Surgical anatomy of the hip: a review of the common open approaches

RM Frank¹*, S Gandhi¹, MB Cross², B Haughom¹, AG Rosenberg¹, BR Levine¹

Abstract

Introduction

Hip pathology requiring surgical intervention varies from osteoarthritis to oncologic diseases. An understanding of hip anatomy and, in particular, the potentially dangerous neurovascular structures that are avoided in most exposures, must be understood to help avoid complications that may thwart an otherwise safe surgical procedure. The purpose of this review is to discuss the most common open exposures to the hip, with a focus on surgically relevant hip anatomy of each approach.

Conclusion

A thorough understanding of pelvic and hip anatomy is critical to perform these approaches safely and efficiently.

Introduction

Osteoarthritis (OA) is an extremely common condition in the adult patient population¹. While non-operative treatment may relieve symptoms, the natural history of the disease is progressive and many patients eventually require a total hip arthroplasty (THA). With an appreciation for the relevant anatomy, each technique can be performed with comparable clinical outcomes²-⁸. Regardless of the specific technique chosen to expose the joint, a complete understanding of the anatomy of each approach is necessary to perform the operation safely. The four major approaches to the hip⁹,¹⁰ (based on the direction of the respective exposure) that will be discussed include: posterior, lateral, anterior, and antero-lateral.

Discussion

Posterior approach (Moore or Southern approach)

The posterior approach to the hip joint was first popularized by Moore and is the most-commonly used approach used in hip replacement surgery¹¹. This approach can be easily extended and, as such, is useful in revision cases when increased surgical exposure may be critical. In addition to arthroplasty, the posterior approach is also extremely useful for posterior acetabular fracture repair, surgical management of deep infection, and removal of intra-articular loose bodies.

Important surgical anatomy and landmarks

The posterior approach has no true landmarks. Regardless of the margins of the split maximus to reveal the gluteus maximus (GMax). The fibres of the GMax are th-

depth of, the GMed.

The middle and posterior rotators of the hip: the piriformis, superior gemellus, obturator internus, and inferior gemellus (Figure 4). The latter three muscles merge to form the conjoined tendon, while the piriformis can typically be visualized and palpated as a separate structure just proximal to the conjoined tendon deep to, and along the posterior border of, the GMed.¹² These ‘rotators’ are cut, as close as possible to their femoral insertion to preserve tendon length and allow for an eventual

Surgical approach

The posterior approach is performed with the patient in the lateral decubitus position, with the operative leg up (Figure 1). Based on surgeon’s preference, patient factors (e.g. size of the patient), as well as the need for an extensile exposure, the incision starts approximately 6–8 cm proximal and posterior to the GT, and extends distally in a curvilinear fashion centered on the posterior aspect of the GT following the direction of the femoral shaft, for a total length of approximately 10–15 cm (or as long as needed for exposure) (Figure 2). Dissection continues through the subcutaneous adipose tissue until the fascia lata is exposed (Figure 3). An incision through the fascia lata is made in line with the skin incision, exposing the GMax. The fibres of the GMax are then split by blunt dissection beginning distally and proceeding proximally. As noted above, the superior and inferior gluteal arteries (and their branches), which supply the muscle, may be injured during blunt dissection. Self-retaining retractors are placed on the margins of the split maximus to reveal the posterior aspect of the hip which includes the gluteus medius (GMed) and the underlying short external rotators of the hip: the piriformis, superior gemellus, obturator internus, and inferior gemellus (Figure 4). The latter three muscles merge to form the conjoined tendon, while the piriformis can typically be visualized and palpated as a separate structure just proximal to the conjoined tendon deep to, and along the posterior border of, the GMed.¹² These ‘rotators’ are cut, as close as possible to their femoral insertion to preserve tendon length and allow for an eventual

⁴ Corresponding Author
E-mail: rmfrank3@gmail.com

¹ Department of Orthopaedic Surgery, Rush University Medical Center, Chicago, IL, USA
² Department of Adult Reconstruction, Hospital for Special Surgery, New York, NY, USA

Competing interests: none declared. Conflict of interests: none declared.

All authors contributed to conception and design, manuscript preparation, read and approved the final manuscript.

All authors abide by the Association for Medical Ethics (AME) ethical rules of disclosure.

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Structures at risk
The sciatic nerve and the inferior gluteal artery are the structures most at risk during the posterior approach to the hip (Table 2). Errant dissection, excessive limb lengthening, and improper retractor placement are often implicated in cases of sciatic nerve injury following the posterior approach.

Direct lateral approach (Hardinge approach)
The direct lateral approach to the hip was first described by Hardinge.

can lead to injury to the GMed and/or minimus, although usually not clinically relevant), and thus patients are unlikely to experience the abductor deficient gait often seen with other exposures. However, because the posterior capsule and short external rotators are incised in this approach, there may be a potential increased risk for hip dislocation following surgery\textsuperscript{13–15}. As such, meticulous soft tissue repair is critical following the posterior approach to the hip. Further, larger head sizes have been implemented in THA to decrease the dislocation rate after a posterior approach\textsuperscript{16–18}.

Table 1 Approaches and associated internervous/intermuscular planes

<table>
<thead>
<tr>
<th>Approach</th>
<th>Internervous</th>
<th>Intra/Intermuscular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior (Southern)</td>
<td>None</td>
<td>GMax (IGN)</td>
</tr>
<tr>
<td>Lateral (Hardinge)</td>
<td>None</td>
<td>GMed (SGN) Vastus lateralis (Femoral)</td>
</tr>
<tr>
<td>Anterior (Smith-Peterson)</td>
<td>Superficial</td>
<td>None</td>
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<tr>
<td></td>
<td>Sartrius (Femoral)</td>
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<tr>
<td></td>
<td>TFL (SGN)</td>
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<tr>
<td></td>
<td>Deep</td>
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<tr>
<td></td>
<td>Rectus femoris (Femoral)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GMed (SGN)</td>
<td></td>
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<tr>
<td>Antero-lateral (Watson-Jones)</td>
<td>None</td>
<td>TFL (SGN)</td>
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<tr>
<td></td>
<td></td>
<td>GMed (SGN)</td>
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</tbody>
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IGN, inferior gluteal nerve; SGN, superior gluteal nerve

Figure 1: Intraoperative photograph of a patient undergoing total hip arthroplasty placed in the lateral decubitus position in preparation for a posterior approach to the hip with the operative hip (right) facing up.
Surgical approach

The direct lateral approach can be performed with the patient in the lateral decubitus or the supine position (which allows both the gluteal musculature and fat to fall posteriorly off the table and away from surgical field). The incision is started approximately 5 cm proximal to the tip of the GT and is continued in a linear fashion distally, centred over the tip of the GT and in line with the femur; for approximately 8–12 cm (or as long as needed to safely complete the exposure). Superficial dissection is continued through the subcutaneous adipose tissue to the underlying fascia lata, which is split in line with the incision. Retraction of the fascia lata anteriorly and the GMax posteriorly exposes the underlying GMed and vastus lateralis. The anterior one-fifth to one-third (varying percentages have been described) of the GMed is subsequently split proximal to the trochanter in line with the muscle fibres (at 45 degrees between straight superior and straight anterior) and continues distally along the muscle’s insertion in 1982. This approach provides adequate exposure to the hip joint for primary arthroplasty as well as revision procedures. It is considered to have a low post-operative dislocation rate, and does not require trochanteric osteotomy to gain broad exposure. Nevertheless, this approach does require release of the anterior portion of the GMed, which may predispose the patient to an abductor lurch (i.e. Trendelenberg limp) following surgery.

Important surgical anatomy and landmarks

The direct lateral approach has no true intervernonous plane, but does utilize an intermuscular plane, as a portion of the GMed and a portion of the vastus lateralis is released during the superficial dissection (Table 1). The GMed is innervated by the superior gluteal nerve, while the vastus lateralis is innervated by the femoral nerve. The most important superficial landmark in this approach is the tip of the GT, which is used to guide incision location and to divide the GMed tendon.

Figure 2: Intraoperative photograph of a patient undergoing total hip arthroplasty via posterior approach (right hip); the incision starts approximately 6–8 cm proximal and posterior to the greater trochanter, and extends distally in a curvilinear fashion centred on the posterior aspect of the trochanter following the direction of the femoral shaft, for a total length of approximately 10–15 cm (or as long as needed for exposure).

Figure 3: Intraoperative photograph of a patient undergoing revision total hip arthroplasty via posterior approach (right hip); dissection continues through the subcutaneous adipose tissue until the fascia lata is exposed.
Intraoperative photograph of a patient undergoing total hip arthroplasty via posterior approach (right hip); visualized are the short external rotators of the hip including the piriformis, superior gemellus, obturator internus, and inferior gemellus. Note the sciatic nerve (asterisk) exiting the pelvis, travelling under the piriformis and over the medial border of the short external rotators as it courses distally.

Figure 4: Intraoperative photograph of a patient undergoing total hip arthroplasty via posterior approach (right hip); visualized are the short external rotators of the hip including the piriformis, superior gemellus, obturator internus, and inferior gemellus. Note the sciatic nerve (asterisk) exiting the pelvis, travelling under the piriformis and over the medial border of the short external rotators as it courses distally.

on the greater trochanter. Care must be taken not to split the medius more than 3–5 cm proximal to the upper border of the GT as at this level is the superior gluteal nerve. The GMed becomes confluent with the proximal portion of the vastus lateralis, which may also be split in line with its fibres to provide distal exposure. The gluteus minimus (GMin) tendon lies deep to the medius and its insertion on the trochanter lies just anterior to the medius insertion along the anterior border of the trochanter. It is incised proximal to the trochanter along the same line as the incision in the medius. Distal to the anterior superior tip of the trochanter, it can be released just anterior to its insertion on the greater trochanter leaving a small cuff of tendon on the proximal femur to allow for subsequent repair. To gain exposure of the joint capsule, the anterior aspect of the split GMed, the underlying GMin, and the split vastus lateralis are elevated from the GT, off the anterior capsule as a single flap. During mobilization of the vastus lateralis, the transverse branch of the lateral circumflex artery can be injured, and so care must be taken to identify and cauterize the vessel when encountered. This vessel originates from the lateral circumflex femoral artery and passes laterally over the vastus intermedius, piercing the vastus lateralis, and ultimately winds around the femur, just below the GT. It anastomoses on the back of the thigh with the medial femoral circumflex artery, inferior gluteal artery, and perforating branches of the profunda femoris artery. Once adequate exposure of the anterior hip capsule is obtained, capsulotomy (or capsulectomy) can be achieved using a T-shaped incision (or by removing the anterior capsule).

As opposed to the posterior approach, the hip is dislocated by traction, flexion, adduction, and external rotation. Care must be taken to avoid extending the incision too far proximally in order to prevent injury to the superior gluteal nerve as it runs between the medius and minimus muscle bellies 3–5 cm proximal to the tip of the GT.

The femoral nerve, artery, and vein are vulnerable to errantly placed retractors or retracting too vigorously, as they course anteriorly in the thigh.

Anterior approach (Smith-Peterson)

The anterior approach to the hip joint, first described by Smith-Peterson, allows for safe access to the anterior aspect of the hip, and can also be extended to gain access to the ilium, and thus is useful for pelvic osteotomies. However, this approach is not extensile posteriorly, as it does not allow for complete exposure of the posterior acetabulum and access to the proximal femur can also be limited. Compared to other techniques, the direct anterior approach can be more time-consuming, and some authors advocate for the use of intraoperative fluoroscopy to aid in visualization of landmarks as well as component positioning.

Important surgical anatomy and landmarks

The anterior approach to the hip utilizes the internervous plane between the sartorius (femoral nerve) and the tensor fascia lata (superior gluteal nerve) superficially (Figure 5), as well as the internervous plane between the rectus femoris (femoral nerve) and the GMed (superior gluteal nerve) at a deeper level (Table 1). Superficial bony landmarks that should be identified prior to planning the incision include the anterior superior iliac spine (ASIS) as well as the iliac crest and greater trochanter.

Surgical approach

With the patient supine, the incision starts 3–4 finger-breadths distal to the ASIS and is angled for 8–12 cm towards the lateral aspect of the...
Femoral nerve

Dangers

For citation purposes: between the rectus femoris (femoral exosposes the deep internervous plane laterally and the sartorius medially, late this vessel. Retraction of the TFL taken to identify and ligate or coagueral aspect of the hip. Care should be deep circumflex iliac artery at the latbranches of the superior gluteal and lata anastomozing with the terminalupwards, beneath the tensor fasciae rior aspect of the hip joint, as it passesexternal rotators.

Structures at risk (Table 2) during this approach include the lateral cutaneous femoral nerve and the GMed (superior gluteal nerve). The two heads of the rectus, the direct and reflected heads, attach to the ASIS and the superior lip of the acetabulum (as well as the anterior hip capsule). At this point, acetabular (and occasionally the ASIS origins of the rectus are released and the rectus femoris is retracted medially, while the GMed is retracted laterally. Once this deep exposure is obtained, the anterior hip joint capsule is visible and can be widely exposed with retractors placed along the supero-lateral capsule, the ante- ro-superior acetabular rim, and the infero-medial capsule. The capsule is then incised or removed allowing dislocation via extension and external rotation. To safely expose the proximal femur for placement of a femoral THA component, it may be necessary to release additional posterior and superior capsules as well as the short external rotators.

Structures at risk

States at risk (Table 2) during this approach include the lateral cutaneous femoral nerve and the ascending branch of the lateral femoral circumflex artery, as described above. Additionally, the femoral nerve and artery or vein injuries can occur if the rectus femoris is inadvertently retracted laterally instead of medi- ally during the surgical approach.

Antero-lateral approach (Watson-Jones)
The antero-lateral approach, also known as the Watson-Jones ap- proach, is now a common approach for THA. This approach provides excellent exposure to both the proximal femur and acetabulum, and is useful for patients who are at higher risk for hip dislocation as the posterior or soft tissue and capsular structures remain mostly intact. However, this approach may require partial disruption of the abductor mechanism and thus, may be associated with a post-operative limp.

Important surgical anatomy and landmarks

The antero-lateral approach has no true internervous plane, but does utilize the intermuscular plane be- tween the TFL and the GMed (Figure 6), both of which are innervated by the superior gluteal nerve (Table 1). The most important superficial landmarks in this approach are the GT, the anterior border of the femur, and ASIS. The interval between the TFL and GMed can be palpated in most patients who are not obese.

Surgical approach

Similar to the direct lateral approach, the antero-lateral approach is per- formed with the patient in either the lateral or supine position. In the lat- eral position, the operating table can be tilted posteriorly so that the surgi- cal site is more easily accessible. Dependent on the surgeon’s preference and patient’s body habitus, an 8–15 cm incision begins 2.5 cm poste- rior and distal to the ASIS and is di- rected towards the tip of the greater trochanter. As it passes toward the posterior third of the trochanter, the incision may be extended distally cen- tered on the anterior border of the greater trochanter and the proximal femur.

Superficial dissection is continued through the subcutaneous adipose tissue to the underlying fascia, which
is incised between the GMed and TFL in line with the proximal limb of the skin incision. The fascial flap, still attached to the TFL, is retracted anteriorly and medially exposing the GMed. The interval between the TFL and the GMed is then developed with blunt dissection, taking care to identify and ligate any crossing vessels. The medius and minimus are then retracted posteriorly, while vastus lateralis origin at the vastus ridge is retracted inferiorly to fully expose the anterior capsule. In rare cases in which adequate exposure cannot be obtained, a greater trochanteric osteotomy can be performed with an oscillating saw, bringing the attached GMed and minimus muscles proximally (or can convert to a direct lateral approach). The vastus lateralis ridge is used as a landmark as the distal osteotomy site is just proximal to this location. Alternatively, partial detachment of the GMed and minimus tendons from their proximal origins on the iliac crest may allow for easier retraction and better exposure. Now, the anterior joint capsule is exposed, and the reflected head of the rectus femoris should be separated from the joint capsule to expose the anterior rim of the acetabulum. Capsulotomy or capsulectomy of the anterior capsule is performed along the intertrochanteric line (distally), just posterior to the rectus femoris (anteriorly), and along the rim of the acetabular posteriorly and superiorly.

Capsulotomy removes a portion of the capsule aiding in exposure, especially in extremely degenerative hips with significant contractures, while capsulotomy cuts the capsule without removing it, making is available for repair. There is evidence to suggest increased stability with capsulotomy and subsequent repair; however, in patients with severe deformity or contracture, the capsule may be adherent to the femoral neck and prevent dislocation without complete capsulectomy and the technique must be tailored to the specific patient.

**Structures at risk**

Structures particularly at risk (Table 2) during this approach include the contents of the femoral triangle, including the femoral artery, vein, and nerve. Compression injury can be caused by medial retraction of the anterior structures, which are also at risk when acetabular retractors are placed, penetrating the iliopsoas instead of retracting it. This complication can be easily avoided by ensuring that the tip of the retractor rests directly on the anterior rim of the acetabulum. More proximally, release and lateral retraction of the medius and minimus must be performed carefully to avoid tension on the superior gluteal neurovascular bundle, which runs from posterior to anterior 3–5 cm proximal to the greater trochanter.

**Conclusion**

Exposure to the hip joint can be safely achieved through a variety of surgical approaches. A thorough understanding of pelvic and hip anatomy is critical to perform these approaches safely and efficiently. Regardless of the specific approach utilized, all exposures that require the use of peri-acetabular lever type retractors have the potential to cause significant

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**Figure 5:** Cadaveric dissection photograph of a patient undergoing total hip arthroplasty via anterior approach (right hip); the superficial internervous plane is between the sartorius (plus sign), which is innervated by the femoral nerve, and the tensor fascia lata (asterisk), which is innervated by the superior gluteal nerve.
injury to structures at the acetabular periphery, either via direct injury or via leverage on 'hidden' structures. Careless retractor placement may result in neurovascular compression and ultimately, neurovascular compromise, which can lead to devastating clinical outcomes. With attention to detail and a fundamental understanding of the acetabular anatomy, these complications can usually be avoided. Overall, the open surgical approaches to the hip described above, including the posterior, lateral, anterior, and anterior-lateral, as well as other less common approaches (i.e. medial approach, Ganz surgical-dislocation approach), are all effective ways to approach the hip joint.

Abbreviations list
GMax, gluteus maximus; GMed, gluteus medius; GMin, gluteus minimus; GT, greater trochanter; IGN, inferior gluteal nerve; OA, osteoarthritis; PSIS, posterior superior iliac spine; SGN, superior gluteal nerve; THA, total hip arthroplasty

References

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