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Surgical technique

A Novel Technique to Detect Femoral Shaft Perforation during Direct Anterior Total Hip Arthroplasty

Fravel William, MD *, Deskins Seth, BS, Kocher Tim, BS, Wood Samuel, BS, Bullock Matthew, DO, MPT

Department of Orthopaedics, Marshall School of Medicine, Huntington, WV, USA

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A B S T R A C T

Despite its popularity, the direct anterior approach for hip arthroplasty is not without complications. Intraoperative femoral shaft perforation using this approach ranges from 0.8% to 7%. A missed perforation can lead to fracture with the need for further surgery if not detected intraoperatively. We describe a reproducible and cost-effective technique using a plastic Yankauer suction handle to help identify proximal femoral perforations during direct anterior total hip arthroplasty. Careful attention to the visual, tactile, and auditory feedback provided by the suction handle can help ensure the cortical continuity of the proximal femur. Familiarity with relevant surgical anatomy, improving surgical technique, and scrutinizing implant positioning helps minimize the risk of complications during the direct anterior approach.

Introduction

The direct anterior approach has gained tremendous traction over the past decade. This minimally invasive approach presents a different view of the proximal femoral anatomy where appropriate soft-tissue and capsular releases are necessary to enhance exposure to successfully perform hip arthroplasty. Studies have demonstrated intraoperative femoral fractures during the direct anterior approach range from 0.8% to 7% for primary cases [1-4]. A simple femoral cortex perforation can lead to fracture propagation if not properly identified intraoperatively. A fracture complication can lead to greater patient morbidity and subpar clinical outcomes [5,6].

Multiple studies have investigated predisposing factors for femoral perforation and fracture. A variety of patient factors including female sex, metabolic bone disease, prior surgery, aberrant femoral anatomy, and morbid obesity have all been implicated [3,7-9]. Furthermore, a literature review by Carmona et al. [10] confirms that age and gender are significant factors impacting the proximal femoral anatomy, which can impact the surgical technique. Surgeon inexperience has also been shown to increase the risk of complications and component malposition for the direct anterior approach [2].

It is well known that cementless femoral components have a higher risk of fracture than cemented components in part due to hoop stresses during insertion of press-fit components [3]. Up to half of all perforations/fractures are missed while patients are still in the operating room [6]. Therefore, it has been strongly suggested that 2-view radiographs after arthroplasty in all patients especially those with the known risk factors mentioned previously is obligatory. Management of the complication depends on stability of the implant and integrity of the surrounding bone.

The purpose of this article is to describe a simple and reproducible method of evaluating a femoral perforation during canal broaching for a direct anterior total hip arthroplasty. We describe characteristic auditory and tactile cues that can be used to distinguish an intact cortex from one that has been compromised. This technique has enabled us to identify several femoral perforations before the final stem prosthesis is placed.

Technique

All hip replacements are performed through a modified direct anterior Smith-Peterson approach using the interval between the tensor fascia lata and sartorius muscles. Fluoroscopy is used during

* Corresponding author. 1600 Medical Center Drive, Huntington, WV 25701, USA.
E-mail address: fravelw@marshall.edu

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femoral neck osteotomy, reaming of the bony acetabulum, and seating of the final acetabular implant. Standard proximal femoral soft-tissue releases are performed. The capsular attachments between the superior femoral neck and medial portion of the greater trochanter (the so called “saddle region”) are meticulously released to allow mobilization of the proximal femur into maximal external rotation, extension, and adduction with the aid of a femoral hook. The piriformis tendon is typically not released unless further mobilization of the femur is necessary. The entire hip capsule along the calcar region is released down to the level of the lesser trochanter before broaching.

Next, a rongeur is used to initiate a channel within the cancellous bone of the residual femoral neck. To help identify the intramedullary portion of the femoral canal, a long hemostat is carefully advanced through the cancellous bone while remaining in close proximity to the anterior cortex of the proximal femur. A blunt-tipped starting broach is then gently impacted down the intramedullary canal followed by the subsequent broach(es) while remaining attentive to the proximal femoral anatomy. The tip of each broach is visually inspected for cancellous bone. If soft tissue is noted on the tip of the broach, a cortical perforation is suspected. At this point, the last broach is removed and replaced with a new sterile plastic Yankauer handle with suction attached (Fig. 1).

The suction handle serves several purposes. First, the direction of the handle must correlate with the relevant anatomy of the proximal femur. The suction tip must traverse the residual femoral neck and remain collinear with the shaft of the proximal femur. The firm yet flexible nature of the plastic Yankauer suction handle can be used to carefully enlarge the cancellous channel of the proximal femur while minimizing the risk of cortical perforation. Third, while using the suction tip as a probe, the intramedullary portion of the proximal femur is manually inspected in a circumferential direction. A step-off or other irregularity may indicate a possible cortical violation.

Finally, we pay careful attention to the auditory feedback provided by the active suction. The reverberations within the intramedullary canal with an intact cortex help ensure proper positioning of the suction tip without cortical breach. If a defect is present, a loss of cortical continuity can usually be detected along with a distinct auditory change when the suction tip comes into contact with adjacent soft tissue. The acoustic profiles are quite discrete and easily distinguishable from each other. A constant dull muffled pitch usually accompanies an intact canal, whereas a sudden sharp pitch change can represent a perforation.

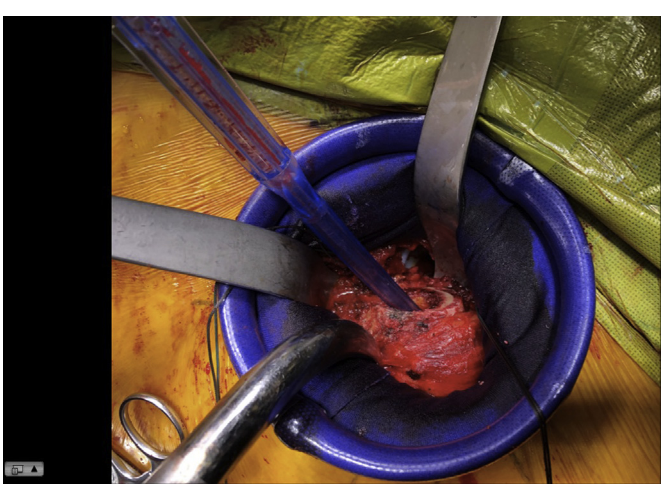

Figure 1. Right-hip intraoperative picture (orientation: cranial to the left and caudal to the right). The Yankauer handle is carefully inserted down the osteotomized femoral neck following the path of the last broach. The direction should mirror the calcar region. Careful attention is paid to the auditory and tactile feedback provided by the suction.

After integrity of the canal has been verified, broaching proceeds in usual fashion until the templated size, impaction pitch change, and cessation of broach advancement are encountered. If a cortical defect is suspected, fluoroscopy is used to confirm the location of the perforation. A cerclage cable is then applied, and the broach is redirected down the femoral canal.

A trial neck and femoral head are then placed, and the operative leg is returned to the neutral position as the hip is reduced. Final fluoroscopic views confirm an acceptable position of the components and the integrity of the proximal femur. Afterward, final implants are placed, the hip is reduced, and standard wound closure ensues.

Discussion

We describe a simple and reproducible technique that helps ensure the integrity of the proximal femur during broaching for direct anterior hip replacement. To our knowledge, this is the first study to describe distinct audio profiles of an intact and perforated femoral canal. The audio profiles can be reviewed at https://www.youtube.com/watch?v=FIbZULi4B50.

A plastic Yankauer suction handle is ideally suited for this technique. The device is readily available in the operating theater and relatively inexpensive ($0.35 at our institution). The firm yet inherently flexible plastic probe is ideal to help navigate the cancellous bone of the proximal femur without placing the proximal femur at a significant risk of fracture or perforation. The 26-cm-long suction handle used for this technique has a tip of 7 mm in diameter with a gentle radius of curvature that correlates well with the proximal femoral calcar anatomy.

Cortical perforations and fracture are known risks of direct anterior hip replacement surgery. Female patients with poor bone quality are at higher risk of these complications [1]. Aberrant femoral anatomy secondary to developmental dysplasia or a low femoral cortex-to-canal ratio should raise caution during the preoperative planning period [4]. Morbid obesity can also increase the risk of intraoperative fracture and malpositioning of components because of soft-tissue constraints [11]. Several studies noted cortical perforations tend to occur early in the initial phases of adopting the direct anterior approach [1,2,5,11]. Masonis et al. [2] demonstrated all direct anterior approach complications decline after the first 100 cases. However, Kagan et al. [5] suggest that this “learning curve” may be fewer cases depending on the extent of surgical training. The importance of this learning curve should not be overlooked. It is during this critical time during assimilation of the direct anterior approach where an extra step should be taken to ensure the proper positioning of components and full integrity of the femoral canal during broaching.

Anatomically speaking, the greater trochanter is situated slightly posterolateral relative to the femoral shaft, while the lesser trochanter is located more posteromedial [12]. The lesser trochanter represents a transition point separating the relatively thin metaphyseal area of bone superiorly from the thicker cortical diaphyseal bone inferiorly. Therefore, during the direct anterior approach, most perforations tend to occur in a posterior direction at the level of the lesser trochanter (Fig. 2) [5].

Broaching of the proximal femur during direct anterior approach is different from other approaches. A gentle curvilinear path mirroring the calcar region has been described. Applying a slight medially directed force on the broach handle during broaching will keep the tip of the broach away from the posterior aspect of the proximal femur and collinear with the intramedullary

Figure 2. An example of femoral perforation during broaching. Note the tip of the broach exits the femur in a posterior direction just inferior to the lesser trochanter.

canal (Fig. 3). Broach version is usually kept parallel to the posterior cortex of the osteotomized femoral neck, but in most instances, the native version of the proximal femur is attained with final broach seating.

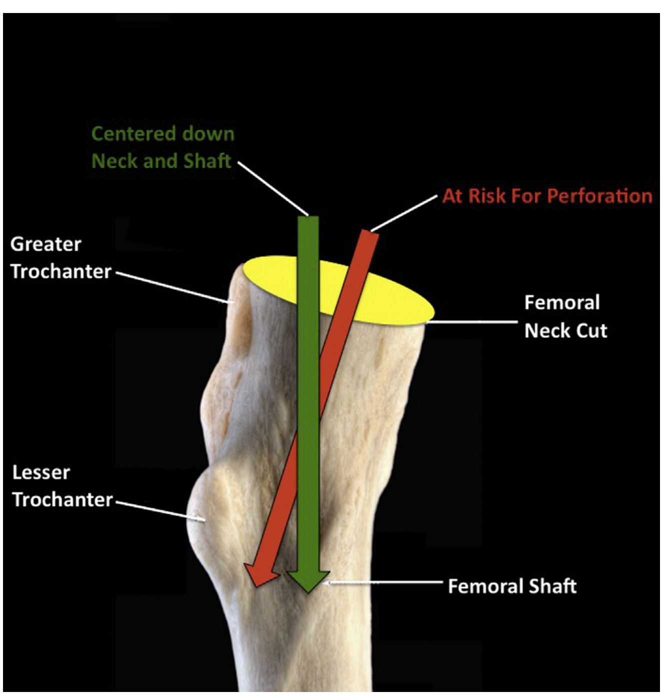

Figure 3. Medial view of a left proximal femur adapted from the study by Dalmau-Pastor et al. [12]. Broaching must traverse the residual femoral neck and remain collinear with the shaft of the proximal femur to avoid perforation. By applying a slight medial-directed force to the broach handle during broaching will angle the broach tip away from the posterior aspect of the femur.

The femoral neck can appear very different from the anterior approach when compared with posterior; therefore, it is imperative a precise neck osteotomy is performed to ensure a proper starting point. The shape, curvature, and buckling ratio are all elements of femoral neck geometry that could provide some insight when avoiding perforation [13]. According to Narra et al. [13], the cross-sectional dimensions of the femoral neck and loading properties of the surrounding bone can change dramatically depending on the location of the osteotomy. An osteotomy closer to the subcapital region of the femoral head will result in a circular neck cross section and can make identification of the calcar more difficult. Conversely, an oval-shaped cross section results from a lower neck osteotomy. The level of neck osteotomy is calculated from preoperative templating.

Our technique requires further fluoroscopic images only when a perforation or fracture is suspected. The tactile and auditory cues provided by the suction handle help reinforce proper positioning of the femoral broach, and there is potential for less radiation exposure for both the patient and surgeon. A study looking specifically at fluoroscopy during direct anterior hip arthroplasty found that on average, patients received 2.97 mGy, a number that they found increases with the body mass index [14].

One potential drawback of this suction tip technique is a theoretical risk of infection. As the suction tip is advanced down the intramedullary portion of the femur, a void of negative pressure can be created, which can draw bacteria deep into the femoral canal. To help mitigate this risk, we typically use a new suction tip when performing our aforementioned technique.

Future studies are necessary to determine the statistical utility of this technique during a variety of approaches to the hip. Although we have described our technique for primary hip arthroplasty during the direct anterior approach, it can easily be used during posterior and lateral approaches and during revision scenarios where femoral perforations are more common [3,8].

Summary

We have described a reproducible and cost-effective technique using a plastic Yankauer suction handle to help identify a proximal femoral perforation during direct anterior total hip arthroplasty. Management of a femoral perforation during direct anterior total hip arthroplasty begins during the preoperative period where the surgeon must remain cognizant of patient risk factors. A missed perforation may lead to fracture propagation with the need for further surgery if not detected intraoperatively. As the literature has demonstrated, a learning curve is evident for direct anterior total hip replacement. Familiarity with the relevant anatomy, surgical technique, and implant positioning helps ensure consistent and reproducible outcomes while minimizing the risk of complications.

Conflict of interest

The authors declare that there are no conflicts of interest.

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