Review Article

Surgical anatomy of the direct anterior approach for total hip arthroplasty

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Abstract: With the increasing popularity of the direct anterior approach (DAA) for total hip arthroplasty (THA), it is imperative that surgeons understand the anatomy associated with the approach. Particular anatomic considerations associated with the approach are reviewed here, with particular attention paid to neurological, vascular, muscular, and osseous structures that the surgeon must be familiar with when performing the approach. These are reviewed within the context of a brief outline of the steps of completing the operation.

Keywords: Direct anterior approach (DAA); total hip arthroplasty (THA); anatomy; lateral femoral cutaneous nerve (LFCN); extensile; transverse acetabular ligament (TAL)

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Introduction

Total hip arthroplasty (THA), first described in its modern form by Charnley in 1961has revolutionized the treatment of hip arthritis (1). A number of different approaches have been described to access the hip joint, including the direct anterior approach (DAA), which was well described approximately 100 years ago by Smith-Peterson (2) and more recently popularized (3,4), gaining renewed interest in the past few decades, owing to its muscle-sparing nature, employment of a true internervous interval, and favorable postoperative stability (5), among other purported advantages. Some data suggest less postoperative pain and shorter length of stay while maintaining reasonable operating times (6). Berend *et al.* (7) have outlined potential early outcome advantages associated with the DAA, including more likely discharge to home and higher hip scores in very early follow up. Other studies have reinforced excellent early outcomes (8). Radiographic studies have shown that muscle damage may be lower with the anterior approach as compared to the posterior approach, as quantified with magnetic resonance imaging (9). While the approach has been described as overall being safe and accessible (10), there are concerns over the technically challenging nature of the approach, with a noted learning curve (11). A number of characteristic complications have been described associated with the unique anatomy of this approach to THA (11-14). Herein we review the relevant anatomy, and cautions and dangers characteristically associated with the DAA.

DAA anatomic limitations and extensibility

A number of concerns exist in total joint arthroplasty done in the obese patient, and the DAA is no exception. Higher BMI patients have been shown to be at higher risks for increased operating time, bleeding risks and overall complication rates (15). Infection in particular has been shown to be higher in those with BMI >35 undergoing DAA THA (16). Furthermore, the Mayo Clinic registry data has shown wound complications to be higher in obese patients undergoing DAA, though still similar to those undergoing posterior THA (17).

One of the purported benefits of the posterior approach as compared to the DAA for THA is the extensile nature of the former. Ghijselings and colleagues have described (18), in a cadaveric model, the distal extension of the DAA, and the locations of neurovascular bundles in relation to the distal extent of the approach. They conclude that it is feasible to extend the DAA, and report a series of extension of the DAA using this “interbundle technique (19),” which could be employed to gain access to the femur, should cabling or other processes be required. Other reported extensions of the DAA (20) recommend exercising caution when employing, owing to potential devitalization of neurovascular structures supplying the quadriceps musculature, specifically with application of a cerclage wire passer.

Neurological considerations

While neurovascular injuries to major structures are rare during THA, specific risks must be considered with any approach, with particular attention paid to specific structures at risk with a given surgical approach and dissection. In general, motor nerve injuries are rare; sciatic nerve injury is more characteristic with posterior approaches, superior gluteal nerve injury associated with lateral approaches (21), and the DAA with femoral nerve injury, though very uncommon (22). Cadaveric studies have demonstrated that, in associated with acetabular retractors, nerve impingement is possible, and specifically that anterior retraction may harm the femoral nerve if contact with acetabular bone is not direct, or if the acetabular retractor migrates over time (23).

Owing to the proximity of the dissection used, the DAA has been associated with damage to the lateral femoral cutaneous nerve (LFCN) (3,12,24). While no motor function is lost with damage to the LFCN, it can be associated with burning pain, though rarely with any functional deficits reported (24). A cadaveric study has shown the location of the LFCN in reference to different anatomic landmarks, and may emerge either above or below the inguinal ligament (25). Reference to bony landmarks, and ratios of distances rather than absolute measurements themselves may be better guides to where the LFCN is, in the authors’ opinion. Patients with smaller measures of hip offset may be at higher risk of LFCN injury during the DAA as well (26), presumably due to the close proximity of the structures involved and smaller amount of area in between incision and the nerve.

Osseous considerations

While characteristically providing excellent access and visibility to the acetabulum, the femoral exposure and visualization can prove more problematic in the DAA for THA. Trochanteric fractures are relatively more common with this approach, and femoral perforations and calcar fractures are well reported as well (14). Retractors placed during femoral preparation may be associated with fractures of the greater trochanter, in one study, occurring nearly 30% of the time (27). In cases of smaller fragments, the clinical significant of greater trochanter fractures is unclear, but smaller trochanters appear to be at greater risk for fracture (27). More displaced or larger trochanter fragments may prove to be more clinically significant and pose considerable morbidity to the patient, especially if associated with abductor dysfunction or Trendelenburg gait.

De Geest (13) described a series of 300 DAA THA patients and noted at least three types of femur-related bony complications: three of which were greater trochanter fractures, two femoral perforations during preparation, and four calcar fractures. However, there were also five patients who were noticed postoperatively to have sustained periprosthetic fractures that were not apparent intraoperatively. They attribute these to have occurred occultly during the surgery. Berend *et al.* (28) reviewed nearly 3,000 DAA THA, of which 26 sustained periprosthetic femur fractures. The only identified risk factor was increased age in the female patient, for whom they recommend exercising caution, different surgical approach or implant design.

Muscular anatomic considerations

A purported benefit of the DAA for THA is the internervous nature of the approach and preservation of muscular attachments (*Figure 1*). However, muscle damage still occurs during the approach (29), and to the extent possible, should be limited. Appropriate function of hip abductor musculature is necessary for good clinical outcomes after THA; abductor deficiency after THA presents a challenging clinical scenario with a number of described techniques to treat (30-32). Radiographic studies have demonstrated that there can be fatty infiltration of gluteus medius and minimus muscles indicating denervation damage after THA (33,34). While appropriate abductor

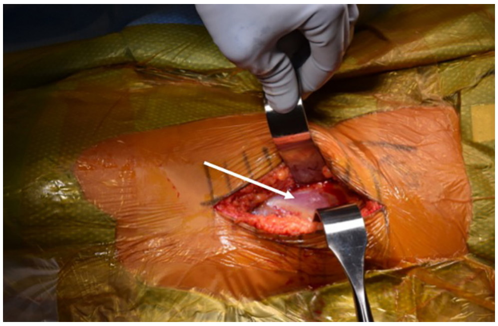

Figure 1 Intraoperative photograph demonstrating the Hueter interval, between the sartorius and the TFL. The rectus femoris is seen, denoted by the white arrow. TFL, tensor fascia lata.

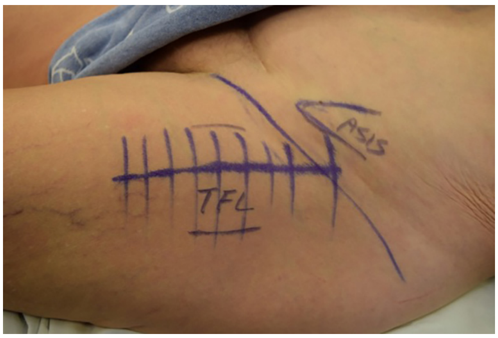

Figure 2 Operative field seen before prepping and draping. The planned skin incision is outlined in relation to the ASIS and TFL. ASIS, anterior superior iliac spine; TFL, tensor fascia lata.

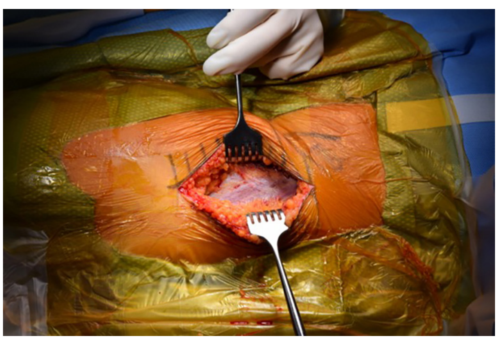

Figure 3 Fascia overlying the muscle belly of the TFL. TFL, tensor fascia lata.

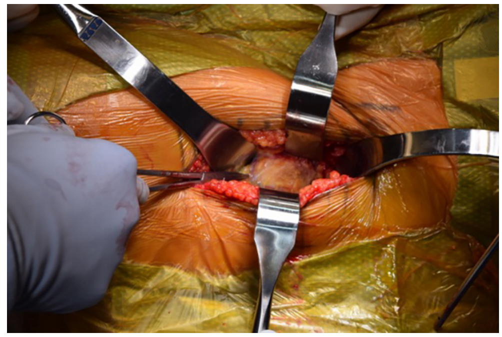

Figure 4 Branch of the lateral femoral circumflex artery, seen at the tip of the tonsil forceps.

function is necessary after THA, damage, as evaluated by MRI, to the gluteus minimus is of less clinical importance than is harm to the gluteus medius (33). While at less risk than during lateral approaches to the hip, the hip abductors must be protected during the DAA, both during the approach as well as bony preparation.

Capsular release and femoral elevation are performed as prerequisites for femoral preparation during the DAA, as appropriate visualization is not possible without doing so. The short external rotators are ideally preserved, even with posterior capsular release for femoral elevation. Cadaveric studies have mapped the short external rotators and conjoined tendon as extending to the anterosuperior portion of the greater trochanter (35). Therefore, during capsular release for exposure and elevation prior to femoral preparation, knowledge of the location of these musculotendinous structures must be known in order to maintain their integrity and preserve the stability they offer after THA.

Technique-specific anatomic considerations

The incision for the DAA is characteristically based off the anatomic location of the anterior superior iliac spine and the greater trochanter (*Figure 2*) (4). So-called "bikini" modifications of the incision have been described as variations of the technique (36,37). After the fascia over the tensor fascia lata (TFL) is incised (*Figure 3*), the interval between the TFL and the rectus femoris is bluntly developed. It is at this point that the ascending branches of the lateral femoral circumflex artery are encountered (20) (*Figure 4*). Once ligated and divided, the pericapsular region is accessible, and is overlain by the reflected head of the rectus femoris. Retractors are placed on either side of the femoral neck and the capsule is exposed by medial reflection and retraction of the rectus femoris. After incising the capsule, the bony femoral neck is accessible for osteotomy

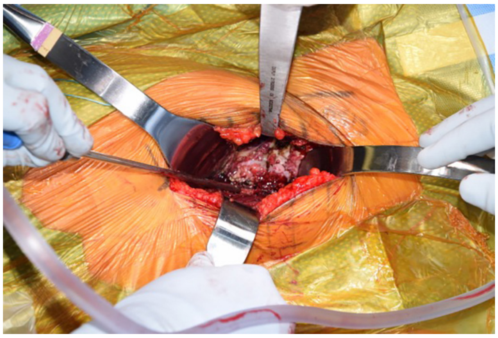

Figure 5 Exposed osteophytic femoral neck.

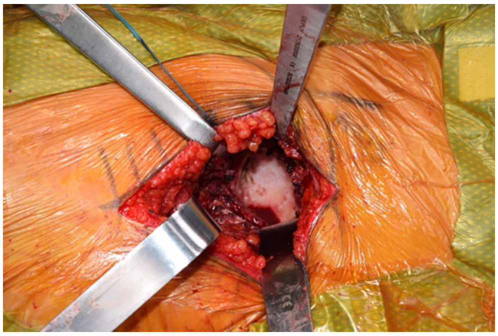

Figure 6 Exposure of the acetabulum.

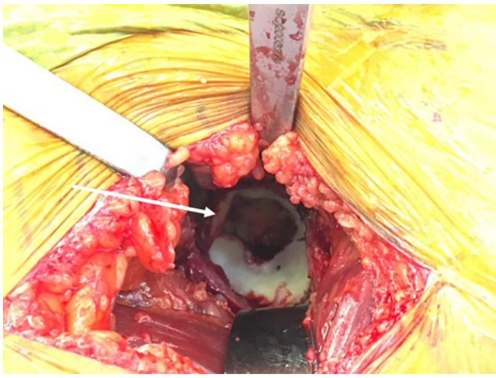

Figure 7 Intraoperative view of the transverse acetabular ligament, seen at the point of the white arrow.

(*Figure 5*).

Once the femoral neck cut is made and the head removed, the acetabulum is exposed (*Figure 6*). Much has been written on the relationship of the transverse acetabular ligament (TAL), and its relationship to orientation of the acetabulum preparation and component placement (*Figure 7*). By identifying the TAL, it may be used as a guide for version and therefore cup position (38-40). However, some authors have noted that the TAL is difficult to accurately identify for positioning purposes (41). Debate exists regarding its use in intraoperative guidance of acetabular positioning in anatomic variations, including dysplastic acetabulae (42,43). Regardless of its utility in guiding acetabular positioning, along with the cotyloid fossa, the TAL may be used as an anatomic landmark to avoid over-medialization of the acetabular reamers (44). During acetabular reaming, the TFL, rectus femoris, and femoral neck cut may all be the cause of anatomic structures that can deflect acetabular reamers, so exposure must be adequate (*Figure 8*).

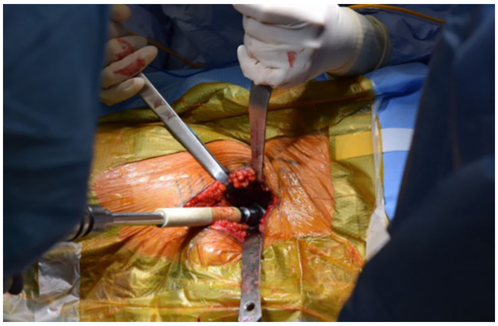

Figure 8 Intraoperative view of the acetabular reamer.

Following completion of the acetabular preparation and cup placement, femoral preparation is undertaken. It is at this point that posterior capsular releases are performed both for appropriate retractor placement as well as for anterior translation of the proximal femur so that the canal can be accessed for bony preparation and broach and implant insertion (4,45). This portion of the operation may be especially technically demanding and dependent on appropriate technique. In order to present the cut face of the femoral neck and allow entrance to the femoral canal, the femur is extended, externally rotated, adducted, and the proximal femur elevated for optimal anatomic positioning. During femoral broaching, a retractor is often placed on the medial aspect of the cut femoral neck, and the authors recommend exercising caution not to damage the iliopsoas tendon which is inferior to this, at the level of the lesser trochanter. With the sum of these anatomic considerations, the components can be safely and reproducibly placed in the DAA.

Conclusions

The DAA for THA is gaining in popularity due to a number of potential benefits the approach offers. However, there are a number of noted complications that are presented by the unique anatomic considerations and challenges associated with this approach. With a thorough knowledge of the involved anatomy and application of sound surgical technique at all points of the operation, the DAA may be safely employed to accomplish THA.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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