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Position of the superficial femoral artery in closed hip nailing

Received: 24 June 2003 / Published online: 29 January 2004
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Abstract *Introduction:* Adduction of the ipsilateral hip joint is necessary to facilitate closed hip nailing for trochanteric fracture. Even though positioning the patient supine with the perineal post against the ipsilateral medial thigh can change the course of the neurovascular structure in the proximal thigh, there have been no reports regarding the position of the femoral artery in the hip nailing position. *Materials and methods:* We studied the position of the superficial femoral artery in 59 thighs using color-flow duplex scanning method in three hip nailing positions. *Results:* The mean of the distance between the superficial femoral artery and the femur in 48 normal limbs was 20.28 mm in neutral position (D1), 11.85 mm in 20° adduction (D2), and 9.53 mm in 20° adduction plus 20° internal rotation of the foot plate (D3). The distances D2 and D3 were always shorter than D1 ($p < 0.001$). D3 was less than 10 mm in 30 of the normal limbs (62.5%) and less than 5 mm in 4 (8%). In 11 patients who sustained a trochanteric fracture, the mean of D1, D2, and D3 in the injured limbs was 25.28 mm, 17.98 mm, and 14.38 mm, respectively. The mid-thigh circumference and D3 of the injured limbs were always greater than those of the normal limbs ($p < 0.001$). However, D3 of both sides was less than 10 mm in 3 patients. *Conclusion:* To lessen the vascular injury during hip nailing, we recommend that the limb be placed in neutral position during preparation of the interlocking holes.

Keywords Trochanteric fracture · Intramedullary nailing · Superficial femoral artery · Ultrasound

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Introduction

The incidence of osteoporosis and trochanteric fracture has increased due to prolongation of the life expectancy [1, 9]. Internal fixation with sliding hip screw or intramedullary hip nail has been a standard treatment for trochanteric fracture. Among the complications associated with the trochanteric fracture, pseudoaneurysm of the deep femoral artery and its branch has been intermittently reported in the literature after internal fixation by fixed angle plate or sliding hip screw [2, 5, 6, 7, 8, 10, 11, 15]. It was first reported in 1964 and occurred in nine patients during 10 years thereafter [15]. There has been no report of gangrene of the ipsilateral limb due to the development of a pseudoaneurysm of the deep femoral artery. However, it may cause a compartment syndrome of the thigh and produce a huge mass which needs excision or vascular stent operation to prevent rupture of the pseudoaneurysm [8, 14]. Since the trochanteric fracture occurs in the geriatric patient, the second operation increases the risk of the anesthesia and the general complications related to surgery. Deeply inserted retractors, which hold the deep femoral vessels close to the femur during the side plate fixation, have been highlighted as a potentially offending instrument as well as plunging of the drill bit [6]. Compared with the sliding hip screw fixation, closed hip nailing needs more adduction of the limb to allow the reamer and the nail to be kept outside the iliac wing during the procedure. Positioning the patient supine in adduction with the perineal post against the ipsilateral medial thigh can compress and shift the neurovascular structure of the medial thigh. We experienced a case of pseudoaneurysm of the superficial femoral artery at the level of the interlocking hole after closed hip nailing for trochanteric fracture [14]. We studied the position of the superficial femoral artery in 59 thighs using color-flow duplex scanning method in three hip nailing positions to scrutinize the factors that could narrow the safety margin.

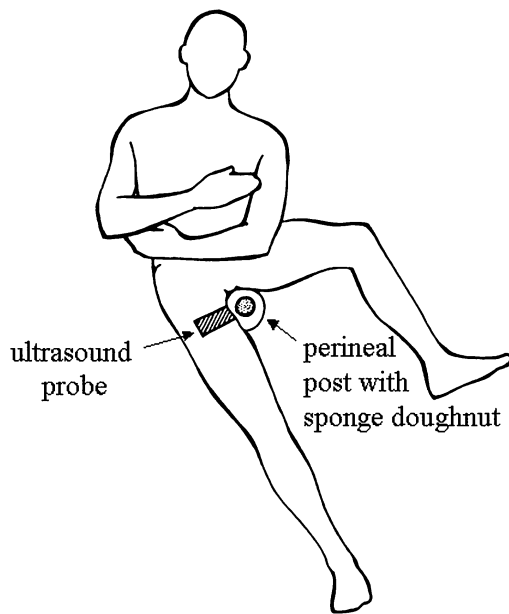
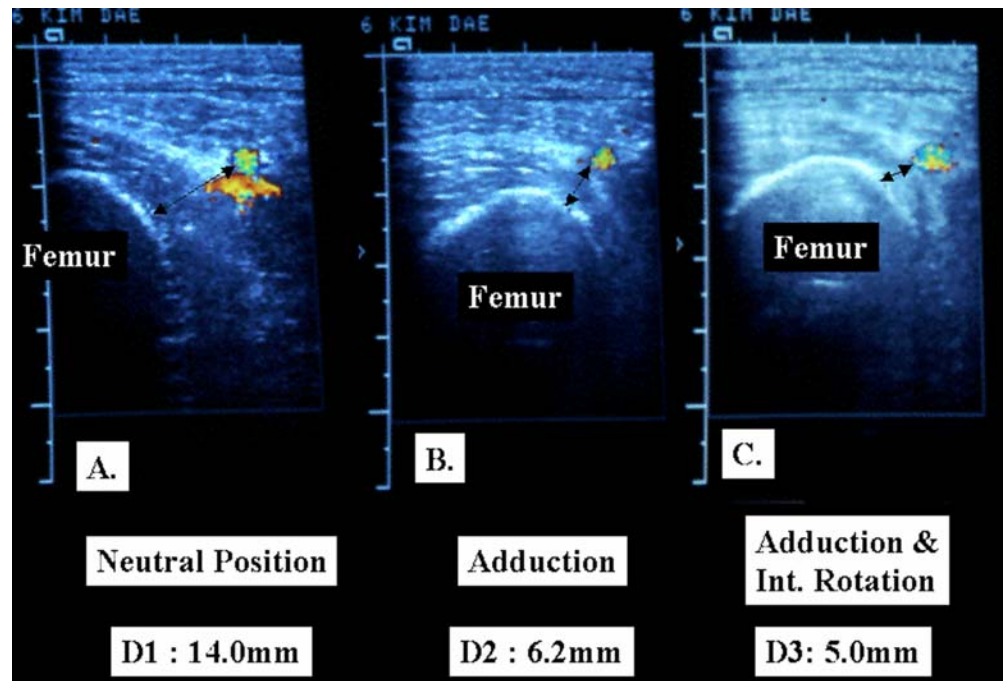


Fig. 1 The test limb was fixed on a foot plate and the other limb was held in a leg holder. The perineal post, which was encircled with spongy doughnut, was placed between the limbs. The ultrasound probe was placed on the anterior aspect of the proximal thigh at level of maximum compression. The figure depicts the position for D2 measurement

Patients and methods

The superficial femoral artery of 59 thighs was examined by color-flow duplex scanning in three positions [3]. Bilateral measurements were performed in 12 healthy volunteers (24 normal limbs) and 11 patients who sustained a trochanteric fracture (11 normal and 11 injured limbs). Thirteen volunteers underwent unilateral measurement due to an injury of the contralateral leg (13 normal limbs).

Fig. 2A–C The position of the superficial femoral artery was assessed using the color-flow duplex scanning method. **A** The distance between the superficial femoral artery and the femur was measured in neutral position (D1, 14.0 mm). **B** The superficial femoral artery was shifted to the femur along the coronal plane when the limb was adducted. It was located anteriorly and medially to the femur (D2, 6.2 mm). **C** When the limb was adducted and rotated internally, it was shifted medially (D3, 5.0 mm). The distance between large bar on the ordinate is 10 mm



The patient or volunteer was placed on the fracture table in the supine position. The perineal post, which was encircled with spongy doughnut, was placed between the limbs at the perineum. The outer diameters of the metal core of the perineal post and sponge doughnut were 3 cm and 12 cm, respectively. The center of the perineum was adjusted to the center of the post, and slight traction was applied on the test limb to lessen the movement of the limb. The test limb was fixed on a foot plate, and the other limb was held in a leg holder. The position of the superficial femoral artery was assessed using color-flow duplex scanning with an Acuson 128 ultrasound machine (Acuson, Mountain View, CA, USA) equipped with a 7-MHz linear array transducer. The probe was placed on the anterior aspect of the proximal thigh at the level of maximum compression (Fig. 1). It was at the level of the center of the perineal post and was approximately 8–9 cm from the perineum. We measured the mid-thigh circumference (MTC) at this level. The position of the superficial femoral artery was assessed in the neutral position (D1), 20° adduction (D2), and 20° adduction and 20° internal rotation (D3). Degree of adduction was defined as the angle between the longitudinal axis of the trunk of the patient and the arm of the fracture table, which held the test lower limb. Degree of rotation of the test limb was defined as the angle of the foot plate. The distances between the superficial femoral artery and the femur were measured in each position (Fig. 2). The superficial femoral artery was shifted towards the femur along the coronal plane when the limb was adducted (D2; Fig. 2B). It was located anterior and medial of the femur. When the limb was rotated internally (D3), it was shifted medially (Fig. 2C). The relationship of these three distances was analyzed using ANOVA method in 48 normal thighs. Pearson correlation coefficients were checked for age, sex, body weight, and MTC. In 11 patients who sustained a trochanteric fracture, we compared these three distances of the injured limbs with those of the normal side using Student's paired *t*-test.

Results

Normal limbs

The patients' mean age was 51.6 years (range 17–89 years). The means of 48 normal limbs were 20.28 ± 5.64 mm in

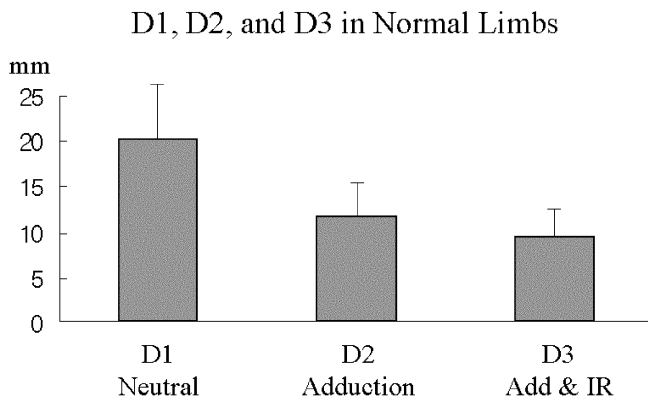


Fig. 3 Means of three distances (*D1*, *D2*, and *D3*) in 48 normal thighs. The bar indicates one standard deviation

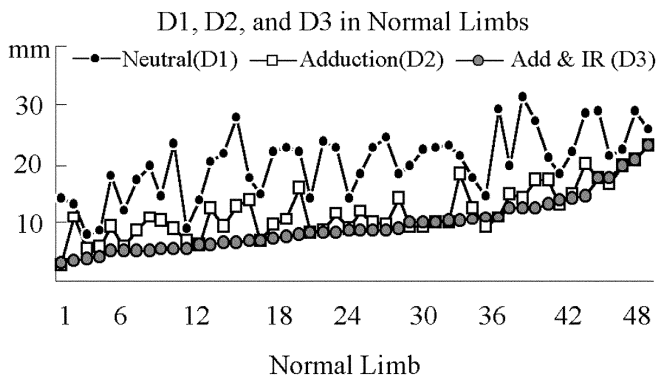


Fig. 4 Three distances (*D1*, *D2*, and *D3*) in 48 normal thighs are plotted. The data from normal limbs were arranged according to the value of *D3*. *D2* and *D3* were always shorter than *D1* ($p < 0.001$). *D3* was less than 10 mm in 30 of the normal limbs (62.5%) and less than 5 mm in 4 (8%). *D2* and/or *D3* was less than 5 mm in 5 thighs

D1 (range 8.0–31.6 mm), 11.85 ± 4.51 mm in *D2* (range 2.9–23.2 mm), and 9.53 ± 4.67 mm in *D3* (range 3.0–23.2 mm) (Fig. 3). The distances *D2* and *D3* were always shorter than *D1* ($p < 0.001$). *D3* was less than 10 mm in 30 of the normal limbs (62.5%) and less than 5 mm in 4 (8%) (Fig. 4). The mean of MTC was 42.8 cm (range 28–55 cm). Pearson correlation coefficients of MTC were 0.36 in *D1* ($p = 0.0297$), 0.44 in *D2* ($p = 0.0069$), and 0.223 in *D3* ($p = 0.190$). Pearson correlation coefficients of age were -0.19 in *D1* ($p = 0.26$), -0.25 in *D2* ($p = 0.14$), and -0.23 in *D3* ($p = 0.17$). Pearson correlation coefficients of height were 0.13 in *D1* ($p = 0.45$), 0.24 in *D2* ($p = 0.16$), and 0.17 in *D3* ($p = 0.30$). Pearson correlation coefficients of body weight were 0.17 in *D1* ($p = 0.30$), 0.38 in *D2* ($p = 0.02$), and 0.21 in *D3* ($p = 0.23$). The people with low body weight had short *D2*. But differences in *D3* were not statistically significant.

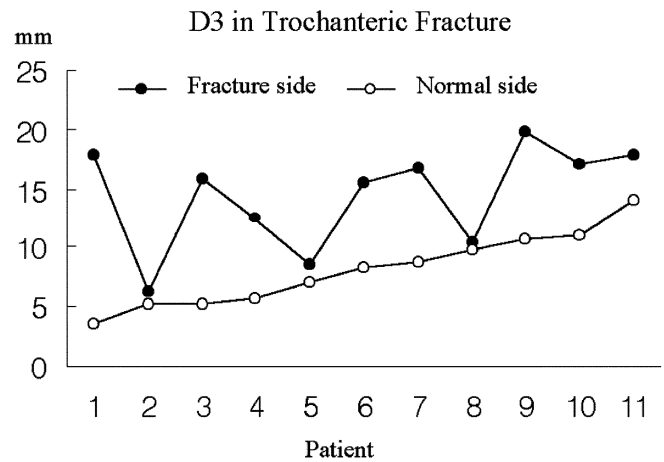


Fig. 5 Comparison of *D3* in trochanteric fracture patients. The data were sorted according to the value of *D3* on the normal side. The difference of *D3* between two sides was small in three patients (numbers 2, 5, and 8) compared with the other patients. The distance *D3* was less than 10 mm in these patients on both sides. Protective soft-tissue swelling was less effective than in other patients

Comparison of normal and injured limb in trochanteric fracture patients

In 11 patients who sustained a trochanteric fracture, the means of *D1*, *D2*, and *D3* in the injured limbs were 25.28 ± 5.42 mm, 17.98 ± 5.63 mm, and 14.38 ± 4.37 mm, respectively. The means of *D1*, *D2*, and *D3* on the normal side were 18.39 ± 5.93 mm, 9.88 ± 2.48 mm, and 8.07 ± 3.12 mm, respectively. These normal side data formed part of the data from normal limbs mentioned above. *D1*, *D2*, and *D3* on the injured side were always longer than those on the normal side, respectively ($p < 0.001$). Comparison of *D3* on both sides revealed that the difference between sides was small in three patients (numbers 2, 5, and 8). The distances *D3* of both sides were less than 10 mm (Fig. 5). The mean MTC of the injured limb was 43.2 ± 4.2 cm and was always larger than that of the normal side, 37.0 ± 4.0 cm ($p < 0.001$).

Discussion

The main cause of pseudoaneurysm of the femoral artery after internal fixation of the trochanteric fracture is plunging of the drill bit and screws [2, 5, 6, 7, 8, 10, 13, 15]. It usually occurs at the third or fourth holes of the side plate of sliding hip screws or fixed angle plate, where the deep femoral artery and perforating branches are close to the femur. Compared with sliding hip screw fixation, closed hip nailing requires more adduction of the injured limb, and it is essential in hip nailing by minimally invasive techniques. Adduction of the limb against the perineal posts changes the course of important neurovascular structures. Cross-sectional anatomy of the normal thigh shows that the superficial femoral artery runs more anteriorly and medially than the deep femoral artery in the proximal one-third of the thigh [4]. This study confirmed that the superficial femoral

artery lies marginally on the medial aspect of the femur, when the limb is fixed on the fracture table in adduction and internal rotation in some patients. It was fixed between the perineal post and femur and abutted significantly to the femur. In this study, it was difficult to locate the deep femoral artery, which has been reported to be injured during internal fixation for trochanteric fracture by sliding hip screw. The superficial and deep femoral arteries are close to the femur at 5–7 cm distant from the lesser trochanter.

The intramedullary hip nails vary in length from 18 to 24 cm. The level of interlocking holes of the short Asian-type hip nail was close to the third and fourth holes of the side plate of the sliding hip screw [14]. Encircling the perineal post with spongy doughnut to protect the perineum shifted the site of compression unexpectedly to a more distal part of the limb. The levels of interlocking hole in the short Asian-type hip nail and in the standard nail are different. The longer the hip nail, the lower the distal interlocking hole. Further study is needed to check D1–3 at the various levels from the inguinal ligament. Rotation of the limb for satisfactory reduction of the trochanteric fracture usually depends on the severity and location of the fracture [12]. In general, the limb is fixed in adduction and internal rotation for satisfactory reduction when the level of the trochanteric fracture is high.

Soft-tissue swelling around the trochanteric fracture increased the distances between the superficial femoral artery and the femur at the proximal thigh. This could provide a reasonable explanation for the rarity of pseudoaneurysm after internal fixation. But D3 of three trochanteric patients was less than 10 mm. Since the MTC and body weight are well correlated with the distances we measured, it is necessary to pay special attention to thin patients. Our case of pseudoaneurysm of the superficial femoral artery occurred in a hemiplegic patient. She sustained undisplaced trochanteric fracture on the hemiplegic side, which was fixed by a Gamma Asia-Pacific locking nail (nail length 18 cm) in adduction and internal rotation [14]. Atrophy of the thigh muscle, minor swelling, and adduction and internal rotation of the limb during the procedure seemed to be the provocative factors in this patient. Hemiplegia and hemiparesis are usually associated with disuse osteoporosis, muscle atrophy, and defective defense mechanisms and are regarded as important risk factors of ipsilateral hip fracture [14, 15]. Popularity of the minimally invasive techniques and increased incidence of trochanteric fracture in the elderly patients imply that we should be more careful with hip nailing. Hakan et al. (Malmo, Sweden) and Yoon et al. (Bundang, Korea) also found pseudoaneurysm of the superficial femoral artery after Gamma nailing (personal communication). After insertion of nail and hip screw, drilling for the interlocking hole can be performed without adduction of the limb. Neutral position of the limb could widen the safety margin and keep the femoral artery away from the operating site.

In conclusion, positioning the patient supine with the perineal post against the ipsilateral medial thigh could shift the superficial femoral artery towards the femur during closed hip nailing. To lessen the risk of vascular injury, we recommend that the injured limb be placed in neutral position during the preparation of the interlocking holes in closed hip nailing, especially in lean patients with minor swelling of the thigh.

Acknowledgements This study was supported by Brain Korea 21 Project for Medical Science, Yonsei University.

References

1. Cooper C, Melton LJ III (1996) Magnitude and impact of osteoporosis and fractures. In: Marcus R, Feldman D, Kelsey J (eds) Osteoporosis. Academic Press, San Diego, pp 419–434
2. Ebong WW (1978) False aneurysm of the profunda femoris artery following internal fixation of an intertrochanteric femoral fracture. *Injury* 9:249–251
3. Farrington WJ, Charnley GJ, Harries SR, Sharp R, Hughes PM (1999) The position of the popliteal artery in the arthritic knee. *J Arthroplasty* 14:800–802
4. Faure C, Merloz P (1987) Transfixation – atlas of anatomical section for the external fixation of limbs. Springer, Berlin Heidelberg New York, pp 65–89
5. Fernandez Gonzalez J, Terriza MD, Cabada T, Garcia-Araujo C (1995) False aneurysm of the femoral artery as a late complication of an intertrochanteric fracture. *Int Orthop* 19:187–189
6. Fordyce A (1968) False aneurysm of the profunda femoris artery following nail and plate fixation of an intertrochanteric fracture – report of a case. *J Bone Joint Surg Br* 50:141–143
7. Karanikas I, Lazarides M, Arvanitis D, Papayanopoulos G, Exarchou E, Dayantas J (1993) Iatrogenic arterial trauma associated with hip fracture surgery. *Acta Chir Belg* 93:284–286
8. Karkos CD, Hughes R, Prasad V, D'Souza SP (1999) Thigh compartment syndrome as a result of a false aneurysm of the profunda femoris artery complicating fixation of an intertrochanteric fracture. *J Trauma* 47:393–395
9. Khosla S, Melton LJ III (1995) Secondary osteoporosis. In: Riggs BL, Melton LJ III (eds). Osteoporosis. Etiology, diagnosis, and management. Lippincott-Raven, Philadelphia, pp 183–204
10. Manner M, Rosch B, Roy K (1999) Vascular injuries complicating osteosynthesis in proximal femur fracture. *Unfallchirurg* 102:227–231
11. Murphy PG, Geoghegan JG, Austin O, Nore-O'Ferrall R, Quinlan WR, Keaveny TV (1999) Pseudoaneurysm of the profunda femoris artery due to intertrochanteric fracture of the hip. *Arch Orthop Trauma Surg* 119:117–118
12. Parker MJ, Pryor GA (1993) Hip fracture management. Blackwell Scientific Publications, Oxford, pp 65–87
13. Rickman M, Saley M, Gaines PA, Eyres K (1999) Vascular complications of osteotomies in limb reconstruction. *J Bone Joint Surg Br* 81:890–892
14. Yang KH, Park HW, Park SJ (2002) Pseudoaneurysm of the superficial femoral artery after closed hip nailing with a gamma nail: report of a case. *J Orthop Trauma* 16:124–127
15. Wolfgang GL, Barnes WT, Hendricks G (1974) False aneurysm of the profunda femoris artery resulting from nail plating fixation of intertrochanteric fracture – a case report and review of the literature. *Clin Orthop* 100:143–150