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ORIGINAL ARTICLE

# Tantalum in type IV and V Paprosky periprosthetic acetabular fractures surgery in Paprosky type IV and V periprosthetic acetabular fractures surgery

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**Abstract**
*Purpose* Periprosthetic acetabular fractures represent a growing and serious complication of total hip arthroplasty (THA). The purpose of the study is to report our experience in the use of tantalum for the treatment of Paprosky type IV and V periprosthetic acetabular fractures.
*Method* We analyzed 24 patients with type IV and V periprosthetic acetabular fractures. Patients were treated with a revision surgery using tantalum components, in some cases in association with posterior plating. Outcomes were evaluated using VAS, Harris hip score and considering the average time of integration of the acetabulum and the number of complications. The endpoint evaluation was established at 24 months.
*Result* Results show that the average time of integration of the neoacetabulum in tantalum was 12.3 months (range 6–18 months). The average VAS pain is 8.7/10 cm at time 0 and gradually returns to basic pre-injury values in the following months. The average value of HHS at time 0 is 13.5 points. This value tends to increase progressively until reaching a mean score of 89.3 points at 24 months, higher than the average pre-trauma value of 84.3 points.
*Conclusion* Periprosthetic fractures of the acetabulum with bone loss are a rare but potentially disastrous complication of total hip prostheses. Their management and therapeutic choice will test the ability of the orthopedic surgeon. It is important to determine the type of fracture and characteristics in order to pursue an adequate therapeutic strategy. The modern biomaterials, such as porous tantalum, offer a greater potential in replacing bone loss, promoting bone regrowth and obtaining a stable implant.

**Keywords** Paprosky acetabular classification · Tantalum · Bone loss · Hip revision surgery · Acetabular periprosthetic fractures · Outcomes

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## Introduction

Periprosthetic acetabular fractures represent a growing and serious complication of total hip arthroplasty (THA). The incidence of periprosthetic fractures is 0.07% [1] with a 0.2% occurring after implantation of cemented prosthesis [2]. The incidence of postoperative acetabular fractures with pelvic disruptions is 0.9% [3]. Most of the periprosthetic acetabular fractures occur during the first installation intervention and/or during acetabular revision surgery [4, 5]. The principal factors associated with the increase in periprosthetic acetabular fractures are imputable to broaden THA

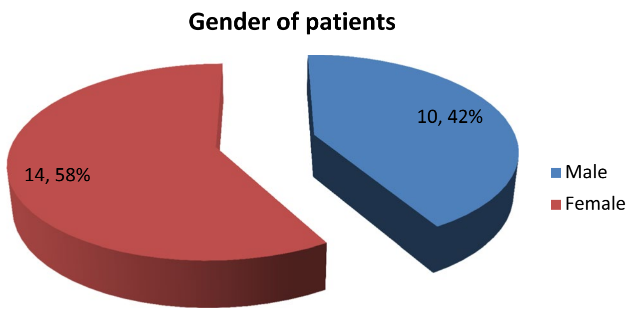


**Fig. 1** Description of the population

**Table 1** Type of Paprosky fracture and number of patients

| Type of Paprosky fracture | Number of patients (%) |
|---|---|
| IVa | 5 (20.83%) |
| IVb | 7 (29.17%) |
| Va | 5 (20.83%) |
| Vb | 6 (25%) |
| Vc | 1 (4.17%) |

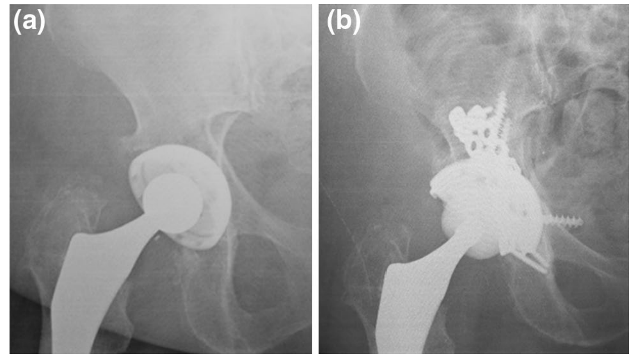


**Fig. 2** After low energy falling from a bicycle in patients, with the patient reports a fracture Paprosky 5a (bone stock > 50% with moderate osteolysis acetabular bottom and loosening of the insert). XR (Fig. 1a): in addition to the above details, there is a decoupling of the posterior column of the acetabulum. In one surgical stage by back approach, we did the revision with tantalum revision shell with wires and plating to recontraction the acetabular posterior column (Fig. 1b)

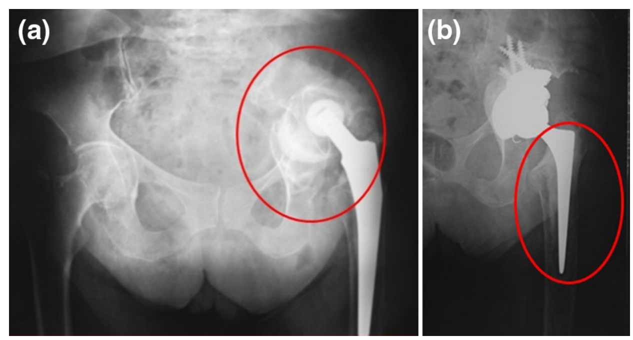


**Fig. 3** Case Paprosky Vb of periprosthetic acetabular fracture, acetabular cup and femoral stem were cemented, with a break of Kohler line (Fig. 2a). This lesion was treated with revision shell and augment in tantalum in distraction for the acetabulum, technique cement on cement for femoral stem (Fig. 2b)

indications, an increased use of cementless implants and the growing population of patients undergoing revision surgery [6]. Periprosthetic acetabular fractures, as dislocations, are the third leading cause of revision after aseptic mobilization and infection [7]. They are associated with a poor functional outcome, increased morbidity and mortality and a growing economic burden. Tantalum is a pure, inert, robust, flexible, corrosion-resistant and biocompatible metal, which guarantees final stability and long-term biological fixing. We used the revised Helfet algorithm to choose the treatment. The goal of the study is to report our experience in the use of tantalum components in acetabular revision and posterior plating in Paprosky type IV and V periprosthetic acetabular fractures.

## Materials and methods

From January 2005 to December 2012, 24 patients with Paprosky periprosthetic acetabular fractures were treated at the Operative Unit of Orthopedics and Traumatology Hospital of AORN and Sacred Heart Hospital Fatebenefratelli, both located in Benevento, Italy. The average age of the patients was 78.25 years (range 68–87 years) with a 5/7 M/F ratio. The average life of the first implant was 10.3 years (3–20 years). We used the Paprosky classification to grade the periacetabular fractures [8]: it classifies the fractures in five types (Fig. 1; Table 1). We excluded from our study patients with type I, II and III fractures. In this sample survey 12 patients had a Paprosky type IV fracture: (5 IVa, and 7 IVb) and 12 had a type V fracture (5 IVa, 6 Vb and 1 Vc). The patients were treated with tantalum components both in revision and in posterior plating (Fig. 2), alternatively with a revision shell and tantalum augment in acetabular distraction without plating (Fig. 3). The follow-up was made with clinical and radiographic periodic inspections at 1, 3, 6, 12, 15, 18 and 24 months after surgery. A detailed radiographic examination in anteroposterior and lateral views was done for every hip. The fracture's healing radiological criteria we considered were the growth of bridging callus and the development of trabecular bone across the site of the discontinuity. We considered the fracture as "possibly healed" if there were no indirect signs of nonunion, such as failure of the hardware or displacement of the fracture and unhealed if the discontinuity was still visible or if there were signs of implant failure.

The outcome evaluation criteria were:

1. The visual analog scale of traumatized hip pain (VAS): This scale is based on an analogical measurement of pain which is evaluated asking the patient to locate, on a line or on a colored 10-cm-long bar, the geometric point that best identifies the pain intensity.
2. The score subject to the Harris hip score: The Harris hip score enables to judge the outcomes of hip surgery. It evaluates four symptoms: pain, function, absence of deformity and range of motion (ROM). The HHS has a maximum value of 100 points. Scoring less than 70 points means a very poor result; between 70 and 80 points, it is an acceptable outcome, between 80 and 90 it is a good result and a value between 90 and 100 shows an excellent result [9].
3. The average time of acetabulum integration.
4. Complications.

The endpoint assessment was set at 24 months. The preoperative evaluation included a RX chart study to evaluate the Kohler line, the U radiographic (Tear Drop), ischial lysis and proximal migration. In addition, it was always worth requesting the Judet X-ray projection: an oblique iliac and obturator projection, useful in the evaluation of retro acetabular lysis. The TC, in some cases, can give indications about the entity and the extent of the lysis. The objectives to be pursued in the treatment of periacetabular fractures are: stabilizing the fracture; preventing its spreading; maintaining alignment and stability of the acetabulum; obtaining fracture consolidation [10, 11]. The choice of implementing treatment was accomplished following the revised Helfet algorithm [5].

### Surgery notes

Patients were evaluated jointly by the surgical and anesthesiology team. All patients underwent general anesthesia with controlled ventilation with orotracheal intubation. All operations were performed in one session. All patients were in the lateral decubitus, and the chosen surgical technique was the posterolateral or posterior (Southern) approach, proximally extended with respect of the gluteal artery. The acetabular bone loss was filled with grafts from bone bank and bone chip grafting bone taken from the ipsilateral femoral head removed. The surgical procedure also provided for the posterior stabilization with plates and screws, the use of tantalum' augmentations. The reduction in the anterior segment of the acetabulum was achieved by inserting screws through the anti-protrusion ring or through the acetabular revision. The general concept was to create an A-frame equivalent, stabilizing both the front and rear columns when necessary. In all cases, a semi-elliptical acetabular cup was fixed, in which a polyethylene insert for the bi-articular mobility was implanted. Also in both methods, the polyethylene insert was in the range of 15°–35° inclination and of 10° and − 15° anteversion.

### Rehabilitation protocol

The rehabilitation protocol included early mobilization and ambulation with a walker and toe-touch weight-bearing on the operated side for 45 days. After that, patients were encouraged to progressively weight-bear as tolerated until they were free of walking assists.

## Results

We used the Watson–Jones approach for all the patients, in order to provide accessibility to the anterior and supra-acetabular area of the iliac bone. Every patient did partial weight-bearing for 5 weeks after surgery.

The results show that the average time of integration of the neoacetabulum in tantalum was 12.3 months (range 6–18 months). The average VAS pain is 8.7/10 cm at time 0 (at the time of the trauma) and in the days following the surgery. These values tend to gradually return to basic pre-injury values in the following months, reaching an average value of 2.1/10 cm to 24 months (at the established time for the endpoint evaluation) (Fig. 4). This value showed to be lower than the average pre-trauma which was 2.7/10 cm (Fig. 4). The average value of HHS at time 0 is 13.5 points (Fig. 5). This value tends to increase progressively until reaching a mean score of 89.3 points at 24 months, higher than the average pre-trauma value of 84.3 points (Fig. 5). We observed eight cases of complication. Three of them were postoperative seroma; two patients needed a reprosthetization of the homolateral stem due to stress shielding (respectively, 6 and 9 months after the surgery); one periprosthetic Vancouver C fracture on the homolateral prosthetic stem six moths after the intervention; 2 painful implants not

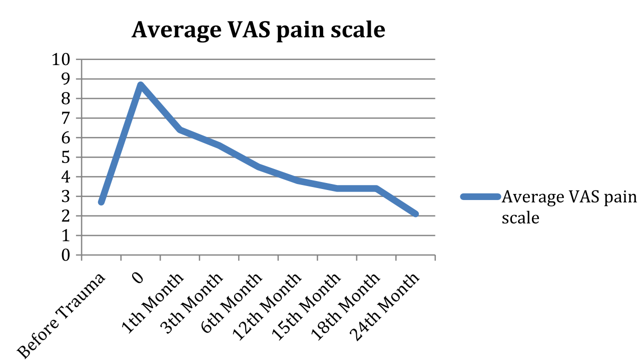


**Fig. 4** Trend of the pain during the 2 years of follow-up. The final results have averaged better than before trauma due to the revision and the new prosthetic implant stability

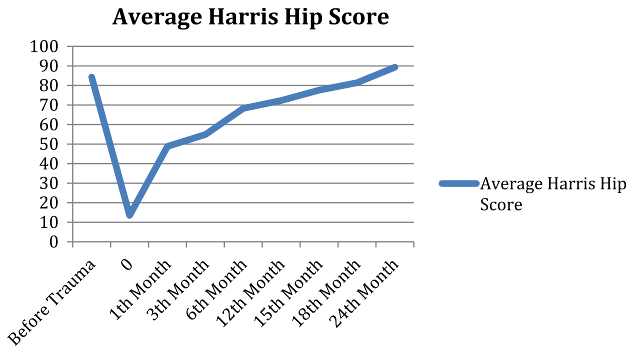


**Fig. 5** Trend of the Harris hip score during the 2 years of follow-up. The final results have averaged better than before trauma due to the revision and the new prosthetic implant stability

attributable to any mechanical or infectious cause. We did not have any complication during surgical interventions.

## Discussion

Periprosthetic acetabular fractures are not common, and therefore, their treatment requires a long learning curve and a good surgical strategy. In 2004, Helfet et al. [5] produced an algorithm for the treatment of this pathology. We observed the following main aspects to take the right decision: the type of fracture, the bone quality, the stability of arthroplasty, the location of the fracture considering the prosthetic implant and how to create a time- and stress-resistant implant. The Paprosky type fractures we examined [12] are the most complex since, independently from the bone stock, type IV coincides to a spontaneous fracture due to stress of the implant, while in the type V the pelvic interruption corresponds to a simple or complex acetabular fracture, according to Letournelle [13]. A good preoperative planning with proper radiological XR and CT imaging should always be done before surgery [14]. A simple X-ray can give us precious indications through 4 landmarks [15]: (1) the Kohler line helps to understand the medial wall and anterior superior column integrity; (2) the U radiographic (Tear Drop), to understand the integrity of the medial wall and of the front and rear columns bottom portion; (3) the ischial lysis to evaluate the integrity of the back wall and the rear of the column; (4) the migration of the proximal tubular dome acetate to understand the acetabular proximal cup migration with tilt and subsequently an acetabular fracture. Judet X-ray projection enable us to understand retroacetabular lysis. CT examination, instead, must be integrated to the normal radiology, letting us to understand the extent and entity of periacetabular lysis. Therefore, the chosen treatment depends on the fracture complexity and on the acetabular prosthesis stability. Surgical treatment for an unstable acetabulum should stabilize the columns of the acetabulum, provide bone grafting of defects and maintain an adequate bone stock for the replacement of a stable acetabular implant. To achieve the union of the acetabular columns and provide a stable environment for reimplantation of an acetabular component, during the surgery it is required a rigorous adherence to the principles of fracture [1 disk]. An exception is made for the pelvic discontinuity because it can be divided into two major classes: acute and chronic. In the first case, the fracture should be treated as described for traumatic fractures with an unstable component. In chronic discontinuity, the pelvis is much stiffer; we thus recommend the use of the acetabular cup reconstruction to allow discontinuity distraction and adequate implant stability [15]. A two-stage technique to treat discontinuities and fractures of the acetabulum is a potential alternative when there is poor quality bone and it is not possible to obtain a sufficiently rigid and stable acetabular construct. Open reduction, internal fracture fixation and reconstruction of any bone loss must be realized in the first stage. In the second stage, when the fracture has consolidated, it is possible to implant a new cup [15]. What we want to emphasize in our surgical choice is the one-stage surgery: In elderly patients, acetabular fracture management [16] sparing an additional shock due to surgical procedures represents a significative improvement. Sometimes, finding out a pelvic discontinuity, we advocate the use of an acetabular distraction technique with a jumbo cup and modular porous metal acetabular augments [17]. The importance of bone substitutes is essential for the treatment of acetabular bone loss. A bone substitute we can use is trabecular metal (a material with a high porosity with a nanostructure) that ensures a scratch fit and facilitates the initial long-term biological fixation of orthopedic implants exploiting bone growth [18]. Among the various possible trabecular metal bone substitutes on the market, we have chosen those manufactured in tantalum, as it is: pure, inert, very robust, flexible, corrosion-resistant and biocompatible. It is also extremely inert in vivo and is considered one of the most biocompatible elements used in implantology, even compared to titanium [19]. Trabecular tantalum guarantees pores of 400–500-μm size and a porosity up to 80%, that is, 18 percentage points more than other materials on the market [20]. The fully interconnected tantalum trabecular pores are designed to promote a bone growth significantly higher than the one displayed by conventional porous coatings. From the biomechanical point of view, tantalum has a friction coefficient on the cancellous bone of 0.98, higher than the one shown by other materials used in implants [21]. This increase in the friction coefficient ensures an excellent initial fixation, reducing micro-movements and ensuring optimization of bone growth [19–21]. However, in laboratory tests tantalum was less performing to the compression forces compared to the trabecular titanium. It is showed, however, to be better in elasticity tests; in both cases, it was always higher than the cancellous bone [19]. With a resistance to compression and shear of 35–40 MPa, the material can support the physiological load associated with acetabular implants, preventing complications that might affect a long-term fixing. In addition, the shear strength of the bone implant was calculated as twice the one of the synthesized spheres and other fixing surfaces [22]. From the biological point of view, the study has shown that the quantity and the quality of bone growth are determined by the porosity and the pore size characteristics of the attachment surface [19, 22]. Optimizing these factors, the material is able of facilitate vascularization and, therefore, to ensure the integration between the porous structure and the surrounding bone. Vascularization facilitates osteogenesis, thus preserving bone health [19–24]. Clinical studies on tantalum trabecular metal components in acetabular implants, some with ten-year follow-up, showed an extraordinary ability of bone remodeling and defect filling [25–27]. In addition, thanks to the flexibility of the augments produced with this material and the ability to associate fixation devices for internal fixation, the tantalum trabecular metal may help the surgeon in the treatment of these diseases, with good results in terms of functional outcomes and patient satisfaction, as shown by our results. The complications we had are compatible with the performed surgery [28]. The limitation of our study is the low number of recruited patients and the 24-month limited follow-up.

## Conclusions

Periprosthetic fractures of the acetabulum with bone loss are a rare but potentially disastrous complication of total hip prostheses. Their management and therapeutic choice will test the ability of the orthopedic surgeon. It is important to determine the type of fracture and characteristics in order to pursue an adequate therapeutic strategy. The modern biomaterials, such as porous tantalum, offer a greater potential in replacing bone loss, promoting bone regrowth and obtaining a stable implant.

The use of a hemispherical cementless acetabulum in combination with tantalum augments, or a Jumbo acetabulum with stabilization of the fracture distraction, is also achievable even for the acetabular revision with marked bone loss in periacetabular fractures in the presence of PTA. Further studies are needed to understand the real potential of tantalum in this type of surgery.

### Compliance with ethical standards

**Conflict of interest** Gabriele Falzarano, Antonio Piscopo, Giuseppe Rollo, Antonio Medici, Predrag Grubor, Michele Bisaccia, Valerio Pipola, Raffaele Cioffi, Francesco Nobile and Luigi Meccariello disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations and grants or other funding.

**Human and animal rights** This type of study does not require any statement relating to studies on humans and animals. All patients gave the informed consent prior to being included into the study. All procedures involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments.

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