



# A flap based on the plantar digital artery arch branch to improve appearance of reconstructed fingers: Anatomical and clinical application

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## KEYWORDS

The plantar digital artery;  
Arch branch artery;  
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**Summary** *Summary Aim:* To investigate blood supply features of the flap based on the plantar digital artery arch and arch branch artery, and the treatment of outcomes of reconstructed fingers by the plantar digital artery arch branch island flap.

*Methods:* Eight fresh foot specimens were employed with red emulsion infusion and microdissection. The vascular organization was observed in the second toe, such as initiation site, the course, and the number of the plantar digital artery arch branch. There were 15 fingers of 13 patients (8 males and 5 females) with finger defects accompanied by toe transfer, using the plantar digital artery arch branch flap inserted in the neck of the second toe to correct the appearance defect caused by a narrow “neck” and a bulbous tip.

*Results:* The intact plantar digital arches were identified in all specimens. The plantar digital artery arch had 5 branches. The range of external diameter of the arch branch was 0.4–0.6 mm. All the plantar digital artery arch branch island flaps and the reconstructed fingers survived. These cases were conducted with a follow-up period for 3–18 months (average, 9 months). All the plantar digital artery arch branch island flaps and reconstructed fingers demonstrated a satisfactory appearance and favorable sense function. The reconstructed finger-tip characteristic was good, with no obvious scar hyperplasia. The range of flexion and extension of reconstructed fingers was favorable as well.

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**Conclusions:** The plantar digital artery arch and arch branch artery possess regular vasa vasorum and abundant vascularity. A flap based on the plantar digital artery arch branch is an ideal selection for plastic surgery of reconstructed fingers.

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The microsurgical transfer from toe to hand was first successfully performed in rhesus monkeys in 1966 by Buncke et al.<sup>1</sup> Cobbett<sup>2</sup> successfully transplanted a great toe to replace an amputated thumb in 1968. Since then, the reconstruction of the thumb or finger by second toe transfer has been performed by clinicians all over the world. With the development of the microsurgical technique, toe-to-hand microsurgical transplantation has been proved to be a safe and effective method of thumb and finger reconstruction. Excellent graft survival and functional results have been reported by many<sup>3-5</sup>; also, numerous refinements to this technique have been implemented.<sup>6-9</sup>

Second toe-to-hand transplantation remains a suitable option among methods for hand reconstruction. However, an obvious appearance defect exists. Due to congenital anatomical differences between fingers and toes, the second toe has two main unattractive features, a narrow "neck" and a bulbous tip. Adverse psychological effects of a deformed hand can be greater than the deformity itself.<sup>10</sup> Therefore, esthetic refinements of toe-to-hand transplantation to solve these problems have been made, such as nail lengthening in free second toe transfer,<sup>11</sup> pulp plasty,<sup>12</sup> a composite tissue strip flap from the fibular of great toe, combined or not with the island dorsal index finger flap and a crescent double-winged dorsal metatarsus flap,<sup>13</sup> and the keyhole flap of great toe inset into the second toe.<sup>14</sup> In our previous study, a triangular flap in the neck and pulp of the second toe was designed and transferred to the finger for the reconstruction of finger morphology. We used the flap for the repair of six fingers, and it not only resolved the enlargement in the finger pulp but also improved stenosis in the neck.<sup>15</sup> We found the presence of the toe artery arch in the dissection of the flap. We assumed that this blood vessel can be used to design the flap.

Based on our experience, for a successful dissection to occur, it is important to perform an anatomical study to ascertain the exact location of the arch branches of the plantar digital artery arch. The purpose of this study is to clarify the exact course of the plantar digital artery arch and arch branch artery to the pulp of the second toe and present the treatment of outcomes of reconstructed fingers by the plantar digital artery arch branch island flap.

## Materials and methods

### Anatomical study

Eighteen feet were obtained from 9 fresh human cadavers with no history of previous injury, vascular disease, or



**Figure 1** The anatomy of the plantar digital artery arch and arch branch artery. 1: The first arch branch. 2: The second arch branch. 3-5: The third, fourth, and fifth arch branch. 6: The plantar digital artery arch. 7: The tibial plantar digital artery. 8: The fibular plantar digital artery.

congenital abnormality. The cadavers spanned a wide range of body habitus types, and the cadaveric age ranged from 50 to 75. There were 5 males and 4 females. In the event of an excessive clot accumulation of blood vessels, we would use a pre-heparin saline (heparin 12500 u injected into the normal saline 500 ml, stirring and mixing) flush before the blood vessel perfusion. The 18 second toes from 9 fresh Chinese cadavers were dissected. The feet were injected with red latex (Keyan Chemical Products Co., Shanghai) into the anterior tibial artery until the tips of the toes showed points of red dye without any force on the syringe. Usually, 50-75 cc was adequate. The perfusion pressure is such that a single thumb is appropriate to push the syringe. The feet, following injection, were frozen for 48 h before dissections. The second toes were disarticulated from the metatarsophalangeal joints. The plantar digital artery was identified and traced distally to the toe tip under the dissecting microscope (Yimeng Testing Equipment Co., Shanghai). The locations and diameters of the plantar digital artery arches and arch branches were measured using a vernier caliper (Shoufeng Precision Instruments Co., Shanghai). **Figure 1** shows blood vessels in the process of the anatomy of the plantar digital artery arch and arch branch artery.

The flap based on the plantar digital artery arch branch was designed on a new second toe injected with red latex. First, we drew the surface projection lines of arch branches of the plantar digital artery arch on the toe according to the microanatomy shown in **Figure 1** (**Figure 2A**). Then, an island flap was designed along the plantar digital artery arch branches (in this specimen, we used the second arch branch from the tibial side of the second toe) in the protuberance (**Figure 2B**). An incision was made along the designed line on

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