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Surgical technique

The “Inside-Out” Anterior Osteotomy of the Proximal Femur via the Direct Anterior Approach in Revision Hip Arthroplasty

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ABSTRACT

Osteotomy techniques used for wide exposure during femoral component revision include the extended trochanteric osteotomy and its modifications. We describe an anterior proximal femur osteotomy technique starting from the inside of the femoral canal at the bone-implant interface and heading outward. The technique is used in conjunction with the extended direct anterior approach and allows direct access to and visualization of the anterior, medial, and lateral bone-implant interfaces. This technique is most useful for the removal of collared, fully hydroxyapatite-coated double-tapered femoral stems, in which bone-implant interfaces need to be accessed for removal of a well-osseointegrated hip arthroplasty implant.

Introduction

As the annual volume of primary total hip arthroplasty (THA) is projected to increase in the coming decades, so too will the burden of revision THA [1,2]. As recently as 2021, uncemented fixation was used in over 95% of THAs in the United States [3]. Among uncemented stems, the use of fully hydroxyapatite (HA) coated implants, including collared variations, has grown in popularity as previous studies have demonstrated a lower incidence of subsidence and aseptic loosening [4-6]. These stems promote osseointegration along the entire length of the femoral component, creating a challenge for implant removal in the revision setting. Careful and meticulous division of the bone-implant interface is essential to decrease the risk of fracture and/or bony destruction during femoral component extraction. Such division necessitates a wide surgical exposure of the bone-implant interface.

Multiple proximal femur osteotomy techniques (as well as various subsequent modifications) have been described to provide wide femoral component exposure and facilitate stem removal. The traditional extended trochanteric osteotomy (ETO) [7-10] performed via a posterolateral approach and the direct anterior ETO [11] are two examples. These osteotomies separate the greater trochanter from the proximal femur. While this maneuver may be beneficial in some cases of proximal femoral deformity, it risks both osteotomy nonunion as well as potential alteration of greater trochanteric anatomy and resultant undesired tension changes in the abductor musculature [12]. Morcos et al. have described a technique for an ETO via the extended direct anterior approach [11]. Their technique describes a longitudinal split in the vastus lateralis and detachment of the origin of the vastus lateralis from the vastus ridge. This technique results in denervation of the posterior aspect of the vastus lateralis muscle and devitalization of the vastus lateralis origin [13,14]. In addition, previous osteotomy techniques utilized cuts that were made from an “outside-in” trajectory. As such, the exact trajectory of the cuts is often not in the ideal plane to access the bone implant interface of the stem.

When utilizing the direct anterior approach in the revision setting, anterior femoral cortical windows are included in the surgeon’s armamentarium to aid in femoral component exposure at the distal extent. This window osteotomy is advantageous in its ability to preserve the greater trochanter and abductor mechanisms. Typically repaired with cerclage wires or cables, this technique has demonstrated similar nonunion rates when compared to more traditional trochanteric osteotomies [15]. However, the anterior cortical window is not without limitations. In addition to providing less exposure than traditional trochanteric osteotomies, its proximal extension is limited by the origin of the vastus

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intermedius and lateralis. As described above, division of these muscles for exposure of the proximal femur results in significant muscular denervation.

Here, an “inside-out” osteotomy of the proximal femur performed via the direct anterior approach is described. The technique provides wide femoral exposure while minimizing detachment or denervation of the vastus lateralis muscle and devascularization of the osteotomized fragment. The authors believe that this technique is useful for the extraction of fully HA-coated, collared, double-tapered femoral components in revision THA.

“Inside-out” anterior osteotomy of the proximal femur technique

The anterior osteotomy (Appendix Figure 1) consists of 3 separate limbs: 1) medial, 2) lateral, and 3) transverse.

It is recommended that the technique be carried out in the following 4 sequential phases: 1) proximal exposure; 2) division of the proximal bone implant interfaces; 3) completion of the medial and lateral limbs of the osteotomy, and 4) distal exposure for extension of the medial and lateral limbs and completion of the transverse limb. Careful attempts at retrograde extraction of the stem can be attempted in sequence after each of the last 3 phases.

Proximal exposure

With the patient positioned supine on a mobile traction table, a standard Smith-Peterson or Hueter approach is utilized [16]. The authors prefer to use a Hana table (Mizuho OSI, Union City, CA, USA). The dissection is carried down to the anterior hip capsule between the tensor fasciae latae and rectus femoris muscles. An anterior capsulectomy or capsulotomy is performed to obtain adequate exposure of the articulation. Traction is applied to the leg to separate the articulation, and the head ball is then disengaged from the trunnion of the stem by retrograde impaction with a bone tamp. The leg is externally rotated, and traction is released. The head ball is removed from the acetabulum. The extremity is then positioned in extension and external rotation, and the proximal femur is elevated using a femoral hook and femoral lift. Capsular releases are performed to gain wide exposure of the proximal bone-implant interface and allow maximal femoral elevation. A round burr is used to clear medial greater trochanteric bone overlying the proximal lateral shoulder of the femoral component (Appendix Figure 2). This step is critical in preventing iatrogenic fracture of the greater trochanter when axially-based, retrograde implant extraction is ultimately attempted.

Division of proximal bone-implant interface

The proximal bone-implant interface is then divided in systematic fashion from proximal to distal. First, a pencil-tip burr is used circumferentially to divide the proximal bone-implant interface, passing the burr as distal as possible to free the metaphyseal portion of the component. The authors prefer to use a Stryker straight router bur, which accommodates the Midus Rex tool. If the implant has a medial collar, the medial bone-implant interface is not accessible. The medial collar can be removed with a metal cutting burr. The authors recommend adjunctive use of a sterile towel coated with sterile ultrasound lubricant as a barrier between surrounding soft tissues and metal debris generated during the process. Alternatively, the collar can be left, and the medial aspect of the proximal bone-implant interface can be accessed after the anterior wall osteotomy is completed. A double-sided reciprocating saw is then introduced to divide the posterior and anterior bone-implant interfaces from proximal to distal. The authors prefer to use a long Stryker double-sided reciprocating saw blade. The saw should stay in continuity with the implant during this process. Care is taken to avoid cortical perforation medially or laterally with the tip of the saw during division of the posterior interface. Finally, specialized semi-flexible osteotomes are used to complete division of the bone-implant interface as distal as possible (Appendix Figures 3 and 4). The osteotomes are used to divide the cancellous bone-implant interfaces in the distal aspect of the metaphysis. Further distally, stems often engage cortical bone, and great care should be taken as aggressive use of the osteotomes risks fracture and iatrogenic cortical perforation. These osteotomes are specifically designed for division of the anterior, posterior, lateral, and medial aspects of the bone implant interface (Appendix Figure 4). Retrograde extraction can now be attempted. Extraction forces that follow the longitudinal axis of the component have been shown to deliver significantly more extraction force compared to “off-axis” attempts [17]. If distal fixation of the stem prevents safe extraction, the next phase of the technique is initiated.

Formation of medial and lateral limbs

The medial limb of the “inside-out” anterior osteotomy is performed with a double-sided reciprocating saw along the anterior bone-implant interface. The saw is reintroduced into the previously divided anterior bone-implant interface. The saw is now used to make the medial osteotomy by cutting through the medial cortex from the inside out. Excessive protrusion of the tip of the saw blade into the soft tissues is avoided by “feeling” the tip complete the cut in the bone (via feedback). This cut is completed as far distal as necessary (Appendix Figure 5, Video 1). The lateral limb of the osteotomy is performed with an identical technique that was used on the medial limb. Proximal completion of the lateral limb will include a small portion of the anterior aspect of the greater trochanter. Completion of these portions of the osteotomy produces a variant of the “slot” osteotomy described by Jack et al [18]. Another attempt at retrograde extraction is then attempted. If successful, the medial and lateral corticotomies are stabilized with 2 to 3 submuscular circumferential luque wires through the distal exposure, as described below. If unsuccessful, the saw blade is then positioned so that the tip protrudes through the lateral osteotomy. The blade is disengaged from the saw and left in the anterior osteotomy plane, so it can be identified during distal exposure. As the reciprocating saw blade is often shorter than the majority of femoral stems of this type, distal extension of the osteotomy may be required, as described below.

Distal exposure and transverse limb

The distal extension of the anterior approach, as previously described by Nogler et al. is then performed [14]. The extremity is placed in a neutral position. The skin incision is extended distally, curving slightly posteriorly. The fascial incision overlying the tensor fasciae latae is extended distally into the fasciae latae. The leg is internally rotated, and the vastus lateralis is elevated from the intermuscular septum anteriorly to gain exposure of the proximal lateral femoral diaphysis in the region of the tip of the saw blade. The tip of the saw blade can now be visualized and defines the orientation of the proximal osteotomy plane (Appendix Figure 6). Fluoroscopy can be used to determine the distal extent of the osteotomy (ie, the distal tip of the femoral component). Once the distal extent of the osteotomy is determined, the vastus lateralis is elevated anteriorly only in the distal aspect to provide exposure for the transverse limb of the osteotomy. The vastus lateralis muscle attachment should remain intact for the majority of the osteotomy fragment. An oscillating saw can be used to extend the osteotomy as far distally as needed by cutting from outside-in and from lateral to medial along the same plane as the proximal portion of the osteotomy. A pencil-tip burr is then used to start the transverse limb. To prevent stress risers, the burr is used to round the distal ends of the longitudinal limbs at a 90-degree angle to transition into the transverse limb. The remainder of the transverse limb can then be completed with a microsagittal saw. To prevent propagation of fracture distally, it is advisable to place a circumferential cable or wire distal to the osteotomy site prior to wedging open the osteotomy. Prophylactic wiring will also limit fracture propagation at time of diaphyseal-engaging revision stem implantation. Multiple osteotomes are introduced from lateral to medial, carefully wedging the osteotomized fragment open laterally with a medial hinge (Appendix Figures 7 and 8, Video 2). Once wedged open, cobra retractors are placed between the osteotomy and the femoral implant for visualization. Proximally, the osteotomy aims to divide the anterior portion of the greater trochanter between the attachment footprints of the gluteus medius and gluteus minimus. The gluteus minimus will be attached to the mobilized anterior portion of the trochanter while the gluteus medius remains attached to the stable lateral aspect of the trochanter, which does not involve the osteotomy. If needed, blunt longitudinal separation of the interval between the gluteus minimus and gluteus medius provides excellent proximal exposure (Appendix Figure 9)

The osteotomy provides full access to the anterior, medial, and lateral bone-prosthesis interfaces. The medial and lateral interfaces are divided by the pencil-tip burr. If the implant is collared (and the collar was not previously removed), the pencil-tip burr can now be used to divide the proximal and medial bone-implant interfaces (Appendix Figure 9 and Video 3). Should any bone remain attached along the distal, posterior aspect of the implant, a Gigli saw can be employed to divide that interface. The implant can now be safely extracted proximally in retrograde fashion (Appendix Figure 10). The osteotomy is reduced and fixed with cables and/or wires (Appendix Figure 11). The remainder of the procedure is carried out in a case-specific manner, as dictated by the particular scenario.

Discussion

This “inside-out” osteotomy technique offers several advantages. First, it utilizes an osteotomy plane that allows for unhindered access to the anterior, medial, and lateral aspects of the bone-implant interface along the entire length of the femoral component. Beyond the osteotomy site itself, it does not require significant soft tissue detachment. The femoral attachment and nerve supply to both the vastus intermedius and lateralis remain intact. Finally, the technique spares the majority of the greater trochanter and allows immediate postoperative weight bearing without restriction.

In our experience, this is a reproducible technique that facilitates efficient and safe removal of implants that are otherwise notoriously difficult to remove. However, this technique is not without limitations. While the osteotomy does not allow direct visualization of the posterior bone-implant interface, this interface can be divided proximally with a reciprocating saw and osteotome and distally with a Gigli saw when necessary. Further, this technique may be less applicable for femoral components with rounded geometry. Finally, as with all osteotomy techniques, there is a risk of fragmentation or fracture of the osteotomy fragment. This risk is reduced by ensuring completion of the osteotomy proximally with the double-sided reciprocating saw. If minor fragmentation does occur, loss of fixation does not compromise function of the gluteus medius. It should be noted that significant fragmentation of the greater trochanter is always a risk, and care must be taken to avoid compromise of the anterior portion of the gluteus medius.

Conflicts of interest

T.L. Bradbury receives royalties from Zimmer Biomet, is an unpaid consultant for TightLine Development, and is a board/committee member of the Georgia Orthopaedic Society; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101219.

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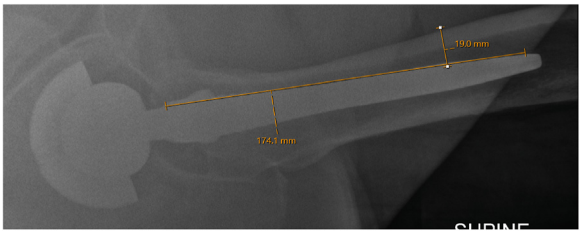
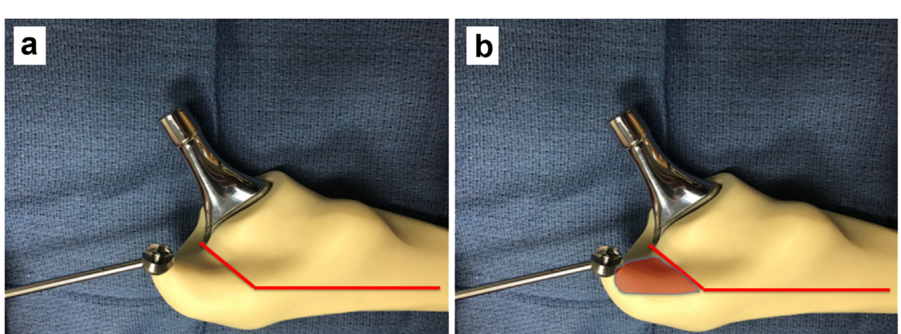
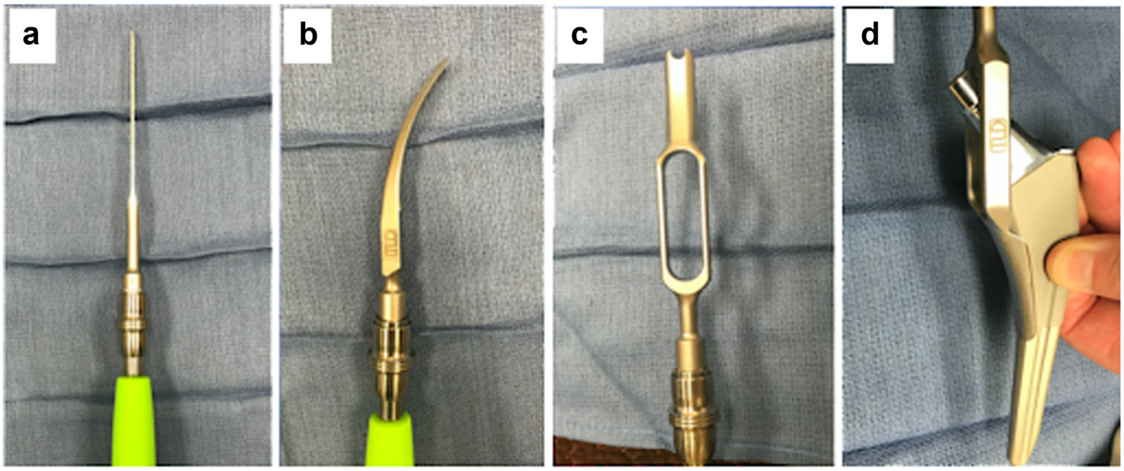
Appendix



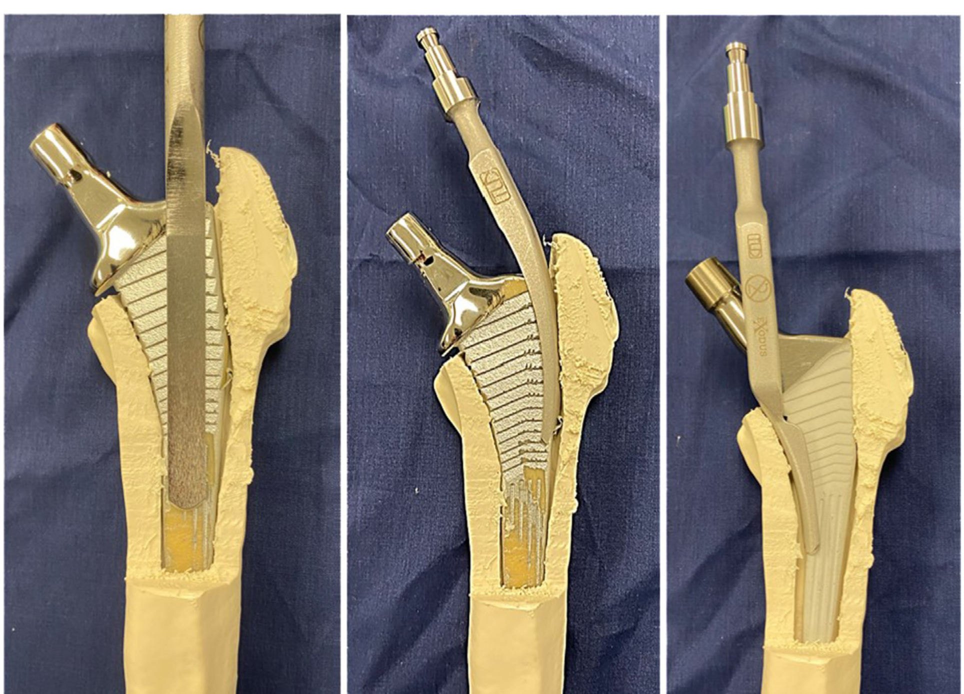
Appendix Figure 1. Lateral radiograph of the femur demonstrating the plane of osteotomy on the anterior aspect of the component. The distal extent of the osteotomy can be measured from the proximal aspect of the stem.



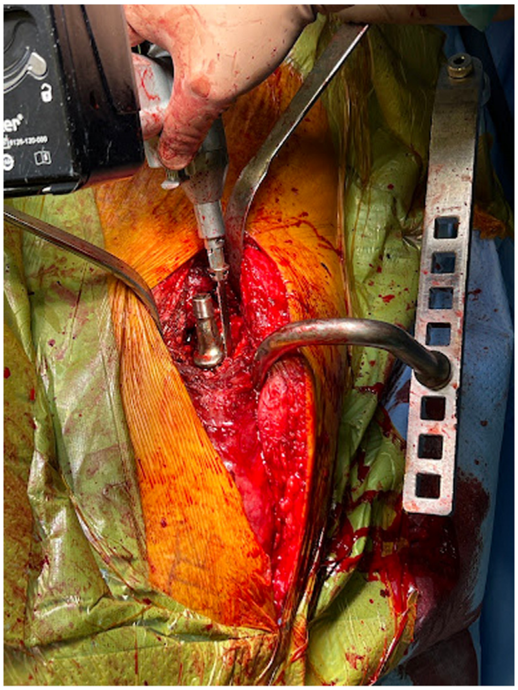
Appendix Figure 2. A round burr (a) is used to clear trochanteric bone overlying the lateral shoulder (b) of the implant, creating a path for eventual removal.



Appendix Figure 3. Specialized proximal femoral osteotomes with modular handle (Exodus). (a) Flat, beveled osteotome for anterior and posterior interfaces (b) Lateral interface osteotome (c) Medial interface osteotome as it (d) advances along medial bone-implant interface.

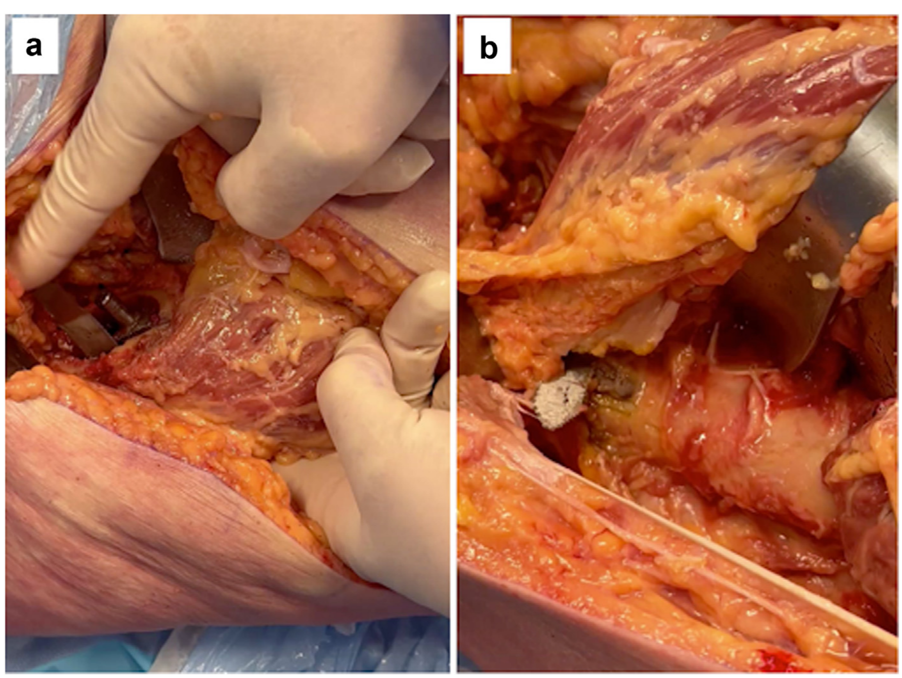


Appendix Figure 4. Synthetic bone model demonstration of the path of osteotomes used to divide the proximal bone-implant interface (as seen from anterior view point). The anterior wall fragment is removed to demonstrate the location of the osteotomy.

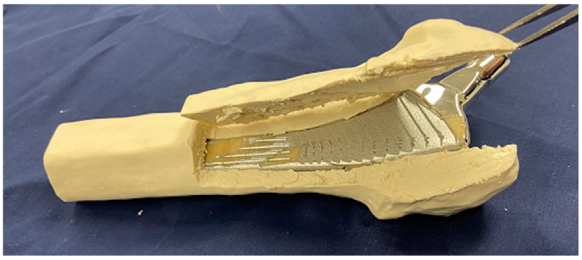


Appendix Figure 5. Double-sided reciprocating saw is introduced along the anterior bone-prosthesis interface as distal as possible. Video 1: Click here.

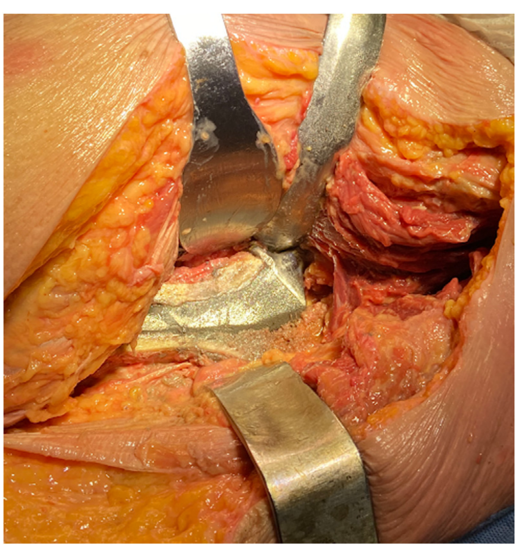
Appendix Figure 7. Multiple osteotomes are introduced laterally in a sequential manner to free and open the anterior osteotomized fragment. Video 2: Click here.



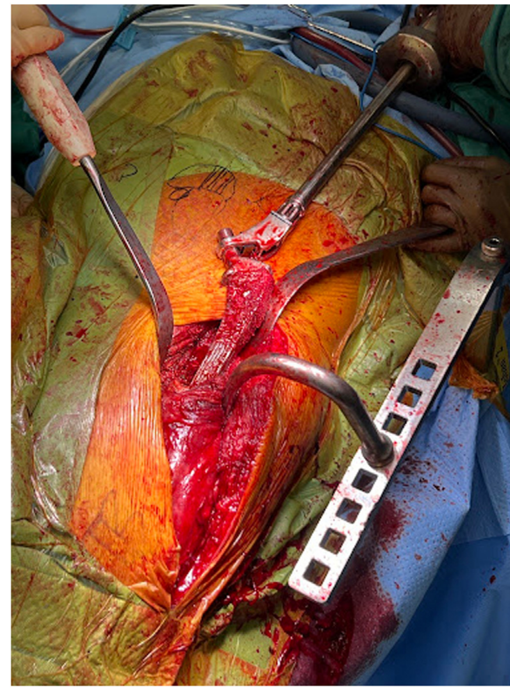
Appendix Figure 6. (a) After formation of lateral and medial limbs of osteotomy with the reciprocating saw from proximally in 'inside-out' fashion, the tip of the saw is pushed through lateral cortex and digitally palpated. (b) The leg is then internally rotated, the vastus lateralis is elevated and retracted anteriorly. The saw tip is visualized, and the osteotomy is completed from 'outside-in,' following the plane of the proximal portion of the osteotomy.



Appendix Figure 8. Synthetic bone model demonstration of the 3 limbs of the osteotomy with fragment hinged medially.



Appendix Figure 9. Cadaveric dissection demonstrating visualization of the femoral component after mobilization of the osteotomy fragment. Proximally, a longitudinal separation of the interval between the gluteus minimus (attached to the trochanteric portion of the anterior osteotomized fragment) and gluteus medius (attached to the greater trochanter) allows full visualization of the medial bone-implant interface below the collar of the femoral component. Video 3: After wedging the osteotomized fragment open, the pencil-tip burr is used to divide the medial and lateral bone-implant interfaces. Click here.



Appendix Figure 10. Retrograde, axially-based component extraction demonstrating minimal proximal femoral bone loss.

Appendix Figure 11. Postoperative anteroposterior radiograph of the hip demonstrating revision stem placement and fixation of the osteotomy site.