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Advantages of using volar vein repair in finger replantations

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Summary Providing adequate venous outflow is essential in finger replantation surgeries. For a successful result, the quality and quantity of venous repairs should be adequate to drain arterial inflow. The digital dorsal venous plexus is a reliable source of material for venous repairs. Classically, volar digital veins have been used only when no other alternative was available. However, repairing volar veins to augment venous outflow has a number of technical advantages and gives a greater chance of survival. Increasing the repaired vein:artery ratio also increases the success of replantation. The volar skin, covering the volar vein, is less likely to be avulsed during injury and is also less likely to turn necrotic, than dorsal skin, after the replantation surgery. Primary repair of dorsal veins can be difficult due to tightness ensuing from arthrodesis of the underlying joint in flexion. In multiple finger replantations, repairing the volar veins after arterial repair and continuing to do so for each finger in the same way without changing the position of the hand and surgeon save time. In amputations with tissue loss, the size discrepancy is less for volar veins than for dorsal veins. We present the results of 366 finger replantations after volar vein repairs.

Replantation surgery is challenging because the surgeon may have a limited amount of tissue to deal with, and it is always necessary to act quickly. Many factors affect the outcome of replantation, but venous insufficiency is a particular problem that complicates finger replantation surgery. Most surgeons repair bone and tendons first, then the arteries, leaving venous repair for the end when the surgeon is tired after hours of extremely intense work. Providing adequate venous return in an amputated finger is, however, one of the most important stages in replantation, and it is known that a higher number of repaired veins increase survival rates.[1] Dorsal veins are selected as they are often used and their repair is reliable. Volar veins are selected only when there is no other choice (such as in

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Tamai zone I amputations), and in some volar oblique amputations where dorsal veins are unavailable in the amputee (Figure 1). Most surgeons do not seek volar veins if dorsal veins are available. However, we always try to perform volar vein repairs regardless of the number of dorsal vein repairs. The aim of this study was to highlight the technical advantages of using volar veins in replantation surgery and the positive effect this can have on survival.

Materials and methods

Three hundred and sixty-six finger replantations with volar vein repairs were reviewed (Table 1). The operations were performed between April 2007 and December 2012. Seventy-five were zone I, 118 were zone II, 98 were zone III and 47 were zone IV replantations. Twenty-eight were ring avulsion injuries.

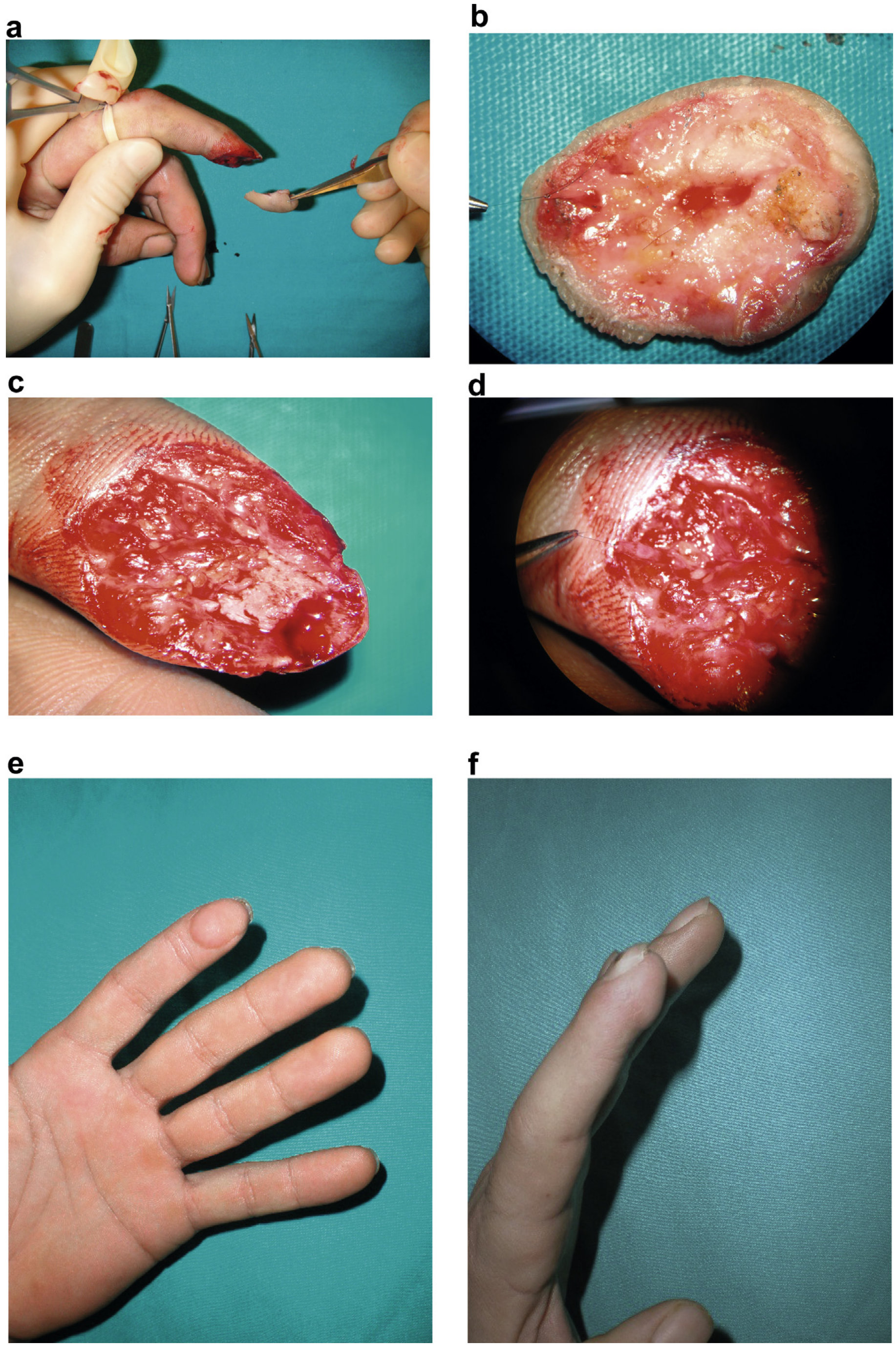

Figure 1 a) A volar oblique amputation of the second finger pulp. b) The artery and volar vein marked with sutures. c) The artery and volar vein marked with sutures in the stump. d) Close-up view of the volar vein in the stump. e), f) Results six months after successful replantation with one artery and one volar vein repair.

Table 1 Characteristics of 366 finger replantations.

Zone of injury	Number of fingers		Mean (total) number repaired			
	Replanted	Survival (%)	All veins	Dorsal veins	Volar veins	Arteries
Zone I	75	66 (88.0)	1.5 (113)	–	1.5 (113)	1.0 (75)
Zone II	118	97 (82.2)	3.0 (354)	1.2 (141)	1.8 (213)	1.0 (118)
Zone III	98	83 (84.6)	4.8 (471)	2.7 (265)	2.1 (206)	1.3 (128)
Zone IV	47	39 (82.9)	4.3 (204)	2.2 (106)	2.1 (98)	1.5 (71)
Ring avulsions	28	19 (67.8)	4.1 (115)	2.4 (68)	1.7 (47)	1.0 (28)
Total	**366**	**304 (83)**	**3.4 (1257)**	**2.1[a] (580)**	**1.8 (677)**	**420 (1.1)**

[a] Excluding zone 1.

The finger amputation zones were classified as follows: zone I, distal to the lunula; zone II, proximal to the lunula to the distal interphalangeal joint; zone III, proximal to the distal interphalangeal joint and distal to the insertion of flexor digitorum superficialis and zone IV, proximal to the insertion of flexor digitorum superficialis and distal to the metacarpophalangeal joint.

All bony fixations were done with K-wires. All vessel repairs were done with 10/0 or 11/0 nylon suture material. Most patients had axillary anaesthesia. General anaesthesia was used in children and uncooperative patients. Starting dissection of the amputee while the patient is being taken to the operating room and getting the anaesthetic saves time. The flexor and extensor tendons, and digital arteries and nerves are dissected before working on the venous network. Dorsal veins are easily dissected from under the skin and are marked with 8/0 nylon sutures. However, it is harder to expose volar veins. Microhaematomas in the subdermal area or subcutaneous fatty tissue, especially superficial to the digital neurovascular bundles, are areas where volar veins are expected (Figure 2). Superficial axial veins in volar sites can be found not only under the dermis but also in the subcutaneous tissue, superficial to the digital bundles (Figure 3). It is important to handle the amputated segment gently to retain as much blood as possible, because gentle squeezing of the amputated pulp enables leakage from collapsed veins to be seen. If no vein is detected in the first attempt, a second look should be taken after arterial repair. Proximal dissection can be performed after marking the volar veins.

The proximal part is prepared using a tourniquet, and it is essential at this point not to drain out venous blood distal to the level of the distal palmar crease. This is achieved by rolling an Esmarch bandage proximal to this level, which helps to detect volar veins with greater ease. Dissection is the same for tendons, arteries and dorsal veins. It is easier to find volar veins in the proximal stump rather than the distal stump. They appear as congested venous stumps or can be identified by blood leaking from the damaged lumen of the volar veins upon gentle squeezing of the proximal stump. The bones are now fixed, the flexor tendon is repaired, the arterial repair is performed and the tourniquet is deflated to check for arterial patency. Arterial patency must be ascertained before continuing with volar vein repair because after the repair of volar veins access to the artery is limited. After repairing the volar veins with 10/0 or 11/0 nylon sutures in single finger amputations, the position of the hand is changed for extensor tendon and dorsal vein repairs. In multiple finger amputations, however, all bony fixations can be done first, followed by all flexor tendon and artery repairs and then volar vein repairs for all fingers without changing the position of the hand and surgeon. The extensor tendons and dorsal veins can then be repaired after changing the position of the hand without being concerned about ischaemia time.

Results

The total number of veins repaired in 366 fingers was 1257 (mean of 3.4 per finger; Table 1). Excluding zone I patients

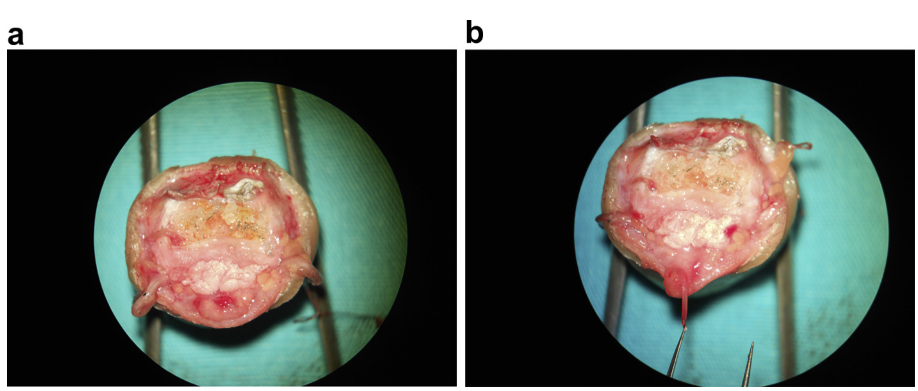

Figure 2 a) Microhaematoma in the subcutaneous fatty tissue of a third finger amputee. b) Volar vein is easily found within the microhaematoma.

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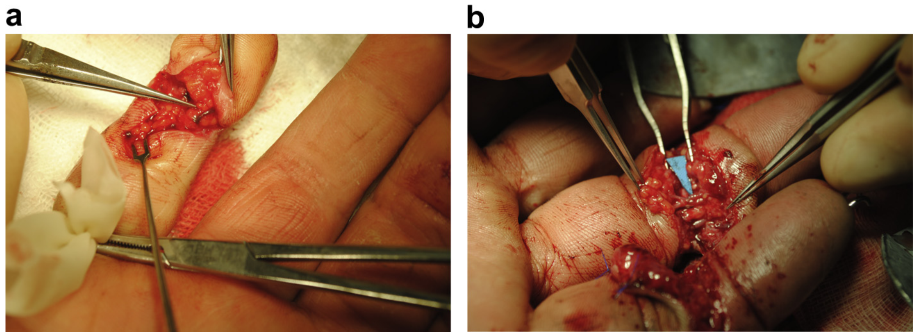

Figure 3 a) Volar vein repaired just under the dermis in a zone II amputation. b) A repaired volar vein within the subcutaneous tissue superficial to the digital bundle. Repaired artery, nerve and volar vein from dorsal to volar in a zone III amputation.

in whom only volar veins can be repaired, the mean per finger increased to 3.9. Six hundred and seventy-seven volar veins were repaired in 366 fingers (mean of 1.8 per finger). A total of 580 dorsal veins were repaired in 366 fingers (mean of 1.6 per finger). Excluding zone I injuries, the mean number of dorsal vein repairs per finger increased to 2.1. The maximum number of veins per finger was seven (four dorsal and three volar) and the minimum number was one. The total number of arteries repaired in 366 fingers was 420 (mean of 1.1 per finger; Table 1). The survival rate was lowest for ring avulsions (68%) and highest for zone I replantations (88%). Proximal interphalangeal (PIP) joint arthrodesis was performed in 32 fingers. Distal interphalangeal (DIP) joint arthrodesis was performed in 55 fingers. One hundred and twenty-three fingers were injured in multi-finger amputations. Dorsal skin necrosis was observed in 36 patients but this healed without causing any circulatory problems in all cases.

Discussion

The vascular anatomy of the upper extremity has been studied in many articles, but only few have examined the digital venous anatomy, and only a few have attempted a systematic classification of venous anatomy. Lucas[2] described a 'venous ladder', while Moss et al.[3] claimed the presence of 'two superficial networks' parallel to the neurovascular bundles. The digital neurovascular bundle was described in detail by Eaton.[4] In a systematic study, Nyström et al.[5] defined 'arborised veins' as the primary venous units of the palmar tissue amongst the four types of volar veins they described. The three other venous structures are venous arches: deep axial veins following the digital arteries, and superficial axial veins which not only are confined to the sub-dermal plane but are also found both superficially and in the deep layers of the subcutis. They reported that these superficial axial veins are those that are most frequently used for volar vein repair in replantations, and this was also the case in our patients.

A detailed study by Smith et al.[6] showed that veins with a diameter of >0.5 mm are evenly distributed between the dorsal and volar sides at the levels of the PIP and DIP joints. At the eponychial level, volar veins predominate in number and have greater diameters. At the DIP joint level, Smith et al. showed that the volar veins are significantly larger. Each region, therefore, has different characteristics. Moving distally, the larger vessels are volar, and proximal to the DIP joint, the dorsal veins tend to have wider diameters, although there are still many repairable veins on the palmar side.

Although only a small number of reports describe and evaluate the use of volar veins in replantation surgery,[7] volar vein repair is worthy of greater consideration as it has technical advantages and is associated with higher survival rates. Increasing the repaired vein:artery ratio increases the success of replantation. Tamai et al.[8] proposed that two veins per artery repair are sufficient. Urbaniak et al.[9] and Goldner et al.[10] concluded in two different studies that a significantly higher success rate was achieved in digits with two or three vein repairs than those with fewer. Baker and Kleinert[11] reported that survival rates increased significantly in infants and young children with an increasing number of vein repairs. Lee et al.[1] showed that in zone I, the survival rate of the digits with a repaired vein was higher than that of digits treated by external bleeding. In zone II, repairing more arteries than veins led to venous congestion and resulted in failure of the replant. Thus, a ratio of the same or a higher number of repaired veins to repaired arteries is an important factor for successful replantation in zone II. In zone III, an equal number of repaired arteries and repaired veins was also an important factor in successful replantations. However, unlike zone II, even when more arteries are repaired compared to veins, venous congestion rarely occurs because the veins in this area are larger, providing sufficient venous drainage. In zone IV, repair of two veins is recommended to yield good results. Lee et al. concluded that it is always desirable to repair as many vessels as possible to increase the possibility of a successful outcome, and no specific vein:artery ratio can be suggested to guarantee this. Each zone has its own characteristics, but in general it can be said that increasing the quality and quantity of vein repairs increases survival rates.

The volar skin covering the volar vein repairs is better vascularised, thicker and less likely to be avulsed during injury compared to dorsal skin. Surgeons frequently observe dorsal skin necrosis over valuable dorsal vein repairs. The dorsal skin is loosely attached to the underlying tissues and easily avulsed during injury. Moreover, the surgical dissection required to find and prepare dorsal veins makes it more prone to necrosis. Debridement of the necrosed dorsal skin is always problematic, even weeks after replantation (Figure 4). Repairing at least one volar vein in any zone will help in such situations.

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Figure 4 Dorsal skin necrosis threatening the valuable dorsal venous repairs.

Bony fixations and arthrodeses are always performed with the joint flexed in different positions. Primary repair of dorsal veins may then be difficult due to the tightness of the skin, especially when there is some dorsal tissue loss. Vein grafts and bone shortening can be used successfully in such cases. However, we think that repairing relaxed volar veins is a better solution for cases of replantation needing a flexed joint position, especially at the PIP level.

Time is valuable in multiple finger replantations. Repairing volar veins after repairing the arteries gives the surgeon a chance for working on all the fingers without changing his position or the position of the hand. Blood loss is also reduced. The dorsal veins and extensor tendons of all the fingers can now be repaired after changing the position of the hand without any hurry. The overall surgical time may be a little longer for the whole procedure since more veins are repaired but the time needed to establish a basic arteriovenous network is less for each finger.

In amputations with tissue loss, the size discrepancy of volar veins is less compared to dorsal veins. The dorsal vein diameter tends to increase from distal to proximal, which can be a problem in replantations with tissue loss due to size mismatch during a repair. Our experience shows that the superficial axial volar veins have a relatively constant diameter from distal to proximal and that there are few or even no size mismatches in amputations with tissue loss.

We do not suggest use of volar veins as an alternative to dorsal veins, rather we feel that they should be repaired more often to augment venous outflow.

The aim of this study was not to demonstrate a statistically significant increase in survival rates with volar vein repairs because there are many other factors affecting survival rates after replantation. A comparative study may also fail to show increased survival rates with volar vein anastomosis because groups of injuries are rarely homogeneous. Although we repair volar veins, our survival results were not significantly superior to the results reported in the literature. This may be partly because of the cultural and social demands made by our patients that force us to perform replantations even in situations with relative contraindications, such as crushed and avulsed fingers, or even in elderly smokers.

In conclusion, volar vein repair in finger replantation gives the hand surgeon the opportunity to repair more vessels to save the replanted digit with technical advantages, and may be associated with a greater possibility of survival.

Conflict of interest/funding

None.

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