Removal of uncemented components: hope for the best, prepare for the worst—technical tips and tricks

C. Michael Goplen[1,2], Jacob Munro[3]

[1]Division of Orthopedic Surgery, Department of Surgery, University of Alberta, Edmonton, Alberta, Canada; [2]Community Service Center, Royal Alexandra Hospital, Edmonton, Canada; [3]Department of Surgery, The University of Auckland, Auckland, New Zealand

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Correspondence to: C. Michael Goplen, MD, MSc, FRCSC. Clinical Lecturer, Division of Orthopedic Surgery, Department of Surgery, University of Alberta, Room 404, Edmonton, T5H3V9, Canada; Community Service Center, Royal Alexandra Hospital, Edmonton, Canada. Email: cgoplen@ualberta.ca.

Abstract: Removing well-fixed uncemented components can be challenging. With thoughtful surgical planning, appropriate surgical instruments, and proper surgical techniques, most implants can be removed expeditiously with little bone loss and minimal impact on the subsequent reconstruction. Preoperative planning is one of the most essential steps to remove uncemented implants. Obtaining previous surgical records, although tedious, should always be attempted preoperatively to determine if specific instruments will be required and to help anticipate which steps may need special attention. These include the presence of ceramic or metal bearings and the presence of acetabular screws or stem collars. Without proper preparation and available tools, the removal of implants can negatively impact the subsequent reconstruction and patient outcomes. We will describe techniques and practical tips for removing uncemented stems from the top (intramedullary) or transfemoral using an extended trochanteric osteotomy. We will also describe techniques and tools to remove uncemented acetabular shells efficiently. Case examples will highlight these clinical situations where careful planning is necessary and potential problems that may be encountered with the recurring theme of preparing for the worst but hoping for the best. We have also included cases such as removing well-fixed cementless collared stems, broken stems, and fully coated stems.

Keywords: Removal of implants; cementless; surgical techniques

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Introduction

Removing well-fixed uncemented components can be intimating. Successful removal depends on careful preoperative planning, appropriate surgical instruments, and proficiency in various surgical techniques. Importantly, implant extraction is often the first step during a revision arthroplasty case and will impact subsequent reconstruction. Therefore, the primary objective of implant removal should always be to minimize bone loss.

This review will cover essential tricks and tips for removing well-fixed implants with case examples to demonstrate important surgical considerations and potential problems that may be encountered with the recurring theme of preparing for the worst but hoping for the best.

Preoperative planning

The surgeon should always obtain prior surgical records to determine previous surgical approaches and implant information. This will allow the surgeon to comprehensively understand the implant's design philosophy and track record before revision. By systemically considering these factors

Figure 1 Right fully coated HA collarless Corail (Depuy Synthes) stem with proximal osteolysis and GT fracture secondary to a pseudotumor. The patient had a metal-on-metal total hip with a 46-mm femoral head and an ASR acetabular shell (Depuy Synthes). HA, hydroxyapatite; GT, greater trochanter.

and careful evaluation of serial radiographs, the surgeon should be able to develop a surgical plan that predicts areas of concern during implant removal and techniques that will enable successful stem extraction with minimal bone loss. We will cover some of these important factors in detail below.

Stem design

Stem geometry and osteointegration technology have evolved over the past 20 years (1). Older generation press-fit stems were cylindrical with circumferential ingrowth surfaces along the entire length of the stem (2). While these stems provided reliable in or on growth, they often resulted in thigh pain and proximal bone resorption due to stress shielding (3). Recent uncemented titanium stems often have proximal-only ingrowth surfaces to promote metaphyseal fixation (4). These bone-preserving stems often have single or dual taper geometries with a trochanteric relief to facilitate proper stem placement through minimally invasive approaches (1). While many stems currently used are designed to have predominately proximal ingrowth, they still may achieve distal fixation (5). Finally, most modern titanium revision stems are fully coated in various surface treatments, resulting in reliable distal on-growth and long-term stability (4).

Understanding these individual stem design features and surface treatments in the context of each patient's radiograph will help predict the areas of osteointegration. For example, single taper stems such as the ML Taper (Zimmer Biomet) can be expected to have proximal-only fixation compared to the fully coated Corail (Depuy Synthes) that may have on-growth along the entire length of the stem (1,4,5). In addition, specific radiographic findings can help highlight areas of osteointegration, such as spot welding, which represents new bone formation between the endosteal surface and prosthesis (6-10). Generally, stems with ingrowth along the entire stem length often require an extended trochanteric osteotomy (ETO) for successful extraction, while proximal-coated primary stems can usually be removed from the top (intramedullary) with minimal bone loss (9).

Finally, various taper geometries have been used, and the specific taper for the stem should be noted if a taper-specific stem extraction tool is going to be used (10). Certain taper adapters specific to the extraction tool may not be available, and an alternative device will be needed.

Proximal femoral morphology

The presence of proximal femoral osteolysis should be carefully noted (*Figure 1*). Osteolysis should not only alert surgeons to the consider potential underlying etiology but also to evaluate the integrity of the greater trochanter (GT). If there is any concern regarding the integrity of the GT secondary to osteolysis, a controlled fracture utilizing an ETO can be considered, as dislocation of the hip during the approach may cause an uncontrolled GT fracture. Loss of abductor function due to a fractured GT should always be avoided as it can result in instability, weakness, and pain (11,12). If the GT has already been fractured, this may be used as an ETO to help access the femoral stem. Other proximal femoral deformities that should be carefully evaluated are GT overhang or varus remodeling, which also may prevent successful intramedullary stem extraction.

Acetabular component

Modern uncemented acetabular components are either hemispherical or elliptical (13,14). Hemispherical cups have

Figure 2 Example of a left hip with a threaded uncemented acetabular shell.

a constant radius of curvature from the center of the cup to the periphery, while elliptical cups have an increasing diameter from the center to the rim (13,14). Regardless of design, the outer diameter of the shell should be determined preoperatively, as this will dictate the extraction device's diameter required for removal. Older acetabular designs may be more challenging due to the presence of threads, spikes, or fins (*Figure 2*) (15,16). In addition, adjuvant screw fixation should be noted as specific screwdrivers, or a broken screw removal set will be required for successful acetabular cup extraction.

Ceramic and metal liners

It should be noted if a ceramic or metal liner was used, especially if screws are present, as removing these liners can be difficult. Companies have implant-specific extraction tools that can be useful for removal and should always be requested before revision. Detailed technical aspects of removing these liners will be covered later in this review.

Summary

Based on all the available preoperative information, the surgeon should determine if they will attempt stem removal from the top without disrupting the medullary canal (intramedullary). If there is significant GT osteolysis, fracture, or a distally fixed stem, the surgeon should consider starting directly with a transfemoral approach utilizing an ETO for stem removal. However, even a proximal coated, single taper stem may be challenging to remove from the top, and the surgeon should always be prepared for the worst-case scenario. Finally, during each step, the surgeon should have an upper time limit in mind, as prolonged time spent on one step can lead to prolonged time in the operating room, leading to excess blood loss and higher infection rates (17,18).

Implant removal techniques

Approach

Any extensile approach can be used for the extraction of uncemented implants. The surgeon should use an approach they are familiar with, as specific soft tissue releases are often to help with exposure. We prefer to use a posterolateral approach for all revisions, and techniques will be discussed in the context of this exposure.

Debridement

The first step of any revision should always be a comprehensive debridement. If a two-sided revision is planned, the deep capsule can be debrided before dislocating the hip. With the hip enlocated, the deep anterior capsule can be visualized and debrided, which will help with eventual acetabular extraction. If an ETO is planned, this can be completed during the approach as it will facilitate acetabular and femoral exposure.

Acetabular revision with retention of the femoral component requires special attention. After removing the femoral head, a pocket is created near the anterosuperior portion of the acetabulum to allow trunnion placement and adequate acetabular exposure (19). In brief, the trunnion is placed in the acetabulum after removing the femoral head. The anterior superior soft capsule is carefully elevated off the acetabular rim for 3–5 cm with a Cobb or diathermy. The femur is then externally rotated to allow the trunnion to sit in this pocket. A retractor is placed anterior and superior so that the femoral component lies behind it and

Figure 3 Example of a taper-specific extraction tool adapter that connects to a slap hammer. Multiple taper-specific adapters are available.

the acetabular can be visualized. In very rare circumstances, an otherwise well-functioning femoral stem may be required to be removed to improve acetabular exposure.

Femoral stem removal

We prefer to start with first removing the femoral stem, as it will facilitate acetabular exposure. The surgeon should first identify and remove all fibrotic and granulation tissue circumferentially around the stem. Care should be taken to completely clear the lateral shoulder of the stem and determine if any further bone needs to be removed with a high-speed burr. If the lateral shoulder of the stem is not debrided, stem removal may not be possible, or the surgeon may fracture the GT by inadvertently levering against it during stem removal.

Bone-stem interface

Understanding the stem coating will help determine the extent of the stem—the bone interface needs to be disrupted. While a proximal-coated, bone-preserving stem such as the ML taper (Zimmer Biomet) may only require disruption of the proximal bone-stem interface before successful removal, a fully coated stem such as a Corail (Depuy Synthes) may require more extensive work before attempted removal.

First, a small curette can help define this interface and remove any remaining soft tissue. A pencil tip burr can be used to disrupt the proximal bone-stem interface. Using a short barrel with the long pencil tip burr maximizes the distance that can be disrupted distally, but care should be taken as the burr or drill bit can break if levered on during insertion. Anterior and posterior access can be easily accessible, and a sagittal saw can even be used for this interface with the appropriate stem, such as a single taper blade stem. In contrast, the medial and lateral aspects of the stem may be more difficult, depending on the presence of a collar or the shape of the lateral shoulder of the implant. Specifics regarding the extraction of a stem with a collar will be covered later in this review.

Next, non-threaded 1.6- or 2.0-mm K-wires are directed at the stem and distal to disrupt the bone-stem interface. If the stem has longitudinal splines, as with the Wagner Cone (Zimmer Biomet), K-wires can be passed between each spline to help separate the implant from the bone. K-wires can be left *in situ*, preventing the subsequent K-wire from following the same track. K-wires can also be passed through the gluteus medius tendon along the lateral aspect of the stem to help with the disruption of this difficult-to-reach area. Patience during this step is critical for successful stem removal. Flexible osteotomes may also be used as an alternative to K-wires. However, we do not routinely use flexible osteotomes during stem extraction.

Stem extraction

While vice grip slap hammers may be used in certain circumstances, a robust stem extraction tool should be considered essential. There are multiple available stem-specific or universal extraction tools available. For example, a taper-specific extraction tool that fits multiple available taper attachments provides rigid fixation to the stem (*Figure 3*). Much less energy is wasted compared to universal stem extraction tools. However, the taper-specific design needs to be known, and adapter available as they attach to stems with specific adapters. Alternatively, a universal rigid vice grip slap hammer can be used if the taper geometry is unknown or a taper-specific extraction adapter is unavailable. Stem-

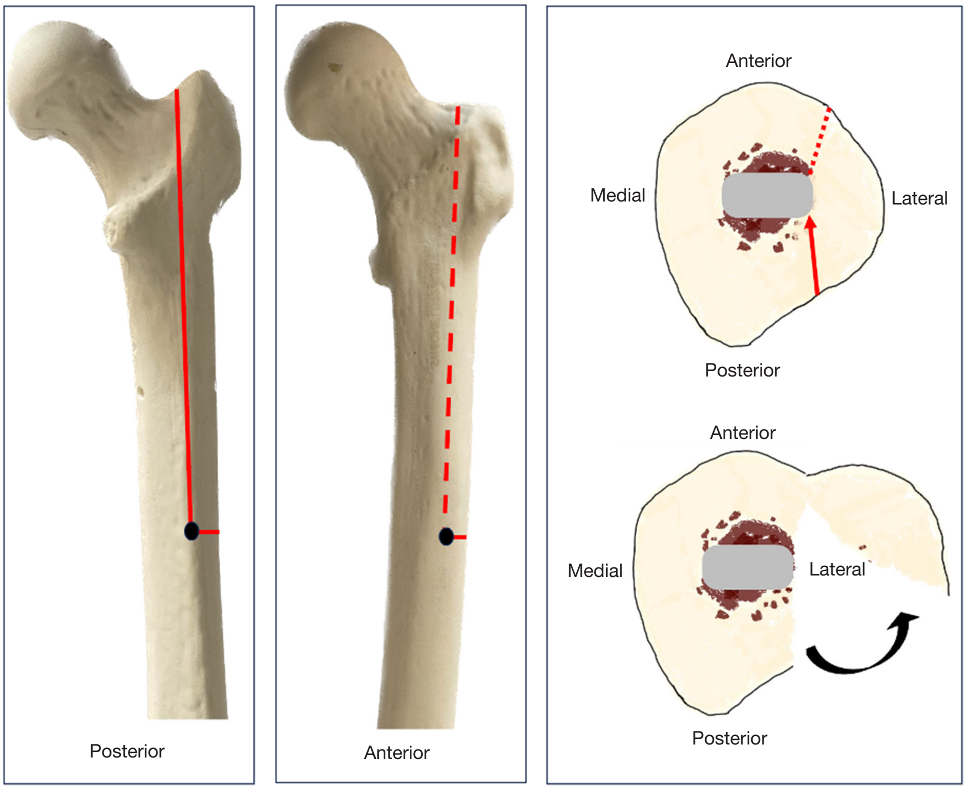

Figure 4 Illustration of an extended trochanteric osteotomy. (A) Posterior view of a femur with the solid red line demonstrating the posterior osteotomy limb completed with an oscillating saw. The black circle represents the distal extent of osteotomy and the placement of a 3.5-mm drill from posterior to anterior. Of note, this posterior limb is the location of a posterior longitudinal split. (B) Anterior view of a femur with dashed lines demonstrating indirect anterior limb completed by controlled fracture. (C) Cross section of a femur osteotomy illustrating osteotomy in relation to femoral stem (grey rectangle) before and after.

specific extraction devices are also available and allow the extractor to be directly screwed into the lateral shoulder of the stem. Lateral GT overhand often makes these devices difficult to use without further bone destruction, and they are not used at our institute.

Regardless of the extraction tool used, the surgeon should first hit the hammer antegrade, as this is thought to aid in disrupting the stem-bone interface. Afterward, the surgeon should apply a retrograde force. Often repeated forceful applications are necessary before stem movement occurs. If unsuccessful, the surgeon should reset and repeat the above steps, removing any further soft tissue and then focusing on overlooked stem-bone interfaces, often medial and lateral.

ETO

With proper patience and technique, most modern primary femoral stems should be removed from the top (intramedullary) without disrupting the medullary canal. This includes hydroxyapatite coated stems with collars. However, an ETO can be utilized if removal from the top is unsuccessful, faced with a fully coated stem with distal ingrowth, significant proximal femur osteolysis, or deformity. Both anterolateral and posterolateral approaches and extensile to allow for an ETO if required (20). We prefer to utilize a posterolateral approach to the hip and a posterior to anterior-based osteotomy, as described by Younger *et al.* (21).

In brief, a subvastus approach to the femur is utilized, and exposure is carried out to the level of the ETO as measured from the tip of the GT. A Hohmann retractor is placed under the vastus lateralis, and a 3.5 mm drill bit is placed from posterior to anterior at this level to mark the distal extent of the osteotomy. A sagittal saw cuts from proximal to distal and posterior to anterior approximal 1/3

Figure 5 Explant device with example large head adapter (black) for head sizes >36 mm. The bottom right demonstrates both long and short disposable explant blades.

of the femur's circumference (*Figure 4*). The starting point should be just lateral to the shoulder of the implant, and care must be taken to keep the GT in continuity with the femoral shaft. Care should be taken to complete the distal transverse limb with either an oscillating saw or a high-speed burr, as notching may create a stress riser and distal fracture propagation. The far cortex can be either cut with the sagittal saw by directing the saw laterally over the stem or by continuing the osteotomy on the far side from distal to proximal with osteotomes. A prophylactic Luque wire may be placed distal to the ETO to prevent fracture propagation. Finally, the ETO is completed by a controlled fracture completed by using multiple broad osteotomes and levering the lateral fragment forward (*Figure 4*).

Multiple methods have been described that can be used to extract the stem, including giggly saws, osteotomes, and burrs. We prefer a high-speed burr to disrupt the stem-bone interface posterior and anterior. Once completed, the stem can be removed from the ETO by hand, or the extraction device can be placed back on the stem and used to free the stem. Once extracted, acetabular work can proceed by retracting the ETO anterior, while the remaining femur will tend to be retracted inferior and medial with a retractor in the obturator foramen.

A posterior longitudinal split is an alternative to a formal ETO. This procedure completes only the posterior limb of the ETO, without the transverse or anterior osteotomy (*Figure 4*) (22). It has been described as an alternative to a formal ETO and allows for the diameter of the femur to expand and for successful extraction with the slap hammer tool. This approach is less invasive, limiting the amount of soft tissue and bony destruction and allowing for a straightforward reconstruction. This technique can always be attempted before completing the transverse and anterior osteotomy of a formal ETO. This technique has been reported to have high success rates with minimal complications (22).

Acetabular component removal

If screws are present, the acetabular liner must be removed during extraction to gain access to the screw. Various techniques have been described to remove polyethylene liners. Liners may have specific extraction tools, but we prefer to utilize universal tools such as a curved osteotome between the liner and shell to remove the polyethylene liner. This should be approached with caution if the shell is retained, as the locking mechanism can be damaged. Alternatively, a 3.5-mm drill can create a pilot hole in the polyethylene liner. A fully threaded AO small fragment screw can then be inserted, and as the screw engages the metal shell, the screw will push the liner out (23). Drilling at the periphery of the polyethylene allows for maximal screw force as more of the threads will engage the polyethylene before the engagement of the metal shell. A second screw can be used if the initial screw is underpowered.

If screws are absent, the cup can be removed with the liner *in situ*, regardless of the liner material. The most common device widely available for cup removal is the Explant Acetabular Cup Removal System (*Figure 5*). This modular tool is a pivoting osteotome with curved blades that disrupt the bone-cup interface with minimal bone loss (24). The stock Explant device is compatible with head diameters less than 36 mm, and the outer diameter of the shell dictates the blade diameter. We prefer using large head adapters if diameters greater than 36 mm are required in cases such as metal-on-metal revisions. A less desirable technique uses trial liners for a 32- or 36-mm head to be placed back in the cup for removal, as the trial liners result in excess motion. Lipped liners can be cut off before using the Explant device, while lateralized liners may need to be removed as a mismatch between the blade diameter and acetabular radius can cause unexpected bone loss.

After the acetabular rim has been cleared, the short-diameter blade is used first, placed between the shell-bone interface and rotating around the outer diameter of the shell. The blade should always be directed toward the shell to prevent excess bone from being removed. Once this interface is created, a longer blade is placed, and the remaining interface is disrupted. If the blade cannot penetrate the sclerotic bone, the blade can be carefully impacted with a mallet. With proper technique, this should take less than 10 min.

We often leave the liner *in situ* even if screws are present and first target the areas around the screws with the Explant device. Once most of the bone has been cleared, we will remove the liner and screws. This allows the liner to be placed back and, even if damaged, can provide enough support to remove the reaming bone-cup interface. This is our preferred approach when removing a revision uncemented acetabular shell with screws that has a cemented liner. Once the cemented liner and screws are removed, a trial liner may be used, or a new polyethylene can be cemented back for the Explant device.

Specific clinical scenarios

Presence of a collar

A collar can limit access to the medial calcar stem interface and prevent stem extraction. All efforts should be exhausted to free the stem's anterior, posterior, and lateral aspects to help with removal. If unsuccessful, techniques can help gain access to the medial calcar bone-stem interface. First, a reciprocating saw may be used to cut under the collar with minimal bone loss. If more access to the medial stem is required, a 5–10-mm horseshoe piece of bone may be removed underneath the collar to help facilitate access (5). The osteotomized bone can be kept and used during reconstruction if needed. Narrow, curved osteotomes can then be passed along the medial aspect to help free the interface. Finally, a metal cutting burr or wheel may remove the collar. Care should be taken to protect the soft tissue from metal debris by placing a sponge around the tissue before cutting. Cutting a stem is time-consuming and will require numerous burrs and cutting wheels. We do not routinely perform this as it is time-consuming and creates excess metal debris.

Ceramic or metal acetabular liners

Fracturing a ceramic liner is the last result, as it will result in considerable ceramic debris and may limit the bearing option during reconstruction. Companies have specific extraction tools that can be useful for removal and should always be requested before revision. If unavailable, a metal cutting burr can create a small trough in the metal acetabular rim, allowing a small punch to disengage the bearing. Other techniques have been described, such as using a punch on the perimeter of the metal shell, which may disengage the taper to allow a pulse lavage gun on suction to remove the liner (25). In addition, metal on metal hips often have larger heads (>36 mm) which are not available in the stock Explant set and a large head adapter may be used for these cases.

Trunnion failure

Certain stem designs have been associated with trunnion failure. For example, when used with a head size greater than 36 mm, the Accolade I (Stryker) stem has been known to be a risk of catastrophic gross trunnion failure (26). The location of the failure will determine the probability of successful removal from the top. If the trunnion fails proximally, a similar approach should be used as described above with debridement, bone-stem interface disruption using burrs, osteotomes, and k-wires, followed by removal with a universal vice grip slap hammer extraction tool that does not rely on taper-specific fixation. However, an ETO may be required if unsuccessful or inadequate trunnion length is available. In a series of trunnion failures reported by Urish *et al.* [2017], only 3 out of the 30 stems required an ETO for removal (27).

Fully porous coated stem

Fully porous stems coated promote ingrowth along the entire stem and often require an ETO (9,28,29). Stems approaching the isthmus level should approach cautiously as the subsequent reconstruction may be limited if less than 4 cm of the medullary canal is available after reconstruction. Studies have demonstrated that 4 cm of taper engagement is optimal for stabilizing modern, taper, fluted titanium stems (30). If the ETO prevents 4 cm of distal fixation, the stem should be extracted in two stages.

Removing a fully porous coated stem in two stages first requires an osteotomy. The level of the osteotomy should be determined based on the length and diameter of the stem and the remaining isthmus available for reconstruction. Once the ETO is completed, the stem is cut transversely at this level with a metal cutting burr or wheels. The diameter of the stem at this level should be known, as trephines available to at least this diameter will be needed to remove the remaining distal stem. The length of the remaining stem should also be compared to the overall length of the trephine. Again, cutting a titanium stem is time-consuming and will require numerous burrs and cutting wheels. In addition, soft tissues should be protected by placing sponges around the exposed area, as significant metal debris is often created.

The second stage involves utilizing trephines to mill overtop of the stem from proximal to distal. The diameter of the trephine should be 1–2 mm larger than the diameter of the stem at that level. Once the trephine has passed the desired length, the distal section can be removed from the canal. Care should be taken to determine if an excess bone will be removed as the trephine moves distally, as most modern revision stems taper 2 to 4 degrees along the taper of the stem (31). If more than 2–3 cm of a tapered stem needs to be removed, it will likely be cut a second time and removed in segments to prevent excess bone loss.

It should be noted if a distal pedestal has formed, removing the distal stem may be challenging. A 3.5 mm drill bit can be introduced laterally at the level of the distal pedestal and, using the same orifice, be redirected to disrupt the remaining distal bone to free the stem.

Fractured stem

Fracture of a stem can occur within the intramedullary canal with both primary and revision modular stems (32-34). Stem failure is often caused by cantilever bending forces of distal fixed stems that lack proximal osseous support (32,33). A fractured primary stem can be removed from the top (intramedullary) by removing the proximal body using the techniques described, followed by using trephines distally under X-ray guidance (34). An alternative approach utilizing an ETO followed by distal trephines should also be used, especially for distal fitting stems.

Summary

Removal of well-fixed uncemented implants can be challenging. However, using a systematic preoperative approach with proper surgical techniques, most implants can be removed successfully with little collateral damage. We will cover four case examples from our institution that outline some considerations and techniques for removing a well-fixed, cemented stem.

Case examples

Intramedullary removal of a well-fixed uncemented femoral stem with distal fixation

A 54-year-old male presented with new-onset pain after a low-energy fall 15 years after a metal-on-metal total hip replacement with a metal-on-metal acetabular component (*Figure 1*).

Preoperative considerations

Implant information was retrieved; size 13 collarless Corail stem (Depuy Synthes) with a 52-mm ASR acetabular shell (Depuy Synthes) and a 46-mm metal head (*Figure 1*). Progressive peri-trochanteric osteolysis secondary to a metal-on-metal articulation caused increased load distally and cortical hypertrophy with distal spot welding, as demonstrated on a computed tomography (CT) scan due to the stem being fully coated with hydroxyapatite. Osteolysis has also resulted in a fracture of the GT. This could be used as an ETO to gain access to the stem. The acetabular shell appears to be well-ingrown the no significant osteolysis. The large head adapter will be required to explant the acetabular component as the head diameter is >36 mm.

Operative technique

A posterolateral approach was used to gain access to the hip joint. The pseudotumor was resected, and the GT still had significant soft tissue attachment and was left *in situ*. Therefore, the stem was removed from the top (intramedullary). After all soft tissue was removed, non-threaded k-wires disrupted the distal stem-bone interface. Distally, the Corail stem has longitudinal ridges that can aid in the passage of k-wires to disrupt this distal fixation. A slap-hammer extraction device was used first to hit antegrade to disrupt any further stem-bone interfaces. A retrograde was then used to extract the femoral stem to aid in the exposure of the acetabulum. The cup was extracted using an explant device with a large head adapter. Reconstruction proceeded with a revision shell and a fluted, titanium distal fitting revision Monoblock stem, securing the GT with a Luque wire (*Figure 6*).

Removal of a well-fixed ingrowth femoral stem with an ETO

A 66-year-old male presented with recurrent right thigh swelling and pain 10 years after a metal-on-metal total hip. The hip was revised to ceramic on polyethylene bearing with retention of the femoral stem (*Figure 7*). The patient

Figure 6 Two-sided revision using an intramedullary approach to a distal fitting, titanium taper Monoblock stem, and revision acetabular shell with multiple screws.

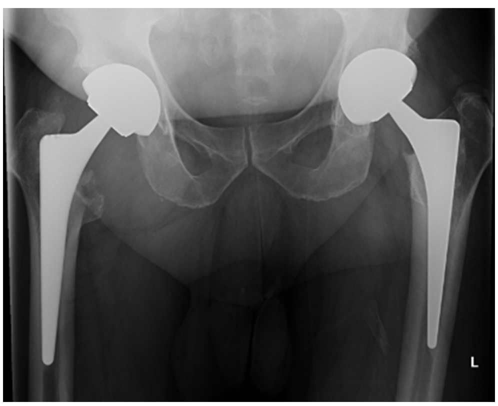

Figure 7 Despite the unique shape, the threaded acetabular shell was successfully removed with an Explant device with minimal bone loss.

presented with a recurrent collection after the revision, and both biochemical and cross-sectioning imaging demonstrated an extensive fluid collection, and infection could not be ruled out. Therefore, the patient was booked to undergo revision to a dynamic cement spacer.

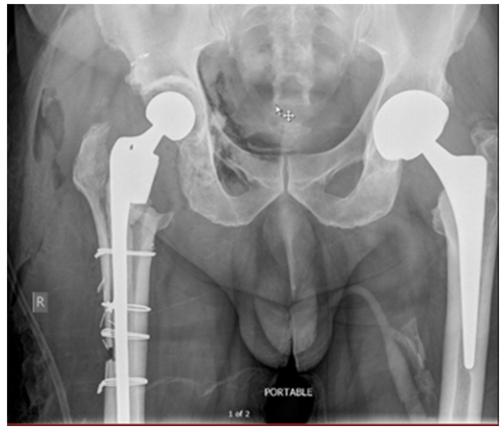

Figure 8 Well-fixed left femoral stem with distal spot welding and proximal osteolysis due to a progressive pseudotumor secondary to a metal-on-metal articulation.

Preoperative considerations

Preoperative radiographs demonstrate a well-ingrown uncemented stem and osteolysis around the less trochanter (*Figure 7*). The stem was determined to be a CLS stem (Zimmer), which is titanium with a three-dimensional wedge shape, sharpened ribs in the proximal region, and fully grit blasted (35). The stem was released in 1984 and had a good track record of on-growth (35). Spot welding at the distal tip of the stem demonstrates the stem's distal fixation. There is GT overhang with no lateral relief and osteolysis around the lesser trochanter. No significant osteolysis or fracture around the GT was noted on plain radiographs. No screw fixation is present, and the liner does not need to be removed (*Figure 8*).

Operative technique

A posterolateral approach was used to resect the residual pseudotumor, and the hip was dislocated. An ETO was used to remove the well-ingrown femoral stem as the stem was anticipated to have on-growth proximally and distally. A reciprocating saw was used from the tip of the stem's lateral should, disrupting both posterior and anterior limbs to the distal aspect of the stem, which had been marked with a 3.5-mm drill bit inserted from posterior to anterior. The transverse limb was completed with a sagittal saw which allowed for the removal of the stem using a pencil tip burr to free the anterior and posterior aspects of the stem. The cup was explanted, and the femur was prepared distally before reconstruction to a dynamic antibiotic spacer using a cemented cup and cemented femoral stem (*Figure 6*).

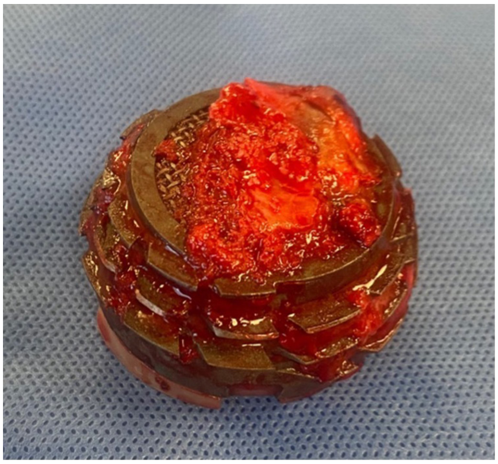

Figure 9 Right hip dynamic antibiotic spacer with cemented acetabular cup and long-stemmed cement spacer with an ETO repaired with Luque wires. ETO, extended trochanteric osteotomy.

Figure 10 Bilateral THA with well-ingrown cementless components. No signs of loosening. On screw present in the right acetabular cup. THA, total hip arthroplasty.

Removal of a threaded acetabular shell

A 72-year-old female presented with progressive right hip pain and eccentric polyethylene wear of a well-fixed uncemented acetabular component (*Figure 2*).

Preoperative considerations

Radiographs demonstrate a well-ingrown threaded acetabular shell with a ceramic on polyethylene bearing and a 28-mm head (*Figure 2*). The femoral stem is well fixed with no signs of loosening or osteolysis (*Figure 2*). A ceramic head was noted, and a taper-specific rescue sleeve will be required for reconstruction with a new ceramic head. If the trunnion has significant damage, the femoral stem will be removed, likely with an ETO.

Operative technique

A posterolateral approach was used to access the hip joint and dislocated. The hip deep hip capsule was debrided, and an anterior superior pocket was created for the trunnion once the head was removed. The trunnion was not damaged, and the femoral stem was retained. An explant device was used despite the shape of the cup. The blade size was estimated based on the outer diameter of the cup, and once the peripheral bone-cup interface was disrupted with the short blade, the cup was removed with minimal bone loss (*Figure 9*).

One-sided acetabular revision

A 79-year-old female presented with recurrent dislocations after a right total hip arthroplasty (THA) (*Figure 10*). A CT scan confirmed her cup had inadequate anteversion with a well-fixed femoral stem. A one-sided revision was planned.

Preoperative considerations

Previous surgical records were obtained, and the outer diameter shell was sized to 52 mm with a neutral polyethylene liner and one single screw (*Figure 9*). The femoral stem was a Lima H-max stem (12/14 taper). No significant bone loss is present.

Operative technique

A posterolateral approach was used to gain access to the hip joint. The hip was dislocated, and the femoral head was removed. A pocket in the superior anterior quadrant was made by elevating the capsule off the acetabular rim. The trunnion was placed behind the anterior superior femoral retractor in this location to allow access to the acetabulum. The rim of the acetabulum was cleared of all soft tissue, and the short 52 mm blade on the Explant device was used, followed by the long blade. Once the blade passed freely except around the area of the screw, the liner was removed with an osteotome, and the screw was removed. The liner was then placed back, and Explant was used to extract the cup. The cup was then revised to a 54 mm cup with more anteversion and adjuvant screw fixation with a 36 mm head and lipped liner (*Figure 11*).

Removal of a well-fixed ingrowth collared femoral stem and acetabular shell

A 57-year-old female presented with a 2-month history

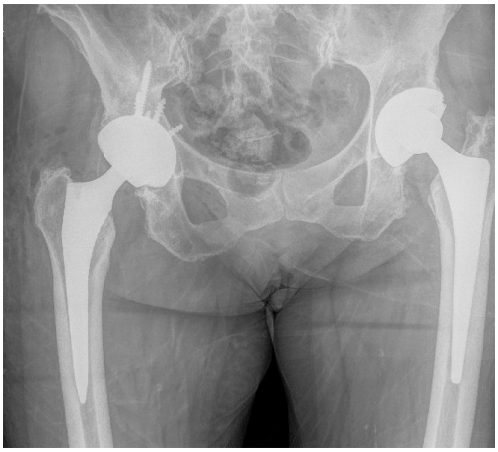

Figure 11 One-sided right revision THA for instability with retention of the femoral stem and insertion of a revision acetabular shell with increased anteversion and a 36-mm femoral head. THA, total hip arthroplasty.

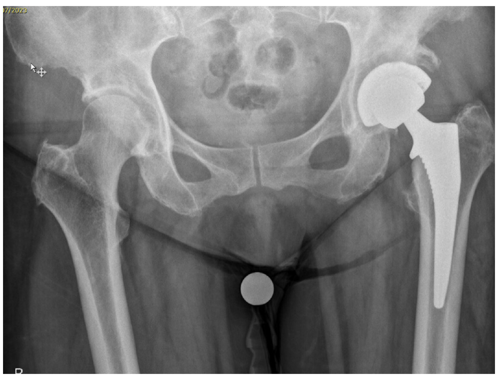

Figure 12 Well-fixed left uncemented collared femoral stem and acetabular shell in the presence of a confirmed periprosthetic joint infection. No radiographic evidence of implant loosening.

of pain and a draining wound eight months after an uncomplicated primary THA (*Figure 12*). An aspirate was positive for staph aureus, and the decision was made to proceed with a single-stage revision.

Preoperative considerations

Previous surgical records were not available as the patient had had the index procedure overseas. The femoral stem appeared well fixed with a presence of a collar and fully coated in hydroxyapatite. The acetabular shell has no screw presence, and size would be confirmed intraoperatively. Intramedullary stem removal was going to be attempted with a backup plan for an ETO. ETO level was noted

Figure 13 Single-stage reconstruction using a short-cemented stem and cemented acetabular shell after removal of a well-fixed implant with minimal bone loss.

preoperatively from the level of GT to the distal stem.

Operative technique

The previous posterolateral approach was used, and the hip was dislocated. The femoral head size was noted for future acetabular removal, and the proximal femoral stem bone-implant interface was clear of all soft tissue. The lateral shoulder of the stem was debrided mechanically, followed by a burr. Next, a pencil tip burr was used to clear the proximal bone-implant interface. A two-sided reciprocating saw was then used to slide down the anterior and posterior stem and under the collar. Next, 2.0 non-threaded k-wires were placed as distal as possible, aimed at the femoral stem to remove the remaining bone-implant interface. A taper-specific slap hammer was used, an antegrade followed retrograde force was applied, and the femoral stem was removed.

The acetabular rim was then clear of all soft tissue, the shell diameter was verified, and the liner was life *in-situ*. Explant device used with short followed by long blades and shell removed with minimal bone loss. Irrigation and debridement were completed, and patient we re-prepped and draped for single-stage reconstruction with a cemented Lima Friendly stem and Smith and Nephew cemented Reflection cup (*Figure 13*).

Conclusions

Preoperative planning is one of the most essential steps to remove uncemented implants. With proper surgical technique, patience with each step, and familiarity with implant characteristics, most uncemented implants should be removed with minimal collateral damage. The goal of implant removal should be to preserve as much bone stock as possible to enable for a successful reconstruction.

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Footnote

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References

1. Radaelli M, Buchalter DB, Mont MA, et al. A New Classification System for Cementless Femoral Stems in Total Hip Arthroplasty. J Arthroplasty 2023;38:502-10.
2. Kim JT, Yoo JJ. Implant Design in Cementless Hip Arthroplasty. Hip Pelvis 2016;28:65-75.
3. Wilhelm SK, Henrichsen JL, Siljander M, et al. Polyethylene in total knee arthroplasty: Where are we now? J Orthop Surg (Hong Kong) 2018;26:2309499018808356.
4. Blankstein M, Haimes MA, Nelms NJ. Selecting a Press-fit Stem for Total Hip Arthroplasty: The Rationale and Evolution of the Modern Femoral Prosthesis. J Am Acad Orthop Surg 2022;30:e1279-90.
5. Young S, Michel MC, Selmi TAS, et al. The Corail® Hip Stem. In: Vidalain JP, Selmi TAS, Beverland D, et al. editors. The Corail® Hip System: A Practical Approach Based on 25 Years of Experience. Berlin, Heidelberg: Springer Berlin Heidelberg; 2011:53-88.
6. Engh CA, Massin P, Suthers KE. Roentgenographic assessment of the biologic fixation of porous-surfaced femoral components. Clin Orthop Relat Res 1990;(257):107-28.
7. Engh CA, Bobyn JD, Glassman AH. Porous-coated hip replacement. The factors governing bone ingrowth, stress shielding, and clinical results. J Bone Joint Surg Br 1987;69:45-55.
8. Vanrusselt J, Vansevenant M, Vanderschueren G, et al. Postoperative radiograph of the hip arthroplasty: what the radiologist should know. Insights Imaging 2015;6:591-600.
9. Masri BA, Mitchell PA, Duncan CP. Removal of solidly fixed implants during revision hip and knee arthroplasty. J Am Acad Orthop Surg 2005;13:18-27.
10. Vajapey SP, Shah VM, Estok DM 2nd. Trunnions and Modularity in Total Hip Arthroplasty: A Historical Review With Current Clinical Implications. J Am Acad Orthop Surg 2023;31:189-97.
11. Elbuluk AM, Coxe FR, Schimizzi GV, et al. Abductor Deficiency-Induced Recurrent Instability After Total Hip Arthroplasty. JBJS Rev 2020;8:e0164.
12. Deckard ER, Meneghini RM. Diagnosis and Treatment of Musculotendinous Deficiencies of the Hip. J Arthroplasty 2022;37:1501-4.
13. Sculco TP. The acetabular component: An elliptical

monoblock alternative. J Arthroplasty 2002;17:118-20.
14. Schneider L, Châtain F, Estour G, et al. Total Hip Arthroplasty Using a Hemispherical Uncemented Dual-Mobility Cup Results in Satisfactory Clinical Outcomes and No Dislocations at 2 years. Arthroplast Today 2021;9:93-7.
15. Effenberger H, Ramsauer T, Dorn U, et al. Factors influencing the revision rate of Zweymueller acetabular cup. Int Orthop 2004;28:155-8.
16. Dayican A, Unal V, Ozkan G, et al. The uncemented CLS expansion cup as a component of a hybrid system in primary total hip arthroplasty: A prospective study. Hip Int 2004;14:223-8.
17. Wang Q, Goswami K, Shohat N, et al. Longer Operative Time Results in a Higher Rate of Subsequent Periprosthetic Joint Infection in Patients Undergoing Primary Joint Arthroplasty. J Arthroplasty 2019;34:947-53.
18. Manara J, Sandhu H, Wee M, et al. Prolonged operative time increases risk of blood loss and transfusion requirements in revision hip surgery. Eur J Orthop Surg Traumatol 2020;30:1181-6.
19. Neil MJ, Solomon MI. A technique of revision of failed acetabular components leaving the femoral component in situ. J Arthroplasty 1996;11:482-3.
20. Wronka KS, Gerard-Wilson M, Peel E, et al. Extended trochanteric osteotomy: improving the access and reducing the risk in revision THA. EFORT Open Rev 2020;5:104-12.
21. Younger TI, Bradford MS, Magnus RE, et al. Extended proximal femoral osteotomy. A new technique for femoral revision arthroplasty. J Arthroplasty 1995;10:329-38.
22. Bauze AJ, Charity J, Tsiridis E, et al. Posterior longitudinal split osteotomy for femoral component extraction in revision total hip arthroplasty. J Arthroplasty 2008;23:86-9.
23. Villanueva-Martınez M, Ríos-Luna A, Pereiro de Lamo J, et al. A simple polyethylene liner extraction method in hip arthroplasty revision surgery. European Journal of Orthopaedic Surgery & Traumatology 2007;17:507-10.
24. Mitchell PA, Masri BA, Garbuz DS, et al. Removal of well-fixed, cementless, acetabular components in revision hip arthroplasty. J Bone Joint Surg Br 2003;85:949-52.
25. Memarzadeh A, Jeffery J. How to safely remove ceramic bearings from the metal shell without expensive tools or the risk of shattering. Ann R Coll Surg Engl 2015;97:477-8.
26. Wylde CW, Jenkins E, Pabbruwe M, et al. Catastrophic failure of the Accolade I hip arthroplasty stem: a retrieval analysis study. Hip Int 2020;30:481-7.
27. Urish KL, Hamlin BR, Plakseychuk AY, et al. Trunnion Failure of the Recalled Low Friction Ion Treatment Cobalt Chromium Alloy Femoral Head. J Arthroplasty 2017;32:2857-63.
28. Matthys F, Van Meirhaeghe J, Pattyn C. Fracture risk during extraction of well-fixed extended cementless stems: porous versus hydroxyapatite coated. Acta Orthop Belg 2021;87:41-5.
29. Laffosse JM. Removal of well-fixed fixed femoral stems. Orthop Traumatol Surg Res 2016;102:S177-87.
30. Gkiatas I, Malahias MA, Xiang W, et al. How Does Contact Length Impact Titanium Tapered Splined Stem Stability: A Biomechanical Matched Pair Cadaveric Study. J Arthroplasty 2021;36:3333-9.
31. Munro JT, Masri B, Garbuz D, et al. Modular tapered titanium stems for femoral revision. In: Callaghan JJ, Rosenberg AG, Rubash HE, et al. editors. The Adult Hip: Hip Arthroplasty Surgery 3e. Philadelphia, PA: Wolters Kluwer Health Adis (ESP); 2015.
32. Lakstein D, Eliaz N, Levi O, et al. Fracture of cementless femoral stems at the mid-stem junction in modular revision hip arthroplasty systems. J Bone Joint Surg Am 2011;93:57-65.
33. Matar HE, Selvaratnam V, Board TN, et al. Fractured Femoral Stems in Primary and Revision Hip Arthroplasties Revisited: Wrightington Experience. J Arthroplasty 2020;35:1344-50.
34. Arafah MA, Almalki AH, Arafah OM. Management of a broken modular femoral stem following total hip arthroplasty in a patient with sickle cell disease using an endofemoral trephine reamer: A case report. Int J Surg Case Rep 2021;81:105643.
35. Zimmer Biomet. CLS ® Spotorno ® Hip Stem. Surgical Technique.

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