Technical Note

Treatment of Coxa Profunda With Open Surgical Hip Dislocation, Rim Resection, Cam Resection, and Labral Reconstruction

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Abstract: Coxa profunda presents a unique challenge in surgical treatment approach given global acetabular overcoverage. Arthroscopic treatment can be fraught with difficulty obtaining hip distraction for safe arthroscopic instrumentation, and limited arthroscopic access may prevent sufficient osseous resection of the excess acetabular rim. Although hip arthroscopy use has increased markedly over the past decades for all types of hip pathology, coxa profunda may represent one unique indication for surgical hip dislocation. This technique describes open surgical hip dislocation, rim resection, femoral osteoplasty, and labral reconstruction using anterior tibialis allograft for coxa profunda with combined-type femoroacetabular impingement syndrome and labral ossification.

Coxa profunda is defined as the floor of the fossa acetabuli touching or overlapping the ilioischial line medially.[1] Coxa profunda, not to be confused with acetabular protrusio in which the femoral head overlaps the ilioischial line medially,[2] can present very similarly to more common types of femoroacetabular impingement syndrome (FAIS) such as cam or pincer type. Previous studies have shown coxa profunda, often also defined as a radiographic lateral center edge angle of >40°, to be present in 55% to 61.6% of patients with FAIS.[2,3]

The global nature of acetabular overcoverage in the setting of coxa profunda can present unique challenges in accessing the hip joint through arthroscopic surgery. Several factors relating to coxa profunda can make arthroscopic management more difficult. Global overcoverage often requires acetabuloplasty of the anterior, lateral, and posterolateral acetabulum. Sufficient hip distraction may be difficult, requiring additional traction force and increasing the risk of traction injury.[4,5] An outside-in technique and potentially acetabuloplasty-first approach may additionally be required to enter the central compartment.[6,7] Because of these challenges, an open technique via a surgical hip dislocation approach has been suggested.[5] Although the use of arthroscopic hip surgery has continued to rise over the past decades, with ever-expanding indications, surgical hip dislocation was initially used as the gold standard treatment for FAIS.[8-14] Surgical hip dislocation was described by Ganz et al.[15] and represents a landmark change in the open approach to hip surgery in that the approach does not compromise the femoral head blood supply from the medial femoral circumflex artery. The trochanteric flip approach also allows full exposure to the acetabulum and does not violate the external rotator muscles of the hip.[15] The following technique describes open surgical hip dislocation, rim resection, femoral osteoplasty, and labral reconstruction using anterior tibialis allograft in the setting of combined type FAIS with cam lesion, coxa profunda,

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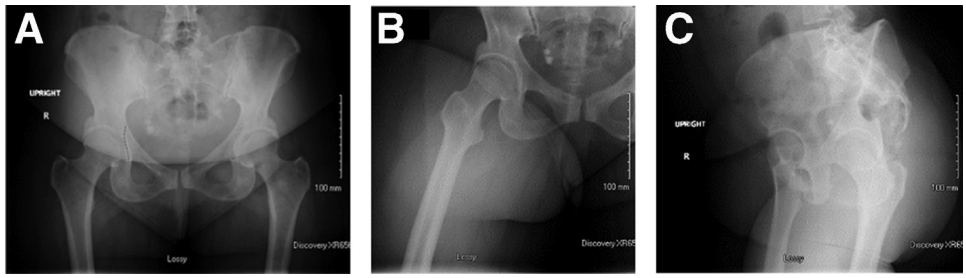

Fig 1. Preoperative (A) standing AP pelvis, (B) modified 45° Dunn lateral, and (C) standing false profile radiographs show coxa profunda, defined as the acetabular fossa (*asterisk*) medial to the ilioischial line (*dotted*) with labral ossification (*arrow*). (A) Lateral center-edge angle (LCEA) measures 56° (dysplasia <20°, normal 20°-40°, overcoverage >40°). (B) Modified 45° Dunn lateral view shows alpha angle of 59° (normal <42°, cam deformity >50°-55°). (C) False profile radiograph shows anterior center edge (ACE) angle of 45° (normal >25°).

and labral ossification. This approach offers the advantage of 360° surgical exposure of the acetabular rim and labrum and addresses both the pathologies associated with coxa profunda, as well as concomitant FAIS and intraarticular derangement.

Surgical Technique

Preoperative Planning

For diagnostic and preoperative planning purposes, the routine work-up for hip preservation patients includes standing anterior-posterior (AP) pelvis, modified 45° Dunn lateral and false profile view radiographs (Video 1; Fig 1).[16,17] Non-contrast magnetic resonance images are obtained to evaluate for labral and cartilage pathology, as well as computed tomography scans with 3-dimensional reconstruction for bone morphology and assessment of radiographic measures, as well as evaluation of extra-articular areas of impingement.[18-21]

Key surgical equipment can be found in Table 1. In addition to this, an anterior tibialis allograft (anterior tibialis allograft 6 to 12 mm × 20 to 38 cm; musculoskeletal transplantation foundation) was available for expected labral reconstruction.

Table 1. Equipment Required for Surgical Hip Dislocation

Jackson surgical table: bean bag, axillary roll, blanket platform
Open hip pan: Charnley retractor, Hibbs retractors, wide and narrow Deaver retractors, Homan retractors
Large C-arm for intraoperative fluoroscopy
Burr: 5 mm round (Stryker) with femoral head sizers
Anterior tibialis allograft (6-12 mm × 20-38 cm; Musculoskeletal Transplant Foundation)
Labral Anchors: 1.4 mm NanoTack Flex (Stryker)
Labral Anchor Drill Bit: NanoTack Flex (Stryker)
Osteotomy fixation: K-wires (smooth, 0.062; Synthes), three 3.5 mm cortical screws (Synthes)
Closing: 0 PDS (polydioxanone; Ethicon), no. 1 Vicryl (Ethicon), 2-0 Vicryl (Ethicon), 3-0 Monocryl (Ethicon), sterile Mepilex Ag with border (Molnlycke)

Patient Positioning

Before administration of general anesthetic, our preference is to use epidural anesthesia for pain control. A Foley catheter is placed before positioning. Patient is placed in the lateral decubitus position on a Jackson table with a bean bag. Padding is placed under the axilla, nonoperative leg, as well as between the operative and nonoperative leg. Care is taken to verify that the operative leg is able to adduct anteriorly over the operative table (Video 1, Fig 2). The operative extremity is prepared with sterile technique and draped using an Ioban "sandwich" technique and impervious stockinette.[22]

Incision and Superficial Dissection

A modified Gibson approach is used to access the hip. The incision is about 14 centimeters in length, centered over the greater trochanter and curved slightly posterior. The dissection is carried down through the subcutaneous tissue, in line with the skin incision. A Cobb elevator and lap sponge are used to clear the iliotibial band and gluteal fascia. The interval between the gluteus maximus (gMax) and the tensor fascia latae is developed with electrocautery following the gluteus maximus muscle belly at the red/white junction and then distally in line with the femoral shaft. The gMax is retracted posteriorly and a Charnley retractor is placed to retract the gMax with special care to protect the sciatic nerve. The gluteus bursa is resected with Metzenbaum scissors.

Deep Dissection

With the hip internally rotated and extended, the interval between the gluteus medius (gMed) and minimus (gMin) is developed bluntly. At this point, the piriformis is left intact (Video 1; Fig 3).

Step-Cut Greater Trochanter Osteotomy

An oscillating saw is used for the step-cut greater trochanteric osteotomy with the leg held internally

Fig 2. Patient is positioned lateral decubitus on a Jackson table with a bean bag. Peroneal nerve is padded on the down leg, and a blanket bridge is used between the legs to appropriately abduct.

rotated and in extension. The saw blade should normally be about 20° to 25° posteriorly off-axis to the tibia in order to be orthogonal to the axis of the greater trochanter. The planned osteotomy is outlined with electrocautery along the posterior aspect of the greater trochanter starting just anterior to the most posterior fibers of the gMed. The osteotomy is carried below the vastus lateralis ridge while staying above the posterior overhang of the trochanter. The osteotomy is made in 2 cuts with a small step in between to provide a stable reduction for later fixation.[23] The bone should be protected from thermal injury with irrigation. The trochanteric segment is mobilized with a wide osteotome. The proximal attachments of the vastus intermedius are released as well to more easily retract the flip osteotomy (Video 1; Fig 4).

Hip Capsule Exposure and Z-Type Capsulotomy

The remaining fibers of the gMed are sharply dissected off of the stable trochanter (Video 1; Fig 5A). Next, the plane beneath the gMin is sharply dissected from posterior to anterior with care taken to stay superficial to the hip capsule (Video 1; Fig 5B). The hip is brought to a position of flexion and external rotation to expose the anterior capsule. The vastus intermedius is sharply dissected free along the anterior capsule. The piriformis remains intact and serves to protect the constant anastomotic vessel between the inferior gluteal artery and the medial femoral circumflex artery that lies at the distal border.

A modified Z-type capsulotomy is used to expose the hip joint. Instead of incising distal to the labral as is done in a typical Z-capsulotomy, the flap is raised subperiosteally anteriorly and posteriorly off of the acetabular bone to allow for later rim excision and capsule repair (Video 1; Fig 6). A tag stitch is placed in each limb, as well as in the capsule to allow for later repair (Video 1; Fig 7).

Acetabulum Rim Recession and Cam Resection

The labrum may be ossified in the setting of coxa profunda as it was in our patient (Video 1; Fig 8 A). If there is viable labrum, a bucket-handle release of the damaged labrum is performed, leaving very anterior and very posterior attachments in place (Video 1; Fig 8 B). With the hip in flexion and external rotation with adduction, the femoral head can be gently dislocated. In the setting of coxa profunda, dislocation may be

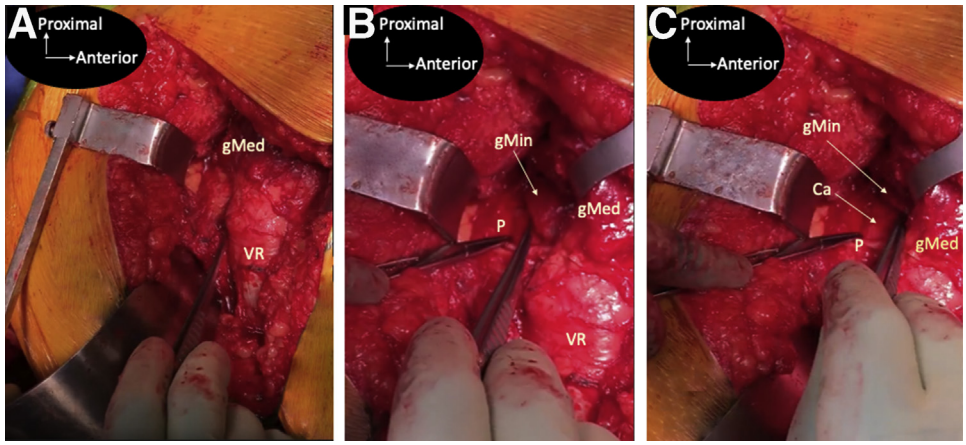

Fig 3. With the patient in the lateral decubitus position, a modified Gibson approach to the hip is made. (A) The gMax is retracted posteriorly and the tensor fascia latae anteriorly with a Charnley retractor. This gives visualization of the vastus ridge and gMed. (B) The interval between the gMed and gMin is developed. (C) The gMin is sharply released to reveal the hip capsule with retraction of the piriformis. VR, vastus ridge; gMed gluteus medius; gMin, gluteus minimus; P, piriformis; Ca, capsule.

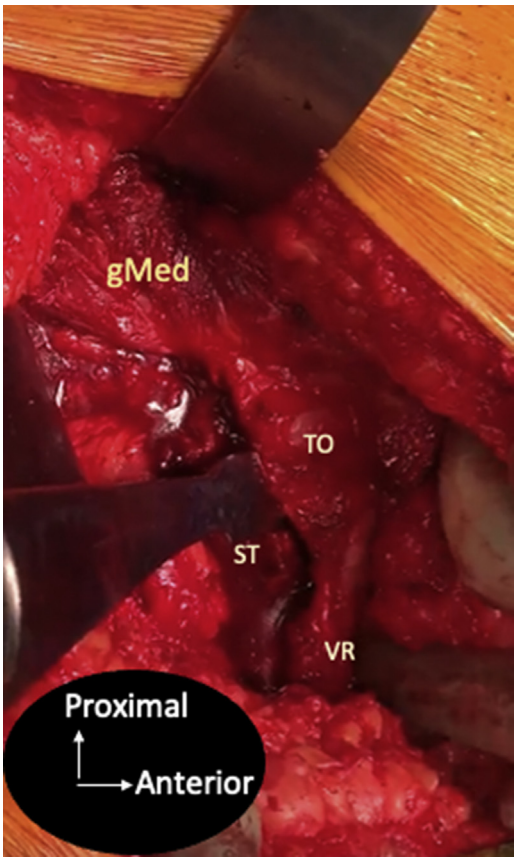

Fig 4. A trochanteric step-cut osteotomy is performed with the gMed tendon, long tendon of the gMin tendon, and vastus lateralis tendon attached to the mobile trochanter by making a cut along the posterior aspect of the greater trochanter starting just anterior to the most posterior fibers of the gMed. TO, trochanteric osteotomy; ST, stable trochanter; gMed, gluteus medius; VR, vastus ridge.

impeded by the amount of acetabular overcoverage. The acetabular overcoverage may be resected with the hip reduced if the hip is not able to dislocate, which is what was required in the current case. The rim is resected using osteotomes while the femoral head is protected with a freer elevator. Amount of acetabular rim resection is based on preoperative center edge angle templating (Video 1; Fig 8 C). The amount of bone resection is confirmed with fluoroscopy. The ligamentum teres may need to be cut with a curved scissors. The hip is then dislocated and flexed, adducted and externally rotated and placed in the pouch of the hip drape on the anterior side of the patient. With the hip still dislocated, the remaining acetabular wall can be contoured with a 5 mm round burr (Video 1; Fig 8 D). If indicated based on preoperative templating, an open subspine decompression is completed with a 5 mm round burr.

There is now excellent visualization of the cam lesion (Video 1; Fig 9 A). A 5 mm round burr (Stryker, Kalamazoo, MI) is used to resect the cam lesion. Femoral head sizers can be used to measure the amount of bone resection to establish femoral head sphericity (Video 1; Fig 9 B).

Labral Reconstruction With Anterior Tibialis Allograft

With the hip dislocated, anchors (1.4 mm NanoTack with flex inserter; Stryker) are placed along the rim of the resected wall. Placing anchors with the hip dislocated allows for verification that suture anchors do not penetrate the chondral surface of the acetabulum. Meanwhile, an anterior tibialis allograft (6-12 cm × 20-38 cm; Musculoskeletal Transplant Foundation) is tabularized with interrupted, circumferential 0 Vicryl suture (Ethicon, Bridgewater, NJ) on the back table.[24,25] The knots are buried within the tendon. The hip is reduced before securing the graft to avoid unnecessary trauma to the reconstruction. The graft is then secured with mattress sutures at the most anterior and posterior aspect to the native labrum and

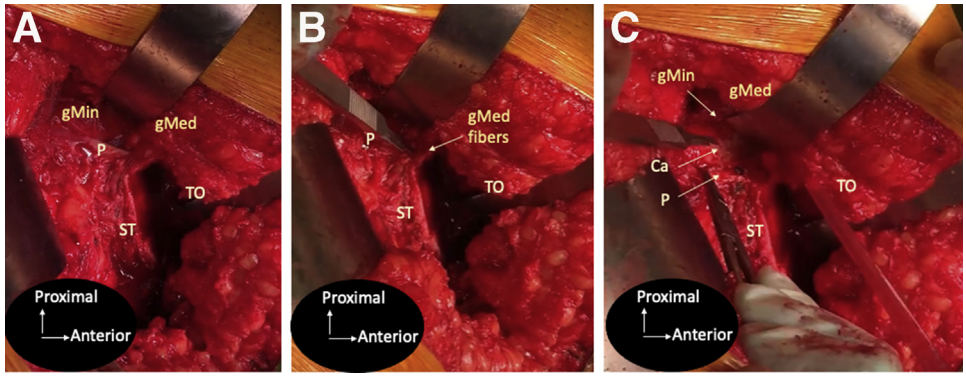

Fig 5. (A) The trochanteric osteotomy is retracted to put the remaining fibers of the gMed on tension and then allowing their sharp release. (B) The remaining gMed fibers are sharply elevated off the stable trochanter. (C) The gMin is sharply elevated from the hip capsule. TO, trochanteric osteotomy; ST, stable trochanter; gMed, gluteus medius; gMin, gluteus minimus; P, piriformis; Ca, Capsule.

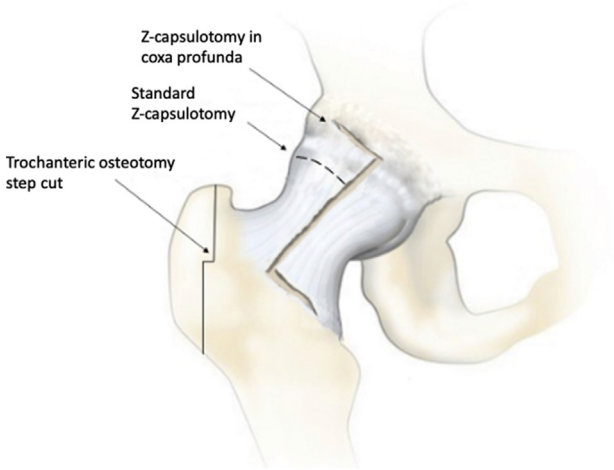

Fig 6. The Z-capsulotomy performed in coxa profunda patients differs from a standard Z-capsulotomy in that it is raised subperiosteally off of the acetabular rim versus distal to the labrum in a standard Z-capsulotomy.

acetabular rim (Video 1; Fig 10 A). Simple suture technique is used for the intervening anchors that incorporates the native labrum if present. The excess allograft is trimmed. On completion of the reconstruction, the suction seal of the hip socket is restored (Video 1, Fig 10 B).

Capsular Closure and Osteotomy Repair

The wound is copiously irrigated. The capsule is closed using a 0 PDS (polydioxanone; Ethicon) suture. The piriformis tendon can also be repaired with 0 PDS (Video 1; Fig 11). Using fluoroscopy, the greater trochanter osteotomy is reduced using a ball spike pusher (Synthes; Johnson & Johnson, New Brunswick, NJ) and held in place with smooth Kirschner wires (K wire 0.062; Synthes) (Video 1; Fig 12 A). Definitive fixation is complete with three 3.5 mm inserted using standard lag by technique (Synthes) (Video 1; Fig 12 B).

Closure

The gluteal and iliotibial band fascia are closed with no. 1 Vicryl (Ethicon). Subcutaneous closure is complete with 2-0 Vicryl, and the skin is closed with a 3-0 Monocryl (Ethicon) in a running subcuticular stitch. SteriStrips are applied. A sterile Mepilex Ag with border (Molnlycke) dressing is placed. A final intraoperative radiograph (AP pelvis) is obtained (Video 1; Fig 13).

Inpatient Postoperative Care

After surgery, the patient is admitted for pain control and mobilization with discharge typically planned on postoperative day 2. We use a continuous passive motion machine to prevent capsular adhesions, initially set from 0° to 30°, on for 2 hours, 3 times per day. Weightbearing is limited to 20% body weight for the first 6 weeks. Deep vein thrombosis prophylaxis consists of chemoprophylaxis for the first month. The patient is discharged home on aspirin 81 mg twice daily with compression stockings for 4 weeks. Heterotopic ossification prophylaxis consists of a 4-day course of indomethacin 75 mg per day. Routine posterior hip precautions are followed, with additional restrictions consisting of no active abduction and no passive adduction past midline for 6 weeks.

Rehabilitation Protocol

During the first 6 weeks after surgery, the goal is to return to a normal gait with assistive device. The continuous passive motion machine is recommend for 6 hours use per day, gradually increasing from 30° to 90° of flexion as tolerated. This is usually discontinued

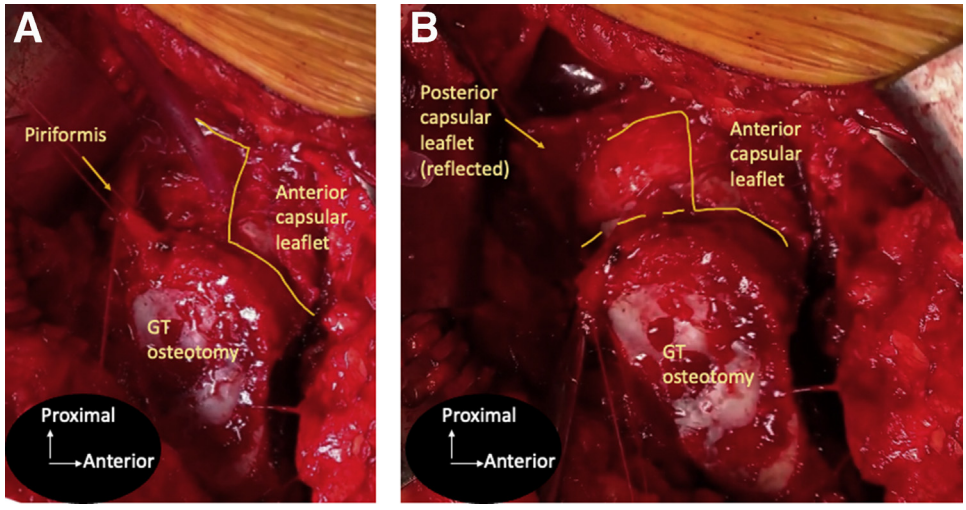

Fig 7. (A) The modified Z-capsulotomy is used to access the hip joint. (B) The piriformis is transected and tagged to complete the capsulotomy and allow greater access to the posterior wall. GT, greater trochanter.

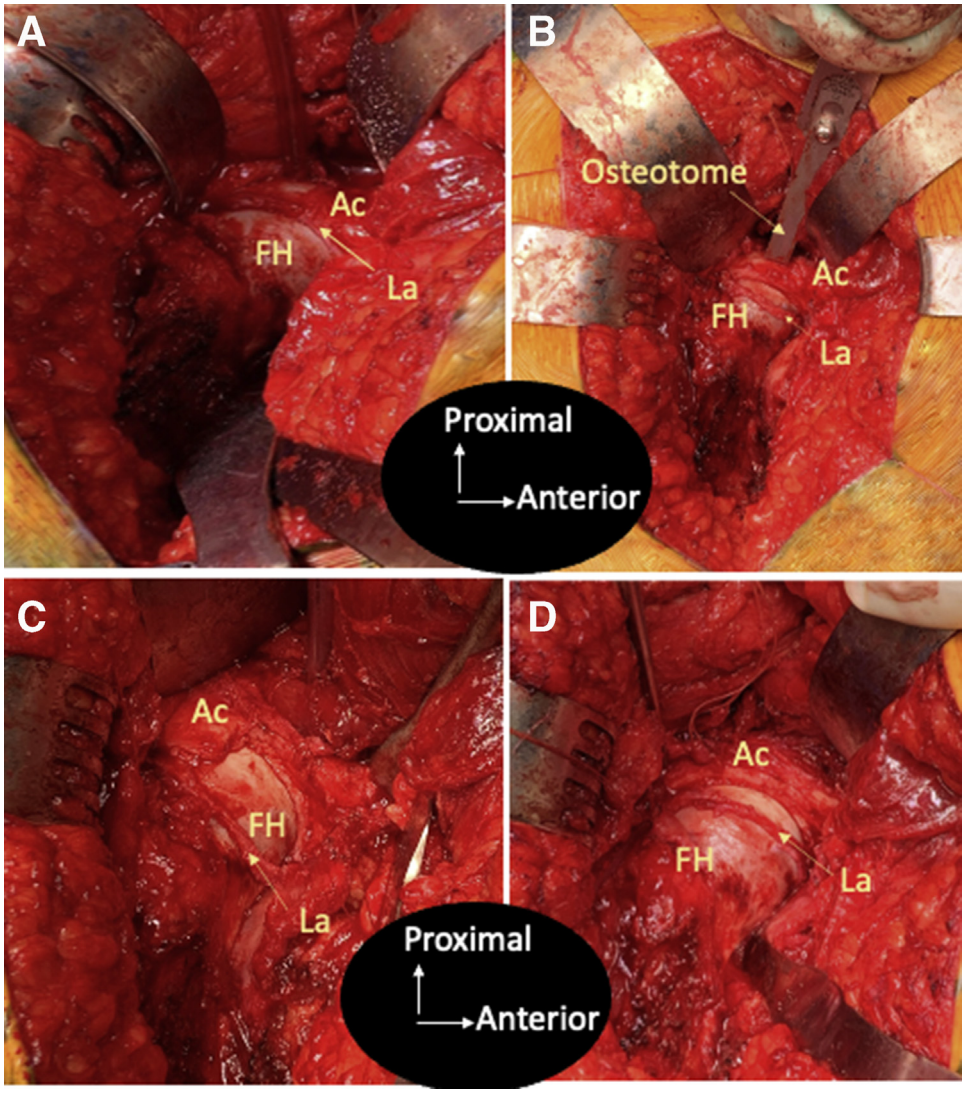

Fig 8. (A) The native labrum is elevated sharply in a bucket-handle fashion. In this case, a majority of the labrum was ossified, so the native labrum was diminutive. (B) The amount of resection required is determined by using the osteotome under fluoroscopy to establish a normal center edge angle. (C) The acetabular rim is resected carefully using osteotome. Here is shown halfway through completion. If it is done with the hip reduced, a freer is used to protect the cartilage. It can also be done with the hip dislocated. (D) The rim resection is complete. The native labrum is left intact at the far anterior and posterior aspect. Ac, acetabulum; FH, femoral head; La, labrum.

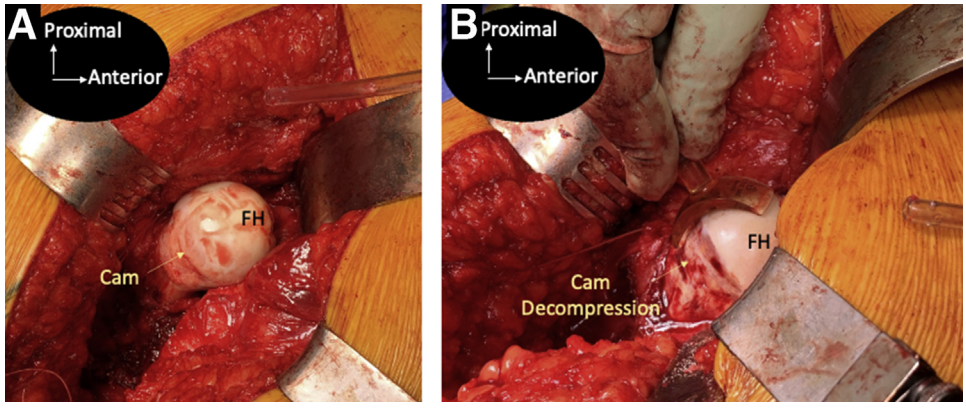

Fig 9. (A) The femoral head can be gently dislocated with hip flexion and external rotation to visualize the cam lesion. (B) A 5 mm round burr is used to perform femoral osteoplasty until sphericity is achieved as confirmed by a femoral head sizer. FH, femoral head.

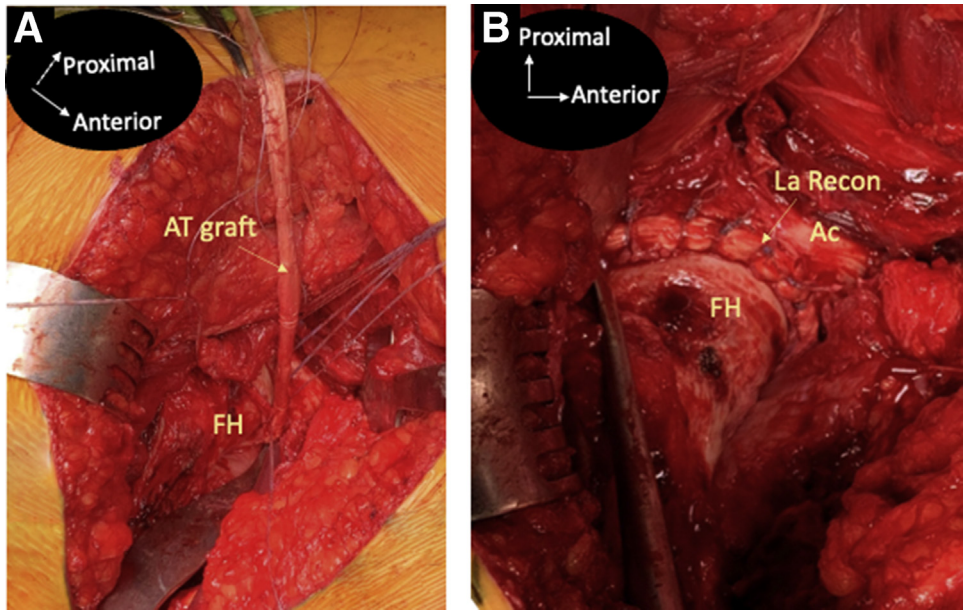

Fig 10. (A) The hip is reduced after anchors are placed along the rim of the acetabulum. The tabularized anterior tibialis allograft is secured in place with mattress stitches at the far anterior and posterior aspect with the hip reduced while incorporating the native labrum if present. (B) The allograft is secured with simple stitches including the native labrum if present through the midportion. The labral reconstruction should restore the suction seal of the hip. AT, anterior tibialis; FH, femoral head; Ac, acetabulum; La Recon, labral reconstruction.

about 2 weeks after surgery. As comfort allows, weightbearing is progressed from 20% of body weight to 75% of body weight. From 6 to 12 weeks, the goal is to progress to normal gait without an assist device, as well as to ascend an 8-inch step with good pelvic control. Strength can be gained with closed chain, balance, and proprioceptive work. Hip range of motion and full motor strength should return with single limb activities possible by week 16. Finally, by 20 weeks after surgery, progressive return to sport can begin.

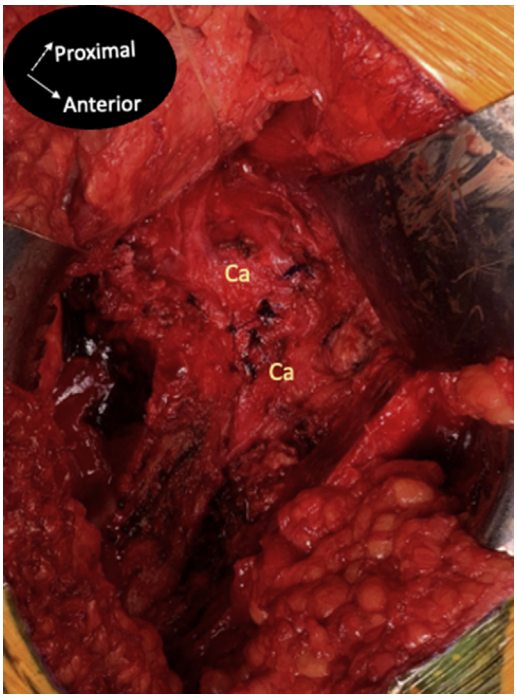

Fig 11. A capsular closure of the modified Z-capsulotomy is complete with 0 PDS. The flaps of the capsule should lay onto the new acetabular rim where they will eventually heal to the exposed bone. Ca, capsule.

Discussion

Surgical goals of hip preservation are to relieve pain, improve function, and preserve the native hip joint. Both arthroscopic and open techniques have been described.[15,26] This Technical Note describes open surgical hip dislocation, rim resection, femoral osteoplasty, and labral reconstruction using anterior tibialis allograft in the setting of coxa profunda and combined-type FAIS with labral ossification (Table 2).

When compared to hip arthroscopy for the treatment of combined-type FAIS and marked coxa profunda, surgical hip dislocation offers the advantage of circumferential exposure and visualization (Table 3). Ahmad et al.[27] showed that surgical hip dislocation had an odds ratio of 10 ($P = .002$) in achieving a lateral center edge angle correction $>12°$ or acetabular index correction $>8°$ compared to hip arthroscopy.[27] For femoral neck osteoplasty, however, there was no significant difference in correction achieved.[27] In the setting of coxa profunda, surgical hip dislocation is also

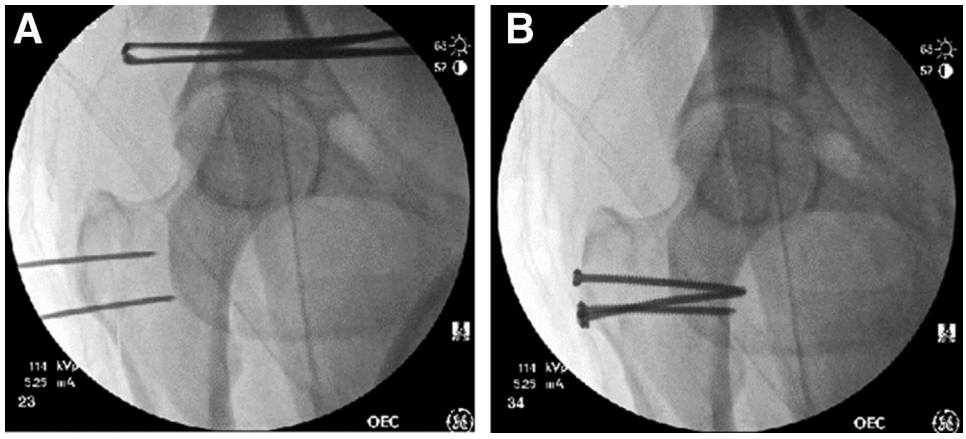

Fig 12. (A) The greater trochanteric osteotomy is reduced and held with k-wires. (B) Definitive fixation of the osteotomy with three 3.5 mm lag screws is confirmed with fluoroscopy.

advantageous given that hip distraction is difficult to achieve, resulting in potential iatrogenic damage to the labrum or cartilage with arthroscopic instrumentation particularly if a lateral or posterolateral acetabuloplasty is indicated.[5]

The disadvantage to surgical dislocation of the hip for treatment of FAIS compared to hip arthroscopy is its invasive nature and longer rehabilitation time. This is largely thought to be related to the greater trochanteric osteotomy.[28] Given that outcomes between arthroscopic and open surgical treatment of FAIS are similar,[29] hip arthroscopy has largely become the preferred surgical method, bolstered by improvements in instrumentation, implants, increasing experience, and training in the technique. Still, the surgical hip dislocation, originally the gold standard treatment for FAIS, does have a role in hip preservation surgery. Marked coxa profunda is one of those indications. The trochanteric osteotomy is usually healed by 8 weeks after surgery, and full abductor force returns 4 to 6 weeks after surgery.[15] Rarely, at a rate reported to be 0.3%, surgical hip dislocation patients develop Brooker grade I or II heterotopic ossification, although this has not translated to any clinical relevance.[9]

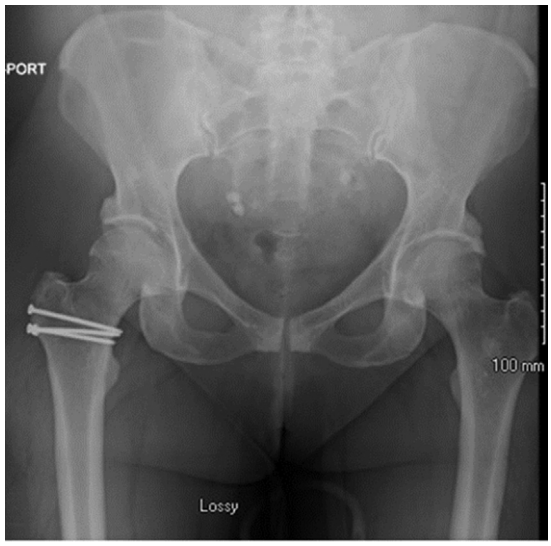

Fig 13. Final intraoperative AP pelvis radiograph shows normal center edge angle, removal of ossified labrum, and trochanteric osteotomy fixation.

Although the most serious complication of surgical hip dislocation remains avascular necrosis, in his original technique article, Ganz et al.[15] highlights that with proper technique there were no cases of avascular necrosis in 213 cases over 9 years. In a study conducted by the Academic Network for Conservational Hip Outcomes Research group, similar results were presented with no cases of osteonecrosis or femoral neck fractures in 334 hips studied over 6 years. The overall complication rate was 9% at a median follow-up of 36 months. The most common complication (60%) was heterotopic ossification. With grade I and II heterotopic ossification excluded, the complication rate decreased to 4.8%. A trochanteric nonunion rate of 1.8% represents the greatest risk that would not have occurred during a less invasive procedure.[9]

The success in addressing FAIS by surgical hip dislocation has been shown to be equivalent to hip arthroscopy in both survivorship and hip-specific patient reported outcomes at mid-term follow-up in a systematic review.[29,30] Steppacher et al.[31] has shown an 80% 10-year survivorship after surgical hip dislocation for the treatment of FAIS. More recently in a propensity-matched analysis of hip arthroscopy versus surgical hip dislocation, Nepple et al.[32] reported no significant difference in postoperative patient reported outcomes after surgery, revision to total hip arthroplasty (surgical hip dislocation 3.1% compared to arthroscopy 0%, $P = .12$),

Table 2. Pearls and Pitfalls

Step	Pearls	Pitfalls
Preoperative planning	Appropriate radiographs (standing AP pelvis, 45° Dunn lateral, false profile) and lose-dose 3D CT hip help assess overcoverage and planned resection amount 3D CT hip also offers acetabular version and femoral version measurements Be prepared with allograft Labral reconstruction is possible	
Patient positioning	Lateral decubitus	Ensure operative lower extremity can adduct and externally rotate over the table's edge
Modified Gibson	Decreased risk of saddlebag deformity Maintains gMax structure and innervation	gMax can be more difficult to retract compared to Kocher-Langenbeck posteriorly compared to gMax split
Step-cut greater trochanter osteotomy	Step cut allows for easy approximation at conclusion of case Find the posterior most fibers of the gMed and start cut just anterior to these	Careful planning and leg positioning is required to ensure the fragment is not too thick or too thin Perforating vessels are often encountered when releasing remaining gMed fibers and piriformis
Hip capsule exposure and Z-capsulotomy	For anterior visualization: assistant flexes, abducts, and externally rotates hip For posterior visualization: assistant extends and internally rotates hip	Iatrogenic labral injury can occur at the proximal limb of the capsulotomy
Dislocate femoral head	If needed, the osteotomy of the acetabular rim can be begun before head dislocation to make dislocation easier (care must be taken to protect the femoral head if this is performed)	In severe coxa profunda, this can be very challenging as the femoral head is captured by the acetabulum
CAM resection	Use a femoral head sizer to estimate resection necessary to establish sphericity A 5 mm hand-held round burr can be used	Dynamic intraoperative assessment of hip motion can confirm adequate resection
Acetabulum wall recession and subspine decompression	Remove non-ossified degenerative labrum in a bucket handle fashion with sharp scalpel dissection Rim can be removed with small straight osteotome Use AP fluoroscopy to establish needed resection for normal center edge angle	Taking too much bone can lead to over-resection and instability. Aim for LCEA in the normal range (30°-40°)
Labral reconstruction	Drill and place anchors prior to reducing hip to visualize the articular surface and make sure the anchors do not penetrate cartilage Reducing hip prior to graft placement can decease potential damage to the final labral reconstruction	Placement of anchors too high on the acetabulum can result in poor suction seal

CT, computed tomography; 3D, 3-dimensional; LCEA, lateral center edge angle.

or persistent symptoms (surgical hip dislocation 24.4% compared to arthroscopy 21.9%, $P = .55$).[32]

In conclusion, surgical hip dislocation remains an effective surgical technique to address certain hip pathology, including coxa profunda. Concomitant pathology such as FAIS or labral tears/degeneration/ossification can be simultaneously addressed.

Table 3. Advantages and Disadvantages

Advantages
Circumferential exposure of the acetabulum and entire femoral head, as well as the femoral head/neck junction
Allows large and complete correction of acetabular overcoverage
Allows dynamic intraoperative examination of the hip joint under direct visualization
Disadvantages
More-invasive surgery
Trochanteric osteotomy, which requires postoperative healing
Slower rehabilitation timeline
Heterotopic ossification at a higher rate than has been reported in arthroscopic surgery

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