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Anatomical characteristics and clinical application of a medial tarsal free venous flap.

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Abstract

This study aims to explore the anatomical characteristics and clinical application of a medial tarsal free venous flap. We identified communicating venous systems in deep and superficial layers of anatomical specimens and tissue sections of the skin and subcutaneous tissue of the medial tarsal region. Based on this anatomical feature, we designed and cut free venous flaps in the medial tarsal region, suturing a vein in the deep layer of the flap to an artery of the hand, and suturing the shallow layer of the flap to a dorsal vein or palmar superficial vein of the finger, to repair soft tissue defects of the palmar fingers. We performed this procedure in 63 cases, and all flaps survived. There was no postoperative congestion or necrosis, as commonly seen in "non-physiological flaps." These cases were followed up for 3 months to 2 years, with good color, elasticity, and appearance of the flaps, and no significant effect on the donor feet. The venous structure of the deep and shallow layers of a medial tarsal free flap and the communicating veins between the 2 layers are very important anatomical features, enabling better effective blood perfusion within the flap, as compared to a traditional venous flap. The application of this "similar physiological flap" enabled a satisfactory outcome.

Keywords: Medial-tarsal vein flap, Free vein flap, Hand injury.

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Introduction

Adjacent finger, abdominal, or foot free flaps are commonly used to repair small defects of the skin and soft tissue of the palmar fingers. Advances in understanding of the venous flap have enabled wider use in repairs of skin and soft tissue defects [1-9]. When the foot is selected to provide the flap, the lateral, medial, or non-weight-bearing areas of the toes are often used. The medial tarsal area of the foot is a non-weight-bearing area, without significant anatomical structures in the deep tissues, and can be used as the flap donor site in the repair of skin and soft tissue defects of the hand. We identified venous structures in the deep and shallow layers in the skin of the medial tarsal region of the foot in preliminary anatomical studies and clinical samples, and consistently found communicating veins between the 2 layers. Based on this anatomical feature, we designed medial tarsal free venous flaps to repair skin defects of the fingers, with satisfactory outcomes. In this study, 12 adult lower limb specimens and 2 adult fresh foot specimens were perfused with red latex and used for further anatomical study in clinical flap applications. This study therefore provided the anatomical basis for application of medial tarsal free venous flaps.

Subjects and Methods

In 12 adult lower limb specimens and tissue sections, this study was conducted in accordance with the declaration of Helsinki. The study was confirmed and approved by the hospital's ethical committee (No. HMCH00061), and obtained the signed informed consent from all patients. We identified an oval-shaped area of about 6.0 cm × 4.0 cm in the medial tarsal area, below the medial malleolus and about 3 cm from the navicular tuberosity, with 2 layers of venous structures in the skin and subcutaneous tissue. The deep layer veins originate from saphenous vein branches, with vessel diameters of 1.2 ± 0.2 mm; the superficial layer includes subdermal veins, with vessel diameters of 0.6 ± 0.2 mm. These features were confirmed in histological sections. Anatomical study of 2 adult fresh foot specimens perfused with red latex identified small veins communicating between the deep and superficial layers in the skin of the medial tarsal region; the vessels in these 2 layers are extremely slender, measuring less than 0.2 mm in diameter. Moreover, anatomic study and tissue samples showed that the dermal structure is more compact in the medial tarsal region, similar to the structure in the palm.

By drawing a line about 3 cm long from below the medial malleolus to the navicular tuberosity, an area 2.0 cm above and below the line can be used as a flap donor site. The direction of flap venous flow should be determined by the finger artery in the receptor area, which determines the axis of the flap. We cut a medial tarsal flap according to the size and shape of the skin and soft tissue defect in the receptor area. The thick portion of the flap should be located deep to the deep fascia, to ensure that the flap contains veins of both deep and shallow layers.

Surgery was performed under brachial plexus anesthesia and epidural anesthesia with a tourniquet. After conventional debridement of the finger injury, we identified the bilateral proper palmar digital artery and palmar superficial vein, or 1 or 2 alternative hand veins. In an injury with a combined bone defect, an ilium graft was initially performed and pinned with Kirschner wires. For a combined tendon defect, we performed a long digital extensor graft. The flap design was determined by the size and shape of the hand defect. We designed the axial direction of the flap to be flexible according to the direction of arteriovenous flow in the receptor area and the direction of venous flow in the donor area. We designed and cut the flap from the 6.0 cm × 4.0 cm medial tarsal area described above. The skin and subcutaneous tissue of the cut flap area should be about 10% larger than that of the receptor area, following the design line. In the dissection and cutting of the free flap from underlying deep fascia, care should be taken to ensure that the flap contains deep and superficial layer veins, to ensure continued communication between the vascular networks of the 2 layers. If the width of the flap from the donor area is less than 2.5 cm, it can be sutured directly; otherwise, a full-thickness skin graft from the groin can be performed. After cutting, the flap was transplanted to the receptor area. The operation was completed under a microscope. Anastomosis was performed between the deep layer veins of the flap and the proper palmar digital artery, and superficial layer veins were anastomosed with palmar or dorsal veins of the fingers; the arteriovenous ratio of anastomosed blood vessels was 1:2. Antibiotics, anticoagulants, anticonvulsants, and other treatments were used postoperatively; circulatory status of the flap was closely monitored.

Results

The flap was observed for revascularization for 2-3 h postoperatively. During this period, the transplanted flap was pale, with slightly lower tension. After this period, the tension of the transplanted flap gradually returned to normal, and the color reddened. With good blood supply, the wound healed and the flap survived. There was no congestion, purple discoloration, blistering, or necrosis. All 63 flap cases survived; only 2 cases showed slight swelling within 24 h after the operation, with spontaneous resolution after 2-3 days. All cases in this group healed by first intention. During a follow-up period of 12 to 36 months, the flaps showed normal color, no abnormal pigmentation, good elasticity, and a good appearance. Thirty-two cases were followed up for over 2 years. Point discrimination in these cases was 5-8 mm. There were no cases with joint stiffness, bone atrophy, or tendon adhesions. All wounds of the foot donor sites healed by first intention. Normal walking and weight-bearing was possible after the sutures were removed.

Discussion

Previous studies identified deep and superficial venous systems in the skin and subcutaneous tissues of the medial tarsal region. The veins of the deep layer originate from saphenous vein branches, with vessel diameter of 1.2 ± 0.2 mm; the superficial subdermal veins have a diameter of 0.6 ± 0.2 mm; communicating veins between the 2 layers provide the anatomical basis for arterialization of the flap. We examined the anatomic characteristics of the medial tarsal flap and found that the superficial veins of the medial tarsal skin were densely distributed, and were connected to the deep vein system through a wide range of three-dimensional communicating vessel networks.

In clinical application, the deep layer veins of the flap were anastomosed to the proper palmar digital artery, and the superficial layer veins were anastomosed to the palmar or dorsal veins of the finger; thus, the level and caliber of blood vessels were well matched. Because the walls were thicker than those of the superficial veins, we arterialized the deep veins, according to the direction of the valves. So the medial tarsal free venous flap possesses specific histologic features, it can be applied widely in hand trauma treated in soft tissue defect.

The medial tarsal free venous flap possesses "similar physiological flap" features. We believe that the structure of the communicating vessels between the 2 layers of veins is a very important anatomical feature, enabling better effective blood perfusion within the flap, as compared to a traditional venous flap. A major reason for necrosis in a traditional venous flap is the difficulty perfusing the capillaries and blood deposited in the flap [4,10-16]. An abundant venous network is the anatomical and morphologic basis for arterialization and venous flap survival [12-14]. When the medial tarsal free venous flap transplantation was completed, arterial blood initially perfused the flap through the deep veins, followed by full and effective perfusion of the inner structure of the flap through communicating vessels and the microcirculation. Finally, blood flowed out through the superficial veins, thus providing "similar physiological" blood perfusion for the flap [10,17-22]. It is a superior technique as compared with using only one venous system separately, either superficial or deep. This is the difference between a medial tarsal and traditional venous flap, and also explains the absence of postoperative congestion seen in a "non-physiological flap". Therefore, the typical physical hemodynamic characteristics of medial tarsal free venous flap are the import foundation of its survival. We believe that a medial tarsal becomes more safe and reliable regarding venous congestion or thrombosis.

Conclusion

Compared with a traditional venous flap, we believe that the interior of a medial tarsal flap contains more abundant venous structures and small communicating veins, thus providing more opportunities for substance exchange with arterial blood. The medial tarsal venous flap is better than a traditional venous flap, with improved survival, appearance, and outcomes.

Conflicts of Interest

All of the authors declare that they have no conflicts of interest regarding this paper.

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