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Anterolateral Intermuscular Approach for Type A2 Intertrochanteric Fractures: A Cadaveric Study

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This cadaveric study was designed to clarify the anatomic basis of using an anterolateral intermuscular approach to repair type A2 intertrochanteric fractures (ITF). The conventional lateral approach to surgery that is used for ITF has several disadvantages that can result in both intraoperative and postoperative complications, especially for type A2 ITF. Previous studies have suggested using minimally-invasive total hip arthroplasty (THA) with an anterolateral approach. The legs of 10 formalin-fixed Asian cadavers were dissected, simulating an anterolateral surgical approach. The distances from the superior gluteal nerve and the lateral femoral circumflex artery branches to the lateral protrusive point of the greater trochanter were measured. The anterolateral intermuscular approach provided excellent exposure of the GT, the lesser trochanter and the femoral neck. The gluteus medius branch of the ascending branch of the lateral femoral circumflex artery (GMB-LFCA) and the most inferior branch of the superior gluteal nerve (MIB-SGN) were found to cross the spatium intermusculare between the gluteus medius and the tensor fasciae latae. The distance from the GMB-LFCA, in the intermuscular plane, to the lateral protrusive point of the GT was (4.04 $\pm$ 1.00 cm, range 2.96–6.62 cm); and the distance from the MIB-SGN to the lateral protrusive point of the GT was (5.47 $\pm$ 1.61 cm, range 3.68–9.56 cm). The anterolateral intermuscular approach is relatively safe, provides excellent exposure, and causes less soft-tissue damage than the traditional approach, and it represents a promising new method to surgically treat type A2 ITF.

Key words: Intertrochanteric fracture – Anterolateral approaches – Cadaveric study – Superior gluteal nerve – Lateral femoral circumflex artery

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Intertrochanteric fracture (ITF), the most common orthopedic injury among the elderly population, refers to the fracture that occurs between the basal portion of the femoral neck and the inferior margin of the lesser trochanter. Osteoporosis and low-energy trauma are the main causes of ITF. With the rapid development of transport and the aging global population, the incidence of ITF is increasing.[1] Several clinical classifications of ITF exist, but the most widely-used classification is AO classification system. Traditionally, most ITFs have been treated surgically with extramedullary and intramedullary fixation systems or with total hip arthroplasty (THA). The dynamic hip screw (DHS), as a representative device of the extramedullary fixation system, remains the standard implant for the surgical treatment of ITF, particularly in cases of stable ITF. Although intramedullary fixation, including the gamma nail and proximal femoral nail (PFN), has overtaken the DHS in the treatment of ITF during the past decade,[2] multiple randomized trials and meta-analyses have failed to show a clear advantage of nails over DHS or vice versa for stable fractures.[3,4] Furthermore, Pui *et al*[5,6] reported that there were also some disadvantages of intramedullary fixation compared with the DHS. THA, however, is appropriate for partially complicated ITF or the conversion after failed internal fixation (extramedullary or intramedullary) of ITF.[7,8] Currently, the lateral approach, which provides direct access to the vastus lateralis muscle from lateral thigh, is the most commonly-used surgical approach for ITF. Unfortunately, this conventional approach has some disadvantages, including limited exposure and substantial bleeding, as well as the need for repeated fluoroscopy and a long surgery duration, all of which may not be fit for type A2 ITF and negatively impact postsurgical rehabilitation. In 2004, Bertin and Rottinger[9] described an anterolateral muscle-sparing minimally invasive THA that exploited the interval between the tensor fasciae latae and gluteus medius. After a decade, the popularity of this surgical technology has increased because of the potential for reduced blood loss, reduced soft tissue damage, shorter hospitalization, and faster recovery.[10–12] The main advantage of this surgical approach is that it provides excellent exposure of the femoral neck, with little soft tissue injury. In theory, fractures of the proximal femur would be amenable to treatment using this approach. Therefore, we designed the study that investigates the effect of using an anterolateral intermuscular approach to treat type A2 ITF.

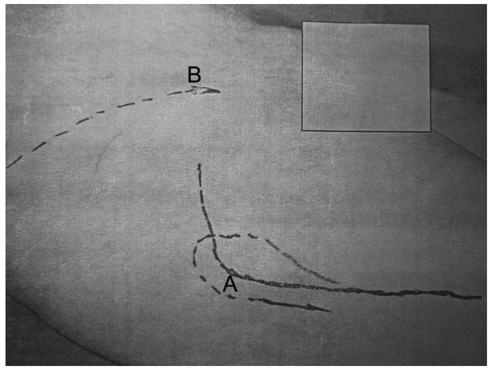

Fig. 1 A skin incision at the hip joint using the anterolateral intermuscular approach (lateral view of the hip): (A) the anterior superior iliac spine (ASIS); (B) the lateral protrusive point of the greater trochanter.

Materials and Methods

Ten formalin-soaked adult cadaveric specimens (6 males, 4 females) with a mean age of 71.1 years (range, 59–81 years) were used to simulate the anterolateral intermuscular approach in this anatomic study. None of the cadavers demonstrated any gross pathology or previous surgical treatment in the examined area.

Each specimen was placed in a calibrated steel frame in the supine position, and the dissections were performed by a skilled anatomist. The anterior superior iliac spine and the lateral protrusive point of the GT were identified and marked (Fig. 1). After removing the skin and subcutaneous tissue, the fascia latae was incised in the space between the gluteus maximus and medius. The fascia was elevated to expose the tensor fasciae latae, the gluteus medius, and the spatium intermusculare between the two muscles (Fig. 2a). The intermuscular fat was cut and completely removed to reveal the GMB-LFCA and the MIB-SGN. Next, the vastus lateralis muscle was partially incised from its origin (i.e., the posterior lateral linea aspera) and cut in the direction of the muscle fiber, its attachment to the femur was released to reflect the proximal femur (Fig. 2b).

The distances from the GMB-LFCA and MIB-SGN passing through the intermuscular interval to the lateral protrusive point of the GT were measured (Figs. 3a, b, c). All measurements were made using Vernier calipers.

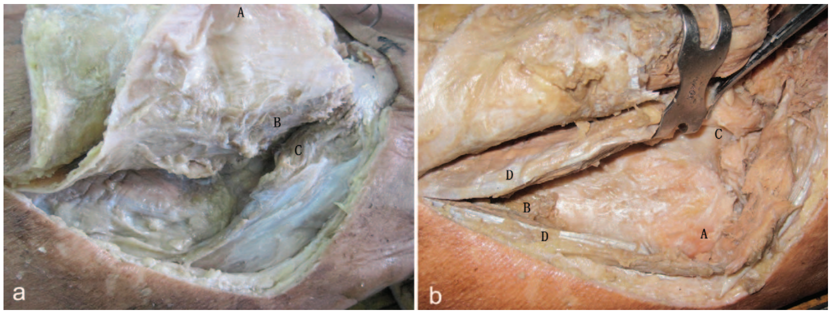

Fig. 2a The spatium intermusculare and the surrounding structures: (A) the fascia latae; (B) the tensor fasciae latae; (C) the gluteus medius.

Fig. 2b The proximal femur and the surrounding structures: (A) the greater trochanter of the femur; (B) the femur; (C) the neck of the femur; (D) the vastus lateralis muscle.

Results

The exposure of the lesser trochanter and femoral neck was excellent, and the soft tissue injury surrounding the incision was minimal using the anterolateral intermuscular approach. Meanwhile, the GMB-LFCA and MIB-SGN were found in the spatium intermusculare.

The SGN exits the suprapiriformis foramen through the intermuscular plane between the gluteus medius and gluteus minimus, the trunk of the nerve is divided into 2 or 3 branches that supply the gluteus medius, gluteus minimus, and tensor fasciae latae. In this specimen group, the distance from the MIB-SGN to the GT interval was 5.47 ± 1.61 cm, range 3.68–9.56 cm.

The LFCA arose laterally to the profunda femoris vessel, passed laterally to the deep aspect of the Sartorius and rectus femoris and divided into ascending, transverse, and descending branches. The GMB-LFCA arose from the ascending branch of the LFCA, which passed superiorly to the lateral side of the hip to the side of the tensor fasciae latae, crossed the intermuscular interval between the tensor fasciae latae and gluteus medius, and supplied the gluteus medius. The distance from the GMB-LFCA in the spatium intermuscular to the lateral protrusive point of the GT was 4.04 ± 1.00 cm, range 2.96–6.62 cm.

Discussion

The present study of the anterolateral intermuscular approach utilized a reverse L-shaped skin incision approximately 16 cm in length, including the top and bottom of the GT. The upper incision along the spatium intermusculare between the tensor fasciae latae and the gluteus medius ranged from the lateral protrusive point of the GT to the anterior superior iliac spine.[9] Zhang *et al*[13] reported that the surface projection of the anterior border of the gluteus medius was a line that pointed from the lateral protrusive point of the GT to 6 cm posterior to the anterior superior iliac spine, this line would move forward or backward according to the cadaver's height and weight. The lower incision, which measured approximately 10 cm in length, ranged from the lateral protrusive point of the GT to the vastus lateralis muscle, along the muscle fibers.

Many anatomic reports have described SGN anatomy and its variations, as used in different

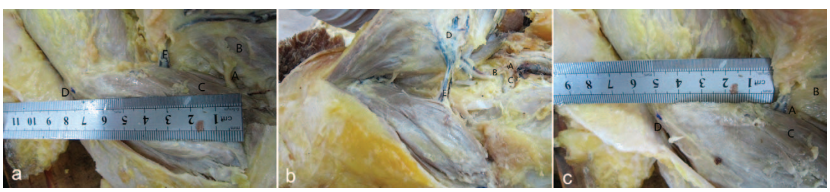

Fig. 3a The most inferior branch of the superior gluteal nerve (MIB-SGN) and the surrounding structures: (A) the MIB-SGN; (B) the tensor fasciae latae; (C) the gluteus medius; (D) the lateral protrusive point of greater trochanter; E) the GMB-LFCA.

Fig. 3b The lateral femoral circumflex artery (LFCA): (A) LFCA; (B) the ascending branch of lateral femoral circumflex artery(AB-LFCA); (C) the transverse branch of lateral femoral circumflex artery (TB-LFCA); (D) the tensor fasciae latae branch of the lateral femoral circumflex artery (TFLB-LFCA); (E) the gluteus medius branch of the lateral femoral circumflex artery (GMB-LFCA).

Fig. 3c The gluteus medius branch of the lateral femoral circumflex artery (GMB-LFCA) and the surrounding structures; (A) the GMB-LFCA; (B) the tensor fasciae latae; (C) the gluteus medius; (D) the lateral protrusive point of the greater trochanter.

THA approaches.[14,15] In this cadaver study, the MIB-SGN stretched laterally between the gluteus medius and gluteus minimus, passed through the interval between the gluteus medius and tensor fasciae latae and innervated and ultimately terminated in the tensor fasciae latae, in accordance with previous studies.[16–19] SGN injury, including overstretching the nerve, may occur in hip surgery or while retracting or detaching of muscles, thereby causing abductor weakness and a postoperative limp with a positive Trendelenburg's sign.[14,15,19–22] A safe area, therefore, was defined with regard to the distance between the caudal branch of the SGN and the apex of the GT.[15,23] Although different researchers reported variable values for this distance, an average distance of 3–5 cm from the MIB-SGN to the tip of the GT has been reported in most studies.[15,19,24–26] In contrast to previously-published studies, which used the tip of the GT, our study employed the lateral protrusive point of the GT as the reference point and the critical point between the upper and lower incision. In our study, the mean distance from the MIB-SGN to the lateral protrusive point of the GT was 5.47 cm (range, 3.68–9.56 cm). Theoretically, the safe distance would be longer than previously studies. In addition, the risk of traction injury would certainly be reduced for the lower incision of the GT, and no surgical procedures in the interval differed from the minimally-invasive THA. Considering these factors, we believed that there would be minimal risk of damaging the MIB-SGN when using an anterolateral intermuscular approach to repair type A2 ITF.

To the best of our knowledge, no studies have investigated using the GMB-LFCA in THA with the anterolateral muscle-sparing approach. Wang *et al*[27] reported that this vessel, which passed through the spatium intermusculare, supplied the gluteus medius and terminated in the lateral of the GT, showed rare anatomic variation. Although the gluteus medius is supplied by several vessels, including the deep branch of the superior gluteal artery (SGA), deep branch of the medial femoral circumflex artery (MFCA), and ascending and transverse branches of the LFCA, it is essential to avoid GMB-LFCA injury as much as possible to limit blood loss. In our report, the mean distance from the GMB-LFCA in the intermuscular interval to the lateral protrusive point of the GT was 4.04 cm (range, 2.96–6.62 cm). The femoral neck could be located by moderate traction without injuring the GMB-LFCA because of the low muscle tension caused by the distant incision under the GT.

Using the conventional direct lateral approach to the thigh for ITF, the vastus lateralis muscle was split longitudinally along the inferior border of the GT, causing substantial blood loss and damage to the overlying soft tissues, which healed nearly cicatricially after the surgery.[28] Moreover, it was difficult to achieve anatomic reduction and fixation because the conventional approach did not provide an adequate surgical field, especially for type A2 ITF. Repeated fluoroscopy, which prolonged the operative time and increased the risk of anesthesia complications, seemed unavoidable during the surgery. Moreover, the soft tissues of the surgical site eventually became rigid and adhered to the callus postoperatively, causing unsatisfactory hip joint function. In contrast, using an anterolateral approach, which took advantage of the spatium intermuscular between the gluteus medius and tensor fasciae latae, the upper incision allowed excellent surgical visualization of the GT and femoral neck; and the lower incision split the vastus lateralis muscle along its muscle fibers, with minimal soft-tissue trauma. The reduction and fixation of the fracture, achieved under direct view, was fairly reliable not only in the lateral but also in the medial aspect of the GT.[29] Furthermore, intraoperative real-time fluoroscopy and the surgical time were reduced significantly compared with the conventional surgical approach.

Several limitations of this study warrant mention. First, the incision was longer using the anterolateral approach compared to the direct lateral approach. However, soft-tissue injury and blood loss were less with the anterolateral approach, because of the design of the modified incision, which exploited the intermuscular plane and split the vastus lateralis muscle along its muscle fibers. Second, we investigated the GMB-LFCA and MIB-SGN in the interval rather than the entire course of the vessels and nerve because it was not necessary to split the tensor fasciae latae and gluteus medius in the anterolateral approach. Finally, our study did not consider body height when standardizing the safe area of SGN because the number of cadaveric specimens is limit and previous studies have reported varied and even contradictory results.[15,25,30] Further research with a larger number of cadaveric specimens is required to better define the safe area based on body height.

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