

Vascular Anatomy of the Proximal Fibula from Embalmed Cadaveric Dissection

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Objectives: To study the vascular pattern of proximal fibula with use of embalmed cadaveric specimens.

Material and Method: The present study was done on 33 lower extremities from 19 embalmed human, adult cadavers. The average ages of the cadavers were 68.6 years (range from 36 to 98 years), 11 females and 8 males. The size and site of vessels around the proximal fibula were recorded.

Results: There were three main blood supplies of proximal fibular, the epiphyseal artery, the lateral genicular artery, and the periosteal blood supply. They are anterior tibial recurrent artery and posterior tibial artery or artery of the neck of fibula posteriorly. Inferior lateral genicular artery was seen in all specimens (33/33). Among them, 42.4% (14/33) had a single artery with double accompanied veins. The average diameter of artery and veins were 1.71 mm (0.75-2.25), and 1.69 mm (1.30-2.10), respectively. The others were single artery and single vein. The average diameter of artery and veins were 1.66 mm (0.65-2.14), and 2.1 mm (0.95-2.30) respectively. Anterior tibial recurrent artery was seen in 31 of 33 specimens (94%). The average size of artery and accompanying vein were 1.24 mm (0.8-2.1), and 1.86 mm (0.8-2.6), respectively. Posterior tibial recurrent artery was an inconsistent branch that appeared in only 11 of 33 specimens (33%). Artery of the neck of fibula appeared in 24 of 33 specimens (72.7%). The others were replaced by the predominant posterior tibial recurrent artery (7/33) and neither of them was found in two specimens.

Conclusion: Based on the present results, the authors recommend preserving the epiphyseal blood supply, the inferior lateral genicular artery, and the periosteal blood supply for free epiphyseal transfer. In addition, surgeons should pay attention to the variation of posterior periosteal blood supply because its variations will affect the viability percentage of proximal fibular epiphyseal transfer.

Keywords: Fibula, Vascular anatomy

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Proximal fibula was commonly used for free epiphyseal transfer to overcome deformities in growth. It has challenged and intrigued investigators since the late 19th century. Recently, developments in the field of microvascular surgery have stimulated experimental work in the transfer of free vascularized epiphyseal plates to maintain growth in the recipient sites. Clinical experiences are limited^(1,2). However, the advantage of transferring a bone with growth potential is attractive in the management of congenital limb deformities and

for cases in which trauma has prevented normal growth. There were three sources of blood supply of proximal fibular, the epiphyseal artery (inferior lateral genicular artery), the metaphyseal artery (nutrient branch from peroneal artery), and the periosteal artery (located circumferentially around the plate and communicate with both epiphyseal and metaphyseal circulations).

The experimental and clinical reports are encouraging and favor the use of three sources of epiphyseal blood supply for free epiphyseal transfer⁽³⁻⁵⁾. The metaphyseal arteries, nutrient branch of peroneal artery, are consistent and locate at 2.5 cm above mid-length of the fibula. The epiphyseal and periosteal artery supplies are not clearly demonstrated. The present

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study was the first of a series on the surgical dissection of vascular pattern of proximal fibula and aimed to describe the vascular pattern of proximal fibula with use of embalmed cadaveric specimens.

Material and Method

The present study was done on 33 lower extremities from 19 embalmed humans, adult cadavers. The average ages of the cadavers were 68.6 years (range from 36 to 98 years), 11 females and 8 males. None of the specimens had any evidence of previous knee surgery or fracture of the fibula. All dissections were performed in the lateral decubitus position of the lower extremities.

The initial dissection was carried out posteriorly to identify popliteal that usually indicate the lateral inferior genicular artery at 1-2 cm. proximal to the fibular head. The origin of lateral head of gastrocnemius and plantaris were carefully removed and medially retracted to identify posterior tibial recurrent artery and veins. The next step was removal of soleus origin from proximal fibula to expose the anterior tibial and peroneal

arteries. The artery of the neck of fibula was identified and searched for its location of branching.

The last dissection was carried out by removal of the muscles anterior to the proximal fibula to trace the anterior tibial artery and its branch, the recurrent anterior tibial artery. These arteries were identified when they pierced through the oval opening of the proximal interosseous membrane. The sizes and sites of all the arteries and veins were measured using vernier calipers. Variations of vascular patterns were recorded. The findings were presented in the figure form and all measurement arteries and veins summarized by mean, rang, number, and percentage.

Results

Site and Size variations

Inferior lateral genicular artery

From the present findings, inferior lateral genicular artery arose from the popliteal artery deep to gastrocnemius (Fig.1). The lateral inferior genicular artery ran laterally across the popliteus and forward over the fibular head to the front of the knee joint, passed

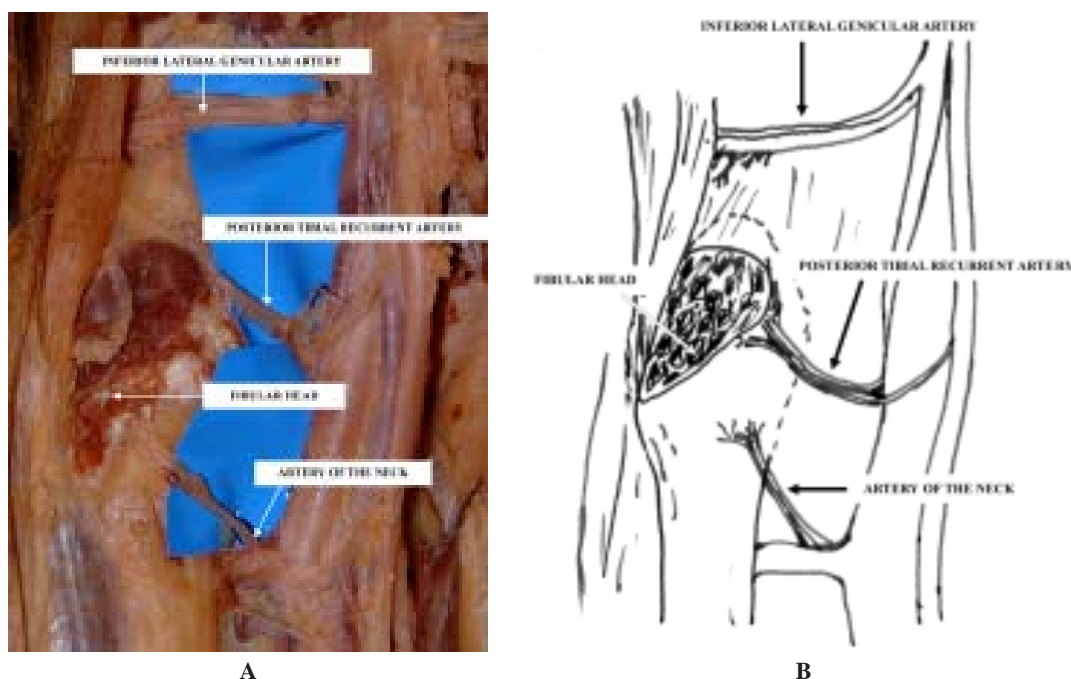


Fig. 1 Picture (A) and diagram (B) of the posterior view of the proximal fibula show the inferior lateral genicular artery and accompanied veins, posterior tibial recurrent artery and vein which are the branches from the popliteal artery and veins
The artery of the neck of the fibula, a branch of the anterior tibial artery, runs obliquely and proximally to the neck of the fibula

Table 1. The average diameter of blood vessels around the proximal fibula and its percentage

Vessels	Diameter (mm)	Number	Percent
Inferior lateral genicular vessels			
- single artery and vein : mean (range)			
- artery	1.66 (0.65-2.14)	19/33	57.6
- vein	2.10 (0.95-2.30)	19/33	57.6
- single artery and double veins			
- artery	1.71 (0.75-2.25)	14/33	42.4
- veins	1.69 (1.30-2.10)	14/33	42.4
Anterior tibial recurrent vessels			
- artery	1.24 (0.8-2.1)	31/33	94.0
- vein	1.86 (0.8-2.6)	31/33	94.0
Posterior tibial recurrent vessels	-*	11/33	33.3
Artery of the neck of fibula	-*	24/33	72.7

*, cannot measure by vernier caliper

under the lateral head of gastrocnemius, fibular collateral ligament, and tendon of biceps femoris. It was seen in all specimens (33/33). Among them, 42.4% (14/33) had a single artery and two accompanied veins. The average diameter of artery and veins were 1.71 mm (0.75-2.25), and 1.69 mm (1.30-2.10), respectively. The others were a single artery with single vein. The average diameter of artery and vein were 1.66 mm (0.65-2.14), and 2.1 mm (0.95-2.30), respectively (Table 1).

Anterior tibial recurrent artery

Arising near the preceding vessel, the anterior tibial recurrent artery ascended in tibialis anterior. It ramified on the front and sides of the knee joint and joined the patellar network. It anastomosed with the genicular branches of the popliteal and circumflex fibular arteries. This artery was seen in 31 of 33 specimens (94%). The average size of artery and the accompanying vein were 1.24 mm (0.8-2.1) and 1.86 mm (0.8-2.6), respectively (Table 1).

Posterior tibial recurrent artery

The posterior tibial recurrent artery was an inconsistent branch found in only 11 of 33 specimens (33%) (Table 1). It arose before the anterior tibial artery, ascended anteriorly to the popliteus and anastomosed with the inferior genicular branches of the popliteal (Fig. 1). It supplied head of fibula and tibiofibular joint.

Artery of the neck of fibula

From the presented dissections, the artery of the neck of fibula sometimes arose from the anterior tibial artery, passed laterally round the fibular neck

through the soleus to anastomose with the lateral inferior genicular, medial genicular, and anterior tibial recurrent arteries (Fig. 1). It supplied bone and articular structures. This artery was seen in 24 of 33 specimens (72.7%) (Table 1). The other seven specimens were replaced by a predominant posterior tibial recurrent. The artery of the neck of fibula and the posterior tibial recurrent artery were not found in two specimens. In 24 specimens, 20 had a single artery of the neck and four had both vessels in equal size. However, the sizes of posterior periosteal vessel were too small to measure by vernier caliper.

Discussion

In humans, the fibula has minimal weight-bearing function. The distal end (the lateral malleolus) is vital to formation of the ankle joint. However, the proximal end is relative dispensable as a donor site that was commonly used for free epiphyseal transfer. Many reports, both clinical and experimental, have been done to study the clinical application of this donor site.

Donski and Donski and O'Brien^(4,5) studied the growth of transferred ulna in puppies. Sixty-three percent of growth occurred when the transfer was based on the nutrient artery and 69% occurred when based on the periosteal supply. Neither study was done with the epiphyseal pedicle.

Tomita et al⁽⁶⁾ reported the effects of variations in the vascular pedicle on the longitudinal growth of the proximal fibular epiphysis in dogs. They demonstrated slightly better growth than controls when both epiphyseal and metaphyseal (nutrient) pedicles were preserved and used. In an animal study, using

the proximal fibula in puppies, Brown et al⁽⁷⁾ reported normal histologic appearance, normal metabolic and mitotic activity (using radioactive praline and thymidine), and only slightly diminished growth when both pedicle were used.

Bos⁽⁸⁾ has described the canine anatomic model for proximal fibular epiphyseal transfer. The human correlation is very similar. In humans, the inferior lateral geniculate artery supplies the epiphysis; and the nutrient artery, a branch of peroneal artery, supplies the metaphysis. They indicated that both arteries should be preserved. However, they did not describe the details and type of periosteal blood supply.

Trueta et al^(9,10) described three sources of epiphyseal blood supply, epiphyseal artery, nutrient artery (metaphyseal or endosteal), and periosteal vessel located circumferentially around the plate, which communicated with the epiphyseal and metaphyseal and metaphyseal circulations.

The presented specimens showed that the lateral inferior genicular artery branched off from the politeal artery, and then ran into the articular capsule of proximal tibiofibular joint. There were two different vascular networks around the neck of the fibula. Posteriorly, the vascularity came from the "artery of the neck" or posterior tibial recurrent artery and anteriorly, the anterior recurrent tibial artery commonly branched off from the anterior tibial artery. The peroneal artery was the predominant artery for the fibular shaft, but did not contribute as much to the perfusion of the head. According to the present anatomic study, two different vascular systems must be preserved to maintain viability of the fibular head. In addition, to preserve the lateral inferior genicular artery and its concomitant veins, one of the following must be selected, depending on the length of defect. In a long defect, peroneal vessels can be used but in the shorter defect, only anterior tibial vessels including the "artery of the neck" or anterior recurrent tibial artery should be used.

Conclusion

Based on the present results, the authors recommended preserving the epiphyseal blood supply, lateral inferior genicular artery, and periosteal blood supply for free epiphyseal transfer. In addition, sur-

geons should pay attention to the variation of posterior periosteal blood supply because its variations will affect the viability percentage of proximal fibular epiphyseal transfer.

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รูปแบบของหลอดเลือดที่มาเลี้ยงบริเวณกระดูกฟิบูล่าส่วนต้นในศพดอง

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วัตถุประสงค์: เพื่อศึกษารูปแบบของหลอดเลือดที่มาเลี้ยงบริเวณกระดูกฟิบูล่าส่วนต้นในศพดอง

วัสดุและวิธีการ: การศึกษานี้ทำในศพดองของผู้ใหญ่ทั้งหมด 19 ตัวอย่าง 33 รยางค์ล่าง อายุเฉลี่ยของศพดอง คือ 68.6 ปี (ช่วงระหว่าง 36-98 ปี) โดยมีเพศหญิง 11 คน และ เพศชาย 8 คน โดยได้ทำการบันทึกขนาดและรูปแบบของหลอดเลือดในบริเวณกระดูกฟิบูล่าส่วนต้น

ผลการศึกษา: พบว่ากระดูกฟิบูล่าส่วนต้นมีระบบหลอดเลือดหลักๆ 2 ระบบ คือ หลอดเลือด *inferior lateral genicular* มาเลี้ยงบริเวณ *epiphysis* ส่วนหลอดเลือดที่มาเลี้ยงเยื่อหุ้มกระดูกประกอบด้วย หลอดเลือด *anterior tibial recurrent* เลี้ยงทางด้านหน้า และหลอดเลือด *posterior tibial recurrent* หรือ *artery of the neck* เลี้ยงทางด้านหลัง จากการ ศึกษาพบหลอดเลือด *inferior lateral genicular* ในทุกตัวอย่าง (33/33) โดยร้อยละ 42.4 (14/33) มีหลอดเลือดแดง หนึ่งเส้นร่วมกับหลอดเลือดดำสองเส้น ส่วนที่เหลือจะเป็นหลอดเลือดแดงหนึ่งเส้นร่วมกับหลอดเลือดดำหนึ่งเส้น ขนาดเส้นผ่าศูนย์กลางของหลอดเลือดแดงและดำของรูปแบบแรกคือ 1.71 (0.75-2.25) และ 1.69 (1.30-2.10) ส่วนขนาดของหลอดเลือดในรูปแบบที่สองคือ 1.66 (0.65-2.14) และ 2.1 (0.95-2.30) มม. ตามลำดับ พบหลอดเลือด *anterior tibial* ใน 31 ตัวอย่าง (ร้อยละ 94) โดยมีขนาดหลอดเลือดแดงและดำเท่ากับ 1.24 (0.8-2.1) และ 1.86 (0.8-2.6) ตามลำดับ ส่วนหลอดเลือด *posterior tibial* พบร้อยละ 33 ของตัวอย่าง หลอดเลือด *artery of the neck of fibula* พบร้อยละ 72.7 หรือ 24 ตัวอย่าง อีก 7 ตัวอย่างพบว่าถูกแทนที่โดยหลอดเลือด *posterior tibial recurrent* ส่วนอีก 2 ตัวอย่างไม่พบทั้งสองเส้น

สรุป: ผลการศึกษานี้พบว่าสามารถใช้หลอดเลือดที่มาเลี้ยงบริเวณ *epiphysis* และหลอดเลือดที่มาเลี้ยงบริเวณเยื่อหุ้มกระดูก คือหลอดเลือด *inferior lateral genicular* และ กลุ่มหลอดเลือดที่มาเลี้ยงเยื่อหุ้มกระดูกในการผ่าตัดย้ายแผ่นการเจริญของกระดูก อย่างไรก็ตาม ศัลยแพทย์ควรให้ความสนใจต่อความผันแปรทางกายวิภาคของหลอดเลือด โดยเฉพาะหลอดเลือดที่มาเลี้ยงเยื่อหุ้มกระดูกทางด้านหลังเพราะมีความผันแปรมาก ซึ่งจะส่งผลต่อการผ่าตัดรักษา
