MENTORS IN ORTHOPEDICS

DUAL MOBILITY SYSTEMS IN REVISION OF TOTAL HIP REPLACEMENT

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SUMMARY

Background: Dislocation remains a prevalent complication following revision total hip arthroplasty (rTHA), with reported incidence rates between 10% and 25%. Factors such as bone loss, abductor deficiency, and lumbopelvic kinematics contribute to construct instability, necessitating advanced implant strategies to restore hip function and stability.

Objective: This article evaluates the clinical utility, biomechanical principles, and outcomes of various acetabular components in rTHA, with a specific focus on the role of dual-mobility (DM) constructs in mitigating dislocation risk.

Key Points: Comparative data indicate that DM cups significantly reduce postoperative dislocation rates compared to large-diameter femoral heads or standard fixed-bearing implants. While large femoral heads increase jump distance, diameters exceeding 36 mm may paradoxically decrease stability by lateralizing the center of rotation. DM options include monoblock, modular, and cemented designs. Modular DM systems facilitate supplemental screw fixation but introduce potential risks of corrosion at the metal-on-metal interface and reduced jump distance. In cases of severe acetabular defects (Paprosky grade >2B), DM cups can be combined with reinforcement devices, such as Kerboull cross-plates or tantalum augments, or utilized within 3D-printed custom triflange implants. Long-term survival rates for DM constructs in complex revisions exceed 90% at 10 years. Constrained liners remain a secondary option for refractory instability but carry higher risks of impingement and mechanical failure.

Conclusion: Dual-mobility constructs provide a versatile and effective solution for reducing instability in rTHA. Successful outcomes depend on a precise preoperative assessment of bone stock and soft tissue integrity to select the appropriate monoblock, modular, or reinforced DM configuration.

KEYWORDS

Arthroplasty, Replacement, Hip; Reoperation; Joint Instability; Hip Prosthesis; Prosthesis Design

INTRODUCTION

Dislocation after revision of total hip arthroplasty (THA) is still a concerning and widespread complication, with the literature showing rates ranging from 10 to 25% [1]. The primary motivation for management is to position the components in order to reduce impingement of the implant on the bone and soft tissue, and to maintain the integrity of the hip abductors. Ever-increasing numbers of arthroplasty procedures are being performed, especially in young and active patients, and this accounts for the corresponding increase in revision of THA (rTHA). Management still remains a challenge. This type of surgery may have multiple objectives but there is just one goal: to restore as much lost function to the hip as possible. Although there is a single goal, there are numerous ways to achieve it, just as there are numerous situations that we must deal with during these procedures.

There are also multiple reasons for revision: instability with recurring dislocation, periprosthetic fracture, infection, component-to-component or periprosthetic impingement, loosening with or without bone loss, adverse reactions to metal debris (ARMD) and aseptic lymphocyte-dominant vasculitis-associated lesion (ALVAL), etc.

There are some patients who seem to be more at risk than others, such as those with neuromuscular or cognitive disorders, major postural imbalance, stiffness or abnormal kinematics of the pelvis and lumbar spine. [2],[3]

Certain causes of secondary instability have to be identified, such as poor implant positioning (acetabular version and offset), poorly managed offset or anteversion of the cup or stem, inadequate restoration of leg length or abductor lever arm (offset, combined stem–cup anteversion and dependent length), poor quality soft tissue and component–component and/or bone–component impingement [4].

Situations uncovered perioperatively can also impact the surgical strategy, such as hardware that cannot be removed, bone quality, bone loss (which is often worsened once the implant is removed), metallosis and corrosion, ARMD and ALVAL, and infection.

These factors have meant that additional strategies have proven to be needed. This has led to the development of new ranges of implants specifically aimed at reducing the risk of secondary instability after rTHA using previous generation implants, a risk that is covered extensively in the literature. Some examples of these new generation components are: jumbo cups [5], larger femoral heads, and implants that address the greater limitations between the components through use of either dual mobility cups (DM cups, widely described since they were developed by Bouquet and Imbert in 1974) or constrained cups.

LARGE FEMORAL HEAD, CONSTRAINED CUP OR DUAL MOBILITY CUP?

A comparative study 4 that included 295 rTHA looked at the risk of dislocation and of revision for any other cause in a group of 184 DM cups compared to standard implants (FB: fixed bearing, 36mm heads in 76.6%, 32mm heads in 15.3% and 28mm heads in 8.1%), with illuminating results. This study showed that in all indications for rTHA, DM significantly reduced the risk of postoperative dislocation with no risk of early aseptic loosening in medium term follow-up. Many other studies confirm this finding [6].

Every option has a long list of advantages and disadvantages. Large femoral heads improve the head–neck ratio, which decreases the theoretical risk of dislocation [7]. However, this method often produces insufficient stability in the context of revision, especially for patients who have undergone a wide synovectomy or who have hip abductor deficiency. Ultimately, the underlying mechanical concept behind the use of large femoral heads is that increasing the jump distance protects against dislocation (Figure 1). However, increasing the head diameter beyond 36mm leads to increased acetabular offset and a lateralised centre of rotation. The centre of rotation is outside the cup and the jump distance (the safety distance that protects against dislocation) is paradoxically decreased.

Elsewhere, many case series have demonstrated that constrained or retentive cups reduce the risk of dislocation after revision procedures [8] but the risks of a decreased range of motion, impingement, accelerated wear, component dissociation due to failure of the retention system, and a build-up of stressors at the bone–implant interface (causing loosening) mean that these components are not a viable option in the majority of revision THA [6],[9],[10].

The DM cup was designed in France in 1974 with the first results published in 1986 13, and it was approved by the FDA in 2009 1. It is based on a principle of both improved stability (by increasing the jump distance, Figure 1) and improved range of motion within the safe zone. There are numerous studies that have confirmed that this implant is effective in reducing the postoperative dislocation rate in revision surgery in comparison to standard implants [14],[15],[16],[17],[18],[19].

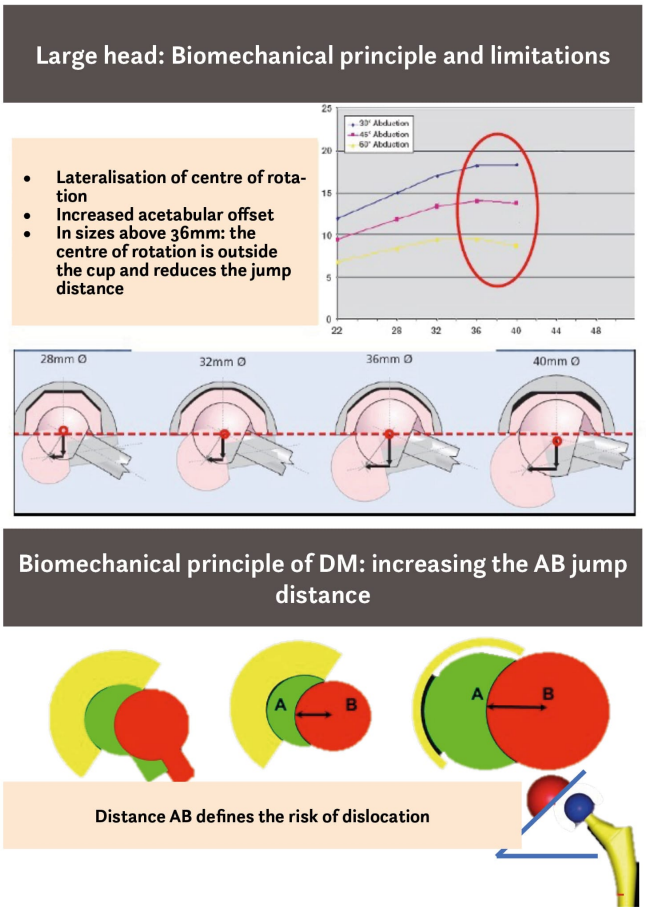

Figure 1: A biomechanical comparison between the large femoral head design and DM cup developed in France by G. Bousquet and A. Rambert [11,12]

EXPECTED BENEFITS AND RISKS

Routine use of a DM system in revision surgery does raise potential concerns. These include the risk of component dissociation, corrosion (especially with modular DM cups), long-term wear and loosening.

Dislocation and dissociation

According to the Australian public registry (2015), 20 the most common indications for revision of a conventional primary THA are loosening/osteolysis (28.0%), dislocation (24.2%), fracture (18.2%) and infection (17.3%), while dislocation secondary to a first revision is the most common reason for a subsequent THA revision (31.1%). The risk factors for implant instability after revision have been extensively described in the literature and concern both patient profile (age, neuromuscular disorders, hip–spine syndrome and imbalanced posture) and the surgical features of the revision. The most notable of these are poor component positioning, leg length discrepancy, abnormal offset, hip abductor deficiency, capsular repair, component–component or bone–component impingement, head–neck ratio and surgeon experience [21].

Mertl et al. [22] reported on a case series of 145 patients who had a rTHA due to recurrent dislocation and were fitted with a monoblock DM cup with 7.7+/-2.2 years of follow-up (4–14). The dislocation rate of the large articulation was 4.8% and component dissociation was 1.4%. A high number of previous procedures and nonunion of greater trochanter were related to recurrent instability.

De Martino et al. [21] recently published a systematic review of component dissociations that looked at 17,908 THA and rTHA, of which 5,064 were rTHA. After a mean of 4.4 years of follow-up, the dislocation rate was 3% (SD 3.0) and the component dissociation rate was 1.3% (SD 2.2). The majority of cases of component dissociations (93%) occurred early, after 3.2 months on average.

Corrosion

In Europe, the majority of DM cups used are monoblock. These types of cups cannot have fixation screws added through the acetabular component. In order for a cementless strategy to still be pursued in cases of poor bone quality or some limited bone loss, modular DM systems were developed, such as the Stryker® Modular Dual Mobility. This offers the surgeon the opportunity to perioperatively improve primary fixation of the cup by adding screws while still using a system that in part takes advantage of the dual mobility design. It includes an additional interface of a cobalt chrome liner that is fitted into the shell. There are limitations to the design in that this imposes a relative reduction on the diameter of the polyethylene liner, which means that it has a smaller jump distance than a monoblock cup of the same diameter. The other concern with this type of impact is corrosion due to the titanium–CoCr interface. In a recent study [23], we reported on at least 5-year follow-up of 102 MDM cups of which 71 were used in revision surgery (69.6%), with no cases of immunoallergic events in spite of initial fears about the titanium cup–CoCr liner as bearing surfaces. The mean concentrations of cobalt (Co) were 0.967 mg/L (0.56-5.3; SD: 1.355) and of chrome (Cr), 0.959 mg/L (0.42-1.4; SD: 0.723).

These figures are similar to those found in the literature with the use of monoblock CoCr DM cups. [24],[25],[26]

Wear, osteolysis and loosening

Appraising the survival curves for these types of complications in revisions remains challenging because there is such variation in the clinical situations, surgical strategies and implants used due to factors that are often interdependent. The factors that influence the survival curve are well known and top of the list are: the reasons for revision, the extent and type of bone loss (cavitary or segmental), whether a cemented cup was used or not,

whether reinforcement devices are used (Kerboull, Ganz, Muller, Burch-Schneider, etc.), whether a cage or augment is used and whether the implant was custom-made. Each one of these many different pictures deserves its own assessment. In the specific context of revisions, results reported only cover the short and medium term [18],[27],[28],[29],[30],[31],[32].

In the Mertl et al. 22 case series with 7.7 years of follow-up (4–14) covering 145 patients, the rate of monoblock cups showing signs of loosening that led to a subsequent revision was 1.4 %, while the rate of possible signs of loosening was 4.1% and the rate of osteolysis around the cup was 9%. The all-cause survival rate was 92.6% (CI 95%, 85.5–96.4%).

Reina et al. [31] carried out a systematic review of six prospective and retrospective studies, and one measure that was compared, among others, was the use of DM versus standard cups in rTHA between 1986 and 2018, reporting a dislocation rate of 2.2% as against 7.1% (P < 0.001) after a mean follow-up of 4.1 years.

The relative risks for the control group compared to the DM group were 3.59 (P < 0.001) for dislocation, 2.46 (P < 0.001) for revision, 4.88 (P 1/4 0.007) for revision due to dislocation, 1.51 (P 1/4 0.32) for infection, 1.18 (P 1/4 .81) for fracture and 2.71 (P 1/4 .003) for aseptic loosening.

Looking at revisions over the longer term, with severe bone loss [33] (Paprosky 2C) and a mean follow-up of 10.7 years (2–16), Sayac et al. [15] published a retrospective study of 77 cases of rTHA treated exclusively with a cemented DM cup in a cage (Kerboull cross-plate, Burch-Schneider ring or ARM cage). Subsequent revisions due to loosening were seen in 3.9% after 9.6 years [7],[8],[9],[10],[11],[12]. The 10-year survival rate of the cup was 96.1%. No progressive radiolucent lines at the bone–component interface were found and bone graft integration was satisfactory for 91% of patients.

Component–component or extra-prosthetic impingement

Using a DM cup to prevent against potential instability in patients at risk is a useful and sometimes essential option. Fitting must nonetheless be done with rigour. Protecting from instability does not remove the risk of impingement, particularly component–component impingement that can be a cause of failure, corrosion, loosening and even component dissociation [34].

REVISION: MULTIPLE PICTURES AND RISKY PATIENTS

As stated earlier, THA revision surgery is by no means one size fits all. Every situation that the surgeon has to deal with must take into account patient-related factors (bone quality, neuromuscular pathology, postural imbalances in the torso, lumbar spine and pelvic stiffness, history of lumbar fusion surgery, etc.) and the mechanics of the area of the hip that requires revision 35 (bone loss, infection, corrosion with metallosis, ARMD, component impingement, wear, hardware that cannot be extracted, etc.)

A close preoperative assessment remains essential. Planning this surgery relies on a firm understanding and appreciation of all of the factors listed above, so that the surgical strategy can be planned as fully as possible and the most suitable implants chosen for the case to be treated. It is essential to anticipate potential perioperative challenges, which may occur due to a failure to fully appraise the preoperative assessment, in terms of the assessment of bone loss especially, but also of poor bone quality or loss of muscle. All of this information will guide the surgeon in choosing the appropriate implants and steps during the operation. While the choice of a DM

cup for hip replacement revision may seem to be accepted in the vast majority of cases, not all DM cups are the same [36]. Choices concerning:

- The type of DM cup
- Cementless fixation (monoblock [37],[38],[39] or modular [23],[40],[41],[42] or cemented fixation (into the native acetabulum [43])
- The handling of existing implants on the basis of their fixation (a securely fixed and integrated cup can be left in place) [8],[44]
- The surgical strategy of biological reconstruction (use of a reinforcement device [15],[27],[30],[43],[45]) or mechanical reconstruction (use of augments 46 or a custom-made implant) and anything beyond the factors set out previously will depend on the surgeon's experience and preference.

Revision with a cementless Dual Mobility (DM) cup

Monoblock DM

The first option is to use a cementless DM cup either with (Figure 2) or without spikes (Figures 3 and 4) or a peg with a minimum implant size of 40, depending on the manufacturer, and a technically demanding fitting process, resulting in good cup stability for patients with bone defects or poor bone quality, which can, in some cases, leave fewer options. This implant is a first line option indicated particularly in patients with implant instability and moderate bone loss. (Figures 2, 3, 4)

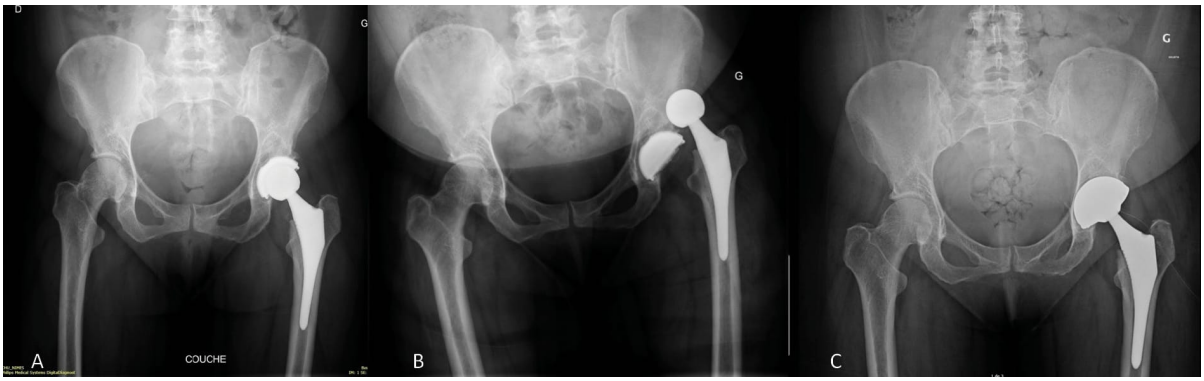

Figure 2: Mrs D., a 50-year-old with implant instability (3 dislocations, last episode graded 2B) following THA with a standard cup and intercurrent pain on weight-bearing. Radiolucent line at the bone–component interface in Gruen zones 1, 2 and 3 (2A), pointing to associated loosening. No bone loss (either pre- or perioperatively, after removal), good bone quality. Unipolar revision with a first line cementless monoblock cup without spikes. Repeat radiography after 5 years (2C).

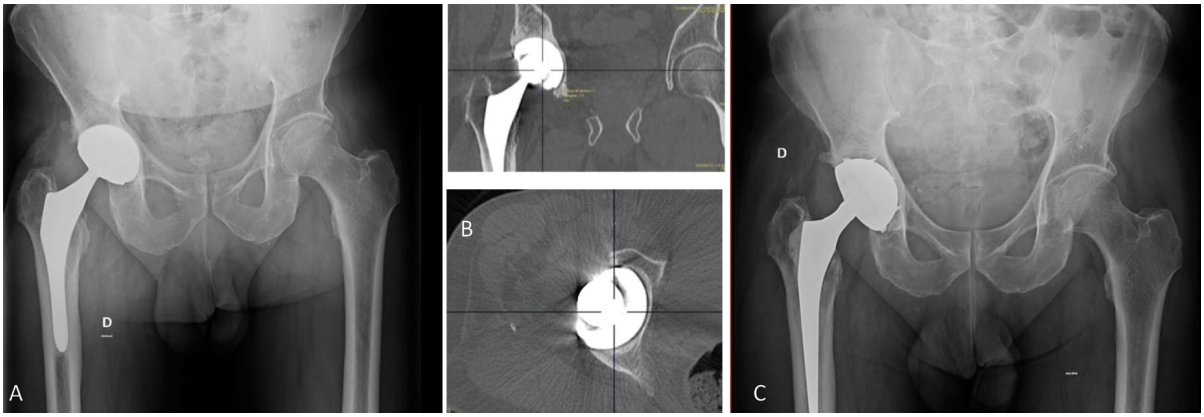

Figure 3: Mr B. THA with a CrCo–ceramic (CoC bearing) fixed liner secondary to hip osteoarthritis (3A). Progression towards symptomatic loosening of the cup confirmed on the CT scan (3B). Perioperative observation: impingement on the neck, requiring bipolar revision. Perfect stem osteointegration. Endofemoral technique for removal. Revision of the cup with a cementless DM cup with spikes (3C). Good implant stability perioperatively. Femoral revision with cemented revision stem. Repeat radiography two years postoperatively. Pain resolved, hip no longer a focus.

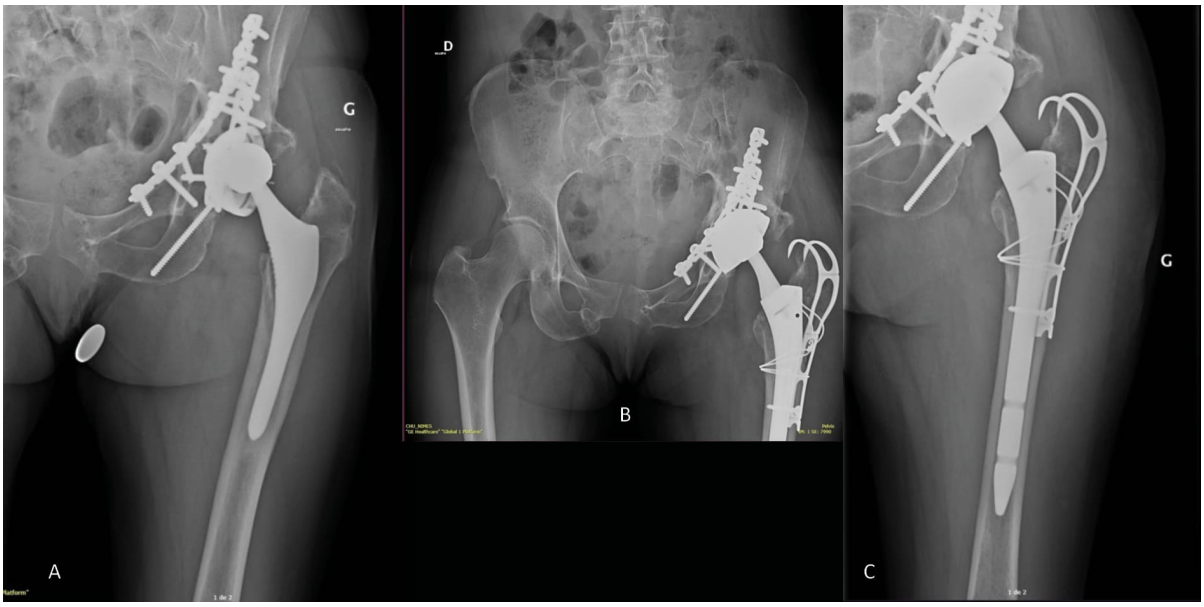

Figure 4: Mrs M., a 51-year-old with a history of complex acetabular fracture treated using an ilioinguinal incision (stabilisation of the anterior column) and Kocher-Langenbeck approach (internal fixation of the column of the posterior wall). Course involved stage 4 avascular necrosis of the femoral head, which was operated on after 1 year by THA (4A). Progressed to loosening and migration of the cup (4B). Radiolucent line at the femur–component interface in Gruen zone 7 with atrophy of the calcar femorale. Perioperative observation: metallosis and corrosion of the morse taper, resulting in the decision for bipolar revision, greater trochanter weakened by osteolysis. Perfect stem osteointegration. Femoral window via extended trochanteric osteotomy (ETO). Cup revised with a cementless DM cup with spikes (4C). Good implant stability perioperatively. Femur revised with a modular locking revision stem. Plating and cerclage wire. Repeat radiography two years postoperatively.

Monoblock DM with iliac stem: The ice-cream cone prosthesis

In some complex cases of revision, especially when there is structural bone loss and/or pelvic discontinuity in elderly patients, the “ice-cream cone” prosthesis can prove to be useful.

Puget et al. [47] described the iliac isthmus as an anatomical beam made up of a dense bridge with a potential entry point at the superior-medial and posterior part of the acetabulum. Fixed with a peg (as used with the Integra cup: length 5 cm, diameter 11mm and orientation 55°) inserted into the ilium [48], this implant results in primary stability that allows patients to quickly regain their independence with weight-bearing from the outset. There are various models, both modular and monoblock, on the market today 49. (Figure 5). They can be used in mechanical reconstructions, in cases when a biological reconstruction using bone grafts no longer appears to be suitable.

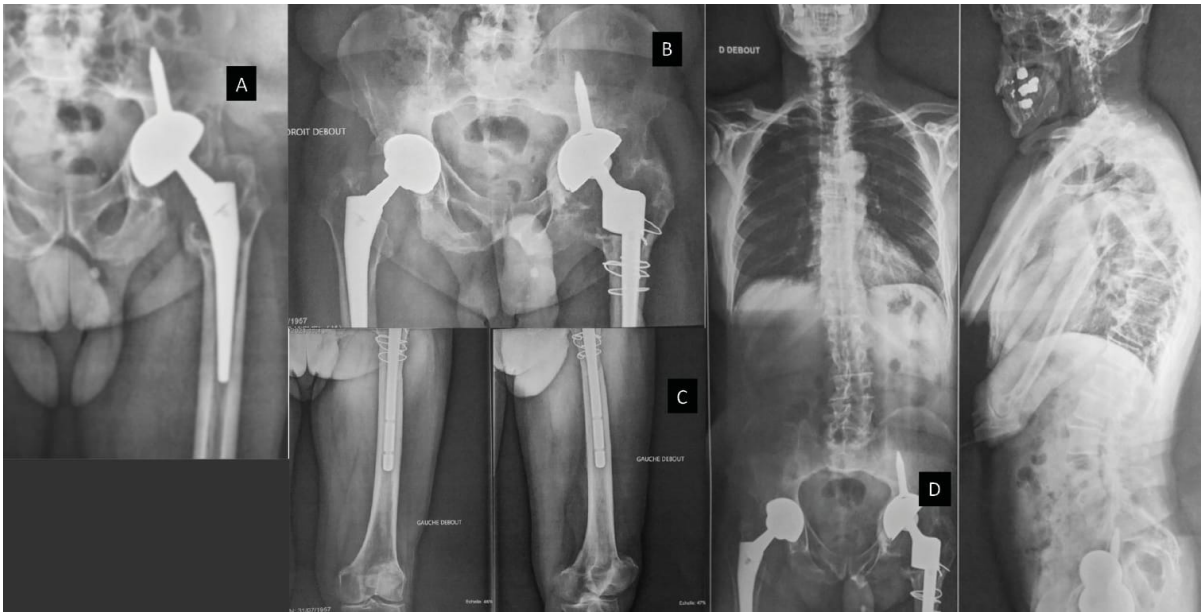

Figure 5: Mr F., 66 years old. Progressive acetabular and femoral osteolysis after 3 revisions (5A). Limping with postural abnormality and leg length discrepancy of 3 cm. No sepsis. Aetiology: corrosion. Iliac isthmus in good condition. Bipolar revision with a new ice-cream cone cup (5 B and C) and conical reconstruction stem. Restoration of equal limb length. Repeat whole spine radiography (PA + lateral views). Good restoration of coronal and sagittal alignment.

Modular DM cup

Another option is the modular dual mobility cup. This type of implant remains useful in cases of moderate bone loss and allows the surgeon to optimise the primary fixations (screws) while still taking advantage of the DM concept. The advantages as well as the potential complications specific to this device have been outlined previously [23]. We should also point out the risk of liner malseating, although this does not appear to have an impact on the medium term survival curve [50],[51],[52] (Figure 6).

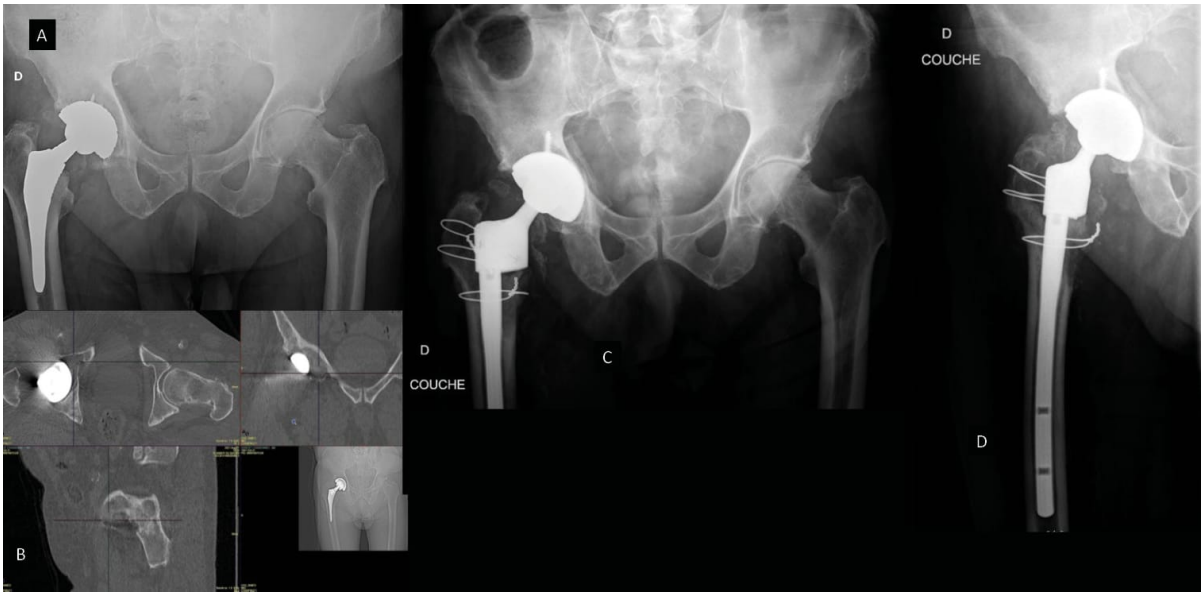

Figure 6; Mr. S, an 80-year-old suffering from groin and thigh pain. Periacetabular osteolysis in Gruen zones 1 and 2 (6A). CT scan (6B) shows progressive anterior and superomedial osteolysis in a male with osteoporosis. Varus stem positioning with partial pedestal sign. ABGII modular stem. Perioperative observations: Stem difficult to extract using endofemoral technique so a femoral window was made. Calcar femorale defect once component removed. Cup removed without difficulty in spite of osteointegration, moderate background cavitary bone loss, poor bone quality. No corrosion. ALVAL confirmed on histology examination. Bipolar revision using a modular DM cup (MDM) with additional screw fixation and an Integra conical reconstruction stem due to the challenging extraction of the primary stem, which was perfectly integrated into weakened bone (6C and D).

Cemented DM in THA revision

In complex revisions involving bone loss with poor bone quality, a cemented DM will often be needed.

Cemented DM without reinforcement

While the cemented versions of dual mobility cups are generally used in combination with a reinforcement device 19, some authors have suggested that the intervention could be simplified in elderly subjects or those who have poor bone stock by cementing the DM cup directly into the bone. To assess whether cemented fixation leads to a higher rate of loosening, as well as to confirm whether it is effective in protecting against dislocation in patients at high risk of instability and to measure the functional results, Haen et al. [43] reported on a retrospective case series of 64 patients (66 hips) at a single site who underwent cemented DM cup implantation with no reinforcement device. The mean age was 79.8 years (40–95 years), and 44% were cases of rTHA. This case series did report radiolucent lines developing at the bone–component interface in only 7% of cases after 3 years of follow-up (3–4) and 1 case of aseptic loosening with migration, but it was not stated whether these observations pertained to the revision cases. With a rate of loosening comparable to that found with the use of a cemented DM with a reinforcement device and considering the rates of prosthetic dislocation or component dissociation in the many other case series that have follow-up data for 1–7 years, it appears to be the alternative of choice in the target population for the author.

Therefore, when there is moderately degraded bone stock or a desire to simplify the operation in an elderly patient, some authors have reported good results using a DM cup without any reinforcement device and cemented

directly into the bone. Haen et al. [43] reported 98% (CI 95% [94–100]) 5-year survival of the cup with a rate of aseptic loosening comparable to that found with cemented DM cups combined with reinforcement.

DM cup cemented into an existing osteointegrated cup

One of the options could be to cement a DM cup into an existing metal acetabular component that is securely fixed. This presents a simple alternative to conventional revision of a securely fixed and well positioned acetabular component that can shorten operations and reduce blood loss, bone damage and overall perioperative morbidity. Wegrzyn et al. [44] showed that a dual mobility acetabular component cemented into a securely fixed metal cup could be a biomechanically acceptable alternative [53]. They reported significant improvement of function in a case series of 28 patients with a mean follow-up of 3.5 years (2–5) and they emphasised the advantages in terms of operating time (107 minutes; 75–140), perioperative bleeding, and an absence of complications, repeat surgery or revision during follow-up.

In conclusion, this strategy involves a simple revision technique that reduces blood loss, effectively restores stability and delivers a secure acetabular construction in frail patients who present a high surgical risk and/or are older than their natural life expectancy. Ciolli et al. carried out a literature review, and, with 1– 4 years of follow-up, reported survival curves ranging from 85 to 100% 19, which suggests that this alternative, although it should be reserved for a target group, appears to be viable.

DM with reinforcement

1. With bone-based biological reconstruction (Figure 7)

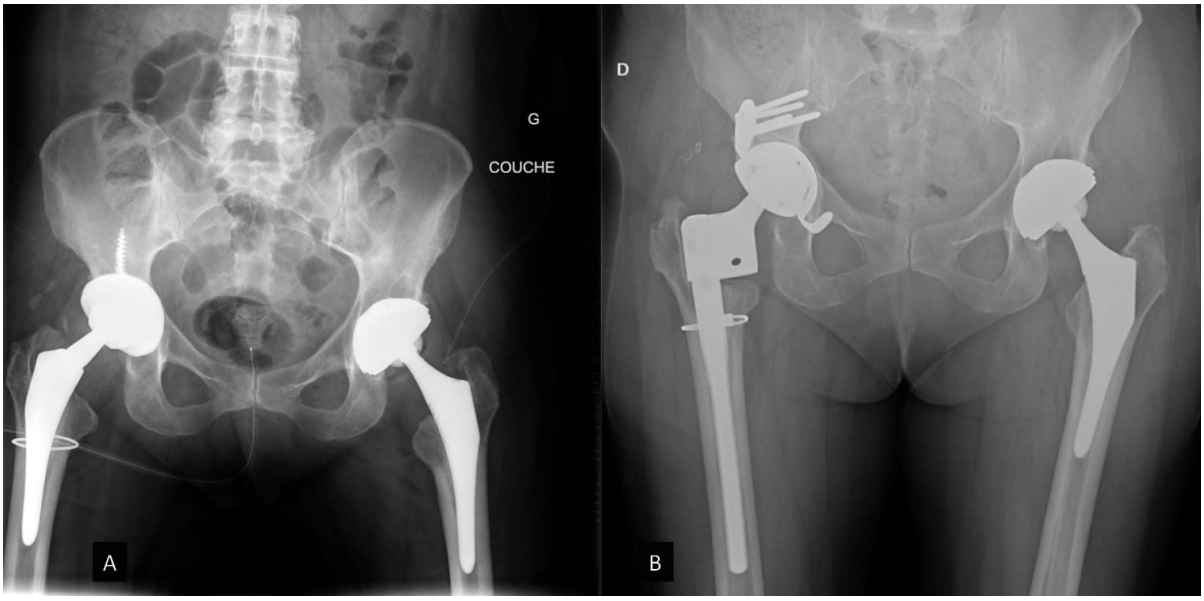

Figure 7: Mrs F, 68 years old. History of MoM bearing THA, revised 7 years after initial surgery with a titanium cup (tritanium^{TM} screws) and CrCo–ceramic fixed liner. ABGII modular stem with ceramic head. Course during 10 years following rTHA marked by pain and onset of bulging at the scar. X-ray: No signs of acetabular component loosening, femoral atrophy in zone 7. No loosening. (7A) Blood analysis: cobalt 7.55µg/l and chrome: 1.39µg/l. Synovial fluid analysis: chrome 62.13µg/l cobalt 455.67µg/l. Bacteriology: negative. Histology: ARMD. MRI: Periprosthetic pseudotumour. Perioperative assessment: metallosis. Infiltrated pseudotumour with atrophy of the abductor muscles. Endofemoral technique for stem removal. Merkel defect[AH1] . Cup: osteointegrated and removed with Paprosky grade 2C bone loss. Bone quality unreliable. Implant examination: corrosion of modular neck. Biological reconstruction using Kerboull cross-plate, allograft, cemented DM and Integra^{TM} stem chosen. Repeat radiography after 2 years. No pain or limping. (7B)

As part of a strategy that aims for bone reconstruction using a bone graft (autologous, allograft [54] or substitute [55]), indicated when there is moderate to significant loss of bone capital, it is often necessary to use an acetabular reinforcement device. Of the devices currently on the market, the Kerboull cross-plate is probably one of the most widely used in France and across Europe. As well as offering mechanical reinforcement, it also helps to restore the centre of rotation of the acetabular component and delivers primary stability that is adequate for subsequent integration of the bone graft. It requires precise positioning, which involves using the cross design as a guide to placement with the hook, centre and pallet in the vertical plane and the horizontal flanges in the horizontal plane, then the pallet should be in the horizontal plane parallel to the operating table. Achieving this final point sometimes requires a bone graft to be positioned between the pallet and the roof of the acetabulum [56]. If integrity of the U-figure (or pelvic tear drop, a bony ridge at the inferior medial acetabulum and overhanging the obturator foramen) is required to ensure stability, a structural graft to reconstruct this bony ridge is by default necessary [56]. Wegrzyn et al. carried out a study that aimed to evaluate the findings of a continuous and prospective case series of 61 revision THA with reconstruction of AAOS grade III and IV acetabular bone defects using a Kerboull cross-plate, structural allograft and cemented DM cup with a minimum follow-up of 5 years and a mean of 7.5 years. They reported no instability, and there was no failed acetabular reconstruction observed in 98% of the cases that presented complete osteointegration of the bone graft. Finally, no sign of mechanical rupture of the Kerboull cross-plate and/or loosening of the cemented cup were seen. As reported in other similar studies [19],[27],[57], this reconstruction technique has produced excellent results at midpoint follow-up in terms of preventing instability after revision, restoring acetabular bone stock and stable cemented fixation of the dual mobility cup.

Irrespective of the type of reinforcement device used, a literature analysis shows that with mean follow-up ranging from 10 to 236 months the survival curve exceeds 90% [19].

In a comparative study based on data from a Swedish registry [58] between 2005 and 2015, consisting of 984 rTHA, 436 of which used a cemented DM cup in a cage, and 355 revisions from the same period that used a cemented standard cup (femoral head size 28–36 mm), 4-year survival for all causes (91% ± 3.7% vs 86% ± 4.1%, p = 0.02) and for dislocation (96% ± 3.0% vs 92% ± 3.3%, p = 0.001) was better for the DM cup group.

Focusing in on complex cases, in which revisions are performed in patients with significant bone loss, the results remain, in view of the context, entirely favourable. Unter Ecker et al. [59] analysed 216 patients who had undergone complex THA revision with massive preexisting bone loss of the acetabulum (Paprosky >2B) and/or proximal femur (at least Paprosky 3), significant involvement of gluteal soft tissue, at least two prior surgical interventions or a one-stage septic revision, or a history of dislocation. A Burch-Schneider ring was used, either with or without augments. The 216 patients received a cemented DM cup. Mean follow-up was 69 months (60–110). The primary endpoint was dislocation or revision for dislocation. The dislocation-free survival rate was 96% (95% CI, 92–98) at 5 years and 82% (95% CI, 72–89) at 9 years. The overall rate of dislocation was 11% at the final follow-up. Survival without revision for dislocation was 99% (95% CI, 96–100) at 5 years and 85% (95% CI, 75–92) at 9 years.

In complex cases of defects of SOFCOT [60] grade 3 (62 cases) and 4 (26 cases), treated with reinforcement (Kerboull, Burch-Schneider, ARM) and structural bone graft in 87.5% of cases, Schneider et al. [18] reported a dislocation rate of 10.4% with a mean follow-up of 41 months (1–101), and five of these occurred more than three months after surgery. No component dissociation was reported. A 9% failure rate for the reinforcement used was noted on radiography. One revision for aseptic loosening and one septic revision were performed. Looking at acetabular component revision for any reason, the 8-year survival rate was 95.6% (95% CI, 93.3–97.7%) and 99.3% (95% CI, 98.9–99.6%) if the endpoint chosen was acetabular component replacement due to infection.

Furthermore, the Sayac et al. study [15] with a mean follow-up of 10 years for revisions in Paprosky >2C defects reported low rates of secondary revisions, whether for loosening or instability.

Nonetheless, bone reconstructions remain a surgical challenge, and all the more so when there is significant bone loss, the patient has undergone multiple operations and there is a context of chronic infection (Figure 8).

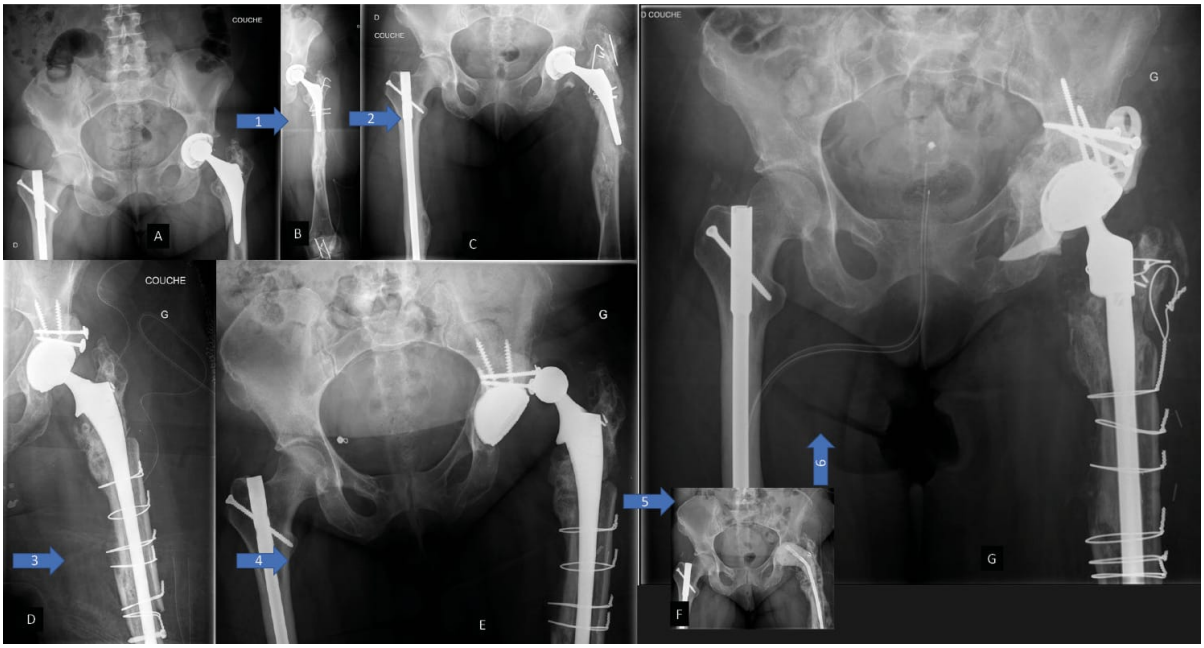

Figure 8: Mrs P., 54 years old, THA 10 years previously due to post-traumatic hip osteoarthritis. History marked by recurrent dislocation with possible management but no records. Fall resulting in a Vancouver grade B2 fracture (8A). Unipolar revision using an uncemeted stem with perioperative fracture wiring of the greater trochanter during extraction (8B). Course was marked by failure of the repair and MSSA infection (8C). A two-stage strategy was chosen. Revision with a MDM cup with screws, autologous graft to acetabular roof and revision locking stem (8D). Progressed to repeated infection and dislocation (8E). Two-stage strategy (8F). Repeat bipolar revision. Paprosky grade 3B defect. Acetabular revision with Burch-Schneider ring, allograft, cemented DM cup and femoral revision with IntegraTM stem (Lepine®) (8G)

2. Non-biological reconstruction: bone loss compensated with augments or custom-made DM implant.

Extensive acetabular bone loss with or without pelvic discontinuity (PD) is a serious challenge in the revision of total hip arthroplasty (THA). In view of the failings of bone-conserving strategies **[61]** due to a failure of the bone graft to integrate and secondary loosening, revision implants with a tantalum coating may be a promising alternative to allografts for some. They have a high coefficient of friction, they are biocompatible, and they deliver good primary stability which is favourable for osteointegration **[62]**. Used with hemispherical revision cups, a wide range of augments of different sizes and geometries are available, which means that they can be adjusted to fit the abnormalities that need to be filled, offering the potential for modular reconstruction as well as treating a wide variety of defects **[63]**.

The studies reporting on the use of these augments seem to be encouraging, with follow-up of 3.3–13.2 years **[64]**. The cage and augment strategy, which combines the use of augments with conventional reinforcement devices to replace structural bone grafts, aims to restore the hip's original centre of rotation while delivering durable and stable fixation of the cage.

However, few studies have reported on use of augments combined with DM cups or implants that incorporate the DM concept. Bellova et al. **[64]** carried out a consecutive case series of 100 patients who had undergone acetabular component revision with an augment against a background of Paprosky grade 2 and 3 defects (including pelvic discontinuity), in which 59 patients were available for follow-up after 6.2 years (0–12), and they reported 8.4% of cases had osteointegration of a cemented DM cup fitted as a first line treatment. However, the study reported on six cases of repeated revision of the PE liner with DM cups. Extraction of the cage and/or tantalum augment was defined as the primary endpoint of the study and revision of the acetabular cup for any reason was the secondary

endpoint. Superiority of the DM system was not statistically significant but the analysis does not contribute much in view of the recent use of the “cage–augment–DM” strategy.

While there is no consensus on how to manage reconstruction in patients with significant Paprosky grade 3B bone defects, secondary revision results from these types of cases and using the strategies described above demonstrates how difficult this can be. The severity of bone loss and quality of the remaining bone have a major impact on the stability of the components used. The recent development of custom-made implants based on 3D printed acetabular cups in cases of very significant bone loss may have potential. Surgeons using these custom 3D printed titanium cups can treat massive acetabular defects that would traditionally have been impossible to reconstruct, meaning they can restore the patient's opportunity to weight-bear from the outset. The clinical evaluation of these implants remains tricky because there is such a wide range of implant designs, materials, manufacturers, techniques and surgical tools. Since this is only a recent and emerging strategy, few studies have been published to date. In the case of custom-made implants, there have been some reports that it can be difficult to precisely position the acetabular implants **[65]**, especially when there is pelvic discontinuity, which worsens the outcomes.

However, some authors have reported encouraging clinical and radiological results **[66],[67]**. In a recent study by Goriainov et al., favourable radiography results and functional outcomes were reported with the use of a 3D printed aMace tri-flange implant (Materialise) with dual mobility bearing to treat massive acetabular defects. This study consisted of 19 patients with a mean follow-up of 53 months (17–88 months). The authors reported significant functional improvement and implant survival of 100%. They also noted that the application of autologous skeletal stem cells behind the implant may have improved bone formation.

Looking at the treatment of Paprosky grade 3B massive acetabular defects, Di Laura et al. **[68]** analysed the results after a minimum of 3 years of use of 3D printed ProMade implants, with a dual mobility bearing incorporated into the device in all cases. This study suggested that these acetabular implants are a good option to treat these types of defects with a cumulative survival rate of 100%, significant improvements on pain and function rating scales and excellent osteointegration. The accuracy and feasibility of surgical planning, assessed by observing implant positioning and orientation on a postoperative CT scan, shows that this strategy can be trusted **[69]**. One way in which it contributes to improving function for patients is by addressing leg length discrepancy, which can often be an issue in revisions when there is significant bone loss **[70]**. An example of planning with a custom-made implant is shown in figure 9.

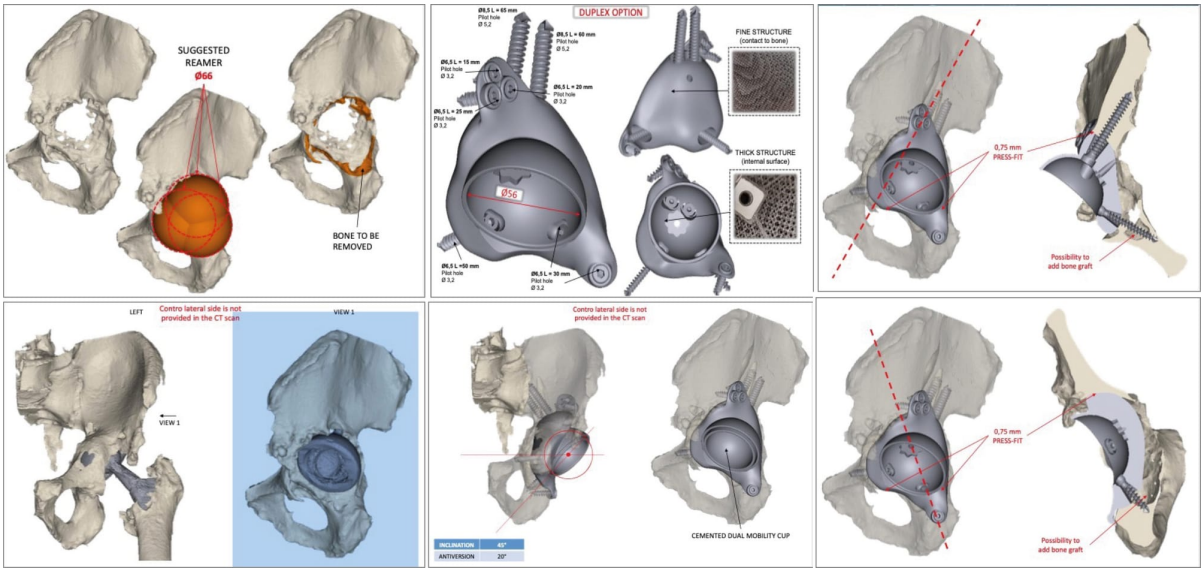

Figure 9: Example of the planning for a custom-made acetabular implant in prosthetic revision with bone loss, in a patient who has undergone multiple operations and presents Paprosky grade 3B bone defects with an implant that uses the dual mobility concept.

The specific case of constrained cups

We are sometimes faced with chronic instability in patients who have undergone multiple operations on their implant and who present recurrent dislocations, and these situations can be difficult to manage and treat. Beyond the main causes that are inherent to poorly positioned implants, causes which should have been avoided in the first instance, some cases of instability are secondary to iatrogenic muscle weakness due to the multiple surgeries these patients have often undergone, or to neuromuscular disorders or even nonunion, displacement, malunion or even atrophy of the greater trochanter. These cases pose a genuine problem in terms of management. The use of a constrained cup remains a potential option [71]. Labban et al. [10] carried out a retrospective case-control study involving a comparative analysis of two matched continuous case series of total hip arthroplasty revisions due to instability with a mean follow-up of 6.5 ± 3 years . These two series included patients who had received an implant of a Lefèvre constrained cup (63 patients) or a DM cup (159 patients). This study reported that the results were comparable in view of the primary endpoint of dislocation. There was no significant difference between the two groups in terms of the survival curve of revision for any mechanical reason.

A recent retrospective analysis at a single site 72 aimed to determine the survival rate 10 years after primary arthroplasty or revision and the complication rate. It included 466 consecutive total hip arthroplasties, 45% of which were revisions using a Lefèvre constrained cup with a theoretical minimum follow-up of 12 years. The study had high rates of deceased patients (57%) and subjects lost to follow-up (10%), so only 154 patients could be analysed. The probability of mechanical complication-free survival at 10 years was estimated to be 87.8% ± 2.7% (95% CI: 82.4%– 93.2%) for the revision groups (p = 0.0017). While the authors did conclude that this implant was a viable choice in patients at high risk of dislocation, they must still be used with caution in view of the higher risk of complications than with DM implants. This strategy is indicated only in patients presenting recurrent dislocation and hip abductor deficiency. Any other cause of instability must be subject to prior assessment.

CONCLUSION

Revision surgery remains a genuine technical challenge. The development of new strategies and implants offers the surgeon new avenues to consider when choosing which procedure to adopt and this must take into account the patient history and predispositions, the risk factors, the specific difficulties due to the complexity of the rTHA and its aetiology, and bone capital and muscle condition. The dual mobility concept can really come to the fore in these decisions.

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