

Revision total hip arthroplasty in Paprosky II and IIIA femoral bone defects

Use of modular uncemented stems with proximal fixation

GERMÁN GARABANO, DIEGO S. MANA PASTRIÁN, HERNÁN DEL SEL

Orthopedics Department, Hospital Británico of Buenos Aires

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Abstract

Background: The purpose of this retrospective analysis was to observe the outcomes of a modular hip system in revision total hip arthroplasty with Paprosky types II and IIIA femoral bone defects, evaluating their performance, offset restoration and leg length discrepancy correction.

Methods: Twenty-two revision total hip arthroplasties were analyzed in 12 women and 10 men (average age 62.38 years). The average follow-up was 62 months. Femoral stems S-ROMR (Depuy, Johnson & Johnson) were used. Paprosky femoral bone deficit were 15 types II and 7 IIIA. Clinical evaluation was performed using the Harris Hip Score, while Engh classification was used for stem fixation. Offset restoration, leg length discrepancy (a difference <5 mm was considered correct) and hip stability were evaluated radiographically.

Results: Offset was properly restored in 16 (72.3%) cases and the leg length was matched in 15 (68.2%). There was a single stem subsidence and according to Engh classification, proximal bone ingrowth fixation was obtained in 17 (77.27%) patients. There were 7 (31.8%) complications: two dislocations that required revision, four intraoperative fractures and a lateral popliteal nerve paresis.

Conclusions: S-ROM® modular system seems to be a valid alternative to solve a complex problem. Its versatility allows to optimize hip stability, leg length equalization and offset restoration in revision total hip arthroplasty, showing an acceptable complication rate.

Key words: Revision; total hip arthroplasty; modular uncemented femoral stem; proximal fixation; offset; leg length discrepancy; joint stability.

Level of Evidence: IV

REVISIONES DE CADERA EN DEFECTOS ÓSEOS FEMORALES PAPROSKY II Y IIIA.

UTILIZACIÓN DE PRÓTESIS NO CEMENTADA, MODULAR, DE FIJACIÓN PROXIMAL Y ANCLAJE DISTAL

Resumen

Introducción: El objetivo de este estudio retrospectivo fue observar el comportamiento de un tallo modular de fijación proximal y anclaje distal en revisiones de cadera con defectos femorales II y IIIA (Praposky), evaluando la estabilidad protésica y articular, la restauración del *offset* y la diferencia de longitud.

Materiales y Métodos: Se analizaron 22 revisiones de reemplazos totales de cadera. Doce mujeres y 10 hombres (edad promedio 62,38 años). El seguimiento promedio fue de 62 meses. El tallo femoral utilizado fue S-ROM® (Depuy, Johnson & Johnson). Los defectos óseos femorales fueron 15 de tipo II y 7 de tipo IIIA de Praposky. Para la evaluación clínica

Conflict of interests: The authors have reported none.

se utilizó el puntaje de cadera de Harris. En las radiografías, se analizó el comportamiento del tallo, su integración, la diferencia de longitud y el *offset* femoral, y se consideró correcta una diferencia <5 mm.

Resultados: El *offset* fue restaurado en 16 (72,3%) casos y la longitud de miembros se restauró en 15 (68,2%). Hubo un solo hundimiento del tallo, y de acuerdo con la clasificación de Engh, se observaron 17 (77,27%) uniones óseas. Se produjeron siete (31,8%) complicaciones, dos luxaciones que requirieron revisión, cuatro fracturas intraoperatorias y una paresia de ciático poplíteo externo.

Conclusiones: Este tallo impresiona ser una alternativa válida para resolver un problema complejo. Por su versatilidad, permite resolver mecánicamente el defecto óseo, devuelve la longitud al miembro y el *offset* a la articulación, con un índice de complicaciones aceptables.

Palabras clave: Revisión; reemplazo total de cadera; tallo modular; no cementado; fijación proximal; anclaje distal; *offset*; discrepancia de longitud.

Nivel de Evidencia: IV

Introduction

In spite of the good medical and functional long-term results achieved with Total Hip Replacement, (THR), the number of revisions keeps on the increase.¹⁻³

The complexity of these procedures stems from the difficulties associated with adequate fixation in injured femur bone, especially in the cases of the considerable loss of bone following loosening of the prosthesis about to be revised, osteolysis, numerous previous surgeries, or the combination of all these factors.²⁻⁶

Failure rates reported with cemented revision stems in hip reconstruction have aroused particular interest for uncemented devices.⁴ The use of non-modular fully porous-coated femoral stems^{5,6} is associated with a sharp decrease in such complications, with prosthetic stability rates of about 93% at 9-year follow-up; however, stress shielding turned attention onto proximally porous-coated femoral stems. Getting adequate proximal contact with the host bone using this type of stems is difficult because of the varying and unpredictable grades of proximal bone deficit.^{1,7} Although reported revisions with these stems have been low, according to Woolson and Delany⁸, progressive subsidence associated with failure in stable fixation is more than 40%.

Modular stems rose, therefore, as an attempt to solve, by their versatility, the issue of adaptation to these defects and, at the same time, they allow restoration of limb length and femoral offset together with joint stability, what has to be thought of at the time of the surgical planning.^{7,9,10}

Using this type of prosthesis, Cameron et al.¹¹ reported good and excellent results in 81% of the 104 revisions that they performed, with a failure rate of 4%.

The aim of this retrospective analysis is to show our experience in hip revision in hips with femoral bone deficit Paprosky¹ type II and type IIIA, using a proximal-fixation and distal-anchorage uncemented modular prosthesis and assessing mainly the outcomes of the stem in terms of proximal and distal fixation. At the same time, we assessed the capability to restore femoral offset, limb length and joint stability.

Materials and Methods

Between 2005 and 2012, we performed in our Centre 412 THRs; in 25 cases (6%) we used proximal-fixation and distal-anchorage uncemented modular prosthesis. Selection criteria for this study were: hip revision surgery, use of proximal-fixation and distal anchorage uncemented modular prosthesis (S-ROM®; Depuy Johnson & Johnson, Warsaw, Ind., USA), patient with femoral bone deficit Paprosky type II or type IIIA, and a minimal of 24-month follow-up.

Three patients were excluded from the study: one of them did not keep minimal follow-up; another one had bone deficit type I, and the third one had been operated on using this prosthetic model in a previous surgery. Thus, the series was made up of 22 THR revisions in 22 patients. Twelve (56.5%) were females and 10, males, and they were, on average, 62.38 years old (ranging from 46 to 78). Average follow-up was 62 months (ranging from 26 to 96).

Revision was mainly indicated for mechanical loosening in 17 (77.2%) cases, hip spacer in three (13.6%) cases, osteosynthesis failure in one (4.5%) case and Gilderstone conversion (sequel of THR infection) in one (4.5%) case. In 15 patients, this one was their first revision, whereas the remaining seven ones had, on average, five previous revisions (ranging from 1 to 17). Revised prostheses were cemented prostheses in 20 cases (Charnley type stems) and one was an uncemented prosthesis. (Wagner type).

In 15 (68%) of the 22 patients we also revised the acetabular component; in 14 of them we used uncemented cups (7 Duraloc 300 and 7 Duraloc 1200, Johnson & Johnson). Three of the inserts used with these cups were constrained acetabular inserts due to a previous shortening of 7 cm and a medical history of 17 previous surgeries (one case) and because of the bad medical status and the muscle deterioration in the other two cases; moreover, they were patients with low functional demand. In two of the uncemented cases it was also necessary to add morselized bone graft at the acetabular bottom because of a contained bone deficit. The only case in which we used a

cemented component was that in which we also used an acetabular reinforcement cage plus bone graft due to an uncontained bone deficit produced by rupture and migration of the acetabular component.

Lastly, in two cases in which the cups used in the previous surgery were uncemented, we only performed an insert change because of their tear. In the cases of conversion and failure of the osteosynthesis, we also used uncemented cups. (one Duraloc 1200 and the other one Duraloc 300). In all cases, we used 28 mm-diameter heads.

Femur bone deficit was classified as stated by Paprosky¹— 15% (68.2%) of type II and 7 (31.8%) of type IIIA.

As femoral stem we used the modular system S-ROM® (Depuy, Johnson & Johnson, Warsaw, Ind., USA). Versatility in this model is due to the fact that it is made up of a distal striated titanium component and a proximally porous-coated component of asymmetric conic shape, with modular neck and head and all of its components interchangeable and combinable between one another. The stem is a right-angled diapason of different lengths and diameters, deeply striated to decrease pain in the anterior aspect of the thigh and fill out the intramedullary canal, giving adequate immediate stability to the construction. The proximal cone (externally porous-coated) is a cylinder that, in one of its aspects (the one that coincides with the medial or calcar femorale area), has some sort of beak (kettle shape).

In other countries, the marketed device is the hydroxyapatite-coated one, but this is not so in the national market, where only porous-coated or titanium-coated devices (used in all the cases of this series) are available. The length, thickness and width of the devices are available in different sizes so as to fit both the medial-lateral and anterior-posterior dimensions of the femoral metaphysis and get adequate contact with the host bone plus favoring future biological fixation in the construction. The femoral-neck version-angle is independent of the position of the proximal cone, i.e., it can be modified 360°; thus, the position of the cone does not determine that of the femoral-neck, what allows to place the cone in accordance with the type of deficit, with the femoral-neck taking up the right position no matter what the deficit is. Femoral-neck lengths are different and, thanks to the different medial-lateral widths available for every femoral-neck length, it is possible to restore the offset without impairing the limbs length, and vice versa. Lastly, heads are also available in different diameters and lengths, what helps the surgeon to get the right offset and stability. These different components can be combined between each other, what explains the wide versatility of the system.

All of the patients were operated on by the same surgical team in a laminar-flow operating-room with hypotensive spinal anesthesia. We used a posterior-lateral approach in 19 patients (86.3%) and a direct anterior-lateral approach in the remaining 3 patients. In four (17.4%) patients, we performed an extended femoral osteotomy so

as to facilitate accessibility and the removal of the failed stems in extremely weak femurs; in other case, we sculpted a bone window for the intramedullary plug removal and, in yet another one, a greater trochanter osteotomy was performed to facilitate surgical accessibility; in the two latter cases, decisions were made during the surgery. In all these patients we used wire loops to close the osteotomy. All patients were given antimicrobial prophylaxis using i.v. cefazolin (3 doses) 1 g. and abdominal s. c. low molecular weight heparin 0.4 cm³ during three weeks.

As for rehabilitation, although it was individualized in every patient, the basic plan consisted of the patient sitting on the bed edge on postoperative day 1, walking with walker as tolerated on postoperative day 2, so as to later move on to Canadian crutches. Postoperative follow-ups were at weeks 3, 6 and 9, and months 3 and 6, with subsequent follow-ups on a yearly basis.

Postoperatively, we assessed patients' medical parameters recording subjective data taken from both statements that patients themselves had contributed with to medical histories and notes written by their surgeons. For objective evaluation, we used the Harris Hip Score. In the postoperative X-ray assessment (June 2014), we evaluated limb length, femoral offset and stems outcomes (subsidence, proximal biological fixation, distal mechanics and changes in bone quality in both segments). Postoperative offset and limb length evaluation (in mm) was made by hand, using both hips anterior-posterior X-ray views, with actual size printing and taking them at a 1 m distance with both lower limbs in 10-15°-internal rotation. Offset was got by determining the distance between the new rotation centre and the femoral anatomic axis, whereas limb length was got by evaluating the distance between the bilacrimial line and the beginning of the lesser trochanter. Both values were considered adequate when differences with the contra-lateral hip was ≤5 mm. Lastly, to determine stems subsidence, we evaluated comparatively at successive follow-ups the distance between the upper edge of the prosthetic component and the upper edge of the lesser trochanter. To evaluate prosthetic fixation, apart from the previous item we used the Eng's criteria¹²; on the other hand, for changes in the femur bone quality, we assessed changes in its density, cortical bone transformation, etc. assessed by direct observation in the successive X-ray follow-ups. All the data were recorded in a Microsoft Excel 2007® platform where we applied different descriptive statistical formulas.

Results

The X-ray assessment showed that the offset was adequately restored in 16 (72.3%) cases and increased, on average, 10.7 mm (ranging from 9 to 15) in four (18.2%) cases; on the other hand, in the two (9.1%) remaining cases the offset resulted 15 and 25 mm inferior to the contralateral hip (Figure 1).

The limbs length was restored in 15 (68.2%) cases (Figure 2); in four (18.2%) cases the limb resulted shorter (14.2 mm on average, ranging from 6 to 35) than the contralateral limb and, in the remaining three (13.6%) cases, the limb averaged 14.24 mm longer than the contralateral limb (ranging from 6 to 25) (Figure 3).

Regarding stems outcomes, we found only one case of subsidence (4.5%) of 5 mm, within the three first post-operative months, but it later got stable and at the final follow-up her results were favorable. It occurred in a patient with a diagnosis of hip osteoarthritis consecutive to a Perthes condition, that was revised due to the mechanical loosening of her cemented prosthesis eight years after the surgery and who showed bone deficit classified as IIIA; she had been subject to extended femoral osteotomy for implant removal.

Considering the Engh criteria, we found 17 (77.27%) cases of stable bone fixation and five (22.7%) cases of stable fibrous fixation. Changes in bone quality were detected in the femoral proximal area (16 cases) and the femoral distal area (12 cases).

In the patient that required a cage plus morselized bone graft and a cemented component, we find adequate bone-ingrowth, as found when bone graft was used with uncemented cups (2 cases) (Figure 2). Regarding the cases with osteotomy, the three cases with extended osteotomy showed adequate bone healing; there was an intra-operative fracture in one of them, on the anterior-medial aspect, at mid-length, with no complications. The distal bone

window also showed adequate bone healing and, in the patient with a greater trochanter osteotomy, we found the greater trochanter rising with subsequent non-union.

At the final follow-up, 18 (81.8%) patients did not report pain, three (13.6%) patients reported moderate and intermittent pain that required pain-killers once in a while, and the remaining (4.5%) patient reported severe pain. Three (13.6%) patients reported the use of some kind of external aid (cane): two out of fear of walking outside home and, the other one, all the time (severe pain reported). Regarding the Harris Hip Score, we found average improvement of 43 points; the preoperative average was 45 (ranging from 25 to 71) and the postoperative average was 88 (ranging from 50 to 94).

We recorded seven (31.8%) complications (Table); two (91%) were prosthetic dislocations that required the acetabular component revision. The first case was that of a female patient who had received hip revision for dislocations and mechanic loosening of the femoral stem. After revision, the limb length was 3 mm shorter and the offset increased 5 mm; the patient underwent three dislocation episodes within the first year following the surgery, because of which it was decided to revise the acetabular component using constrained insert in which the system failed, the retentive ring got uncoupled and the patient suffered yet another dislocation; therefore, she was operated on again and received a tripolar cup, and her outcomes are good up today. The remaining case is that of another female patient with no revision history who also

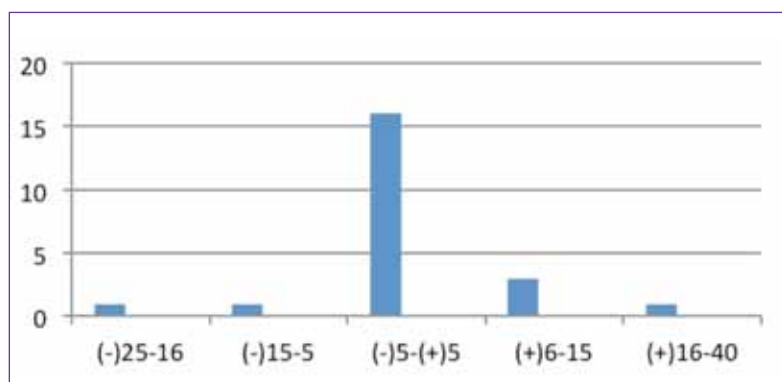


Figure 1. Distribution of postoperative comparative evaluation of femoral offset.



Figure 2. Patient revised because of a mechanical loosening, Paprosky type II. Femoral offset and limb length were adequately restored. Note remodeling of the bone graft used at the acetabular bottom and bone fixation to the proximal femoral component (kettle), in the area of the calcar femorale.

Table. Number and percentages of complications, and need of revision

Complications	Number (%)	Revision
Dislocation	2 (9.1)	Both
Intraoperative fracture	4 (18.2)	No
Lateral popliteal nerve paralysis	1 (4.5)	No

was operated on due to mechanical loosening. In this case, it was only performed an insert change. The offset and the limb length were respectively 3 and 5 mm shorter. The patient suffered two dislocation episodes at postoperative months 3 and 6, that is why it was decided revision to a tripolar cup; she had also done well at the final follow-up. There were four (18.2%) intra-operative fractures, three of which involved the greater trochanter. One of them, found in the postoperative period, healed adequately because it was not displaced (Figure 4), whereas the other two cases were treated with wire loops and also healed adequately. The other case of intra-operative fracture involved one of the sheets of the extended osteotomy aforementioned. Lastly, there was a case of paresis of the lateral popliteal sciatic nerve; this patient recovered almost completely with p.o. medication. It is worth mentioning

that, anyway, at no time did she require external splinting. In view of the complications found in our series, although there was no case requiring revision of the femoral component, and taking revision for any cause as the end of the analysis, prosthesis survival was of 90.9% at the final follow-up.

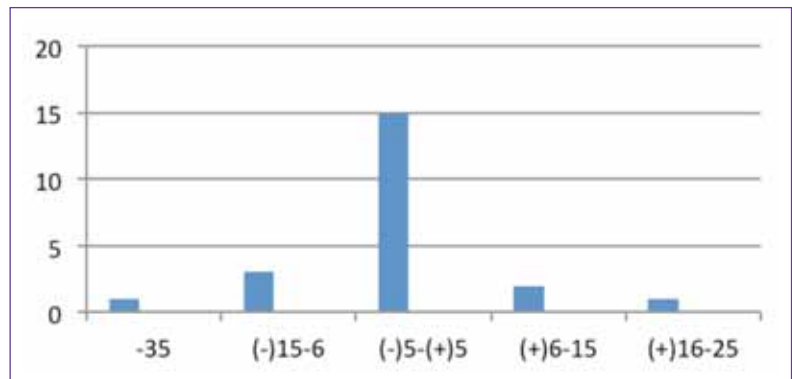
Discussion

Hip revision is a complex procedure whose results are not as predictable as the ones of primary THR are.^{4,7} The procedure difficulties increase proportionately to the number of previous surgeries and the behavior of the bone of the femur to revise.

In these reconstructions, due to either anatomic disorders or loss of bone, there is no geometric correlation between the femoral metaphysis and the femoral shaft, what makes it difficult for a non-modular stem to get implant stability and, at the same time, adequate contact with the host bone all along the prosthetic surface.^{13,14} Either if non-modular stems are of proximal or distal fixation, they have been associated with different complications such as stress shielding, pain in the anterior aspect of the thigh, osteolysis, subsidence and loosening.^{9,13,15}

Modular femoral stems are quite an option in hip revision; they get adapted more harmoniously to the aforementioned differences between the femoral proximal segment and the femoral shaft.^{7,13} The diverse combination

Figure 3. Postoperative distribution of limbs length. ▶



▲ **Figure 4.** Patient who suffered a great trochanter non-displaced intra-operative fracture that healed adequately. Note bone fixation to the prosthesis in its proximal area.

of their components allows the surgeon to restore the lost bio-mechanics to the hip.⁷

Metaphysis biological fixation will favor load transmission, minimizing stress shielding and, in those revisions in which proximal femoral bone is impaired, this is a key factor, but at first it will be necessary to get adequate shaft mechanic stability so as to overlap the metaphysal defect.^{9,10}

The model that we used in this series has been associated with low failure rates. McCarthy et al.¹⁶ reported subsidence rates of 4%, and new revision rates of 1.5% in 133 cases at five-year follow-up. Bono et al.⁹ evaluated 63 hip revisions with femoral deficit Paprosky type II and type III, and reported loosening rates and subsidence of 6% at almost 6-year follow-up. Cameron et al.¹¹ reported similar results in 91 cases. Meanwhile, Bolognesi et al.,¹⁷ in their report of 53 hip revisions with four-year follow-up, showed an implant survival of 95%, and it was only necessary to carry out two revisions (one due to pain and the other one due to loosening). Moreover, bone-ingrowth occurred in 96% of the cases, they detected 11 (20.7%) peri-prosthetic fractures and had to carry out acetabular revisions for dislocation. Christie et al.,¹⁸ in 129 revisions, reported the need of only one more revision due to loosening (<1%). Ninety-two point two percent of the components showed stable bone-ingrowth, whereas the subsidence reported in this series was of 2.9%, and there were 23 (22%) cases of intra-operative fracture, in which they always used wire or cable loops and results were good.¹⁸

In our series, we got similar results to those published about subsidence (4.5%), postoperative pain (4.5%), dislocations (9.1%) and peri-prosthetic fractures (18.2%); we got bone healing in all cases with wire loops. Regarding prosthetic fixation as stated in the Engh criteria, we found 17 (77.27%) cases of stable bone fixation and five (22.7%) cases of stable fibrous fixation, what are results similar to those reported by Christie et al.¹⁸ As regards Christie et al.'s results, bone healing was more frequent

in type II defects [12 (80%) out of 15 cases] than in type IIIA defects [(71,4%) out of 7 cases]; although these are results to be expected, the size of the sample does not allow us to infer statistical conclusions on the subject.

Although we did not find bibliography about hip bio-mechanics restoration using this prosthetic model, Restrepo et al.⁷ using a similar uncemented modular model reported correction of limb length differences in 78% and offset correction in 66% of the 118 cases that they assessed. In our series, we got these outcomes in 72.3% and 68.2% of the cases, respectively, figures which comparatively look acceptable.

This study limitations are, first of all, the inherent ones in a retrospective study; secondly, the number relatively low of patients with an average follow-up which was relatively low (5.2 years), and thirdly, the fact that the series was made up of femur bones with different degrees of bone deficit as stated by the Paprosky classification and the different numbers of previous surgeries (ranging from 1 to 17), what, we believe, affect the final outcome of the revision.

We believe that the strengths of this study are focused on the fact that all the patients were operated on at the same surgical Centre, by the same surgical team and using a unique prosthetic model that is currently marketed. Although follow-up is short, the assessed values (restoration of limb length, offset along with prosthetic and joint stability) can be calculated throughout this follow-up.

Conclusions

We believe that the use of uncemented modular stems for femoral revision surgery is an excellent option for the solution of a complex problem. Their great versatility allows the surgeon to solve mechanically bone deficit in a relatively easy way, whereas they restore length to the limb and offset to the joint. Moreover, complication rates are acceptable for these types of reconstructions.

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