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Basic Anatomy of Direct Anterior Approach for Mini-Invasive Hip Surgery

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ABSTRACT

Background: The direct anterior approach (DAA) for mini-invasive hip surgery is becoming a preferred method owing to its reported benefits. The aim of the present study was to identify and describe the structures that are potentially at risk during the execution of this surgical procedure, as well as to discuss the potential advantages of using DAA in total hip arthroplasty (THA). **Methods:** Twenty sides' adult embalmed cadavers (12 male and 8 female) were examined at the Department of Anatomy, Histology and Embryology at the Medical University of Sofia, Bulgaria. We performed the incision of anterior approach and studied its relation to structures in proximity to the hip joint. **Results:** We identified the lateral femoral cutaneous nerve and the lateral femoral circumflex vessels as being potentially at risk when DAA to the hip joint is performed. We also observed and described their location and course and did not report the presence of any variations. **Conclusion:** This study demonstrates the location and course of the anatomical structures that may be encountered and damaged during DAA and provides important information intended to help surgeons minimize the risk of neurovascular injury.

Keywords: *Direct Anterior Approach, Hip Surgery, Anatomical Structures, Risk.*

INTRODUCTION

Total hip arthroplasty (THA) has proven to be one of the most successful orthopaedic surgical interventions and a 10-year survival rate of more than 90% has been reported.[1] The rapid development of minimally invasive surgery (MIS) has led to the proposal and development of MIS techniques for THA.[1] The direct anterior approach (DAA) for mini-invasive hip surgery is becoming a preferred method owing to its reported benefits. It is used for various surgical procedures other than THA, such as hemiarthroplasty, hip resurfacing and corrective procedures for femoroacetabular impingement.[2] Patients who underwent surgery with a long incision (mean length 17.9 cm) were not as satisfied with postoperative results as those who had a small incision (mean length 9.6 cm) as part of THA.[3] Furthermore, patients who preferred the minimally invasive surgery achieved their primary goal, as opposed to patients with a long incision, 40% of whom were not satisfied.[3] The DAA provides an effective exposure for carrying out primary total hip arthroplasty.[4] Excellent visualization of the acetabulum is afforded by this direct approach.[4] Because of the limitations of the anterior approach of the conventional hip surgery, which include a larger incision, separating the tensor fasciae latae (TFL) and the gluteal muscle and the possibility of injuring branches of the lateral femoral cutaneous nerve (LFCN), the anterior approach for minimally invasive hip surgery is preferred.[5] By using the direct anterior approach surgeons lower the damage of soft tissue, reduce the recovery time and achieve better cosmetic appearance after the procedure. The duration of the operation is an average of 65 minutes.[4]

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Considering the exact positioning of anatomical structures located in close proximity to the hip joint and the zone of the incision is of key importance for the successful execution of the DAA. The surgeon

performing the intervention should carefully identify the structures consecutively as they appear in the operative field, dissect the deep fascia layer-by-layer, and observe the branches of the LFCN.[5] The incision of the deep fascia between the sartorius and the TFL reveals the exact course of the branches of the lateral femoral circumflex artery (LFCA) and the respective veins which provide blood supply to the zone of the incision. The ascending branch of the LFCA which enters or passes beneath the TFL and provides blood supply to the muscle is also distinguishable at the site of the incision.[5] The descending branch of the LFCA runs distally, passing below the rectus femoris muscle and enters the heads of the muscle medially to the incision, where it provides branches to the vastus lateralis muscle. Thus, knowledge of the topographic anatomy, blood supply and innervation of the muscles is of key importance for a successful procedure with a minimal possible risk for injury or damage to these anatomical structures.

The aim of the present study was to identify and describe the structures that are potentially at risk during the execution of this surgical procedure, as well as to discuss the potential advantages of using DAA in total hip arthroplasty (THA).

MATERIALS AND METHODS

Twenty sides' adult embalmed cadavers (12 male and 8 female) were examined at the Department of Anatomy, Histology and Embryology at the Medical University of Sofia, Bulgaria, in compliance with the regulations approved by the Medical Legal Office and the Local Ethics Committee. The site of the incision of anterior approach was determined in the following way. First, we palpated the anterior superior iliac spine (ASIS). From this point, we then measured 3 cm laterally and 3 cm distally to find the starting point and orientate the incision along the longitudinal axis of the TFL. After performing the incision we proceeded to reviewing the underlying anatomical structures through a layer-by-layer-approach. After cutting through the skin and subcutaneous tissue, we moved the skin flap to the side and demonstrated the deep fascia. We then opened the fascia and followed the course of the lateral, middle and medial branches of the anterior branch of the LFCN. By removing the deep fascia between the sartorius and the TFL, we demonstrated the ascending branch of the LFCA which provided branches ensuring blood supply to the TFL. The rectus femoris muscle was subsequently lifted to expose the underlying descending branch of the LFCA which was traced into the vastus lateralis muscle. We also measured the distance between the LFCN and the mark of the anterior approach incision at three points, as well as the distance between the LFCA and the mark of the anterior approach at two points. We did not observe any variations in the origin, course and location of the muscles and blood vessels relative to the site of the incision.

RESULTS

Our observations revealed that the structures located in the region of the incision that are of critical importance for the successful execution of the DAA and may be damaged during the procedure are the lateral femoral cutaneous nerve and the lateral femoral circumflex artery.

Lateral femoral cutaneous nerve (LFCN). The nerve was found originating from the dorsal divisions of the second and third lumbar nerves. It then passed behind the psoas major, and continued in distal direction along the front surface of the iliac muscle covered by this muscle's fascia. Proximally to the ASIS it passed through the lacuna musculorum under the inguinal ligament and entered the femoral region where it perforated the femoral fascia and divided into anterior and posterior branch. The anterior branch ensured innervation of the skin on the anterior and lateral side of the thigh. It subdivided into lateral, middle and medial branch which were situated at the site of the anterior approach incision, with the middle branch located directly under the line of the incision. The posterior branch perforated the fascia lata and ensured the innervation of the skin on the lateral side of the thigh from the level of the greater trochanter to the area above the knee. In the space between the sartorius and TFL, the nerve was located subfascially and emerged from this space or from the body of the sartorius. Assessment of the LFCN as a structure of critical importance with regard to possible risk of injury was conducted through measurement of the distance between the nerve and three starting points. The first starting point was determined in the area mediosuperior to the great trochanter. The distance between this point and the LFCN measured 9.20 cm (SD ± 1.53 cm). The distance between the second starting point which was situated medially to the ASIS and the LFCN measured 2.30 cm (SD ± 1.30 cm). The distance between the nerve and the third starting point which was located medially to the line connecting the ASIS and the lateral border of the patella measured 0.75 cm (SD ± 0.64 cm) [Table 1, Figure 1a].

Lateral femoral circumflex artery (LFCA). The LFCA arose from the profunda femoris artery and passed in lateral direction behind the rectus femoris and sartorius where it divided into an ascending and descending branch. The ascending branch was observed at the site of the incision, in the space between the sartorius and

the TFL below the deep fascia. Its course was traced upwards below the TFL to which it provided blood supply and to the lateral side of the thigh. The descending branch was observed running in distal direction below the rectus femoris and towards the vastus lateralis, which it entered and divided into numerous branches. These two branches were located within the zone of the anterior approach incision and therefore we assessed the distance between each of them and the mark of the incision through two measuring points. The first point was located in the area mediolinferior to ASIS. The distance between this point and the point of crossing of the ascending branch of the LFCA and the anterior approach incision mark measured 7.96 cm (SD ± 0.43 cm). The distance between the first point and the point of crossing of the descending branch of the LFCA and the anterior approach incision mark measured 11.35 cm (SD ± 1.21 cm). The second measuring point was located in the area mediolinferior to the great trochanter. The distance between this point and the point of crossing of the ascending branch of the LFCA and the anterior approach incision mark measured 5.41 cm (SD ± 0.85 cm). The distance between the second point and the point of crossing of the descending branch of the LFCA and the anterior approach incision mark measured 6.53 cm (SD ± 1.23 cm) [Table 2, Figure 1b].

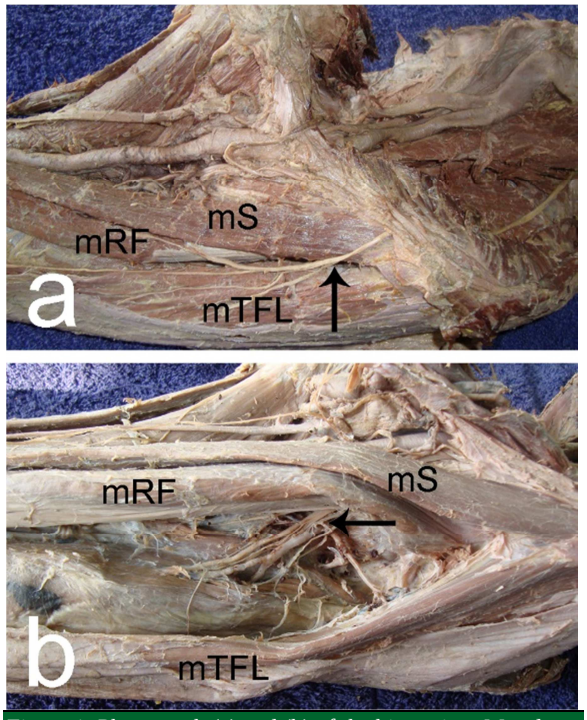

Figure 1: Photograph (a) and (b) of the hip region: Muscles – mS, sartorius muscle; mRF, rectus femoris muscle; mTFL tensor fasciae latae muscle. a) Nerve, LFCN – arrow, b) Artery – LFCA – asterisk.

Table 1: Distance between the lateral femoral cutaneous nerve and the mark of the anterior approach incision.

Measure	Starting point mediosuperior to greater trochanter (cm)	Starting point medial to ASIS (cm)	Starting point medial to the line from ASIS to the lateral border of patella (cm)
LFCN	9.20 ± 1.53	2.30 ± 1.30	0.75 ± 0.64

Table 2: Distance between the lateral femoral circumflex artery and the mark of the anterior approach incision.

Measure	Mediolinferior to anterior superior iliac spine (cm)	Mediolinferior to greater trochanter (cm)
The point of crossing of the ascending branch of the LFCA and the anterior approach incision mark	7.96 ± 0.43	5.41 ± 0.85
The point of crossing of the descending branch of the LFCA and the anterior approach incision mark	11.35 ± 1.21	6.53 ± 1.23

DISCUSSION

Complications of THA include intraoperative fractures, damage to nerves and blood vessels, prolonged operation time and repeat surgery.[6,7] Injury of the LFCN is the most commonly encountered complication.[2] The medial, middle, and lateral branches of the anterior branch of the LFCN are located directly below the zone of the incision of anterior approach in THA and a 10% rate of variations found in these branches has been reported.[5] An extension of the incision in distal direction may lead to injury of the distal branches of the LFCN.[2] Numbness in the area lateral and distal to the incision resulting from damage of the trunk of the LFCN has been observed in almost all cases, while temporary paresthesia of the distal lateral thigh has been reported in 5% of patients.[8] A study of Barghava et al. in 81 hips undergoing THA through DAA found that paresthesia was observed in only 12 cases (14.8%), of which 4 were resolved within 6 months, 6 were resolved by 1 year and 2 cases remained unresolved.[9] According to this study, frank numbness in the affected limb was not observed.[9] Kennon et al. reported incidence of LFCN injury in only 5 out of 2,132 cases (<0.01%) with a curved transverse incision or short straight incision.[10] One multicenter observational study found neurological impairment in 13 out of 1,152 patients who underwent THA through DAA: seven cases of palsy of the LFCN, five cases of numbness in the lateral aspect of the thigh and one case of anterolateral thigh paresthesia.[11,12]

These data point out the significance of LFCN as a possible structure that may be injured during DAA.

The ascending and descending branch of the LFCA should be identified carefully as their location below the line of the incision between the sartorius and the TFL may lead to accidental injury. Failure to identify the vessels and accidental damage to their wall may cause excessive blood loss and lead to undesired complications.[2] Routine electrocauterization has been reported as a proper method for ligation of these vessels.[2] Failure to provide hemostasis can increase the risk of postoperative hematoma formation. The course of the vessels may vary and instead of arising from the profunda femoris, they may arise from the femoral artery proximally to the origin of profunda femoris or together with the obturator artery. The vessels may be doubled or made up of a number of separate arteries, which may form a common stem in 72-75%.[13]

The precise site of the incision can be determined through two methods. One is to palpate the ASIS and then measure 3 cm laterally and 3 cm distally which determines the starting point.[14] The incision then follows the longitudinal axis of the TFL.[14] This approach was used to perform the anterior approach incision in the present study. Another method used to find the incision site is to draw a line between the ASIS and the greater tuberosity (GT). The proximal extent of the incision starts on this line about halfway between the two landmarks.[14]

The reported benefits of the DAA include a fast postoperative recovery, less intraoperative blood loss, minimal soft tissue dissection and trauma and small size of the incision.[17] There is still a certain degree of controversy in literature regarding the precise definition of minimally invasive hip arthroplasty with regard to the size of the incision.[16,17] Some authors have considered an incision of fewer than 10 cm, while others ignore the size of the incision as part of the definition.[8] One of the basic principles in orthopedic surgery is to ensure approach through intermuscular and internervous planes to minimize soft tissue trauma.[8] In interventions on the hip joint, this condition is met only by the DAA.[8] The technique is known to enhance the accuracy of acetabular cup positioning and to improve postoperative rehabilitation while having comparable outcomes in terms of loosening or component failure. Another benefit of the procedure is the decreased amount of thromboembolic events compared to other approaches.[18] The specific location of the anatomic structures described in the present study and the risk of injury represent an important disadvantage of this method.

CONCLUSION

The direct anterior approach has proven to be a preferred method for mini-invasive hip surgery used in THA. The advantages of this method include decreased time for postoperative recovery and minimal trauma to the soft tissues. This study demonstrates the location and course of the LFCN and LFCA which may be encountered and damaged during DAA and provides important information intended to help surgeons minimize the risk of neurovascular injury.

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