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Case report

Reconstruction of Proximal Metaphyseal Femoral Defects Using Trabecular Metal Augments in Revision Total Hip Arthroplasty

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ABSTRACT

Porous tantalum augments are widely used in revision total hip arthroplasty for the reconstruction of severe bone defects. Here, we present the first 3 cases who underwent femoral revision arthroplasty using standard distal femoral and proximal tibial porous tantalum cones to reconstruct severe bone loss in the proximal femur. Cones were inserted press fit, followed by implantation of a cemented revision stem in all cases. After a mean follow-up period of 15.8 months, all patients showed an improved Harris-Hip-Score and no radiological signs of subsidence or loosening. Porous tantalum cones may be an option in the reconstruction of severe femoral defects in revision total hip arthroplasty. The shape of the tantalum cones should be optimized for the use in the proximal femur.

Introduction

Large femoral defects are a major challenge in revision total hip arthroplasty (rTHA). To achieve durable femoral fixation particularly in the presence of substantial bone loss, several strategies have been used: long cemented stems, impaction bone grafting, and various types of uncemented revision stems, including extensively coated, distally locked stems, and proximal femur replacement [1–8]. However, none of these strategies have completely eliminated problems with fixation in patients with severe loss of proximal femoral bone stock.

Porous metal constructs made out of tantalum or titanium alloy have been widely used to address large bone defects in revision hip and knee arthroplasty. They are available as cones, sleeves, or augments and come in various sizes and shapes [9–11]. Studies have shown excellent long-term data in revision total knee arthroplasty (rTKA) where porous tantalum cones were used in the distal femur, as well as in the proximal tibia [10,12,13]. Moreover, porous tantalum augments have been used to reconstruct contained and uncontained acetabular defects in rTHA [14,15]. However, there are no reports on the use of porous tantalum cones in the reconstruction of severe bone loss of the proximal femur in rTHA [10,14–19].

Here, we present the first 3 cases who underwent femoral revision arthroplasty using standard distal femoral and proximal tibial porous tantalum cones to reconstruct severe metaphyseal bone loss in the proximal femur in combination with cemented revision stems.

Statement of informed consent

The present case series was approved by the institutional review board (EK11/2020). The included patients were informed and agreed to data concerning the case being submitted for publication. These cases are presented according to the Case Report (CARE) criteria.

Case histories

Case 1

A 58-year-old male patient presented with a history of massive groin pain and squeaking of his right hip, 8 years after initial

Level of Evidence: IV.

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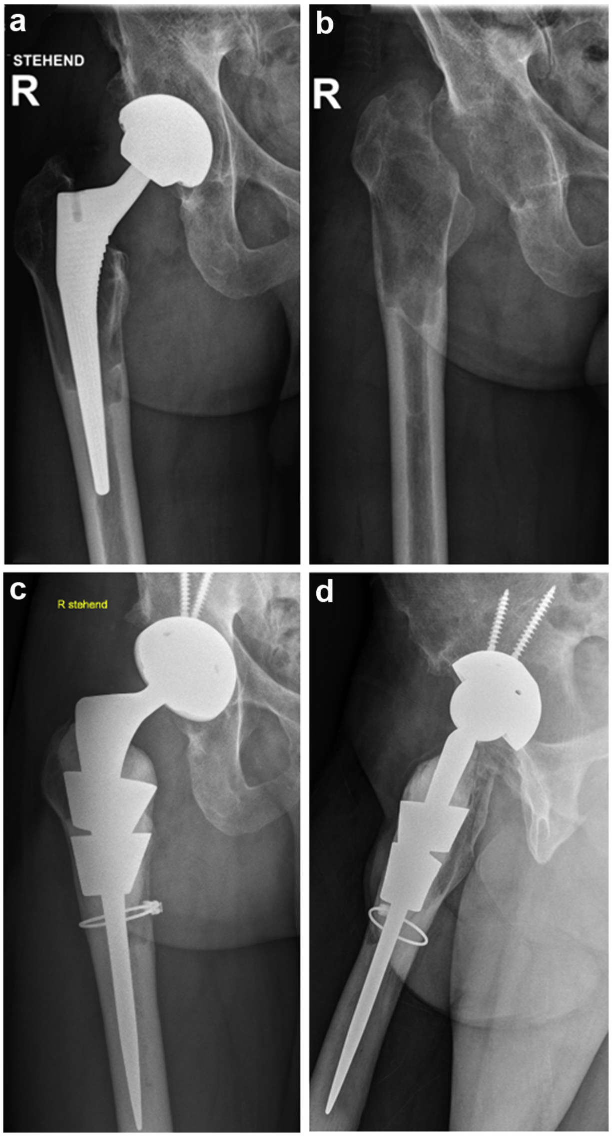

Figure 1. Pelvic anterior-posterior AP radiograph (a) and a postoperative pelvic AP radiograph after resection arthroplasty (b). Pelvic AP (c) and axial (d) radiograph after TM cones implantation at the time frame of last follow-up.

primary THA. Preoperative plain radiographs indicated an extended femoral osteolysis (Fig. 1a). Owing to low-grade infection and severe metallosis, a two-stage procedure was performed. In the first-stage procedure, no spacer was used because of the poor femoral bone stock and the risk of fracture (Fig. 1b).

Six weeks later, the second-stage procedure was performed through a lateral approach in supine position. The femur was broached distally, then the cones were inserted press fit after preparation. Two tantalum cones were used to address the femoral defect (Trabecular Metal proximal tibial cone 51 × 34 × 25 mm; distal femoral diaphyseal cone 30 mm size L; Zimmer Biomet Holdings, Inc., Warsaw, IN). In this case, a segmental cortical defect was present (Fig. 2a). The proximal cone had a good lateral, anterior, and posterior bone contact but had no medial bone contact (Fig. 1c, d and 2c). The distal cone had a good circumferential bone contact (Figs. 1c, d and 2b). Good press fit was achieved with both cones. A cement restrictor was used, and high-pressure lavage was performed before cementing. A cemented revision stem (CPT, size 4 × 200; Zimmer Biomet Holdings, Inc., Warsaw, IN), a Continuum Acetabular System Trabecular Metal Shell, size 58/36, multi hole (Zimmer Biomet Holdings, Inc., Warsaw, IN) with 2 screws, and a highly cross-linked polyethylene liner were implanted (Fig. 1c and d and Tab. 1).

At the most recent follow-up, 13 months after second-stage procedure, the patient presented pain free and with a Harris Hip Score (HHS) of 93 compared with 72 preoperatively. Plain radiographs showed no signs of loosening or subsidence (Fig. 1c and d).

Case 2

An 80-year-old female patient presented with a subtrochanteric nonunion and recurrent dislocations after revision arthroplasty of the left hip after a periprosthetic fracture. Primary THA was performed at the age of 54 years. She sustained a periprosthetic fracture at the age of 73 years and underwent revision surgery at different institution. A Hyperion (Zimmer Biomet Holdings, Inc., Warsaw, IN) revision hip system with 2 distal locking titanium screws and 3 cerclage fixations (Fig. 3a and b) were used. She developed a subtrochanteric nonunion and massive widening of the proximal femur. Moreover, she dislocated multiple times and had to use a hip brace permanently. Preoperatively the hip was aspirated to rule out infection.

She underwent revision arthroplasty through a lateral approach in supine position. The femur was broached distally, then the cones

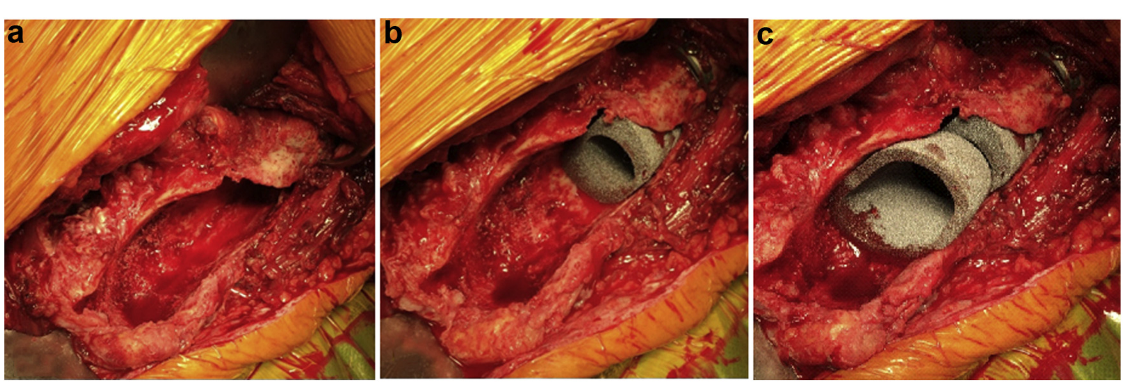

Figure 2. Intraoperative cone-shaped metaphyseal defect (a), intraoperative implantation of the distal femoral diaphyseal cone (b) and intraoperative implantation of the proximal tibial cone (c).

Table 1
Overview about the used implants in our patients.

Case nr.	Femoral cone	Tibial cone	Stem	Cup
Case 1	30 mm size L	51 × 34 × 25 mm	CPT revision stem, size 4 × 200	Continuum size 58/36
Case 2	30 mm size L	55 × 36 × 25 mm	CPT revision stem, size 4 × 230	Durasul 46/36 liner
Case 3	30 mm size M	55 × 36 × 25 mm	Weber stem size M	Continuum size 68/36

were inserted press fit after preparation. In order to address the mobile proximal femur and severe metaphyseal bone loss, 2 tantalum cones (Trabecular Metal proximal tibial cone 55 × 36 × 25 mm; distal femoral diaphyseal cone 30 mm size L; Zimmer Biomet Holdings, Inc., Warsaw, IN; Figure 4a–d), as well as a 4.5 ten-hole LCDC-plate (Limited Bone Contact dynamic compression; DePuy Synthes Companies, Monument, CO) were used. The proximal cone had a good lateral and anterior bone contact but only had a focal

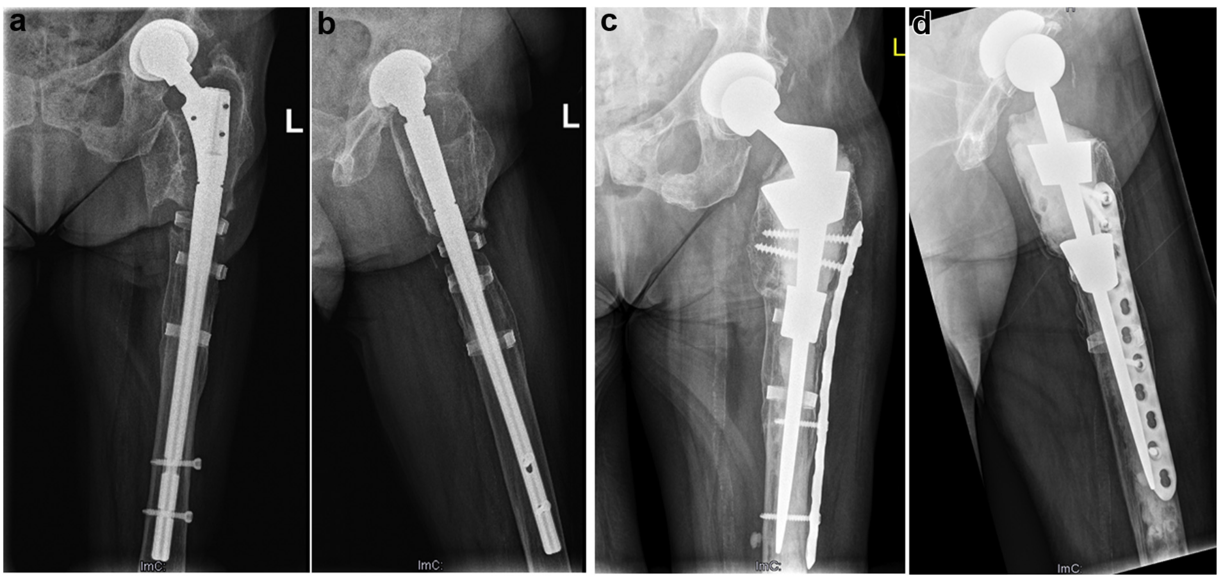

Figure 3. Pelvic AP (a) and axial (b) radiograph after a cementless revision hip system with a huge cone-shaped metaphyseal defect and a subtrochanteric nonunion. Postoperative AP (c) and axial (d) pelvic radiograph after TM cones implantation at the time frame of last follow-up.

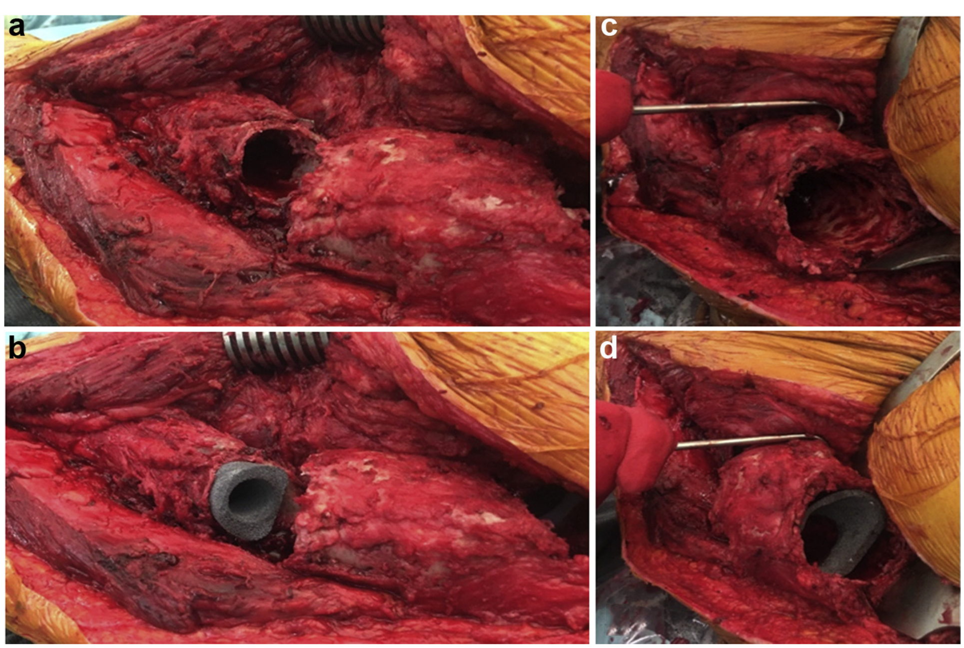

Figure 4. Intraoperative cone-shaped defect at the distal femur fragment (a), intraoperative implantation of the distal femoral diaphyseal cone (b), intraoperative cone-shaped metaphyseal defect at the proximal femur fragment (c), and intraoperative implantation of the proximal tibial cone (d).

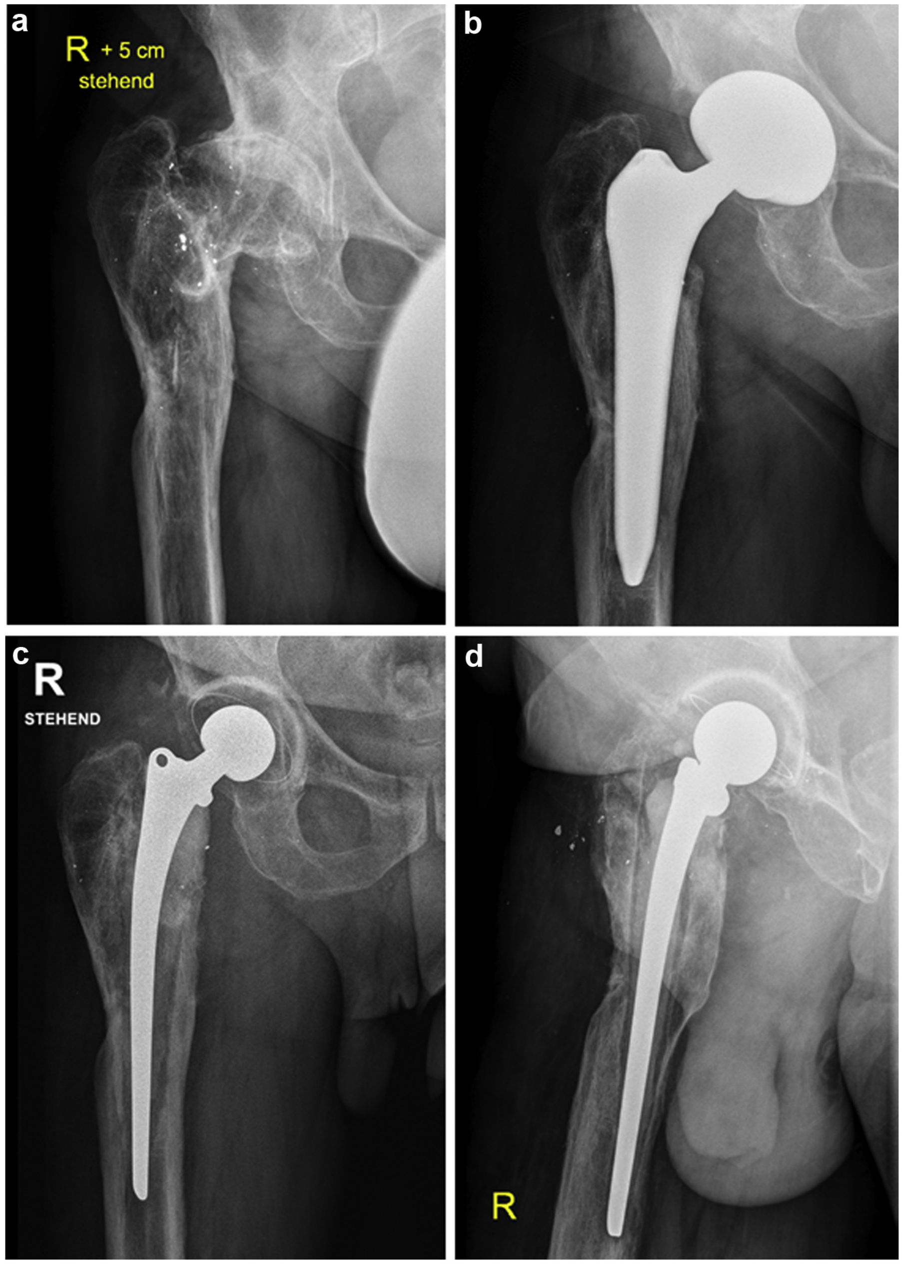

Figure 5. Pelvic AP radiograph after a healed femur fracture due to gunshot (a) and after primary THA in 2017 (b). PROSTALAC type implant in 2017 in AP (c) and axial (d) view.

medial contact point (Fig. 3c and d). No ideal contact with host bone was achieved posteriorly (Figs. 3d and 4d). The overall press fit was still adequate. The distal cone had good circumferential bone contact and excellent press fit despite the poor bone quality (Figs. 3c, d and 4b). A cement restrictor was used, and high-pressure lavage was performed before cementing. A cemented revision stem (CPT; size 4 × 230; Zimmer Biomet Holdings, Inc., Warsaw, IN) was used in this case. She had a well-fixed cup that was retained. The original cup size would only allow a 32 head. Hence, we cemented a Durasul 46/36 liner into the cup to use a 36 head (Fig. 3c and d and Table 1).

She dislocated the stem 2 months postoperatively, and it was treated successfully through a closed reduction maneuver. She then used a brace for 6 weeks. After 1 year, the patient presented free of pain and with an HHS of 87 compared with a preoperative score of 48. Plain radiographs showed no signs of loosening or subsidence (Fig. 3c and d). The patient did not sustain another dislocation and does not wear a brace.

Case 3

A 66-year-old male patient presented with posttraumatic osteoarthritis of the right hip after femoral fracture caused by a gunshot at the age of 19 years and a leg length discrepancy of approximately -5 cm. Primary total hip arthroplasty failed because of a periprosthetic joint infection with *Pseudomonas aeruginosa* 9.5 months after index surgery (Fig. 5a and b). As part of a two-stage rTHA, the patient received a PROSTALAC type implant as part of a first-stage procedure (Fig. 5c and d) [20]. The second stage was done 17 months after first-stage procedure through a lateral approach in supine position. The femur was broached distally, then the cones were inserted press fit after preparation. To address the femoral metaphyseal bone loss, 2 tantalum cones (Trabecular Metal proximal tibial cone 55 × 36 × 25 mm and a distal femoral diaphyseal cone 30 mm size M; Zimmer Biomet Holdings, Inc., Warsaw, IN) were used (Fig. 6a and b). The proximal cone had a good lateral and anterior bone contact but only has a focal medial contact point and partial posterior bone contact (Fig. 6c and d). The distal cone had a good circumferential bone contact (Fig. 6c and d). A cement restrictor was used, and high-pressure lavage was performed before cementing. A cemented Weber stem (straight, size M; Zimmer Biomet Holdings, Inc., Warsaw, IN), a Continuum Acetabular System (Trabecular Metal Shell, size 68/36, multi hole; Zimmer Biomet Holdings, Inc., Warsaw, IN) fixed with 2 screws, and a highly cross-linked polyethylene liner were implanted (Fig. 6c and d and Table 1).

At the most recent follow-up, 22.4 months after the 2nd stage procedure surgery, the patient was pain free and presented with an HHS of 97 compared to a preoperative score of 60. Plain radiographs showed no signs of loosening or subsidence (Fig. 6c and d).

Discussion

We present 3 revision arthroplasty cases, where we used standard tantalum cones of the distal femur and proximal tibia to reconstruct severe metaphyseal bone loss of the proximal femur in combination with a cemented revision stem. While the used cones are designed for revision of proximal tibial or distal femoral defects in revision knee arthroplasty, in these 3 cases, they were used to allow cementless metaphyseal fixation in combination with a cemented revision stem. All patients had a satisfactory clinical and radiological result at the latest follow-up.

Reconstruction of the proximal femur during revision surgery is a challenging procedure. Numerous treatment options exist, such as cementless diaphyseal locking stems, cemented revision stems, impaction bone grafting, and proximal femur replacement. Cementless diaphyseal locking stems are widely used in rTHA. Unfortunately, progressive subsidence, stress shielding, and unreliable ingrowth remain a frequently reported complication, and their use is limited by the quantity and quality of the remaining bone stock [1–6,21–24]. The benefit of cemented stems is the lower risk of initial subsidence. However, owing to absence of trabecular bone after numerous revisions, there is less cement-trabecular bone interlock, resulting in a high risk of aseptic loosening [1,5,8]. Impaction bone grafting has been reported as a useful tool, especially in young patients, in whom further reoperations are probable. In rTHA, it shows a beneficial postoperative outcome, but its outcome mainly depends on the extension of the bone defect. Furthermore, it is a very time-consuming and technically demanding procedure [7,14]. Proximal femur replacement should be used with caution in revision cases [1,2,25,26]. However, none of these strategies have completely eliminated problems with fixation in patients with severe loss of proximal femoral bone stock.

Porous metal cones such as tantalum or titanium alloy constructs have been successfully used in revision arthroplasty [10,13,16,17]. The high coefficient of friction vs cancellous bone is responsible for its initial fixation [27]. The increased metaphyseal load may prevent stress shielding and therefore may preclude further bone loss. Tantalum cones showed promising mid-term outcomes on managing bone loss in rTKA, and histological studies have shown a reduced infection risk [13,14,28,29]. For titanium cones, only short-time follow-up studies are available for rTKA [30]. Tantalum cones show a higher osteoid formation than titanium in in-vivo experiments [10,31]. Titanium and tantalum cones show similar low initial micro-motion which is essential for secure bone ingrowth and fixation [14,32]. Removal of a well-ingrown trabecular metal construct may be challenging in case of re-revision [14]. More long-time follow-up studies are needed for both materials to evaluate if their clinical results differ.

It is important to note that this is an off-label use of a medical device. In this study, we used porous tantalum cones that were designed for the use in rTKA; therefore, a perfect bone-cone contact was not always achieved. The size and shape of the cones could be optimized for the use in the proximal femur to resolve some of our concerns. There are commercially available titanium augments of the proximal femur; however, no data have been published. There are also some other technical issues that need to be addressed. We

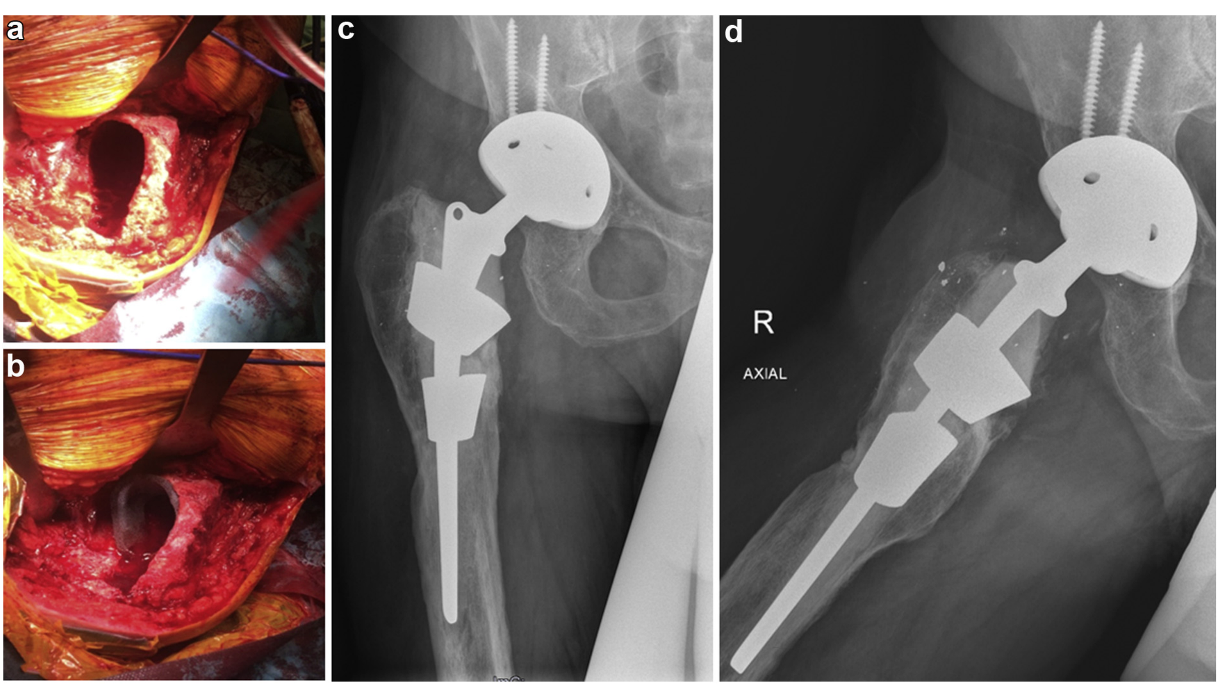

Figure 6. Intraoperative cone-shaped metaphyseal defect (a) and implantation of the TM cones into the metaphyseal defect (b). Postoperative pelvic AP (c) and axial (d) radiograph after TM cones implantation at the time frame of last follow up.

cemented a revision stem into the tantalum cones. During the curing process, the cement expands and may cause the cones to lose the initial press fit. Another concern may be that the use of cones may lead to malalignment of the stem. At this stage, it is not known if the cone subsides in regions with poor bone-contact. Moreover, a focal bone contact could be a stress riser at the bone interface and may lead to a periprosthetic fracture. However, we did not observe this intraoperatively or postoperatively. We will assess these patients every 6 months clinically and radiographically to get long-term data.

There are several limitations in our study. We only have a limited sample size with a short follow-up period. Moreover, it was an off-label use of cones designed for the use in rTKA. Longer follow-up is needed to assess the outcome.

Our results demonstrate another treatment option, to address severe bone loss in the proximal femur during revision arthroplasty using porous tantalum cones.

Summary

Tantalum cones may be used for metaphyseal bone reconstruction in the setting of severe bone defects in the proximal femur. Ideally the size and shape of these constructed should be optimized for addressing proximal femur defects.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

References

[1] Della Valle CJ, Paprosky WG. The femur in revision total hip arthroplasty evaluation and classification. Clin Orthop Relat Res 2004:55.
[2] Sheth NP, Nelson CL, Paprosky WG. Femoral bone loss in revision total hip arthroplasty: evaluation and management. J Am Acad Orthop Surg 2013;21:601.
[3] Tanzer M, Graves SE, Peng A, Shimmin AJ. Erratum to: is cemented or cementless femoral stem fixation more durable in patients older than 75 Years of age? A comparison of the best-performing stems. Clin Orthop Relat Res 2020;478:1131.
[4] Hernigou P, Dupuys N, Delambre J, et al. Long, titanium, cemented stems decreased late periprosthetic fractures and revisions in patients with severe bone loss and previous revision. Int Orthop 2015;39:639.
[5] Tyson Y, Rolfson O, Karrholm J, Hailer NP, Mohaddes M. Uncemented or cemented revision stems? Analysis of 2,296 first-time hip revision arthroplasties performed due to aseptic loosening, reported to the Swedish Hip Arthroplasty Register. Acta Orthop 2019;90:421.
[6] Apostu D, Lucaciu O, Berce C, Lucaciu D, Cosma D. Current methods of preventing aseptic loosening and improving osseointegration of titanium implants in cementless total hip arthroplasty: a review. J Int Med Res 2018;46:2104.
[7] Colo E, Rijnen WH, Schreurs BW. The biological approach in acetabular revision surgery: impaction bone grafting and a cemented cup. Hip Int 2015;25:361.
[8] Holt G, Hook S, Hubble M. Revision total hip arthroplasty: the femoral side using cemented implants. Int Orthop 2011;35:267.
[9] Xie S, Conlisk N, Hamilton D, Scott C, Burnett R, Pankaj P. Metaphyseal cones in revision total knee arthroplasty. Bone Joint Res 2020;9:162.
[10] Lei PF, Hu RY, Hu YH. Bone defects in revision total knee arthroplasty and management. Orthop Surg 2019;11:15.
[11] Klim SM, Amerstorfer F, Bernhardt GA, et al. Excellent mid-term osseointegration and implant survival using metaphyseal sleeves in revision total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2020;28:3843.
[12] Mancuso F, Beltrame A, Colombo E, Miani E, Bassini F. Management of metaphyseal bone loss in revision knee arthroplasty. Acta Biomed 2017;88:98.
[13] Schmitz H-CR, Klauser W, Citak M, Al-Khateeb H, Gehrke T, Kendoff D. Three-year follow up utilizing tantal cones in revision total knee arthroplasty. J Arthroplasty 2013;28:1556.
[14] Mancuso F, Beltrame A, Colombo E, Miani E, Bassini F. Management of metaphyseal bone loss in revision knee arthroplasty. Acta Biomed 2017;88:98.
[15] Sheth NP, Nelson CL, Springer BD, Fehring TK, Paprosky WG. Acetabular bone loss in revision total hip arthroplasty: evaluation and management. J Am Acad Orthop Surg 2013;21:128.
[16] Bonanzinga T, Gehrke T, Zahar A, Zaffagnini S, Marcacci M, Haasper C. Are trabecular metal cones a valid option to treat metaphyseal bone defects in complex primary and revision knee arthroplasty? Joints 2018;6:58.
[17] Sculco PK, Abdel MP, Hanssen AD, Lewallen DG. The management of bone loss in revision total knee arthroplasty: rebuild, reinforce, and augment. Bone Joint J 2016;98-B:120.
[18] Baauw M, van Hooff ML, Spruit M. Current construct options for revision of large acetabular defects: a systematic review. JBJS Rev 2016;4.
[19] O'Neill CJ, Creedon SB, Brennan SA, et al. Acetabular revision using trabecular metal augments for paprosky type 3 defects. J Arthroplasty 2018;33:823.
[20] Biring GS, Kostamo T, Garbuz DS, Masri BA, Duncan CP. Two-stage revision arthroplasty of the hip for infection using an interim articulated Prostalac hip spacer. J Bone Joint Surg Br 2009;91-B:1431.
[21] Tsai SW, Chen CF, Wu PK, Chen CM, Chen WM. Cement augmentation in the proximal femur to prevent stem subsidence in revision hip arthroplasty with Paprosky type II/IIIa defects. J Chin Med Assoc 2018;81:571.
[22] Tangsataporn S, Safir OA, Vincent AD, Abdelbary H, Gross AE, Kuzyk PR. Risk factors for subsidence of a modular tapered femoral stem used for revision total hip arthroplasty. J Arthroplasty 2015;30:1030.
[23] Koster G, Walde TA, Willert HG. Five- to 10-year results using a noncemented modular revision stem without bone grafting. J Arthroplasty 2008;23:964.
[24] Palumbo BT, Morrison KL, Baumgarten AS, Stein MI, Haidukewych GJ, Bernasek TL. Results of revision total hip arthroplasty with modular, titanium-tapered femoral stems in severe proximal metaphyseal and diaphyseal bone loss. J Arthroplasty 2013;28:690.
[25] Sakellariou VI, Babis GC. Management bone loss of the proximal femur in revision hip arthroplasty: update on reconstructive options. World J Orthop 2014;5:614.
[26] DeRogatis MJ, Issack PS. Total femoral replacement as a salvage operation for the treatment of massive femoral bone loss during revision total hip arthroplasty. JBJS Rev 2018;6:e9.
[27] Meneghini RM, Ford KS, McCollough CH, Hanssen AD, Lewallen DG. Bone remodeling around porous metal cementless acetabular components. J Arthroplasty 2010;25:741.
[28] De Martino I, De Santis V, Sculco PK, D'Apolito R, Assini JB, Gasparini G. Tantalum cones provide durable mid-term fixation in revision TKA. Clin Orthop Relat Res 2015;473:3176.
[29] Schildhauer TA, Peter E, Muhr G, Köller M. Activation of human leukocytes on tantalum trabecular metal in comparison to commonly used orthopedic metal implant materials. J Biomed Mater Res A 2009;88A:332.
[30] Denehy KM, Abhari S, Krebs VE, et al. Metaphyseal fixation using highly porous cones in revision total knee arthroplasty: minimum two year follow up study. J Arthroplasty 2019;34:2439.
[31] Bandyopadhyay A, Mitra I, Shivaram A, Dasgupta N, Bose S. Direct comparison of additively manufactured porous titanium and tantalum implants towards in vivo osseointegration. Addit Manuf 2019;28:259.
[32] Faizan A, Bhowmik-Stoker M, Alipit V, et al. Development and verification of novel porous titanium metaphyseal cones for revision total knee arthroplasty. J Arthroplasty 2017;32:1946.