SUBSPECIALTY PROCEDURES

APPLIED ANATOMY OF THE DIRECT ANTERIOR APPROACH FOR FEMORAL MOBILIZATION

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Introduction

Study of the anterior anatomy of the hip reveals specific aspects that are crucial to success in performing both the surgical approach to the hip and mobilization of the femur. In this article, we present the relevant anatomy and our operative technique.

The direct anterior approach (DAA) for total hip arthroplasty (THA) has gained much popularity among surgeons and patients over the past decade¹. A thorough understanding of the anterior anatomy is essential to success in performing THA through the DAA and avoiding complications during the learning curve². Exposure of the acetabulum through the Hueter or Smith-Petersen interval is accomplished with little difficulty. The necessary exposure for femoral implant positioning requires anterior mobilization of the femur³. The femur is properly exposed only when there is no medial impingement on the tissues, allowing reaming and broaching to occur without violation of additional soft tissue. With a comprehensive understanding of the anterior anatomy, there are specific releases that we recommend for mobilization of the femur. Following these releases, the proximal part of the femur and the greater trochanter can be elevated anteriorly in front of the acetabulum with minimal force on the femur. The femur is held in this position with assistance from a table-mounted femoral elevator retractor system.

The steps that we recommend are as follows: (1) release of the superior-posterior capsule off the femur, (2) release of the conjoint tendon, (3) “flip” of the piriformis posteriorly, (4) release of the piriformis, and (5) release of the obturator externus (rarely performed)^{4,5}. Proper femoral exposure is accomplished in the majority of patients with steps 1, 2, and 3; however, for more challenging cases, release of the piriformis may be required. This is common in patients with large muscles or a short varus neck deformity, in which the ilium may overhang the proximal part of the femur.

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Indications & Contraindications

Indications

- Direct anterior THA for osteoarthritis, osteonecrosis, developmental dysplasia of the hip, and femoral neck fracture.
- Direct anterior hip hemiarthroplasty for femoral neck fracture.
- Direct anterior hip revision arthroplasty.

Contraindications

- Poor skin integrity in the area of the incision site.

Relative Contraindications

- A body mass index of $>40 \text{ kg/m}^2$.
- Proximal femoral deformity and/or malunion.

Step 1: The Anterior Anatomy of the Hip (Video 1)

Review the anatomy of the hip as it relates to the surgical technique as doing so is essential to understanding the surgical technique⁶.

- Anterior view of the hip
 - The insertion of the gluteus medius tendon is resected. The video shows the gluteus minimus muscle and tendon inserting anteriorly, the reflected head and direct head of the rectus, the iliocapsularis muscle, and the vastus lateralis (Figs. 1-A and 1-B).

Fig. 1-A

Fig. 1-B

Video 1 The anterior anatomy of the hip.

Figs. 1-A and 1-B The anterior anatomy of the hip after removal of the tensor fasciae latae and gluteus medius shown without (**Fig. 1-A**) and with (**Fig. 1-B**) annotations. The resected gluteus medius is outlined in pink; the gluteus minimus, in dark blue; the vastus lateralis, in yellow; the iliocapsularis, in green; the rectus femoris, in light blue; and the reflected head of the rectus femoris, in red.

- Superior view of the hip
 - The video shows the insertion of the gluteus minimus anteriorly, the piriformis inserting onto the top of the trochanter, the obturator internus and associated gemelli under the piriformis and attaching in an anterior position, and the posteriorly positioned obturator externus muscle and tendon (Figs. 2-A and 2-B).
- Posterior view of the hip
 - The insertion of the gluteus minimus, the piriformis on the top of the trochanter, the obturator internus underneath and inserting anteriorly, and the obturator externus at its posterior position are seen in the video (Figs. 3-A and 3-B).

Fig. 2-A

Fig. 2-B

Fig. 3-A

Fig. 3-B

Figs. 2-A and 2-B The superior anatomy of the hip after removal of the gluteus medius and maximus shown without (**Fig. 2-A**) and with (**Fig. 2-B**) annotations. The gluteus minimus is outlined in lavender; the piriformis, in green; the obturator internus with associated gemelli muscles, in orange; and the obturator externus, in yellow.

Figs. 3-A and 3-B The posterior anatomy of the hip after removal of the gluteus medius, gluteus maximus, and quadratus femoris shown without (**Fig. 3-A**) and with (**Fig. 3-B**) annotations. The gluteus minimus is outlined in blue; the piriformis, in green; the obturator internus with associated gemelli muscles, in orange; and the obturator externus, in yellow.

- Tendon attachments on the trochanter
 - An anatomic and retracted view of the inner aspect of the trochanter, as seen in the video, shows the piriformis tendon on the top of the trochanter, the obturator internus centrally and anteriorly covering the inner aspect of the trochanter and its groove, and the obturator externus attaching at the base of the femoral neck posterior trochanter junction (Figs. 4-A and 4-B).
- Capsular attachments around the hip
 - The adhesions of the gluteus minimus, iliocapsularis, obturator internus, and reflected head of the rectus are shown in the video. We release these adhesions intraoperatively to fully mobilize the capsule from the femur (Figs. 5-A and 5-B).

Fig. 4-A

Fig. 4-B

Fig. 5-A

Fig. 5-B

Figs. 4-A and 4-B The anatomy of the inner aspect of the trochanter with the tendons in the anatomic (left) and retracted (right) positions shown without (**Fig. 4-A**) and with (**Fig. 4-B**) annotations. The tendon of the piriformis is outlined in green; the obturator internus with associated gemelli muscles, in orange; and the obturator externus, in yellow.

Figs. 5-A and 5-B The superior capsular attachments of the hip shown without (**Fig. 5-A**) and with (**Fig. 5-B**) annotations. The insertion of the gluteus minimus is outlined in blue; the obturator internus and associated gemelli muscles, in orange; and the reflected head of the rectus femoris, in red.

Step 2: Approach to the Anterior Aspect of the Hip (Video 2)

Review the surgical approach to the hip.

- To allow extension of the leg intraoperatively, position the patient with the greater trochanter at the hinge of the operating table. The goal is to allow extension of the leg and access for the C-arm to make an anteroposterior pelvic radiograph (we routinely use fluoroscopy).
 - In some tables, this requires using the bed in a “diving board” configuration, with the headpiece attached to the foot of the bed.
- Make an incision lateral and distal to the anterior superior iliac spine, to minimize the risk of lateral femoral cutaneous nerve injury, centered over the tensor fasciae latae muscle and approximately 10 to 12 cm in length (Fig. 6)⁷.
- Incise the tensor fasciae latae and mobilize the muscle laterally from the fascia.
- Expose and coagulate the lateral femoral circumflex vessels between the rectus femoris and the tensor fasciae latae (Figs. 7-A and 7-B).

Fig. 6

Fig. 7-A

Fig. 7-B

Video 2 The approach to the anterior aspect of the hip.

Fig. 6 The incision and its relationship to the anterior superior iliac spine (ASIS).

Figs. 7-A and 7-B Entering the tensor fasciae latae (TFL) and exposure of the lateral femoral circumflex vessels shown without (**Fig. 7-A**) and with (**Fig. 7-B**) annotations. The rectus femoris is in blue, the TFL is in lavender, and the vessels are in grey.

- Enter the fat plane under the inferior fascia and resect the fat lying anterior to the capsule.
- Identify the reflected head of the rectus, the rectus tendon, the deeper iliocapsularis, and the vastus lateralis (Figs. 8-A and 8-B).
- Perform the capsulotomy immediately adjacent to the iliocapsularis, underneath the reflected head of the rectus, which can be preserved in most cases (Figs. 9-A and 9-B).
- Release the lateral capsule from the vastus ridge, being mindful of the minimus tendon.
- Release the medial capsule only as required for exposure of the neck cut and acetabulum. A complete release to the lesser trochanter is often required in patients with stiff, large, or contracted muscles. Conversely, this release is minimized in patients with hypermobile joints or who have had THA in the setting of a femoral neck fracture. Over-release of the medial iliofemoral and pubofemoral ligament can result in anterior instability of the hip.

Fig. 8-A

Fig. 8-B

Fig. 9-A

Fig. 9-B

Figs. 8-A and 8-B The anatomic landmarks, without (**Fig. 8-A**) and with annotations (**Fig. 8-B**), seen on every exposure: the reflected head of the rectus is in red; the rectus muscle, in blue; the iliocapsularis muscle, in green; the vastus lateralis muscle, in yellow; and the gluteus minimus muscle, light blue outlined in pink.

Figs. 9-A and 9-B The capsulotomy (**Fig. 9-A**), indicated by the green dashed line (**Fig. 9-B**), is performed immediately adjacent to the iliocapsularis muscle underneath the reflected head of the rectus femoris. The reflected head of the rectus is in red; the rectus muscle, in blue; the iliocapsularis muscle, in green; and the gluteus minimus muscle, light blue outlined in pink.

- Osteotomize the femoral neck according to the preoperative planned neck cut. Following the osteotomy, the posterior and lateral capsule is seen along with the labrum (Figs. 10-A and 10-B).
- Prepare and ream the acetabulum with or without the assistance of fluoroscopy, as described elsewhere^{8,9}.

Fig. 10-A

Fig. 10-B

Fig. 10-C

Figs. 10-A, 10-B, and 10-C The posterior capsule, labrum, and lateral capsule following the osteotomy. **Fig. 10-A** The capsule as seen after the osteotomy. **Fig. 10-B** The posterior capsule is indicated by the black dashed line; the lateral capsule, by the white dashed line; and the labrum, by the yellow dashed line. **Fig. 10-C** The standard release of the superior-posterior capsule indicated by the red dashed line. The inferior capsule indicated by the green dashed line and is left intact.

Step 3: Release of the Capsule (Video 3)

In the first step of femoral mobilization, release the superior-posterior capsule.

- Matsuura et al. reported that release of the superior-posterior capsule is essential for femoral anterior mobilization. There was much less mobilization achieved by releasing the inferior portions of the capsule (Fig. 10-C)¹⁰.
- In our technique, the superior-posterior capsule is mobilized by releasing the gluteus minimus adhesions to the capsule, with subsequent release of the capsule from the trochanter¹¹.
- Enter the plane between the reflected head and the capsule, where there are no attachments to the minimus (Figs. 11-A and 11-B).
- Retract the capsule medially and centrally in the socket in order to develop the plane between it and the minimus muscle. Once the capsule is freed from the minimus, retract it proximally and release its posterosuperior attachments to the femur to allow mobilization of the femur anteriorly.
- Identify the plane for insertion of the femoral elevator. Note the position of the greater trochanter; pull anteriorly with a bone hook on the femur to assess mobility. If the release of the capsule is complete, the trochanter can be mobilized anterior to the acetabulum at this stage, independent of the capsule. Releasing the capsule in this fashion allows visualization and selective release of the short external rotators.

Fig. 11-A

Fig. 11-B

Video 3 Release of the capsule.

Figs. 11-A and 11-B The release of the lateral capsule from the gluteus minimus adhesions as seen intraoperatively (**Fig. 11-A**) and as indicated by the dashed green line (**Fig. 11-B**). The plane for the dissection is found at the reflected (indirect) head of the rectus as it branches from the direct head, where there are no capsular adhesions to the minimus (see Video 3).

Step 4: Release of the Conjoined Tendon and Piriformis Flip (Video 4)

If sufficient elevation of the femur is not achieved with release of the capsule, perform rotator visualization and serial release.

- Use a table-mounted femoral elevator (we prefer the Integra Omni-Tract Table Mounted Femur Elevator Retractor System, but there are several other options available) for femoral elevation. Insert the hook around the proximal part of the femur with careful attention to not entrap any posterior soft tissues (Fig. 12).
- The operating table is put into Trendelenburg and the foot is dropped, extending the involved extremity at the hip. The noninvolved extremity is allowed to rest in a neutral position on a Mayo stand. Note the position of the greater trochanter while performing this maneuver as it may impinge on the acetabulum. This can prevent the femur from moving anteriorly, and if unrecognized, can cause a fracture while attempting anterior distraction. To avoid this, manually elevate the proximal part of the femur anteriorly prior to extending the leg. This maneuver allows the trochanter to move anterior to the acetabulum and should require minimal force. Hold this position with light anterior tension with the table-mounted femoral elevator. Place retractors on the medial calcar, the posterior trochanter anterior to the piriformis tendon, and the lateral trochanter in the interval between the piriformis and the gluteus minimus (Fig. 13).

Fig. 12

Fig. 13

Video 4 Release of the conjoined tendon and piriformis flip.

Fig. 12 The positioning of the bed with placement of the table-mounted femoral elevator is seen. The table is placed in the Trendelenburg position, and the leg is placed in extension. The noninvolved leg is placed on the Mayo stand.

Fig. 13 The retractors are placed on the medial calcar, with the posterior part of the trochanter anterior to the piriformis tendon and the lateral part of the trochanter in the interval between the piriformis and the gluteus minimus.

- Develop the interval between the piriformis tendon and the conjoined tendon of the obturator internus and gemelli muscles to allow isolated release of the conjoined tendon. This is found along the inner aspect of the superior trochanter just proximal to the neck (Figs. 14-A and 14-B).
- The cautery is taken to the insertion of the conjoined tendon in the inner aspect of the trochanter, allowing it to retract medially, thereby exposing the superior inner aspect of the neck and separating it from the piriformis. The inner aspect of the trochanter is revealed for proper lateral access to the femoral neck (Figs. 14-A through 14-D).

Fig. 14-A

Fig. 14-B

Fig. 14-C

Fig. 14-D

Figs. 14-A through 14-D The inner aspect of the trochanter. GT = greater trochanter. **Fig. 14-A** The intraoperative view. **Fig. 14-B** The inner aspect of the trochanter in pink with the overlying piriformis in green and conjoined tendon in blue.

Figs. 14-C and 14-D The release of the conjoined tendon is indicated by the red dashed line in the intraoperative view (**Fig. 14-C**) and by the red line in the graphic design (**Fig. 14-D**).

- Once the conjoined tendon is released, mobilize the piriformis tendon posterior to the trochanter. This allows the proximal part of the femur to be delivered further anteriorly. This occurs in stages, first with mild abduction and external rotation, with subsequent adduction and additional external rotation (Figs. 15-A, 15-B, and 15-C). In this process, the inner aspect of the trochanter becomes visible, and the piriformis can be flipped over the top of the trochanter from an anterior to posterior position (Figs. 16-A, 16-B, and 16-C).

Fig. 15-A

Fig. 15-B

Fig. 15-C

Fig. 16-A

Fig. 16-B

Fig. 16-C

Figs. 15-A, 15-B, and 15-C The inner aspect of the trochanter is seen after release of the conjoined tendon (**Fig. 15-A**), with the piriformis seen overlying the inner aspect of the trochanter (**Fig. 15-B**), with the leg in an abducted and externally rotated position (**Fig. 15-C**).

Figs. 16-A through 16-D The inner aspect of the trochanter is seen after mobilization of the piriformis posteriorly (**Figs. 16-A and 16-B**), with the involved leg in an extended, adducted, and externally rotated position beneath the noninvolved leg (**Figs. 16-C and 16-D**).

Following proper release and mobilization, the involved extremity can be adducted beneath the noninvolved extremity with minimal force (Fig. 16-D).

- On completion of the mobilization, the obturator externus tendon can be seen and released if necessary.
- Increase the force on the table-mounted femoral elevator to hold the proximal part of the femur anteriorly, delivering it out of the wound. This allows direct exposure of the lateral aspect of the neck and appropriate entry to the proximal part of the femur. Burr the lateral aspect of the neck to allow for adequate femoral implant lateralization (Fig. 17).
- The femur is properly exposed when there is no medial impingement on the tissues, allowing reaming and broaching to occur without violation of additional soft tissue. If this is not achieved, further soft-tissue release is required (Fig. 18).
- Following completion of the surgery, repair the capsule with nonabsorbable suture (we routinely use number-1 Ethibond [Ethicon, Johnson & Johnson]). We do not routinely repair the released tendons.

Fig. 16-D

Fig. 17

Fig. 18

Fig. 17 The lateral cortex at the head-neck junction is burred to allow for adequate lateralization of the implant.

Fig. 18 Following release, the canal finder is inserted into the femur and the leg is repositioned to avoid any soft-tissue impingement, allowing broaching to occur without violation of additional soft tissue. If this is not achieved, further femoral release is required.

Results

Our prospective, nonrandomized study compared DAA THA using our technique for femoral mobilization with the posterior approach THA¹². It demonstrated objective and consistent benefits of the DAA with respect to early mobility, specifically, the timed up-and-go (TUG) test, motor component of functional independence (m-FIM), and Harris hip score (HHS). Most findings were equalized after 2 weeks postoperatively; at the 6-week postoperative period, there were no measurable differences between the groups. There was 1 dislocation in the posterior group, compared with zero in the anterior group¹². Our data on muscle strength and gait showed that patients managed with the DAA THA may have early flexion weakness, most of which resolves by 6 months. Gait analysis at the 6-month follow-up evaluation failed to demonstrate a notable difference between anterior and posterior approach THA⁴. In our follow-up study¹³, we prospectively documented the amount of soft-tissue release required in 200 consecutive patients who underwent DAA THA. Fifty-eight hips (29%) required no release beyond the capsule. Proper exposure was

achieved in most of the hips using the piriformis flip technique (122 hips; 71%). The piriformis had to be released in 20 hips (10%). The obturator externus tendon did not require release in this series of 200 patients¹³.

There are challenges in learning this technique. The results of our learning curve series showed a higher anterior dislocation rate in the first 100 hips managed with DAA (2 hips) compared with a cohort of 300 hips managed with the posterior approach (1 hip)⁵. We had no additional dislocations in the subsequent 800 hips. There were 2 displaced fractures of the greater trochanter in the learning curve that occurred during the neck cut, compared with zero in the posterior THA cohort. Some studies have found a high rate of femoral perforation in learning the DAA THA¹⁴. In our series, there was no femoral perforation, highlighting the importance of adequate femoral mobilization prior to femoral preparation.

In summary, separation of the capsule from the dense minimus adhesions allows for direct visualization of the rotators and initial mobilization of the femur. Release of the posterior-superior capsule allows the femur to be distracted anteriorly. Release of the conjoint tendon allows for posterior displacement of the piriformis behind the trochanter, without release. Occasionally, the piriformis also requires release for proper surgical exposure. The obturator externus tendon rarely requires release. Proper mobilization is achieved when the femur is delivered out of the wound, allowing for broaching without soft-tissue impingement.

Pitfalls & Challenges

- Overweight patients with large abdominal panniculus are prone to skin complications. Taping the abdomen to the opposite side of the table can aid in protecting the skin and facilitating initial exposure¹⁵.
- Damage to the gluteus minimus tendon may occur with release of the lateral capsule.
- The trochanter is at risk for fracture in the following scenarios:
 - If it is not protected during the femoral neck cut.
 - If it impinges on the posterior part of the acetabulum during femoral elevation.
 - If excessive anterior force is applied to the femur in the setting of inadequate soft-tissue release.
- With inadequate femoral exposure, femoral perforation and/or implant malpositioning may occur.

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