Anatomy of the medial femoral circumflex artery and its surgical implications

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The primary source for the blood supply of the head of the femur is the deep branch of the medial femoral circumflex artery (MFCA). In posterior approaches to the hip and pelvis the short external rotators are often divided. This can damage the deep branch and interfere with perfusion of the head.

We describe the anatomy of the MFCA and its branches based on dissections of 24 cadaver hips after injection of neoprene-latex into the femoral or internal iliac arteries.

The course of the deep branch of the MFCA was constant in its extracapsular segment. In all cases there was a trochanteric branch at the proximal border of quadratus femoris spreading on to the lateral aspect of the greater trochanter. This branch marks the level of the tendon of obturator externus, which is crossed posteriorly by the deep branch of the MFCA. As the deep branch travels superiorly, it crosses anterior to the conjoint tendon of gemellus inferior, obturator internus and gemellus superior. It then perforates the joint capsule at the level of gemellus superior. In its intracapsular segment it runs along the posterosuperior aspect of the neck of the femur dividing into two to four subsynovial retinacular vessels. We demonstrated that obturator externus protected the deep branch of the MFCA from being disrupted or stretched during dislocation of the hip in any direction after serial release of all other soft-tissue attachments of the proximal femur, including a complete circumferential capsulotomy.

Precise knowledge of the extracapsular anatomy of the MFCA and its surrounding structures will help to

avoid iatrogenic avascular necrosis of the head of the femur in reconstructive surgery of the hip and fixation of acetabular fractures through the posterior approach.

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The intraosseous vascular anatomy of the head of the femur has been well described. The blood supply to the weight-bearing portion is derived from the medial femoral circumflex artery (MFCA). The deep branch of the MFCA gives rise to two to four superior retinacular vessels and, occasionally, to inferior retinacular vessels.¹⁻¹² The head can be completely perfused by the superior retinacular vessels alone.⁷ The medial epiphyseal artery usually perfuses only the perifoveolar area^{5,7-11,13-16} and rarely supplies a significant area of the head. Branches from the metaphyseal and lateral femoral circumflex arteries contribute very little.^{4,5,7,11,12,14}

The anterior aspect of the extraosseous course of the MFCA has been described in textbooks of anatomy,^{9,17-26} but the portion of the MFCA most important to the hip surgeon is the peripheral extracapsular division of the deep branch, which can be damaged during a posterior approach. No anatomy textbook or atlas of surgical approaches gives sufficient detail to guide the surgeon in reconstructive surgery.²⁷⁻³⁰

The frequency of vascular disturbances to the head of the femur can be explained by the terminal nature of the subsynovial branches of the MFCA and their exposed course along the neck.¹⁴ Necrosis of the head is due mainly to obstruction of the intraosseous vessels from atraumatic causes,^{31,32} and from direct mechanical damage by rupture, compression or kinking of the extraosseous vessels as a result of injury.^{3-5,12,33-38} Subcapital fractures are particularly prone to the development of osteonecrosis. It is in this region that the terminal branches of the MFCA enter the head.^{33,39} In traumatic dislocations and fracture-dislocations the neck and thus the subsynovial terminal branches remain intact. The deep branch, however, is at risk either in its extracapsular course, or at the point of entry into the capsule of the joint. Bauer, Kerschbaumer and Poisel⁴⁰ reported iatrogenic damage to the MFCA in inter-

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Table I. The five consistent branches of the MFCA

Branch	Path
Superficial	Courses between pectineus and adductor longus
Ascending	To adductor brevis, adductor magnus and obturator externus
Acetabular	Gives off the foveolar artery (medial epiphyseal artery)
Descending	Courses between quadratus femoris and adductor magnus, supplying the ischiocrural muscles
Deep	To the head of the femur

trochanteric osteotomy, especially with osteotomy of the greater trochanter. Necrosis of the head has also been reported after intramedullary nailing of the femur in adolescents with open growth plates,⁴¹⁻⁴⁴ and a rate of osteonecrosis of 5% to 31% has been reported with fractures of acetabulum. This is not considered to be iatrogenic^{30,45} but to be due to the injury.^{46,47}

Our aim was to investigate the course of the MFCA and its topographical relationship to the tendons of the external rotator muscles and the capsule of the hip.⁴⁸ We also investigated the effect of surgical dislocation of the head on the vessel.

Materials and Methods

We carried out bilateral anatomical dissections on 12 fresh cadavers. There were seven women and five men, with an age range between 60 and 80 years. None had evidence of previous trauma or surgery to the hip. In 20 hips, the common femoral artery was prepared and cannulated with a Venflon. The vessel was then injected with 200 to 250 ml of green-labelled neoprene-latex (Polychloroprene and Phtalocyanine Green; Lefranc & Bourgeois, Le Mans, France). In four hips, the injection was into the internal iliac artery. The common iliac artery was ligated proximally and the superficial femoral artery distally in order to reduce the volume of the injection. After polymerisation of the latex, dissections were carried out by sequential anterior and posterior surgical approaches.

In ten hips we measured the distances between the vessel and the lesser trochanter, and the insertions of the tendons of obturator externus and internus. In three hips the integrity and tension of the deep branch of the MFCA were tested during dislocation of the head after dividing all muscles at their insertion around the proximal femur. Photographs were taken with a 35 mm camera.

Results

Topography of the deep branch of the medial femoral circumflex artery. In 20 specimens the MFCA originated from the profunda femoris artery and in four from the common femoral artery. There are five consistent branches of the MFCA (Table I). The deep branch runs towards the intertrochanteric crest between the pectineus medially and the iliopsoas tendon laterally along the inferior border of obturator externus. Posteriorly, it can be identified in the space between quadratus femoris and the inferior gemellus.

In four specimens, there were two branches to the inferior aspect of the neck of the femur, the inferior retinacular vessels. At least one constant branch is given off adjacent to the proximal border of quadratus femoris, crossing over the trochanteric crest towards the lateral aspect of the greater trochanter, the trochanteric branch. The main division of the deep branch crosses posterior to the tendon of obturator externus and anterior to the tendons of the superior gemellus, obturator internus, and the inferior gemellus. It perforates the capsule of the hip obliquely just cranial to the insertion of the tendon of the superior gemellus and distal to the tendon of piriformis where it divides into two to four terminal branches. These course beneath the synovial sheath of the reflected portion of the capsule of the joint posterosuperiorly on the neck of the femur. They perforate at a distance 2 to 4 mm lateral to the bone-cartilage junction of the head (Fig. 1). We identified four terminal branches in 18 hips and two in six hips which had constant anastomoses. In 20 hips there was a more superior-dominant perfusion of the head, i.e., exclusively from the superior retinacular branches. In four hips, a contribution from additional posteroinferior branches was also found. The posterior aspect of the neck was free from retinacular vessels in all specimens.

Table II shows the mean distances of the deep branch of the MFCA to the superior aspect of the lesser trochanter, to the insertion of obturator externus and to the insertion of obturator internus.

Central and peripheral anastomoses of the MFCA. We have defined central anastomoses as those present medial or anterior to the lesser trochanter and peripheral anastomoses

Table II. Distances (mm) of the deep branch of the MFCA to the trochanteric crest

Pelvis	Side	Distances at the level of the		
		Lesser trochanter	Insertion of obturator externus	Insertion of obturator internus
1	R	10	6	8
	L	17	9	15
2	R	15	13	14
	L	20	15	13
3	R	16	5	10
	L	17	16	14
4	R	20	6	18
	L	20	8	12
5	R	22	4	10
	L	25	5	10
Mean		18.2	8.8	12.4

Fig. 1a

Fig. 1b

Figure 1a – Photograph showing the perforation of the terminal branches into bone (right hip, posterosuperior view). The terminal subsynovial branches are located on the posterosuperior aspect of the neck of the femur and penetrate bone 2 to 4 mm lateral to the bone-cartilage junction. Figure 1b – Diagram showing: 1) the head of the femur; 2) gluteus medius; 3) the deep branch of the MFCA; 4) the terminal subsynovial branches of the MFCA; 5) insertion and tendon of gluteus medius; 6) insertion of tendon of piriformis; 7) the lesser trochanter with nutrient vessels; 8) the trochanteric branch; 9) the branch of the first perforating artery; and 10) the trochanteric branches.

Table III. Anastomoses of the MFCA

Anastomosis with (artery, branch)	Anastomosis from (branch of MFCA)
Central	
Obturator artery	
Anterior (superficial) branch	Ascending branch
Posterior (deep) branch	Acetabular branch
Lateral femoral circumflex artery	
Descending branch	Deep branch at the base of the neck of the femur
Periphery	
First perforating artery	Trochanteric branch posterior to the quadratus muscle
Lateral femoral circumflex artery	
Transverse branch	Trochanteric branch
Superior gluteal artery	
Deep branch	Deep branch at insertion of gluteus medius
Inferior gluteal artery	Deep branch along inferior border of piriformis, posterior to conjoined tendon
Internal pudendal artery	Deep branch on the retroacetabular surface

as those lateral or posterior to it. There are two main central and five main peripheral anastomoses of the MFCA (Table III). All of the latter were found to be extracapsular, and the largest and most consistent was a branch of the inferior gluteal artery which runs along the inferior border of piriformis. This branch was often as large as the deep branch itself. In none of our adult specimens did we find an anastomosis with the ascending branch of the lateral femoral circumflex artery surrounding the base of the neck of the femur on the cranial aspect.

Surgical dislocation of the hip. In the three specimens in which sequential tenotomy of the muscle insertions around the proximal femur, including circumferential capsulotomy,

had been carried out, dislocation of the head of the femur did not influence the natural course and tension of the extracapsular deep branch and intracapsular branches of the MFCA, as long as obturator externus was left attached (Fig. 2). This observation was not influenced by the direction of displacement of the head. The maximal distance allowed by obturator externus, measured between the inferior border of the fovea capitis and the superior border of the fossa acetabuli, ranged between 9.5 and 11 cm.

Discussion

There is a striking difference in the reported rate of avascular necrosis (AVN) after uncomplicated dislocation and fracture-dislocation of the hip. After uncomplicated dislocation treated non-operatively the incidence of AVN is up to 11%,⁴⁶ while in fracture-dislocation treated operatively, it rises to 31%.^{30,45,47} From an anatomical point of view, the only significant difference between these two groups may be the iatrogenic trauma to the MFCA and/or its peripheral anastomoses during surgery. Our findings allow a possible explanation as to why traumatic dislocation can lead to AVN. We postulate that, at least in patients with early reduction, necrosis is due to rupture of obturator externus or its tendon and resultant damage to the deep branch of the MFCA.

The distances of the MFCA to specific anatomical landmarks reported in our study may serve as a guide to the orthopaedic surgeon when operating on the posterior aspect of the hip. As shown by the range of values between specimens, there is individual variation. The MFCA, however, is always furthest from the lesser trochanter and

Fig. 2a

Fig. 2b

Figure 2a – Photograph showing the integrity of the deep branch of the MFCA during dislocation of the head of the femur (right hip, superior view). After complete capsulectomy and tenotomy of all external rotators, except for the tendon of obturator externus, the head of the femur is dislocated with external rotation of the femur. There is no stretch or compression of the deep branch of the MFCA during dislocation and the normal course of the vessel remains unchanged. Obturator externus and its tendon protect the vessel. Figure 2b – Diagram showing: 1) the head of the femur; 2) the tip of the greater trochanter; 3) rectus femoris; 4) obturator externus and its tendon; 5) the acetabulum; and 6) quadratus femoris.

closest to the insertion of the tendon of obturator externus.

When using a Kocher-Langenbeck approach, we have changed our technique for incising the conjoined tendon. We first identify the consistent trochanteric branch of the MFCA. This gives the superior margin of quadratus femoris and, anterior to this, the position of the tendon of obturator externus. The next most proximal muscle belly to quadratus is gemellus inferior, followed by the tendons of obturator internus and gemellus superior. The conjoint tendon is then divided from distal to proximal (i.e., from unsafe to safe) about 1.5 cm or more from the trochanteric crest, where the deep branch still runs at the inferior border of the tendon of obturator externus. This tendon is never divided. If the tendons are reattached superficial sutures only should be used to prevent injury to the vessel.

Despite previous descriptions,^{9,12,14,17,18,20-22,24,49} we found no anastomotic branch surrounding the neck of the femur on its cranial aspect which communicated with the ascending branch of the lateral femoral circumflex artery. This anastomosis is seen before the age of one year before it undergoes involution.¹⁶ The lateral femoral circumflex artery contributes little to the vascularity of the head. There is a significant constant anastomosis between the MFCA and a branch of the inferior gluteal artery along piriformis. Our findings suggest that this anastomosis may be capable of compensating after injury to the deep branch of the MFCA. We have used this knowledge successfully when treating an osteosarcoma near the lesser trochanter in which radical resection included sacrifice of the MFCA. Vascularity of the femoral head was successfully preserved, apparently via the anastomoses.

Knowledge of the anatomy of the MFCA is also essential when performing both trochanteric and intertrochanteric osteotomies. The deep branch of the MFCA can be damaged, especially if retractors leave the posteromedial area proximal to the lesser trochanter unprotected. While isolated injury to the MFCA at this level may be inconsequential, the vascularity of the head may be interrupted by trochanteric advancement.

Intramedullary nailing of the femur may be complicated by AVN in children and adolescents.⁴¹⁻⁴⁴ Analysis of these reports shows that a common factor is the relatively large size of the implant, which is intended for use in adults and not for the rather thin adolescent neck of the femur. Preparation for insertion of the nail may damage the superior retinacular vessels. It is debatable whether the fact that the epiphyseal plate of the head of the femur may still be open contributes to the increased risk of the development of AVN.⁵⁰ The posterior surface of the neck is free from retinacular vessels which explains why an osteomyograft placed in this area does not lead to vascular disturbance of the head.^{51,52}

This study on the course of the MFCA may provide important information when considering future developments such as biological resurfacing of the hip.

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