Are Customized Implants a Solution in Acetabular Revision Surgery? A Case Study

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ABSTRACT
We present the case of a 73-year-old patient, previously treated with two hip prosthesis revisions due to a chronic infection caused by a multidrug-resistant microorganism, who consulted after the first surgical procedure. Radiographic and computed tomography studies revealed a Paprosky type IV femoral defect and a type IIIA acetabular defect. Following clinical and laboratory monitoring, it was decided to perform acetabular reconstruction using a custom-made implant and a tumor stem. Two years later, the patient shows a favorable evolution: he is able to walk with a cane and without pain. The implant is stable and properly positioned, with no recurrent infection.
Keywords: Revision; acetabular; custom-made.
Level of Evidence: IV

¿Son los implantes "personalizados" una solución en la cirugía de revisión acetabular? A propósito de un caso

RESUMEN
Se presenta a un paciente de 73 años que había sido sometido a dos revisiones de prótesis de cadera debido a una infección crónica por un microorganismo multirresistente. Acude a nuestro centro tras un primer tiempo quirúrgico. En la radiografía simple y la tomografía computarizada, se observan un defecto femoral tipo IV y un defecto acetabular tipo IIIA de Paprosky. Tras un control clínico y análisis de laboratorio, se decide la reconstrucción acetabular mediante un implante "personalizado" y un vástago tumoral. A los 2 años, el paciente evoluciona favorablemente: deambula con bastón y sin dolor. El implante está estable y en posición normal, no hubo recidiva infecciosa.
Palabras clave: Cirugía de revisión acetabular; implante personalizado.
Nivel de Evidencia: IV

INTRODUCTION

The number of revision surgeries after hip arthroplasty is expected to increase by 137% between 2005 and 2030,[1] mainly due to the aging population and arthroplasty performed on younger patients with higher functional demands.[2] Chronic infection is second only to aseptic loosening as a reason for revision surgery, which increases surgical aggressiveness and the number of complications caused by the procedure itself.[3,4] During surgery, there is an added risk of bone stock defect due to the etiology itself and other factors, e.g., removal of prosthetic material.[3]

We present a clinical case of femoral revision surgery with a tumor stem and acetabular revision using the following construction: a) acetabular revision with a custom-made implant (Figure 1) and b) femoral reconstruction using an extended stem (Figure 2).

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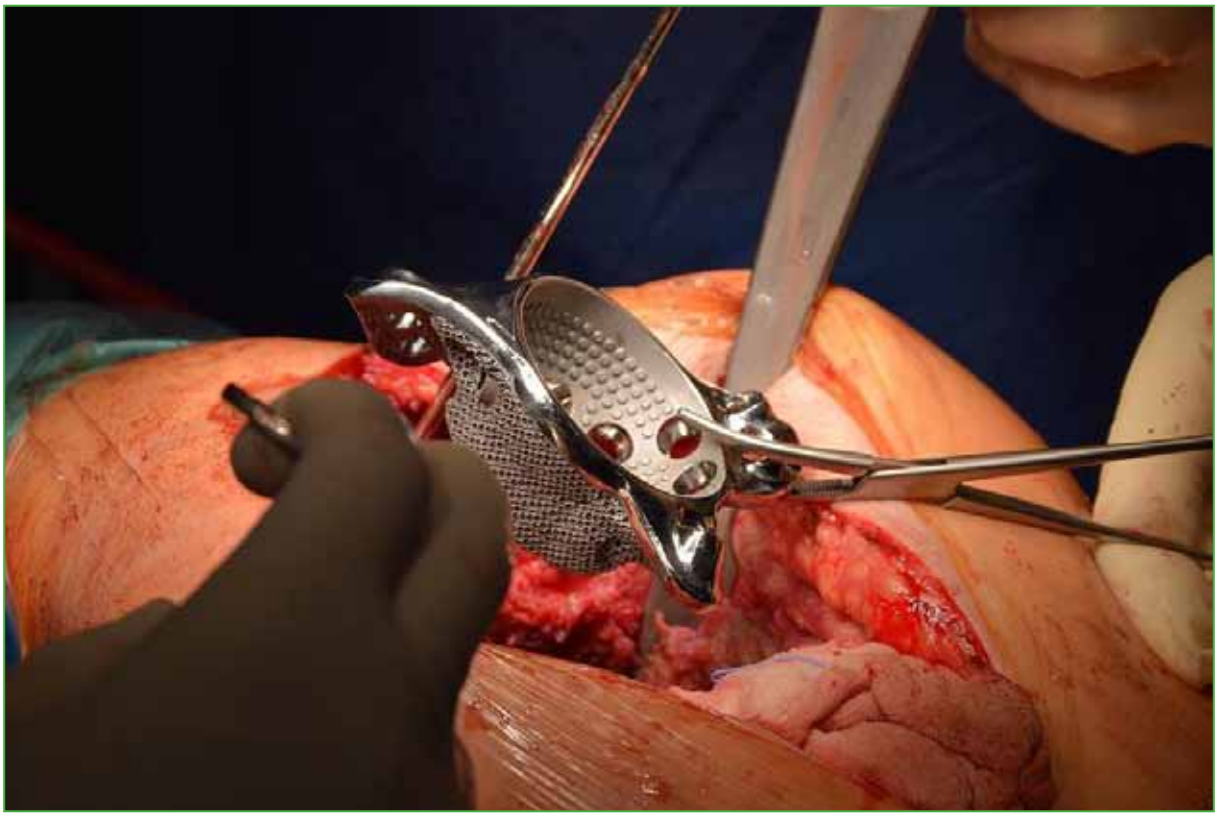

Figure 1. Intraoperative image. Customized acetabular implant before insertion in the acetabular defect.

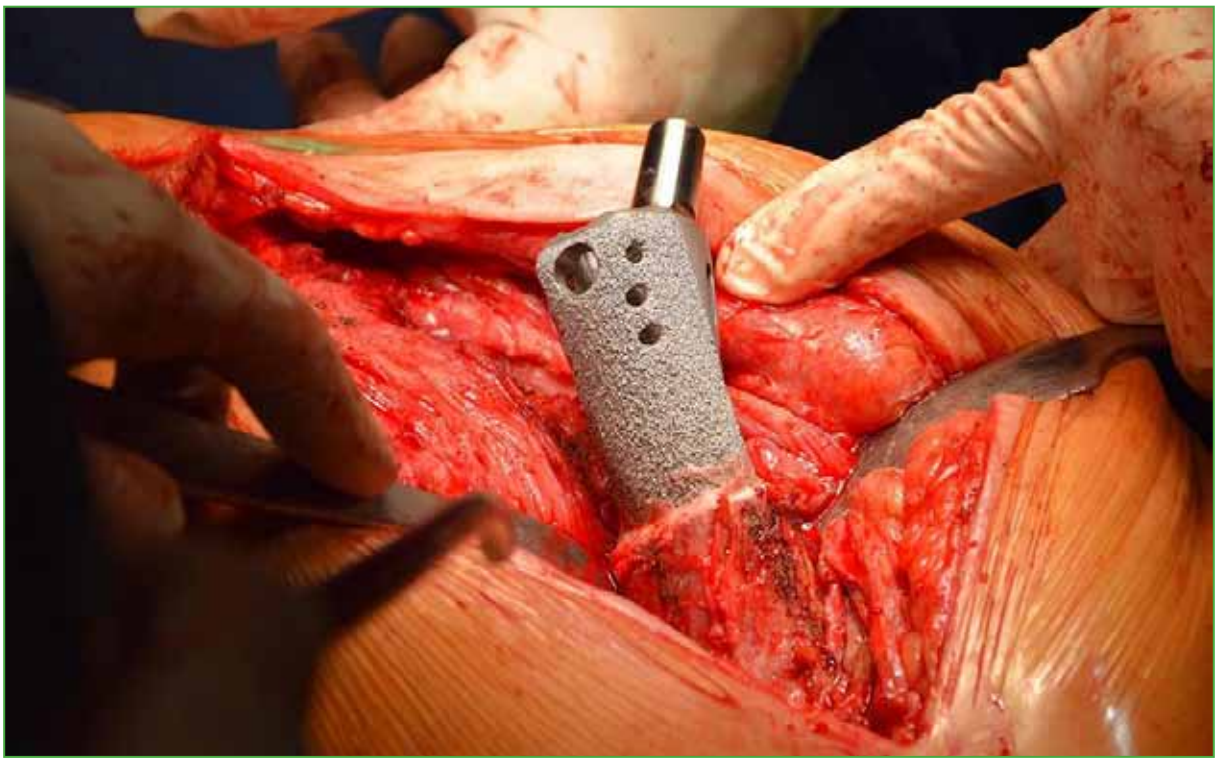

Figure 2. Intraoperative image. Cemented tumor femoral implant after implantation.

CLINICAL CASE

A 75-year-old man, referred to outpatient clinic from another hospital. The medical and surgical history of interest included: complete remission of localized colorectal cancer, obesity, non-insulin-dependent diabetic mellitus, and arterial hypertension treated with standard treatment. He underwent a left total hip arthroplasty in February 2018; six months later (August 2018), he developed a chronic *Staphylococcus capitis* infection (a multidrug-resistant microorganism) and required the first revision surgery, which included a first stage of prosthetic material removal and, two months later (November 2018), a second stage of total hip arthroplasty.

After three months (February 2019), he had a new chronic infection and it was decided to perform another first stage, in which a cement spacer with antibiotic (gentamicin and vancomycin) was placed. During surgery, a considerable bone stock defect was detected: he had a type IV femoral defect and a Paprosky's type IIIA acetabular defect.

In June 2019, he attended outpatient consultations at our hospital center to evaluate definitive treatment (Figure 3).

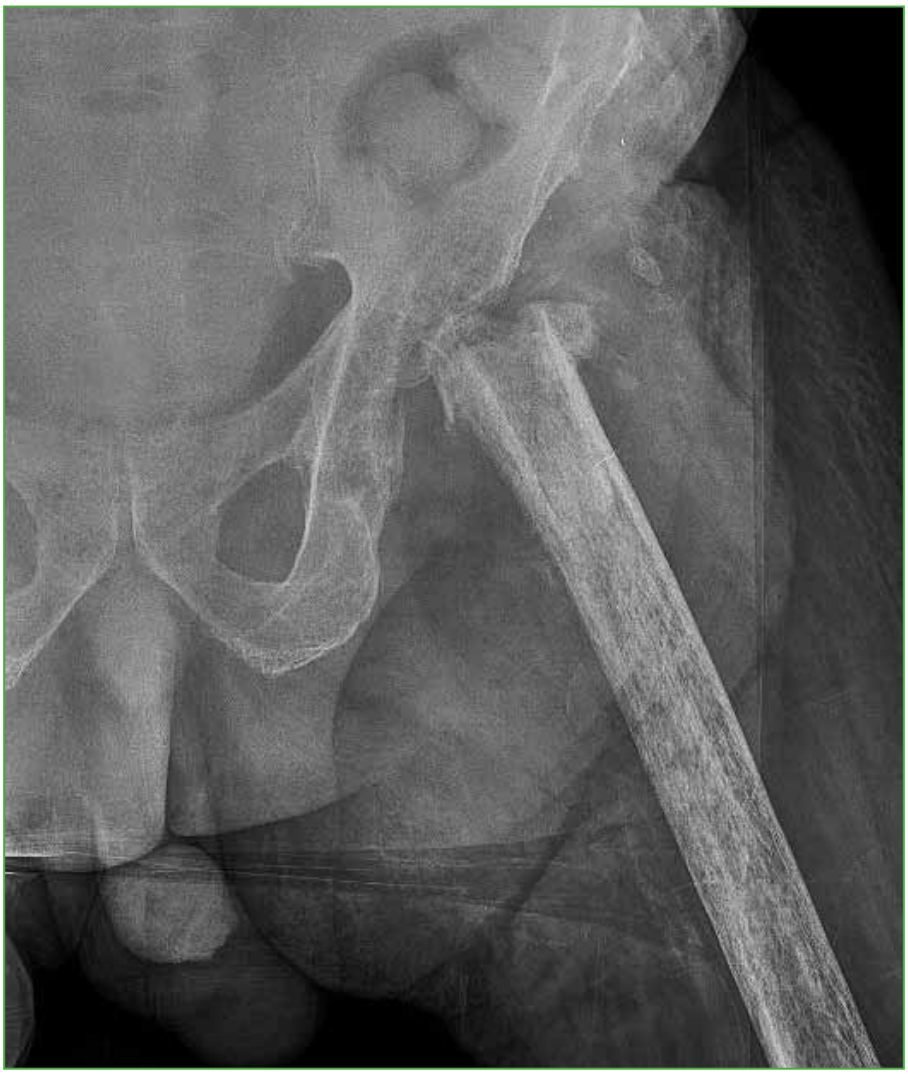

Figure 3. Preoperative anteroposterior radiograph of the pelvis. Femoral and acetabular defects before surgery.

The patient was monitored for eight weeks by clinical and laboratory evaluations until the parameters were in the normal range to plan the second surgical procedure (September 2019).

Due to the femoral and acetabular defects, the placement of a revision tumor stem to solve the proximal femoral defect was planned in a clinical session, along with a custom-made implant to address the acetabular defect.

For the design of the acetabular component, a high-resolution computed tomography of the pelvis was performed, with slices every 3 mm (recommended dimension for the 3D reconstruction of the images). The images obtained were sent to an external center for the manufacture of the component (Materialise, Leuven, Belgium).

The design was made according to the images sent, both of the pathological hip and of the contralateral hip. A scan of the healthy and pathologic bone tissue, as well as the remaining cement (placed during the initial revision operation), was performed. With these variables, we calculated the center of rotation of the hip (Figure 4), the definitive size of the acetabular implant, the estimated bone stock after cement removal, the bone surface to be removed before implantation, the orientation of the definitive cup according to the center of rotation, the custom-made guides for the screws, as well as their order, size and orientation with different templates for correct acetabular fixation (Figure 5).

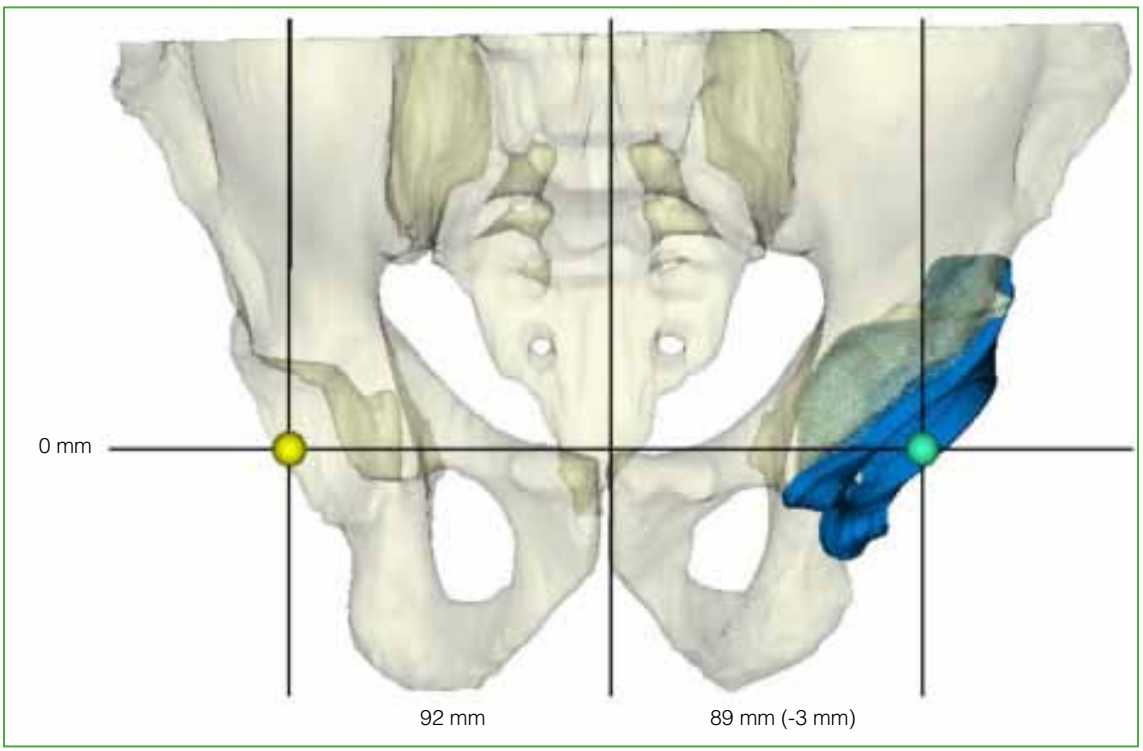

Figure 4. Design of the definitive implant. Calculation of the center of rotation, according to the contralateral hip.

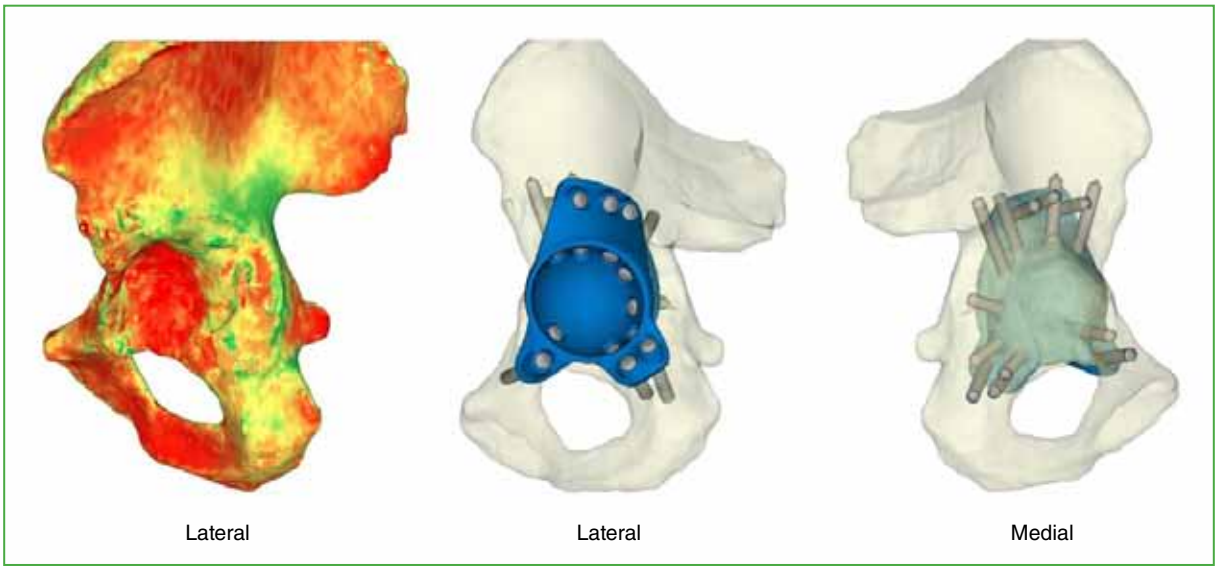

Figure 5. Design of the definitive implant. Lateral and medial views before and after implantation. Visualization of the pathologic bone region (red) and remaining bone stock (yellow color: suboptimal; green color: optimal). Proposed position and orientation of the implant with screw fixation.

Surgical procedure

The operation was performed through an extended posterolateral hip approach. During surgery, tissue and periarticular fluid samples were collected, and an alpha defensin test was done, which yielded a negative result. After cement removal, no other bone defects were observed.

The process of the cup was initiated by removal of osteophytes and bone surface according to the surgical technique, as well as reaming to a size of 62 mm. Once prepared, the customized cup was inserted and the screws were drilled in the indicated order and in the recommended direction. Polyethylene-ceramic bearings with a dual-mobility functional regime were chosen.

After a thorough and systematized pulsatile saline lavage, a 7 cm proximal femoral osteotomy was performed, the canal was reamed and a cemented 18 x 150 mm femoral tumor stem was placed. Before completing the surgery, the mechanical stability of the prosthetic material was checked and found to be optimal, and the surgery was completed by re-anchoring the gluteal and abductor musculature to a polyethylene terephthalate mesh. This component is a restrictive mechanical element that subsequently generates a neo-capsule together with the anchored elements and provides joint stability (Figure 6).

The patient did not require transfusion of red blood cell concentrates during hospitalization. Before discharge, he managed to walk 20 steps in a row with the aid of a walker, with relative independence.

At the last clinical control (two years after the last operation), the patient's evolution was satisfactory (Figure 7). Joint balance was correct, with no reported dysmetria. Barthel test score[5] was 80; the patient was pain-free except after excessive ambulation (over 1000 m) and he walked with a cane. Control radiographs revealed no loosening or subsidence of the acetabular or femoral material. On the other hand, compared to the contralateral hip, the center of rotation was recovered. He has also experienced no neurovascular lesions during his evolution.

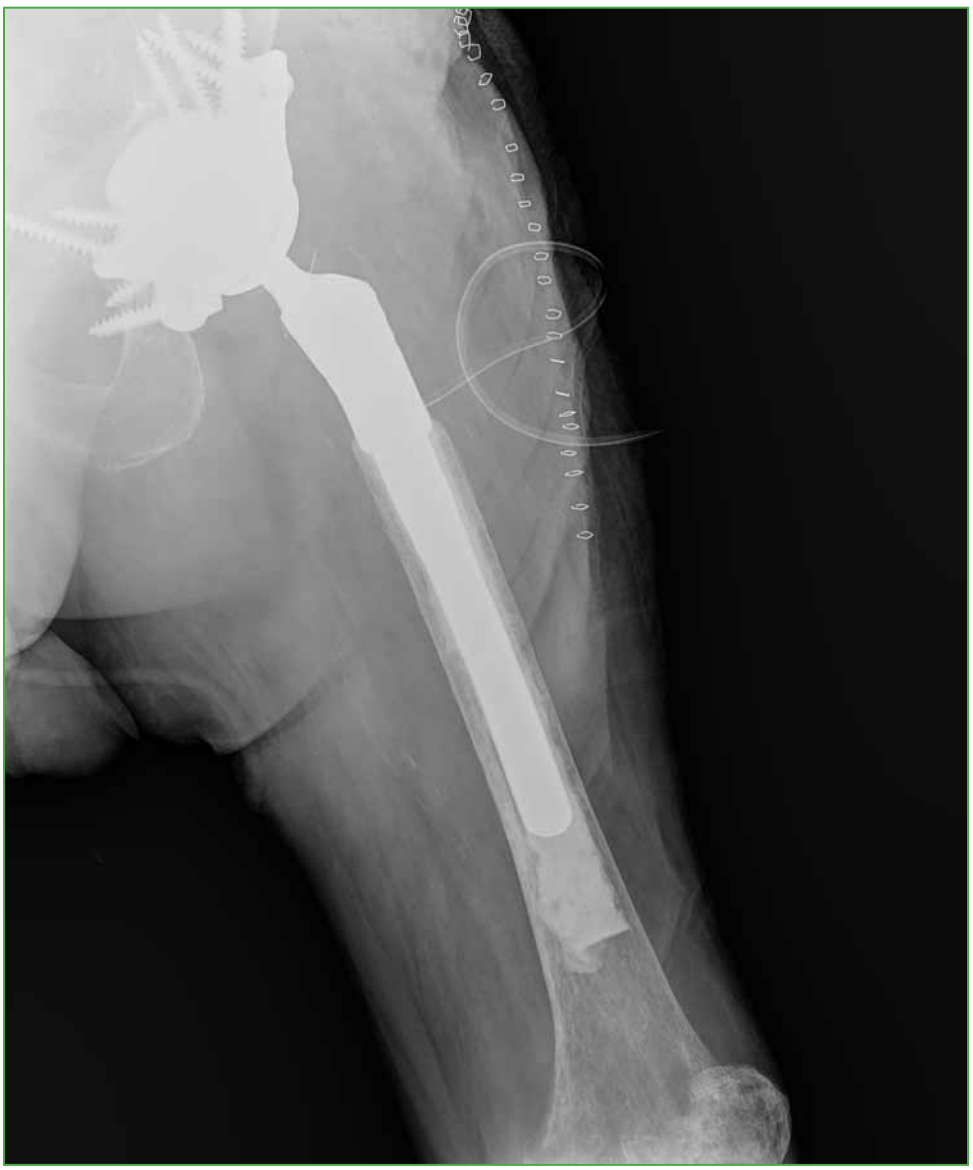

Figure 6. Anteroposterior radiograph of femur. First post-surgical control.

DISCUSSION

Acetabular revision surgery is a complex surgical procedure and the choice of implant is critical. The combination of an acetabular bone defect, anatomical changes and insufficient healthy bone stock requires a revision strategy aimed at restoring the acetabular surface and achieving proper fixation of the prosthetic component.

In 1994, Paprosky[6] defined his classification of acetabular defects based on radiographic criteria studied on an anteroposterior pelvis radiograph. Type III defects already include severe bone loss of the anterior and posterior columns, as well as the superior dome. He defined defect IIIA as one with <50% bone loss, with medial wall involvement, but without pelvic migration, as in our patient.

Multiple therapeutic methods for revision surgery have been presented for defects of substantial severity, one of which is the use of custom-made acetabular components.[6]

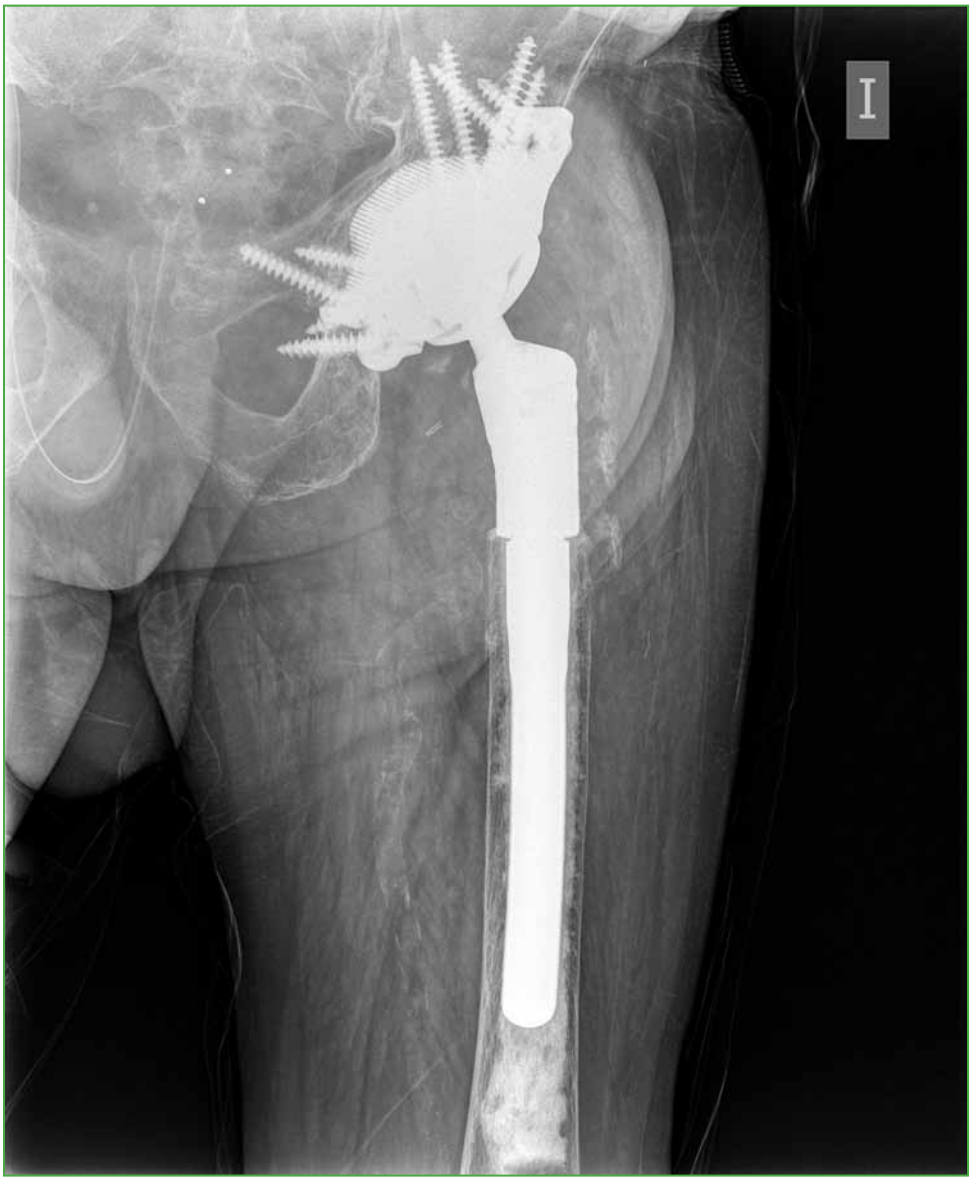

Figure 7. Anteroposterior radiograph of femur. Control after two years of evolution.

Articles have been published on this therapeutic choice, such as that of Van Eemeren et al.,[7] who also presented a clinical case operated on using a "customized" cup, but via the anterior approach.

Citak et al.[8] presented a series of nine patients operated on with a customized cup via the posterior approach. The results obtained were comparable in the short term to those of the cup-cage system, the only drawback being the delay in obtaining the prosthetic material due to the design time. It is not only comparable to other systems, but it can also serve as a rescue for them, as proposed by Zanasi and Zmerly,[9] who chose a customized cup following the aseptic loosening of a triflange cup.

If a new surgical procedure is finally proposed, it ought to be for the following reasons: at least equal clinical, functional, and radiological results in the medium term;[9,10] option or salvage surgery for severe acetabular defects where therapeutic options have already been exhausted;[9] better acetabular orientation; shorter surgical time, and less blood loss.[10] Disadvantages have also been reported, such as higher health care costs, pending more long-term

cost-effectiveness data;[11] a longer time between treatment planning and obtaining the definitive implant; a learning curve for the surgical team. Likewise, postoperative complications have already been published. Gruber et al. reported a clinical case of posterior dislocation three months after surgery.[12]

Delay in manufacturing is likely to be a relative and acceptable disadvantage. According to published articles, it takes between four weeks and months from planning to obtaining the implant.[9,10] This is a process that requires a computerized tomography scan when the patient no longer has the prosthetic material. High resolution images are sent for fabrication, detailing all the aspects mentioned above. Special caution should be taken, since, as described by Di Laura et al.,[13] surgical planning prior to removal of the prosthetic material may lead to discordance of the healthy bone stock present at definitive surgery.

Short- and medium-term functional outcomes after surgery have been published. In the largest series,[8] an improvement of 22.1 (range 9-40) to 58.7 (range 9-92) was obtained in the Harris hip score. This scale has also been used in other studies,[14] in which the mean score was 79 (range 36-100), with no preoperative data collected. In their systematic review of retrospective and prospective studies after a minimum follow-up of two years, Chiarlone et al.[15] published a Harris hip score of 76.1 (standard deviation 8.6).

On the other hand, Li et al.[16] reported that the radiographic evaluation of customized implants is challenging due to the intrinsic design of the devices, and reported an acceptable rate of loosening, implant migration, as well as material breakage and the presence of radiolucency lines.

CONCLUSIONS

Custom-made implants are a valid treatment for acetabular defects with major bone involvement (deficient bone stock). The published results are promising and these implants represent one more option within the clinical and surgical challenge posed by these patients.

More studies are needed to contrast the scientific evidence, as well as more extensive follow-up to draw long-term conclusions.

Conflict of interest: The authors declare no conflicts of interest.

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