



# Intraoperative anatomy of the vascular supply to the medial femoral condyle

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## KEYWORDS

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**Summary** The arterial anatomy of the medial femoral condyle (MFC) for vascularized bone grafting has been extensively studied in cadaveric specimens. A majority of cadaveric studies have limited numbers of specimens, and the data from these studies are extrapolated to the surgical environment. The purpose of this study is to evaluate the vascular anatomy of the medial femoral condyle in a large clinical series. A retrospective review of operative reports was conducted of medial femoral condyle and trochlea vascularized bone grafts performed by the senior surgeons between 2005 and 2018. A total of 113 patients were included in the study. Demographic data, preoperative diagnosis, and type of graft harvested were collected. The descending genicular artery, a branch of the superficial femoral artery, was the dominant pedicle in 77% of cases. It was also the dominant arterial pedicle for medial femoral trochlea (MFT) bone grafts in 7 out of the 9 cases (77.8%). The superomedial genicular artery was the dominant pedicle in 23% (26 of 113 total) of all cases. In eight patients, a descending genicular branch was not identified. The superomedial genicular artery was absent in 2% of cases (2 of 113). The descending genicular artery was the dominant arterial pedicle for vascularized bone grafts from the medial femur and was present in 93% of cases. This is in contrast to published cadaveric studies showing the artery was present in 89% of specimens.

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## Introduction

The medial femoral condyle is a source of a variety of bone flaps that can be applied to nonunion and avas-

cular necrosis in upper and lower extremity surgery but has also expanded its application to head and neck microsurgical reconstruction.<sup>1–13</sup> Bony flaps can be harvested as a corticoperiosteal or corticocancellous medial femoral condyle (MFC) flap, most commonly described for scaphoid nonunion. Källicke et al. described the medial femoral trochlea (MFT) osteochondral flap in providing a

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vascularized articular surface for the reconstruction of both scaphoid and lunate proximal pole articular defects.<sup>14</sup> The blood supply to the medial supracondylar femoral region is within the periosteum and derived from either the descending genicular artery (DGA) off the superficial femoral artery or the superomedial genicular artery (SGA) off the popliteal artery.<sup>15</sup> Hertel and Masquelet first described the anatomical basis for a medial knee flap in 1989 as a pedicled reverse flow osteoperiosteal flap for skeletal reconstruction of the leg with the furthest extent to the middle third of the leg.<sup>16</sup> Anatomic descriptions of the arterial anatomy of this region are well described in cadaveric studies, but clinical studies that corroborate the vascular anatomy have been limited.<sup>8,17-29</sup>

Yamamoto et al. studied fourteen cadaveric specimens and identified the DGA in 89% of specimens while the SGA was present in 100% of specimens.<sup>28</sup> Additional studies report a range of the DGA being present in 79 to 100% of cadaveric specimens.<sup>23,27,30,31</sup> This study aimed to determine the clinical application of cadaveric findings to determine the vagaries of anatomy of the medial femoral region in a large clinical series.

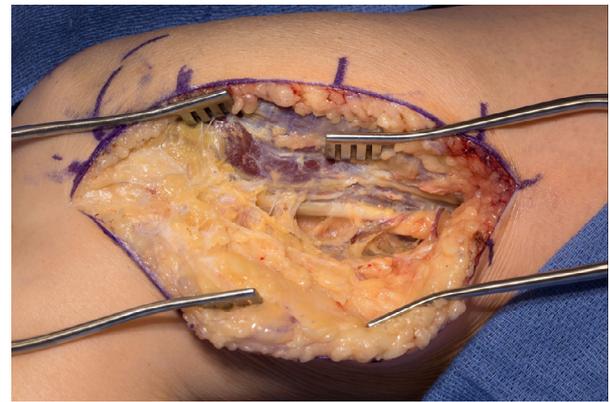
## Methods

A retrospective chart review of free medial femoral condyle and MFT vascularized bone flaps performed by the senior two surgeons at a single institution from 2005 to 2018 was conducted. A total of 113 patients were included in the study. Operative reports were reviewed to determine arterial anatomy as well as dominant pedicle harvested. Demographic data, preoperative diagnosis, and type of graft harvested were collected. Institutional review board approval was obtained for this investigation.

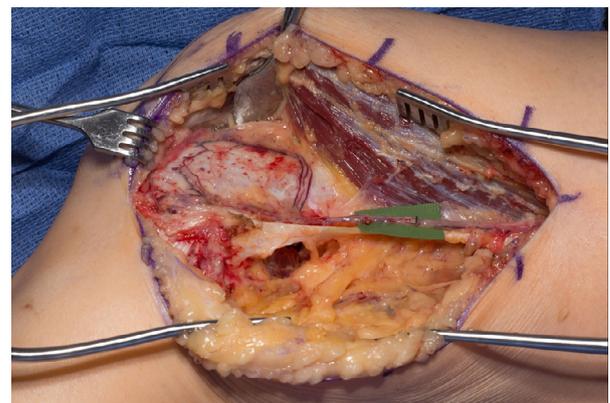
One hundred and thirteen patients underwent a medial femoral bone flap. Mean patient age was 36 years (range, 14-72 years). There was a predominance of male patients (90 male and 23 female). The most common indication was revision scaphoid surgery, which was performed in 52 patients. Prior scaphoid interventions in this group included vascularized bone graft from the distal radius, non-vascularized bone graft, or bone graft substitute with concomitant fixation. Thirty-eight patients had a diagnosis of primary scaphoid nonunion treated with free-vascularized MFC as the initial surgery. Nine patients underwent a MFT osteoarticular flap of which five patients had a diagnosis of Kienbock's disease, one patient was diagnosed with Preiser disease, and three patients were treated for a diagnosis of scaphoid proximal pole nonunion. Patients with pedicled medial femoral condyle flaps were excluded from the study.

## Surgical technique

The surgical technique for harvest of the medial femoral condyle has been extensively reported. Briefly, under tourniquet control, longitudinal incision is made along the posterior border of the vastus medialis muscle extending 15 cm proximal from the joint line. The fascial envelope of the vastus medialis is opened along its posterior border and the muscle retracted anteriorly. The descending



**Figure 1** Exposure of the descending genicular artery and the three branches-muscular, osteoarticular, and cutaneous saphenous.



**Figure 2** Superomedial genicular artery visible as it crosses from behind the adductor magnus tendon.

genicular vessels are identified emerging from the adductor hiatus (**Figure 1**). Their presence or absence was part of the standardized operative dictation. These vessels are then followed from their origin at the superficial femoral vessels and distally onto the face of the medial femoral condyle (**Figure 2**). The proximal longitudinal and transverse branches of the femoral condyle blood supply are identified as well as the SGA, which is visualized originating from the popliteal artery more distally, is identified. Their presence or absence was part of the standardized operative dictation. If both the DGA and SGA vessels are present, it was determined which had the larger caliber vessel and it was chosen as the dominant pedicle to supply the bony flap and used for microanastomosis (**Figure 3**).

## Results

The DGA was the dominant pedicle utilized for microvascular anastomosis in 77% patients for combined MFC and MFT groups (87 of 113 total). It was present in 105 of 113 total patients (93%). The SGA was dominant in 23% of all cases (26 of 113) and present in 111 of 113 all patients (98.2%).

Seventy-five percent of MFC cases (78 of 104 total) utilized the DGA. It was also dominant for MFT bone flaps in 7



**Figure 3** Medial femoral corticoperiosteal flap with dissected descending genicular artery (A) and vena comitans (V) for microanastomosis.

out of the 9 (77.8%) cases. The DGA was present in all but one of the MFT patients (89%). The SGA was the dominant pedicle in 3 of the 9 total MFT patients (33.3%). The SGA was the dominant pedicle in 23% (24 of 104 total) of MFC cases. (Figure 4)

The primary finding for all patients in whom the descending genicular was not utilized was inadequate vessel caliber. Within this group, there were 8 patients (7% of total patients) who did not have a descending genicular branch, thus necessitating the use of the SGA as the main arterial pedicle. Pedicle length was determined to be adequate for microvascular anastomosis in all cases (Figure 5).

## Discussion

Yamamoto et al. studied 19 cadaveric lower limbs to determine both extraosseous and intraosseous anatomy of the medial femoral condylar region and found that the DGA was present in 89% of specimens while the SGA was present in 100% of specimens.<sup>28</sup> This is in contrast to the current study in which the DGA was present in 93% of the total patients while the SGA was present in 98%.

The discrepancy in the percentage of each type of pedicle found in each group may be attributable to the small sample size in the cadaveric study as there were only 14 cadaver specimens studied, indicating that the prevalence of the DGA is higher in the population than in the previous report. This finding is consistent with its more frequent use as the dominant pedicle to bony flaps harvested from the medial knee and a fortuitous one given that the mean vessel caliber for the DGA is near double the SGA. Vessel caliber was not recorded for study in this retrospective review, but average internal diameter was found to be 1.5 mm for the DGA and 0.78 mm for the SGA in the cadaveric study.<sup>28</sup> There have been many anatomic studies of the arterial supply of the knee region.<sup>5,17-28,32</sup> A systematic review of the vascular anatomy of the DGA aligns with this study's finding, with the DGA being present in 92% of cases.<sup>17</sup> Ziegler et al. reported the presence of the SGA in 97% with use as the main arterial pedicle in 15% of cases.<sup>17</sup> The remaining 85% of cases

utilized for the dominant pedicle was the DGA in contrast to the present study reporting 77%.<sup>17</sup> The DGA vessel and its osteoarticular branch also have a longer pedicle length given the more proximal branching point from the femoral artery at an average of 13.7 cm from the medial condyle versus the average 5.2 cm pedicle length for the SGA.<sup>28,33</sup> The longer pedicle length of the DGA may allow greater flexibility for inset of the bone graft within the defect.

This study provides clinical data in regards to the prevalence of the DGA in the setting of bony flap reconstruction. To optimize surgical outcomes, the surgeon should be aware of anatomic variations when harvesting bone from the region of the medial femur. If a long vascular pedicle is critical for the reconstruction, the preferred arterial pedicle may be the descending genicular, but nearly one-third (23%) of the cases in this study found that the SGA was the dominant pedicle, primarily due to inadequate vessel caliber.

The vascular anatomy of the medial knee is especially crucial when planning for an osteocutaneous flap. The location of skin perforators as well as the anatomic variability in the saphenous artery is critical before fully committing to a flap design. Yamamoto et al. found that the saphenous branch was detected in 79% of the specimens branching off a common trunk with the osteoarticular branch or directly off the DGA.<sup>28</sup> This is a variable finding in other studies with the presence of the saphenous branch ranging from 79 to 95%.<sup>17-20,24-26</sup> Higgins et al. supported the use of a skin paddle with harvest of the MFC as it allows for accurate monitoring of the underlying bone perfusion as well as tension-free closure over the anastomosis.<sup>1,5,8,24</sup> Iorio et al. conducted a cadaveric study of skin perfusion of the medial knee and identified the saphenous artery branch being present in 92% of specimens while the cutaneous branch of the DGA was present in all twelve specimens.<sup>24</sup> Skin paddles were not used in any of the cases in this study, and there were no cases of wound closure issues. The controversy of what to do when the skin paddle fails remains unanswered and was not the focus of this study.

The majority of the published literature on vascular anatomy is based on cadaveric studies, which afford the researcher the opportunity to process the specimen to evaluate the vascular anatomy in microscopic detail.<sup>28</sup> The limitations of cadaveric studies are evident given the discrepancy in the clinical findings of the MFC pedicle and are a reminder that the cadaveric model is not a perfect one for clinicians. First, the cadaver is processed and hence the measurements provided in regards to distance from anatomic landmarks may be distorted given that in vivo patients have pliable soft tissues that are hydrated and can alter length measurements. This can be an area of further study in a clinical study, but the distance from the knee was not measured in the operative reports used for this retrospective review. Along those lines, although latex injection of vessels can elucidate vessel anatomy, this again may be subject to force and human error in regards to processing and may have variable results depending on the lab performing the process. This is applicable to the other forms of cadaveric processing including the Spalteholz technique used to evaluate the size and distribution of the perforating nutrient vessels in the cadaveric study performed by Yamamoto et al.<sup>28</sup> An additional weakness of cadaveric studies is the age group of the specimens in con-

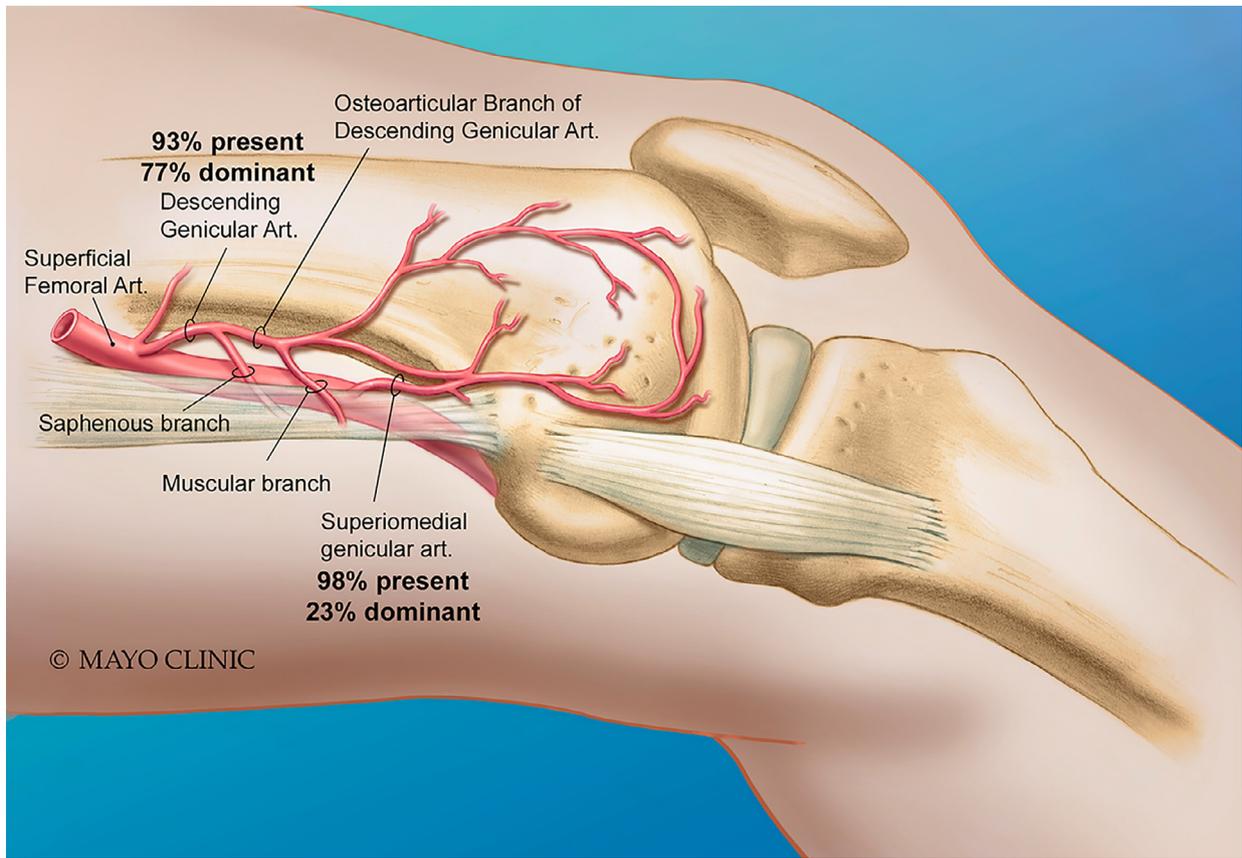


Figure 4 The extrasosseous branching patterns and arterial anatomy supplying the medial femoral condyle. "Used with permission of Mayo Foundation for Medical Education and Research. All rights reserved."

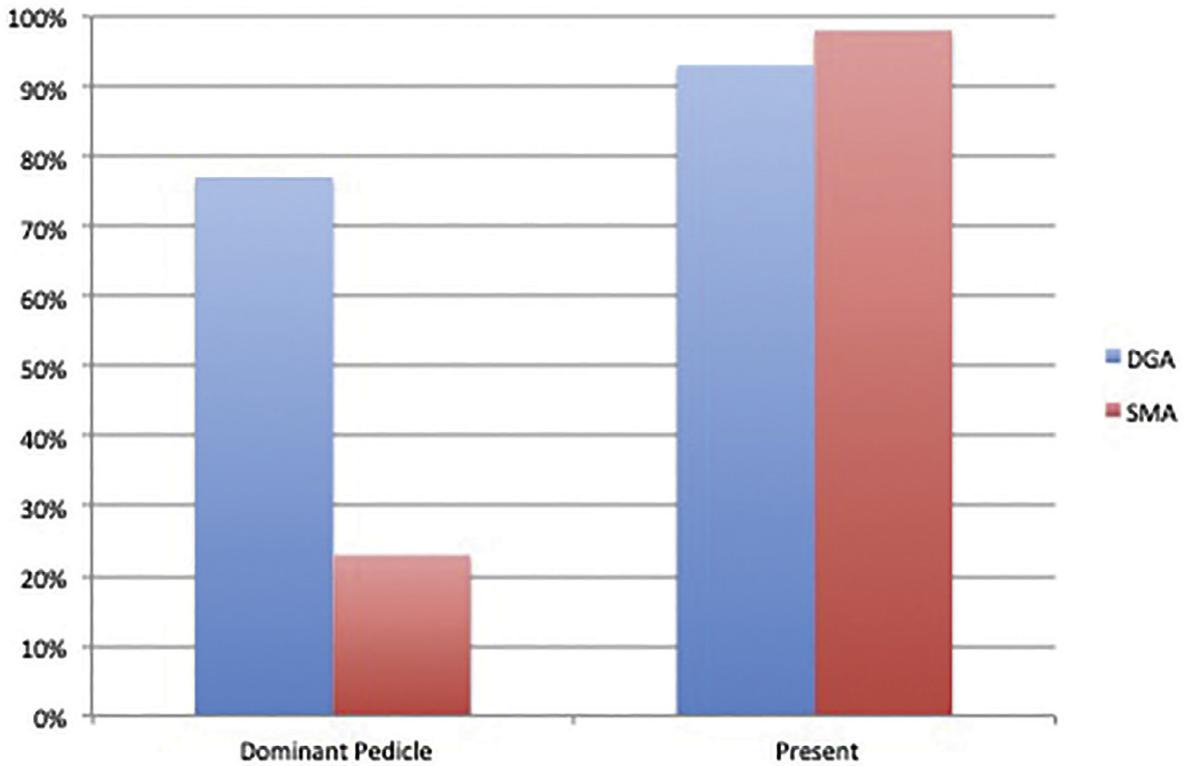


Figure 5 Graph showing arterial pedicle dominance and presence.

trast to the clinical patient population in which the MFC is most commonly utilized. The mean age of the total patients in this study was 36 years in contrast to the age range of 40 to 99 for the cadaveric specimens.<sup>28</sup> Although the vascular anatomy of the DGA and SGA likely do not change with aging, this is a stark difference in cadaver study versus the present one, which should be acknowledged.

## Conclusion

In this clinical study, the DGA was the dominant arterial pedicle for vascularized bone grafts from the medial femur in 77% of cases and was present in 93% of patients. This is in contrast to a cadaveric study showing the artery was present in 89% of specimens. The SGA was absent in 2% of cases but was the dominant pedicle in 23% of all patients. The DGA is typically of larger caliber with a longer pedicle allowing greater flexibility in regards to vessel anastomosis and bony inset. Surgeons need to be aware of the anatomic vagaries of the vascular supply of the medial femoral condyle.

## Disclosures

None of the other authors have a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

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