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ORIGINAL STUDY

Arterial anatomy of the free vascularised corticoperiosteal graft from the medial femoral condyle

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The free vascularised corticoperiosteal flap from the medial femoral condyle, as described by Doi and Sakai, can be used for difficult non-unions. This flap is supplied by the Descending Genicular Artery (DGA) and the Superomedial Genicular Artery (SMA).

In this anatomical study we describe the anatomy of these arteries. The DGA was dominant in 24 of 34 cases (70%). If the DGA was absent or too small, the SMA was sufficiently large for an adequate supply of the graft area. We concluded that of all the dissected specimens the arteries were sufficiently large and long enough to be suited for microsvascular anastomosis.

Keywords : femur ; free flap ; vascularity ; anatomy ; non-union.

INTRODUCTION

The vascularised corticoperiosteal flap from the medial condyle of the femur as described by Doi and Sakai (*5*), is a possible treatment for non-unions and recalcitrant fractures. Clinical studies prove its efficiency (*1-3,5,6,10*).

The medial distal femoral periosteum receives its blood supply from the Descending Genicular Artery (DGA) and often also from the Superomedial Genicular Artery (SMA). The thin layer of cortical bone of the medial distal femur is usually supplied by the Descending Genicular Artery (DGA) (*1,3,5,6, 8,10-13*).

However the DGA is prone to anatomical variability. The pattern of blood supply dominance between the two major supplying arteries (DGA and SMA) can vary among individuals.

This anatomical study describes the anatomy of the blood supply to the medial distal femoral condyle.

MATERIALS AND METHODS

In total, 27 Caucasian cadavers were dissected in this study, 15 males and 12 females. A total of 38 knees were dissected. All of them were preserved with phenol. Twenty two of the dissected limbs were paired. Four knees were left out of the results because they had undergone previous surgery, leaving 34 knees for statistical analysis.

The incision of the skin extended about 10 cm upward from the joint line along the medial intermuscular septum. The medial femoral condyle was dissected.

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Then, the blood supply to the periosteum was retrieved, and the supplying artery was tracked back to its origin.

The supplying artery – SMA or DGA – could then be identified. In order to completely expose the DGA, if present, the vastus medialis muscle was detached and reflected (Fig. 1).

The most relevant variables of the DGA were : length, diameter, dominance and number of branches to the periosteum. Dominance and number of branches did not require a special measuring method. The dominant vessel is defined as the artery that supplies the flap area on the medial femoral condyle with most branches *(3)*. The length of the artery was measured using a tape measure. The length was defined as the distance from the origin to the division into multiple terminal branches supplying the periosteum. The result was expressed in centimetres (with an accuracy of 0.1 cm). After dissecting the artery to its origin, we introduced an IV needle in the lumen of the artery, at the artery's origin. (BD Insyte 22 Gauge 0.9 mm × 25 mm). We perfused the artery with saline through the needle until it reached it's normal shape. Then the diameter was measured using a calliper (Mitutyo, Japan) and results were expressed in millimetres, with an accuracy of 0.01 mm. The results were statistically analyzed.

RESULTS

The origin of the DGA is the femoral artery, before it enters the adductor hiatus (Hunter's canal). The artery then runs downwards on the lateral intermuscular septum, and most commonly rises 2 to 3 muscular branches to the vastus medialis muscle, 2 branches to the periosteum and one cutaneous branch (saphenous branch) which travels to the skin below the knee joint.

The average size, branching pattern and dominance pattern of the DGA (if present) is shown in Figure 1.

The DGA was dominant over the SMA in 24 of 34 cases (70%). In 7 cases (21%) the SMA was dominant over the DGA (1 case) or the DGA was absent (6 cases). In 3 cases (9%) the DGA and SMA had an equal share in the blood supply to the medial femoral condyle. The division of the diameters of the descending genicular arteries was left skewed. The arteries had a diameter between of 1.60 mm and 2.50 mm with an average of 2.43 mm (SD = 0.88 mm).

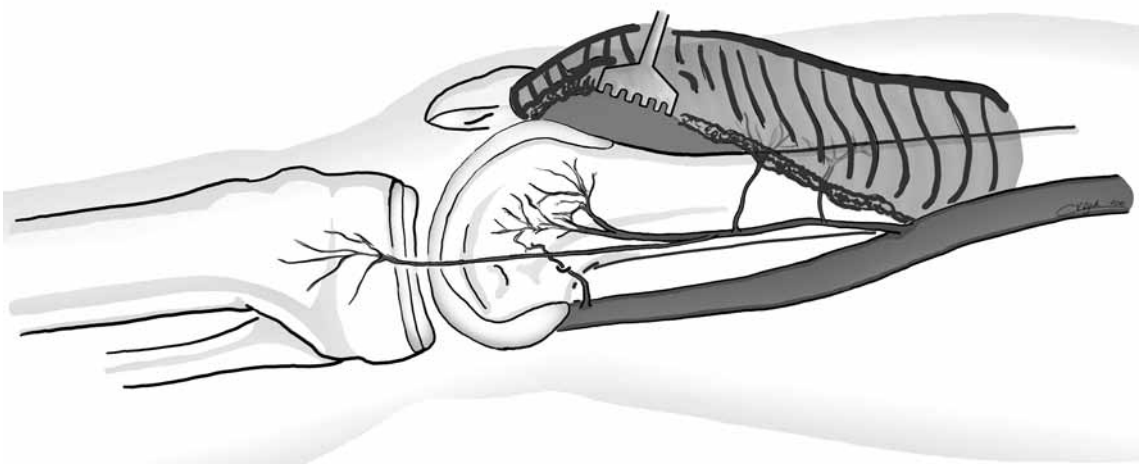

Fig. 1. — The average descending genicular artery. It originates from the femoral artery before the adductor hiatus, rises 2 intramuscular branches, 2 periosteal branches and 1 saphenous branch supplying the skin below the knee joint.

The distribution of the results for vessel length was irregular. The DGA spanned 5 through 13 cm, with an average of 8.9 cm (SD = 2.18 cm). The mean origin was 13.7 cm (SD = 1.88 cm) above the knee joint. All of the dissected arteries had 2 or more branches to the medial femoral condyle and 2 or more intramuscular branches to the vastus medialis muscle. A saphenous branch was present in 14 cases (41%) of the cases. The SMA had an average length of 4.4 cm (SD = 1.21 cm, Range = 3.4-6.3 cm), an average diameter of 1.76 mm (SD = 0.52 mm, Range = 1.00-2.40 mm) and originated on average 6.5 cm (SD = 2.21 cm, Range = 6-9.3 cm) above the knee joint.

One of the dissected DGA's followed a complex intramuscular trajectory. It originated from the femoral artery, near the adductor hiatus, and travelled anteriorly in the vastus medialis muscle. It ran downwards and exited the muscle prior to supplying the periosteum. Dissection of the muscle should be necessary in such cases.

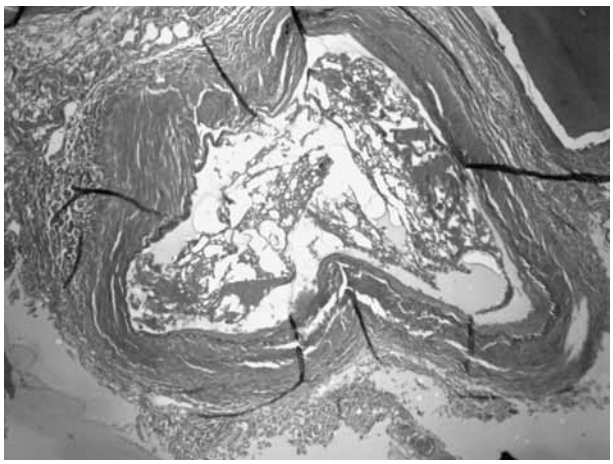

Fig. 2. — Histological cross-section of the descending genicular artery. The artery has an irregular lumen caused by formalin fixation and histological preparation.

DISCUSSION

The descending genicular artery is most often the main supplying artery to the medial femoral condyle. The DGA is subject to anatomical variability between individuals, and even between limbs from one individual. Anatomical variability of the artery, used in the Sakai flap, could have implications on the viability of the graft. The use of the SMA as the artery supplying the graft is also an option to be taken into account.

We chose macroscopic measurements of the outer diameter of the artery over histological measurements of the inner diameter (*7*). The problem regarding histological measured diameters is that it is impossible to obtain a representative result for the vessel diameter. Vessels that are fixed in paraffin for histological purposes lose their shape. As a result of this process, luminal diameters are either over- or underestimated because the vessel no longer has its characteristic round form. Instead, the vessel has an irregular, often oval or elliptical diameter (Fig. 2).

Another problem regarding histological measurement of the diameter occurs when an artery from a fresh frozen cadaver is fixed. When the artery is preserved in formalin, it shrinks (with a factor of -34%) (*4,14*). Other studies stated that the mere excision of human tissue causes shrinking (*9*). By measuring macroscopic outer diameters, there is no need for a fixation process nor for excision of the artery.

Previously, there have been several studies on the anatomy of the blood supply of the medial femoral condyle. Doi and Sakai (*6*) stated that a thin vascularised corticoperiosteal graft can be used to treat difficult bony non-unions. The vessel that is used in this flap can be either the SMA or the DGA. They report that the DGA is better suited for the flap, as it is larger and longer. Scapinelli (*11*) studied the vasculature of the human knee. He reported that there was a supreme descending genicular artery with 3 branches, a musculo-articular branch, a deep oblique branch and a saphenous branch. Yamamoto *et al* (*13*) also studied the anatomy of the vascular supply to the medial femoral condyle. They concluded that the DGA was present in 89% of the cases, and averaged an internal diameter of 1.5 mm and an origin of 13.7 cm above the knee joint. They concluded that all of the dissected specimens had sufficiently large arteries (either SMA or DGA) for a vascularised corticoperiosteal graft of the medial femoral condyle (*13*). Hugon *et al* (*8*) reported that the DGA was dominant in 85% of the cases and had

its origin on average 15.36 cm above the femorotibial joint line. The average SMA originated 7.06 cm above the joint line. They found an average inner diameter of 1.168 mm for the DGA and 0.745 mm for the SMA *(8)*.

In this study, we dissected a larger number of limbs than previous reports. The majority of these limbs were paired, but arterial symmetry was rarely observed. We found that the DGA was dominant in 68% of the cases and averaged an outer diameter of 2.43 mm and an origin 13.7 cm above the knee joint. A Sakai flap using the DGA could be harvested in 77% of the cases, when the DGA was dominant or when the DGA and SMA were co-dominant (9% of the cases). In the case of an absent DGA, there is always a sufficiently large SMA supplying the flap area with 2 or more branches. The pedicle will then be shorter and the dissection more difficult, as the surgeon will have to track the vessel to the popliteal artery.

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