosening, or cup migration. Mean overall osteointegration, based on the average percentage of the 3 zones in both views, was $55\%\pm21\%$ (range, 25%-95%). The maximum amount of overall osteointegration was more evident on the false profile view than on the anteroposterior view (Table 3). Eighty-two percent of false profile views and 71% of anteroposterior views showed more than 50% overall osteointegration (Figure 2).

**DISCUSSION**

Patients with periacetabular bone loss pose a challenge during revision total hip arthroplasty. The presence of circumferential radiolucent lines has been associated with poor clinical outcomes, and the identification of patients at risk of failure is essential. The use of anteroposterior and false profile views with EBRA software allows for the assessment of osteointegration and the identification of radiolucent lines, which can guide management decisions.
Figure 2: Anteroposterior hip radiograph before revision in a patient with a failed cemented socket with severe medial bone loss (arrow) and intact anterior inferior iliac spine (arrowhead) that were reconstructed with an uncemented oversized Tritanium cup (Stryker, Mahwah, New Jersey) with multiple-screw fixation (A). Anteroposterior radiograph of the hip (B) and false profile view showing superior osteointegration and nonprogressive demarcation at Charnley zone 3 after revision (arrowheads) (C).

hip arthroplasty, even to the experienced orthopedic surgeon. The success of such complex surgical reconstructions is the achievement of stable fixation in deficient host bone. Recent studies showed that a high-porosity surface, such as a tantalum cup, improves bony fixation.16-18 These components also remain inert in vivo, allowing them to resist corrosion and undergo less periprosthetic stress shielding.17,19 With this bone-like microstructure, these implants have a very high volumetric porosity that is analogous to trabecular bone (75%-80% of its total volume20,21), a low modulus of elasticity, and a relatively high coefficient of friction that promotes initial stability and facilitates bone ingrowth.5,20,22,23 Naziri et al17 showed excellent clinical and radiographic outcomes and survivorship of Tritanium cups in 288 THA procedures at a mean of 3 years. Tritanium cups also appear to be reliable devices for revision acetabular arthroplasty with uncemented fixation in patients with major acetabular defects.6,24 However, there are limited data on the use of oversized porous Tritanium cups in moderate to severe acetabular bone loss when a primary interference fit is achieved. The authors hypothesized that, with these features, as long as an interference rim fit can be obtained between the anterior inferior iliac spine, pubis, and ischium, oversized uncemented Tritanium cups have reliable osteointegration and may require less bleeding bone to achieve fixation. The goal of this study was to assess the clinical and radiographic results and the osteointegration pattern of these implants.

Limitations of the current study are the relatively small sample size and the lack of computerized scans to accurately assess 3-dimensional osteointegration. However, this study used strict criteria on multiple radiographs with 3 observers to assess the amount of osteointegration. Although long-term follow-up of the study cohort is required to determine the survivorship and durability of Tritanium cups in revision, midterm results are encouraging. The strengths of this study are its prospective 100% follow-up and the detailed radiographic assessment.

In this study, 66% of the defects (22 hips) were Paprosky type III acetabular defects, with or without pelvic dissociation, and 79% of the cups used were 60 mm or larger. Osteointegration was noted in all hips, with at least 1 zone in each view showing no evidence of loosening. This study also found that interface demarcation is best seen on the false profile view. In 7% of cases, the amount of demarcation was underestimated without the false profile view. Ramappa et al26 reported similar outcomes in a prospective study of 43 acetabular component revisions, with Tritanium cups showing 95% integration at 6 weeks. However, the mean follow-up of that study was shorter (18 months). In addition, about half (49%) of the hips had American Association of Orthopaedic Surgeons type II defects (cavitary deficiencies) and 5% had no bony defect. In the current study, most hips had a type IIIa or IIIb acetabular defect that reflected the severity of bone loss and the complexity of reconstruction.

No re-revision occurred in this cohort at 2 to 7 years of follow-up. This finding was similar to or better than that of other studies of the clinical results with tantalum metal cups in revision THA.2,3,5,25-31 Skytta et al32 used a population-based hip registry to assess the survival of 827 acetabular revisions with tantalum shells and reported a 2% revision rate for aseptic loosening. In a retrospective review of 25 patients undergoing acetabular component revision with porous tantalum cups for a Paprosky type II or III defect, Malkani et al31 reported that 21 patients (84%) had well-fixed and functioning implants and showed ingrowth along the tantalum surface despite having deficient host bone. At short-term follow-up (mean, 24 months), Unger et al2 assessed the radiographic and clinical data of 60 consecutive patients who underwent revision THA with trabecular metal acetabular components. Preliminary results showed excellent clinical outcomes at follow-up, with 3-year survival of 98%. A study by Fernandez-Fairen et al2 of 263 consecutive patients who had revision THA with porous tantalum acetabular components showed 87.3% improvement after revision at 5-year follow-up.

A potential disadvantage of the use of an oversized cup is elevation of the hip center, which may alter hip biomechanics and cause hip instability.34,35 However, with proper combined antversion, restoration of leg length and offset, and use of larger femoral heads, the risk of dislocation can be significantly reduced. In cases of significant abductor deficiency, the use of constrained liners is recommended.
Another potential issue is overhang of the cup anteriorly, which may lead to impingement of the iliopsoas tendon. 

Earlier studies suggested that at least 50% contact with healthy or bleeding host bone is necessary to achieve adequate osseointegration with uncemented cups. The current study found that the minimum required osseointegration with cups with a highly porous surface could be less than 50%. This finding confirms that Tritanium cups have excellent efficacy for bone ingrowth, which lowers the previous standard for minimum osseointegration. This study achieved stability and osseointegration with uncemented oversized cups in all hips. This technique requires 3-point fixation when the anterior inferior iliac spine, pubis, and ischium are sufficient for stability after reaming. Obtaining a computed tomography scan in Paprosky type III acetabular defects is highly recommended for accurate assessment of acetabular osteolysis. Intraoperatorically, after removal of the previous acetabular component, the decision to use an oversized cup is dependent on the remaining bone stock. When medial bone loss is significant but 3-point fixation can be achieved, an oversized cup can be used, and this is assessed by using a trial cup that is 2 to 4 mm larger than the reamed cavity.

CONCLUSION

The current study showed excellent safety and efficacy of Tritanium cups in acetabular revision surgery and reproducible use of oversized cups when achieving interference fit between the anterior inferior iliac spine, pubis, and ischium.

REFERENCES


