

Total Hip Arthroplasty Using Modular Trabecular Metal Acetabular Components for Failed Treatment of Acetabular Fractures: A Mid-term Follow-up Study

De-Yong Huang, Liang Zhang, Yi-Xin Zhou, Chun-Yu Zhang, Hui Xu, Yong Huang

Department of Orthopedics, Beijing Jishuitan Hospital, Fourth Clinical College of Peking University, Beijing 100035, China

Abstract

Background: Porous-coated cups have been widely used in acetabular reconstruction after failed treatment of acetabular fractures, and good results have been reported with the use of these cups; however, the durability and functionality of modular trabecular metal (TM) acetabular components in acetabular reconstruction after failed treatment of acetabular fractures remain unclear. This study aimed to examine the radiographic and clinical outcomes associated with the use of modular TM acetabular components for failed treatment of acetabular fractures to assess the durability and functionality of these components in acetabular reconstruction after failed treatment of acetabular fractures.

Methods: A total of 41 patients (41 hips) underwent total hip arthroplasty (THA) using modular TM acetabular components for failed treatment of acetabular fractures at our hospital between January 2007 and December 2012. Among these patients, two were lost to follow-up. Therefore, 39 patients (39 hips) were finally included in this study. The Harris hip score before and after the surgery, satisfaction level of the patients, and radiographic results were assessed.

Results: The mean Harris hip score increased from 34 (range, 8–52) before surgery to 91 (range, 22–100) at the latest follow-up examination ($P < 0.001$). The results were excellent for 28 hips, good for six, fair for three, and poor for two. Among the 39 patients, 25 (64%) and 10 (26%) were very satisfied and somewhat satisfied, respectively. All cups were found to be fully incorporated, and no evidence of cup migration or periacetabular osteolysis was noted.

Conclusions: Despite the technically demanding nature of the procedure, THA using modular TM acetabular components showed good durability and functionality and may be an effective reconstruction option for failed treatment of acetabular fractures.

Key words: Acetabular Fracture; Trabecular Metal; Total Hip Arthroplasty

INTRODUCTION

Acetabular fractures after high-energy trauma are serious and uncommon orthopedic injuries that can have late complications, such as posttraumatic arthritis and avascular necrosis of the femoral head.^[1-3] Total hip arthroplasty (THA) is an effective surgical option to relieve pain and restore function after failed treatment of acetabular fractures. Previous studies have demonstrated encouraging outcomes with regard to cementless porous-coated acetabular components.^[4-8] Trabecular metal (TM) (Zimmer Corp., Warsaw, IN, USA) is a porous material made of tantalum, with a high coefficient of friction of 0.98 and a high porosity of 80%. It has excellent biocompatibility and safety, with the inherent advantages of maximum initial

stability and quick and safe patterns of bone ingrowth and soft tissue vascularization. A series of histological and clinical studies have reported that TM cups show rapid infiltration with healing of fibrous and osseous tissues as well as early mechanical stability.^[9-11] Although the results of monoblock and revision TM acetabular components in complex primary and revision THA conditions are

Address for correspondence: Dr. Yi-Xin Zhou,
Department of Orthopedics, Beijing Jishuitan Hospital, Fourth Clinical
College of Peking University, Beijing 100035, China
E-Mail: orthoyixin@yahoo.com

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encouraging,^[11-16] the durability and functionality of modular TM acetabular components in acetabular reconstruction after failed treatment of acetabular fractures remain unclear.

We hypothesized that modular TM acetabular components may provide good long-term reconstruction for irregular acetabula after failed treatment of acetabular fractures in selected cases. The purpose of this study was to examine the radiographic and clinical outcomes associated with the use of modular TM acetabular components for failed treatment of acetabular fractures to assess the durability and functionality of these components in acetabular reconstruction after failed treatment of acetabular fractures.

METHODS

Patient demographics

A total of 41 patients (41 hips) underwent THA using modular TM acetabular components for failed treatment of acetabular fractures at our hospital between January 2007 and December 2012. Among the 41 patients, two were lost to follow-up. Therefore, 39 patients (39 hips) were finally included in the present study [Table 1]. We also reviewed 42 consecutive patients (44 hips) treated with a titanium hemispheric component reconstruction for failed treatment of acetabular fractures at our hospital between 1998 and 2007^[8] as a control group [Table 1].

Surgical technique

All hips in both groups were exposed through a posterolateral approach. We did not intend to remove any instruments

unless they were interfering with the reaming and fixation of the acetabular cup. In all cases, the initial stability and orientation of the cup were confirmed with intraoperative radiographs. In all hips, 2–3 screws were used with the cups to enhance their initial stability.

We used the highly cross-linked polyethylene (PE) liner longevity PE (Zimmer Corp., Warsaw, IN, USA) in the group using a tantalum cup, with a standard offset and an elevation of 10°. The mean diameter of the TM shells was 50.7 mm (range, 44–60 mm). We used shells equal to or smaller than 48 mm and corresponding 28-mm femoral heads in 13 patients and shells equal to or larger than 50 mm and corresponding 32-mm femoral heads in 26 patients. In all hips, Biolog Forte (CeramTec, Plochingen, Germany) Al₂O₃ femoral heads and cementless stems were used. In the group using a titanium cup, we used a ceramic-on-ceramic bearing surface in nine hips, a ceramic-on-PE bearing surface in 20 hips, and cobalt-chrome heads on a PE bearing surface in 15 hips, with corresponding 28-mm femoral heads in all patients.

Postoperative rehabilitation

Starting on the 2nd postoperative day, the patients in the tantalum cup group were mobilized with toe-touch weight-bearing on crutches for the first 2 weeks, followed by partial weight-bearing in the 3rd week, full weight-bearing with crutches after 6 weeks, and discontinuation of the use of crutches at 8–12 weeks after THA. In the titanium cup group, patients were allowed toe-touch weight-bearing with crutches for 6 weeks, and then they advanced to 50% weight-bearing as tolerated with crutches for 6 weeks.

Evaluation of outcomes

All patients were routinely examined at 3 months, 6 months, 1 year, 2 years, and then every 2 years thereafter. All clinical and radiographic results were reviewed by one of the authors who was not involved in patient care. Clinical outcomes were evaluated using the Harris hip scoring system.^[18] The Harris hip score is based on an assessment of pain, function, deformities, and range of motion. On a 100-point scale, a score of 90 points or more is considered as an excellent outcome; 80–89 points, a good outcome; 70–79 points, a fair outcome; and 70 points or less, a poor outcome.

Serial radiographs included anteroposterior, lateral, and two 45° oblique views of the involved hip. Computed tomography images of the involved pelvis were routinely reviewed. Radiographic assessments of the acetabular components were performed in the three zones proposed by DeLee and Charnley. The presence and extent of radiolucent lines were evaluated using the criteria of Callaghan *et al.*^[19] The immediate postoperative radiographs were reviewed for a periacetabular gap, which often indicates incomplete seating of acetabular components. At the follow-up visits, we recorded whether the gap resolved, persisted, or expanded and when these occurred.^[20] Radiographic failure was determined by a vertical or horizontal migration of over 3 mm, a change in the inclination angle of over 5°, and the presence of fewer than two signs of osteointegration, according to the Moore criteria.^[21]

Table 1: Patient characteristics

Variables	Tantalum cup group (n = 39)	Titanium cup group (n = 44)
Sex		
Male	32 (82)	32 (76)
Female	7 (18)	10 (24)
Operative side		
Left	22 (56)	24 (55)
Right	17 (44)	20 (45)
Mean age at fracture (years)	41.5 (21–57)	38.6 (19–61)
Mean age at THA (years)	47.3 (22–70)	45.4 (22–65)
Time between fracture and THA (months)	72.0 (9–314)	78.5 (7–360)
Cause of fracture		
Motor vehicle accident	35 (89.7)	40 (90.1)
Weight compression injury	2 (5.1)	3 (6.8)
Fall from a height	2 (5.1)	1 (3.1)
Classification by Judet <i>et al.</i> ^[17]		
Simple pattern	29 (74)	26 (59)
Complex pattern	10 (26)	18 (41)
Initial treatment		
ORIF	30 (77)	30 (68)
Non-ORIF	9 (23)	14 (32)

Data are presented as number (%) or mean (range). THA: Total hip arthroplasty; ORIF: Open reduction and internal fixation.

Heterotopic ossification (HO) was categorized according to the classification system of Brooker *et al.*^[22] All patients were administered indomethacin after surgery (25 mg twice a day for 4 weeks) as prophylaxis against HO.

The present study was approved by the institutional review board of our hospital and was performed in accordance with the guidelines of the *Helsinki Declaration*.

Statistical analysis

The preoperative and final follow-up Harris hip scores were compared using the Mann–Whitney signed rank test. All analyses were performed using SPSS software for Windows (version 15.0; IBM, Armonk, NY, USA). A *P* value < 0.05 was considered statistically significant.

RESULTS

Patient characteristics

The patient characteristics are presented in Table 1. The mean age of the patients at the time of THA in the group using tantalum cup was 47.3 years (range, 22–70 years), and the mean body mass index was 25.7 kg/m² (range, 17.5–35.6 kg/m²). The mean duration of follow-up was 58.4 months (range, 25–101 months). According to the initial fracture pattern classification system of Judet *et al.*,^[17] 29 (74%) hips had simple fracture patterns (posterior-wall fractures, 27 [69%]; transverse fractures, 2 [5%]) and 10 (26%) hips had complex fracture patterns (transverse plus posterior-wall fractures, 4 [10%]; posterior column plus posterior wall fractures, 3 [8%]; double column fractures, 2 [5%]; and T-shape fractures, 1 [3%]). According to the criteria for acetabular bone defects proposed by the American Academy of Orthopaedic Surgeons, 14 hips had type I segmental acetabular defects, eight had type II cavitory defects, six had type III combined defects, and one had type IV pelvic discontinuity. Among the 39 patients, 21 received acetabular bone grafts (18 received morcellized autografts and three received bulk autografts).

In the titanium cup group, 26 (59%) hips had simple fracture patterns and 18 (41%) hips had complex fracture patterns. Moreover, 19 hips had type I defects, seven had type II defects, and seven had type III combined defects. In all patients in both groups, the degree of cup coverage by the host bone was over 70%.

Clinical assessment

In the group using TM cups, the mean Harris hip score increased from 34 (range, 8–52) before surgery to 91 (range, 22–100) at the latest follow-up examination (*P* < 0.001). The results were excellent for 28 hips, good for six, fair for three, and poor for two. Regarding postoperative pain, 33 patients had no pain, two had mild pain, two had moderate pain, and two had severe pain. In addition, 14 (36%) patients had a limp. Among the 39 patients, 25 (64%), 10 (26%), 2 (5%), and 2 (5%) patients were very satisfied, somewhat satisfied, somewhat dissatisfied, and very dissatisfied, respectively, with the results of the procedure.

These results compared favorably with those in the control group treated with a titanium component, in which the average Harris hip score improved from an average of 49.5 points to an average of 90.1 points (*P* < 0.05), and 80% of the patients had a good or excellent result.

Radiographic results

All TM cups were found to be fully incorporated, and no evidence of cup migration or periacetabular osteolysis was noted. Periacetabular gaps were observed on immediate postoperative radiographs in 10 (25.6%) hips. The gap persisted without any change in location and width in only one patient and the gaps in the other patients resolved within one year after THA. At the latest follow-up, new onset radiolucency was noted in one hip, and it was located in zone 1 and had a width of <1 mm. No acetabular screw breakage was noted in any of the patients.

In the control group, postoperative periacetabular gaps were observed in seven hips. All of these gaps, but three, disappeared within the initial 14 months after THA. The new onset radiolucency was noted in three hips. In two, the radiolucency was <1 mm wide, and in one, it was more than 2 mm wide. All of them were associated with a good or excellent Harris hip score and were considered stable.

Complications

In the group using TM cups, perioperative complications included one iatrogenic sciatic nerve injury in a patient with posterior wall fracture and periprosthetic infection in two patients. The patient with sciatic nerve injury was treated with methylprednisolone injection and dorsal extension orthosis, and partial resolution was noted within one year. In the two patients with periprosthetic infection, microbial culture tests were used to confirm infection. Both patients had undergone open reduction and internal fixation (ORIF) for their initial posterior wall fractures, and they were treated with initial implant removal, irrigation, and debridement. The two cups and stems were stable at the time of removal. Unfortunately, both patients refused to undergo further THA revision. Among the study patients, no patient needed revision because of aseptic loosening.

After surgery, 6 (15.4%) hips demonstrated HO with no adverse clinical effects. Of these six hips, three had Brooker class I HO, two had class II HO, and one had class III HO. No patient required further procedures for HO.

In the control group, perioperative complications included one dislocation and three sciatic nerve injuries. After surgery, 16 hips (31%) demonstrated HO with no adverse clinical effects. Seven hips (14%) had Brooker class I HO, 6 (12%) had class II HO, and 3 (6%) had class III HO.

DISCUSSION

THA is an effective surgical option to relieve pain and restore function after failed treatment of acetabular fractures. Romness and Lewallen reported a failure rate of 50% at 10 years for cemented fixation, which is not currently

recommended.^[23] In recent years, many authors have suggested the use of cementless porous-coated components to reconstruct acetabular fractures after failed treatment and have emphasized its advantages for excellent prosthesis survival.^[4-8] Our study also demonstrated that THA using TM acetabular components for failed treatment provided excellent fixation, with a low complication rate and a high level of patient satisfaction.

The majority of clinical and radiographic studies of TM acetabular components in primary THA have focused on the use of monoblock acetabular cups with direct compression-molded ultra-high-molecular-weight PE liners, and these studies have consistently reported successful early and mid-term results with these components.^[11,13,20,24] The advantages of a monoblock elliptical cup include elimination of backside wear as a source of PE debris and blockage of the potential pathways that allow debris to enter the periacetabular region of the pelvis, resulting in a low incidence of aseptic loosening.

There are several advantages in the use of a modular TM cup instead of a monoblock TM cup for failed treatment of acetabular fractures. First, at the time of surgery, residual pelvic deformities can lead to distortion of the anatomy and a sclerotic or deficient host bone bed that may reduce the initial stability of acetabular components. The cluster-hole shell in a modular THA cup provides the option of using dome screws for adjunctive fixation and, in the present study, two to three screws were used in all cups. Second, initial trauma and subsequent ORIF may predispose hips to a high risk of instability. With the modular TM cup, a liner with the appropriate elevation can be used to optimize the femoral head coverage and prevent dislocation. Intraoperatively, we used a liner with an elevation of 10°. Accordingly, taking account of enhanced intraoperative stability and quick bone ingrowth, after THA, our patients were allowed to recover their full weight-bearing earlier when compared to the patients treated with a titanium component reconstruction. Third, patients with acetabular fractures are generally young and have monoarticular arthrosis that results from a high activity level. In the present study, the mean age of the patients at the time of THA was only 47.3 years (range, 22–70 years), and wear of the PE liner and associated osteolysis were issued. The modular TM cup allows the use of the highly cross-linked PE liner longevity PE; this liner has been shown to have a substantially low wear rate in laboratory studies and clinical follow-up reports.^[25-27] However, if the problem of wear occurs, the liner can be easily changed. Kamada *et al.*^[28] reported the clinical results of modular TM cups used in 45 dysplastic hips at a mean follow-up period of 9.8 years. In their study, the mean Japanese Orthopaedic Association hip score improved from 48.2 preoperatively to 92.1 at the most recent follow-up. In addition, all cups were radiographically stable with no evidence of progressive radiolucency or osteolysis, regardless of bone grafting, and no cup needed revision surgery.

In our study, all cups were found to be fully incorporated, and no evidence of cup migration or periacetabular osteolysis was noted. We observed periacetabular gaps on immediate postoperative radiographs in 10 hips and, of these 10 hips, nine showed resolution of the gaps within one year after THA. New onset radiolucency was detected in one hip. Our radiographic findings are in accordance with the findings reported by Gruen *et al.*^[11] and Macheras *et al.*^[13] who used a monoblock cup, Kamada *et al.*^[28] who used a modular cup, and Noiseux *et al.*^[20] who used a hybrid monoblock and modular cup. Gruen *et al.*^[11] reported the results of monoblock cups used in 414 primary cases at a minimum follow-up of two years. In their study, 80 hips had postoperative radiolucent gaps, and the gaps were completely filled in 67 of the 80 hips (84%) at the most recent follow-up. In addition, no new radiolucent line, progression of any gap, osteolysis, or aseptic loosening requiring revision was noted. Macheras *et al.*^[29] and Kamada *et al.*^[28] reported the similar results.

In the present study, only cluster-hole TM shells were implanted. The component has a hemiellipsoid geometry, and the equatorial diameter is 2 mm larger than the polar diameter, allowing for an initial 2-mm press-fit with line-to-line reaming. This maximizes bone contact and enhances initial stability. Compared with the group of titanium cup, more serious bone defects cases were noted in the group using TM cups (six had type III combined defects, and one had type IV pelvic discontinuity), which clinically confirms the availability of TM cups in complex circumstances of acetabular reconstruction.

Use of TM acetabular components for reconstruction after failed treatment of acetabular fractures is technically challenging as evidenced by the results of our study. Several factors should be considered when performing THA using TM acetabular components for failed treatment of acetabular fractures, including the presence of instruments and necrotic or deficient bone, fracture nonunion, ankylosis, scarring and tethering of the sciatic nerve, and risk of infection.

In patients who have undergone previous ORIF, infection should be ruled out before performing THA. Appropriate baseline tests include assessment of the erythrocyte sedimentation rate and C-reactive protein level. If these values are abnormal or if there is a high suspicion of infection despite normal laboratory values, aspiration of the hip joint should be performed. The fluid should be analyzed for synovial cell count with differential, and aerobic and anaerobic microorganisms. If infection is confirmed, the surgery should be performed in stages. In the first stage, any residual implants should be removed and debridement of the hip joint should be performed, including removal of all cartilage, followed by placement of an antibiotic-loaded spacer. In the second stage, revision should be performed after confirming eradication of the infection [Figure 1]. The choice of intravenous or oral antibiotics depends on the results of intra- and post-operative cultures.

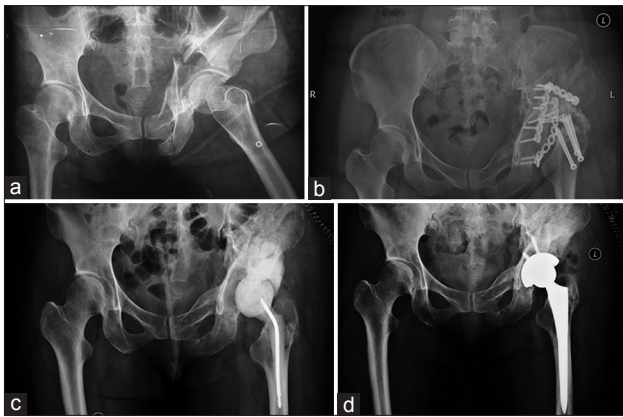


Figure 1: Radiographs of a 40-year-old woman who underwent two-stage reconstruction owing to arthritis, avascular necrosis, and infection. (a) Radiograph showing acetabular and femoral head fractures after high-energy trauma. (b) Radiograph obtained one year after open reduction and internal fixation showing posttraumatic arthritis, avascular necrosis of the femoral head, and improper union of the acetabular fracture. (c) Radiograph obtained at the first-stage operation showing removal of all instruments because of infection and placement of an antibiotic spacer. (d) Radiograph obtained at the second-stage operation showing reconstruction with trabecular metal acetabular components and a porous-coated stem.

The present study presented several limitations. First, this was a retrospective study and not a prospective randomized study, which increased the possibility of selection bias. Second, the number of patients in the study was relatively small, and further studies involving more participants are anticipated. Finally, the follow-up duration was relatively short, and a long-term follow-up study should be performed in the future.

In conclusion, despite the technically demanding nature of the procedure, THA using modular TM acetabular components showed good durability and functionality and may be an effective reconstruction option for failed treatment of acetabular fractures. TM acetabular components can provide immediate stable macrofixation and an environment for optimum biological microfixation. Good functional outcome and prosthetic survival can be expected with THA using modular TM acetabular components in patients with failed treatment of acetabular fractures.

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Conflicts of interest

There are no conflicts of interest.

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