MENTORS IN ORTHOPEDICS

THE PHILOSOPHY OF TOTAL HIP REPLACEMENT REVISION AT MAYO CLINIC

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SUMMARY

Background: Revision total hip arthroplasty (THA) rates are increasing, with instability, aseptic loosening, and infection identified as primary indications for surgery. Managing significant acetabular and femoral bone loss remains a complex challenge, requiring standardized classification systems to guide reconstruction strategies.

Objective: This article reviews current surgical protocols and clinical outcomes for complex THA revisions, specifically focusing on the management of bone defects and periprosthetic fractures using techniques employed at the Mayo Clinic.

Key Points: Preoperative evaluation must prioritize the exclusion of infection via inflammatory markers and joint aspiration. Acetabular reconstructions are categorized by the Paprosky classification; Type 3 defects often necessitate jumbo cups, porous tantalum augments, or custom triflange implants to achieve stability. In cases of pelvic discontinuity, tantalum cup-cage constructs or distraction techniques are utilized, showing high short-term survival despite risks of stress fractures or reduced bone stock. Femoral revisions utilize modular fluted tapered stems (TMFT) for Paprosky Type 3 and 4 defects, providing superior axial and longitudinal stability compared to cemented options. Extended lateral femoral osteotomy is frequently employed to facilitate component removal. Periprosthetic fractures are managed according to the Vancouver classification, with stable stems treated via internal fixation and loose stems requiring TMFT or proximal femoral replacement.

Conclusion: Successful THA revision relies on meticulous preoperative planning and the selection of implants that ensure osseointegration and mechanical stability. The shift toward porous metal technology and modular femoral components has improved outcomes in cases of severe bone deficiency.

KEYWORDS

Arthroplasty, Replacement, Hip; Reoperation; Acetabulum; Femur; Periprosthetic Fractures

INTRODUCTION

The number of THR revisions is rising, which is a trend that will likely continue. In 2010, there were 67,534 THR revisions, corresponding to 9.6% of THRs. There are different reasons to perform THR revision, and these need to be considered separately (in the form of the percentage of each cause in the United States between 2005 and 2010 (1)):

- instability (22%),
- aseptic loosening (20%),
- infection (15%),
- periprosthetic fracture (6%).

In 43% of cases, revision involved the cup and stem, and in 28% of cases it involved either the cup or stem in equal in equal proportions.

Before any revision surgery, the risk of infection must be reduced by measuring C-reactive protein level and sedimentation rate and by performing joint aspiration to test joint fluid. Infection is suspected when white blood cells >2500-3000 cells/μl in the test fluid.

Preoperative assessment includes frontal and side x-rays of the pelvis and often includes three-quarter lateral x-rays (Judet views) to examine the acetabular columns. Bone and computed tomography (CT) scans are used only rarely. Preoperative planning must be meticulous, but the plan may be changed by what happens intraoperatively.

1. THE ACETABULAR SURFACE

Four major principles govern long-lasting and efficient reconstruction:

- the use of cementless fixation, if possible;
- a tight fit between implant and bone;
- system stability (mobility <40-50μm);
- even stress distribution.

According to Paprosky, there are three types of acetabular defect (Table 1) that are defined using four variables: the position of the head centre over the superior obturator line, the presence of osteolysis of the ischium and/or teardrop lysis, and protrusion (when Köhler's ilioischial line is crossed).

Classification	Definition	Treatment
Type 1	Hemisphere intact, columns intact	**Standard**
Type 2	**Migration of head centre <3 cm**	
A	Superior & anterior bone defects	**Standard** cup
B	Superior defect	**Standard** cup
C	Medial wall absent	**Standard** cup + **spongy allograft**
Type 3	**Migration of head centre >3cm**	
A	Superior & lateral ('up and out')	**Jumbo cup** or **Tantalum**
B	Superior & medial ('up and in')	
	With no discontinuity	Reinforcement **ring** + allograft (spongy or structural) or **Tantalum** or **Triflange**
	With acute discontinuity	Compression: **plate** + ring/tantalum
	With chronic discontinuity	Distraction: **Tantalum** or **Triflange**

Tableau 1 : Acetabular defect classification (Paprosky) and corresponding treatment at Mayo Clinic.

For type 3, the implant must bridge the defect. It is also necessary to have a precise understanding of the degree and localisation of the defect (whether anterosuperior, posteroinferior or, less frequently, posterosuperior). At least 50% of the cup must be in contact with the bone.

Acute pelvic discontinuity (consolidation possible) = compression

Three or four screws must be fixed with, if possible, two screws in the ischium or iliopubic ramus. A plate must be fitted in compression to the posterior column with a structural allograft or directly with a porous cup.

Chronic pelvic discontinuity (consolidation possible) = distraction

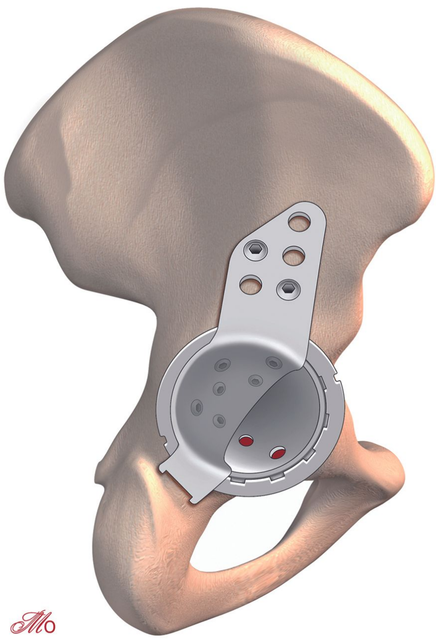
When dealing with pelvic discontinuity, superficial debridement is a must, but it should not be too deep to avoid causing pelvic instability or intrapelvic lesions.

A reinforcement ring can be used, but failure rates are on the order of 50-60% due to loosening and fractures in the pelvic cage or brackets. The combined use of bone allograft is a satisfactory option (with 60-67% good results at 15-20 years' follow-up) but has of late been somewhat abandoned (due to infection and bone resorption) in favour of porous metal augments.

Using a jumbo cup (≥62 mm for women and ≥66 mm for men, which is approximately 10 mm bigger than a primary cup) has given satisfactory results (88%) at 20 years' follow-up. Its disadvantages are that bone stock is not restored, and an oblong defect is converted into a hemisphere (bone loss).

According to David G. Lewallen, tantalum (porous trabecular metal) is used in 5% of THR revisions at Mayo Clinic. Using a tantalum cup with an augment provides satisfactory stability with a quicker and easier technique and with no risk of augment resorption. The disadvantages of this technique are a lack of long-term follow-up, debris generation at the interface, stress fracture, and reduced bone stock for any future revision.

A tantalum cup-cage construct (Figure 1) has so far shown a 90-100% rate of survival, but follow-up is short (<4 years). In this system, a tantalum jumbo cup is implanted (osseointegration), followed by a reinforcement ring (for mechanical stability). A tantalum augment can be put in place before (primary stability) or after (supplementary fixation) cup insertion. In either case, the augment must be fixed using several screws and cemented to the cup.



Triflange custom-made implants are also used (81-90% survival rate with follow-up <10 years (2)); they can be porous or coated with hydroxyapatite. A CT scan is a prerequisite for constructing a plastic model of the pelvis and allowing this implant to be custom-made. Longer follow-up will clarify this rigid implant's survival rate.

Acetabular distraction is another technique that can be used (3). At Mayo Clinic, acetabular distraction uses the association of cup + augment. For example, it is possible to fit the cup and then embed the augment between the cup and acetabulum, and this enables acetabular distraction.

2. THE FEMUR SURFACE

Treatment choice is dependent on the quantity of bone loss and quality of remaining bone. The aim is to obtain stability in the axial plane (rotation) and longitudinal plane (insertion). The main criterion that must be examined is the width of the diaphyseal canal in the femur.

Classification	Definition	Treatment
1	Minimal loss of metaphyseal sponge, diaphysis intact	Standard stem without cement
2	Massive loss of metaphyseal sponge, diaphysis intact	(Cylindrical stem or) **TMFT**
3A	Metaphysis destroyed and >4 cm of diaphysis intact	(Cylindrical stem or) **TMFT**
3B	Metaphysis destroyed and <4 cm of diaphysis intact	**TMFT**
4	Enlarged femoral canal, isthmus destroyed	**TMFT** or **impaction** or **APC** or **PFR**

Tableau 2 : Femoral defect classification (Paprosky) and corresponding treatment at Mayo Clinic (5).

The cement-on-cement technique involves cementing a new implant in a pre-existing cement mantle that is intact without fissures. Some researchers recommend minimal scraping of the mantle a little to improve bonding. This requires the use of low-viscosity bone cement after the mantle has been cleaned.

Cylindrical stems fully coated with chrome-cobalt (for stages 2 and 3A) and titanium modular fluted tapered stems (TMFT) have given the best results. The main risks are intraoperative fractures and stress shielding (in cylindrical stems) and secondary insertion (in TMFT stems). The main overall risk is postoperative dislocation (of the greater trochanter and abductors). Cemented stems and stems with proximal coating have high failure rates due to insufficient bone quantity (providing little interface between spongy bone and cement) or poor bone quality (bone that is smooth and sclerotic).

The first titanium tapered stem used was Wagner's monoblock stem (with three-point fixation). The modular system allows leg length, version, and offset (independently of the distal end) to be restored. Modular stems have a 3° curve adapted to the curve of the femur, which improves filling. At least 2 cm of cortical contact is required for satisfactory results. Two types of modular tapered stem are used at Mayo Clinic: either the LINK MP reconstruction stem or the Stryker restoration modular stem.

In cases of an ectatic ('stove-pipe') canal where a stem cannot be inserted without cement, there are three solutions:

- spongy graft impaction – with cemented polished stem;
- allograft-prosthetic composite (APC) – long stem cemented into massive proximal femoral allograft, in young patients;
- segmental proximal femoral replacement (PFR), in elderly patients and cases of massive bone loss – Global Modular Reconstruction System, Stryker.

The risks involved with graft impaction are intraoperative fracture and postoperative insertion.

Extended femoral osteotomy

This technique is widely used at Mayo Clinic in femoral prosthesis revision (approximately 70-80 cases per year). There is Wagner's original technique (anterior osteotomy) and a technique currently used at Mayo Clinic (lateral osteotomy) (6). The minimum length is 10 cm from the greater trochanter (or 7-8 cm from the lesser trochanter). The osteotomy is closed using two or three cable grips.

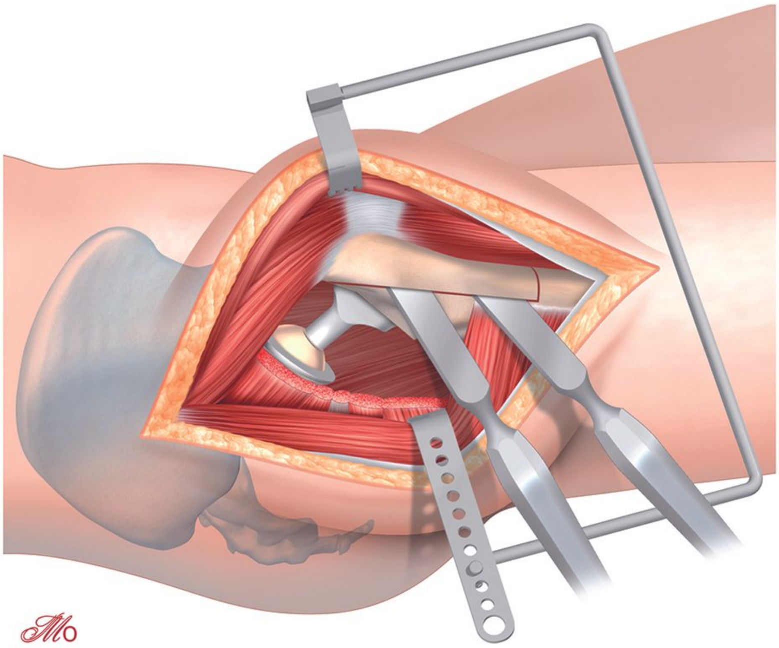


Figure 2

It is used to remove any cement remaining distally or an implant that is well fixed, or where there is a proximal femur deformity. The main risks involved are non-consolidation of the osteotomy and proximal femur fracture.

2.2. Periprosthetic fractures

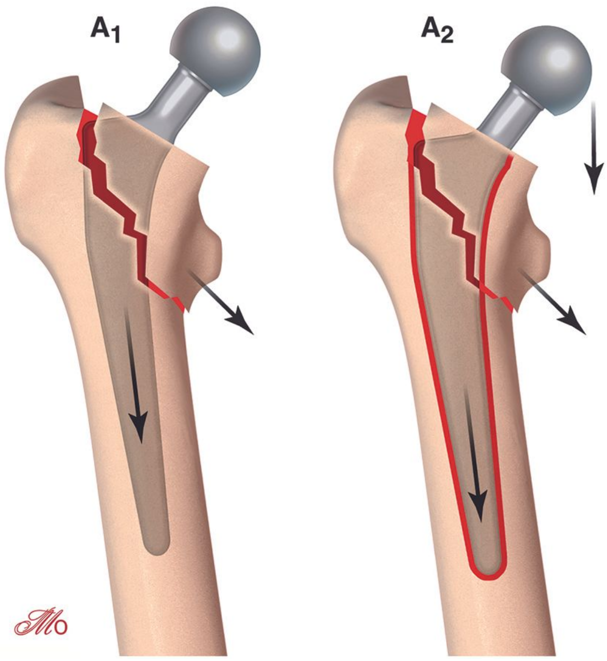


Figure 3

The Vancouver classification is used; it covers fracture localisation, whether the stem is well fixed or loose, and bone quality. In 2014, Capello described a 'clamshell' fracture, usually occurring during impaction of a cementless stem and affecting the spur and lesser trochanter.

Vancouver	Definition	Treatment
A	**Around the trochanter**	
A_G	Greater trochanter	Displacement <2 cm: **conservation** or cerclage
A_L	Lesser trochanter	
A_1 & A_2	Clamshell fracture	Stem stable: conservation, otherwise cf. B_2
B	**Around the stem**	
B_1	Stem well fixed	**Osteosynthesis** (ORIF)
B_2	Stem loose	**TMFT**
B_3	B2 + poor bone quality	**TMFT** or **PFR**
C	**Below the femoral stem**	**Osteosynthesis** (ORIF)

Tableau 3 : Periprosthetic fracture management at Mayo Clinic with the Vancouver classification (8).

CONCLUSIONS

In contrast to the philosophy that is seemingly prevalent in France, this author is not aware of any use of long locking stems at Mayo Clinic. Surgeons at Mayo do not use reinforcement rings in isolation; they will use either a jumbo cup or tantalum implants, or they use a ring (from which the ischiatic part has been cut out) sandwiched between a tantalum cup (embedded) and a cemented cup (inside). They are also likely to perform osteotomy to remove cemented stems. TMFT stems without cement are commonly used.

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