DORSAL APPROACH FOR VASCULAR REPAIRS IN DISTAL FINGER REPLANTATIONS

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Introduction: Distal finger replantations are technically difficult operations due to small vessel sizes and narrow field of vision. The results of 25 distal finger replantations performed by dorsal approach are presented. The technical benefits and details of this technique is discussed with a literature review. *Patients and methods*: Twenty-five distal finger replantations were performed by dorsal approach. In dorsal approach volar skin was repaired first and arterial and venous repairs were performed from dorsal side before bone fixation and nailbed repair. Twenty-one cases were Tamai zone I amputations 4 cases were Tamai zone II amputations. 3 amputations were in children and the other patients were adults. Nine amputations were transverse type and the others were oblique amputations. *Results*: Twenty-three fingers survived and 2 fingers were lost despite revision surgeries (92% success rate). Dorsal approach provided about 2 times wider exposures compared to the volar approach. Fourteen patients had external bleeding to prevent congestion. Mean duration of external bleeding was 6.8 days (range, 6 − 8 days). Mean hospitalization period was 7.7 days (range, 6 − 10 days). The mean follow up period was 13 months (range, 6 − 28 months). Six patients had nail deformity. Four patients had pulp atrophy. Three patients had restriction of range of motion in distal interphalangeal joint. *Conclusion*: Dorsal approach provides a better exposure of vessel repair sites without tension and helps in technical difficulties of distal finger replantation. All types of distal finger amputations are amenable to dorsal approach for vascular repairs and oblique amputations are ideal ones. © 2016 Wiley Periodicals, Inc. Microsurgery 36:628–636, 2016.

Distal finger replantation has become a routine operation in many hand units. Although controversy exists for the benefits of fingertip replantation, a successful distal finger replantation preserves the finger length and nail and provides good and sensate skin cover. The results are superior to stump revision and other reconstruction methods both functionally and cosmetically. Longer operation times, longer hospital stays, longer time off work, and higher costs are main drawbacks of this operation.[1]

Technical difficulties are another important drawback of this operation. The vessel sizes are about 0.8 mm to 0.3 mm.[2,3] The vessels are thin walled and their flexibility is less compared to proximal replantations. 11/0 sutures are needed in most cases. Tension is not tolerated by this very thin vessels during repair. The bulk of the pulp tissue precludes a wide view of the repair site. Retraction of skin and pulp tissue increases tension on the anastomosis. It is difficult to use microvascular clamps in this narrow field of vision. The artery is in the deepest location just over the periosteum.

We use dorsal approach to overcome some of these technical difficulties. Dorsal approach has been described by Foucher and Norris for distal thumb replantations.[4] Since then very little emphasis is found in the literature about dorsal approach.[5,6]

The purpose of this report is to present the results of 25 cases of distal finger replantations, performed by dorsal approach for vascular repairs. The details of this technique and its benefits are discussed with a literature review.

PATIENTS AND METHODS

Totally, 25 cases of distal finger replantations were performed by dorsal approach between 2011 and 2015 in 18 male and 7 female patients. Table 1 shows patients' information and results. There were no inclusion or exclusion criteria for this study. Twenty-one cases were Tamai zone I amputations 4 cases were Tamai zone II amputations. Three amputations were in children and the other patients were adults. All operations were performed by the same single surgeon.

The amputated fingers were the middle finger in 9 cases, the index finger in 6 cases, the thumb in 5 patients, the little finger in 4 patients and the ring finger in 1 patient. Six cases had interventions to other fingers other than replantation. Four operations were performed under general anesthesia, 5 under axillary anesthesia, and 16 under digital anesthesia.

Eleven cases were crush amputations and 6 cases were crush-avulsion amputations and 8 cases were guillotine type amputations. Nine cases were transverse amputations, 7 were volar oblique amputations, 5 were dorsal oblique amputations, and 4 were radial or ulnar oblique amputations.

SURGICAL TECHNIQUE

In dorsal approach the vascular repairs were performed from dorsal side before bone fixation. After preparing and tagging the vessels and nerves of the amputated part and

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Table 1. The Information and Results of Patients

Patient number	Age	Gender	Replanted Finger	Tamai zone	Type of injury	Type of amputation	Number of veins repaired	Nerve repair	Vein grafting For artery	Duration of External bleeding (days)	Survival S: survived F: Failed	Secondary surgery	Hospitalization (days)	Nail deformity	Pulp atrophy	Return to work (weeks)	Restrictionof DIPmotion	Follow upperiod
1	24	Male	Thumb	1	Crush	Transverse	2	Yes		6	S		7	Yes	Yes	11		12 months
2	20	Male	Middle	1	Guillotine	Dorsal oblique	1				S		7			10		6 months
3	32	Female	Little	1	Guillotine	Radial oblique	2			7	S		8			10		10 months
4	26	Male	Ring	1	Crush	Volar oblique	3				S		7		Yes	9	Yes	18 months
5	8	Male	Index	1	Crush and avulsion	Transverse	1		Secondary in revision surgery		F	Vein grafting for the artery at the second day and Amputation, stump closure due to failure at the second week	10					
6	19	Male	Index	2	Crush	Transverse	3	Yes			S		8	Yes		10	Yes	12 months
7	12	Female	Middle	1	Guillotine	Ulnar oblique	0			8	S		9					20 months
8	37	Male	Middle	1	Crush	Transverse	2				S		7			11		16 months
9	35	Male	Thumb	1	Guillotine	Volar oblique	0	Yes		8	S		9			10		8 months
10	43	Male	Thumb	1	Crush	Volar oblique	0	Yes		7	S		8	Yes		10		22 months
11	28	Female	Index	2	Guillotine	Transverse	3	Yes			S		6			6		28 months
12	33	Female	Little	1	Crush	Volar oblique	0			6	S		7	Yes	Yes	10		12 months
13	27	Male	Middle	2	Crush	Dorsal oblique	2		Primary		S		7			12	Arthrodesis	9 months
14	33	Male	Index	1	Crush and avulsion	Dorsal oblique	0			7	S		8			11		12 months
15	6	Female	Index	1	Crush	Transverse	0	Yes	Primary	8	S		9	Yes				13 months
16	18	Male	Middle	1	Guillotine	Transverse	1			6	S		7			10		6 months
17	24	Male	Thumb	1	Guillotine	Radial oblique	0			6	S		7			11		20 months
18	22	Male	Middle	1	Crush and avulsion	Volar oblique	2				S		7		Yes	10		14 months
19	32	Female	Index	1	Crush and avulsion	Volar oblique	1				S		7			10		6 months
20	32	Male	Middle	1	Crush and avulsion	Volar oblique	3				F	Revision of arterial repair in the fourth day and amputation, stump closure due to failure at the tenth day	10			7		
21	47	Male	Little	1	Guillotine	Ulnar oblique	1			6	S		7			10		13 months
22	27	Male	Middle	2	Crush	Dorsal oblique	3				S		7			11	Yes	12 months
23	33	Male	Middle	1	Crush and avulsion	Transverse	1			7	S		8	Yes		10		6 months
24	21	Female	Little	1	Crush	Transverse	0	Yes		7	S		8			11		12 months
25	48	Male	Thumb	1	Crush	Dorsal oblique	0			6	S		8			10		12 months

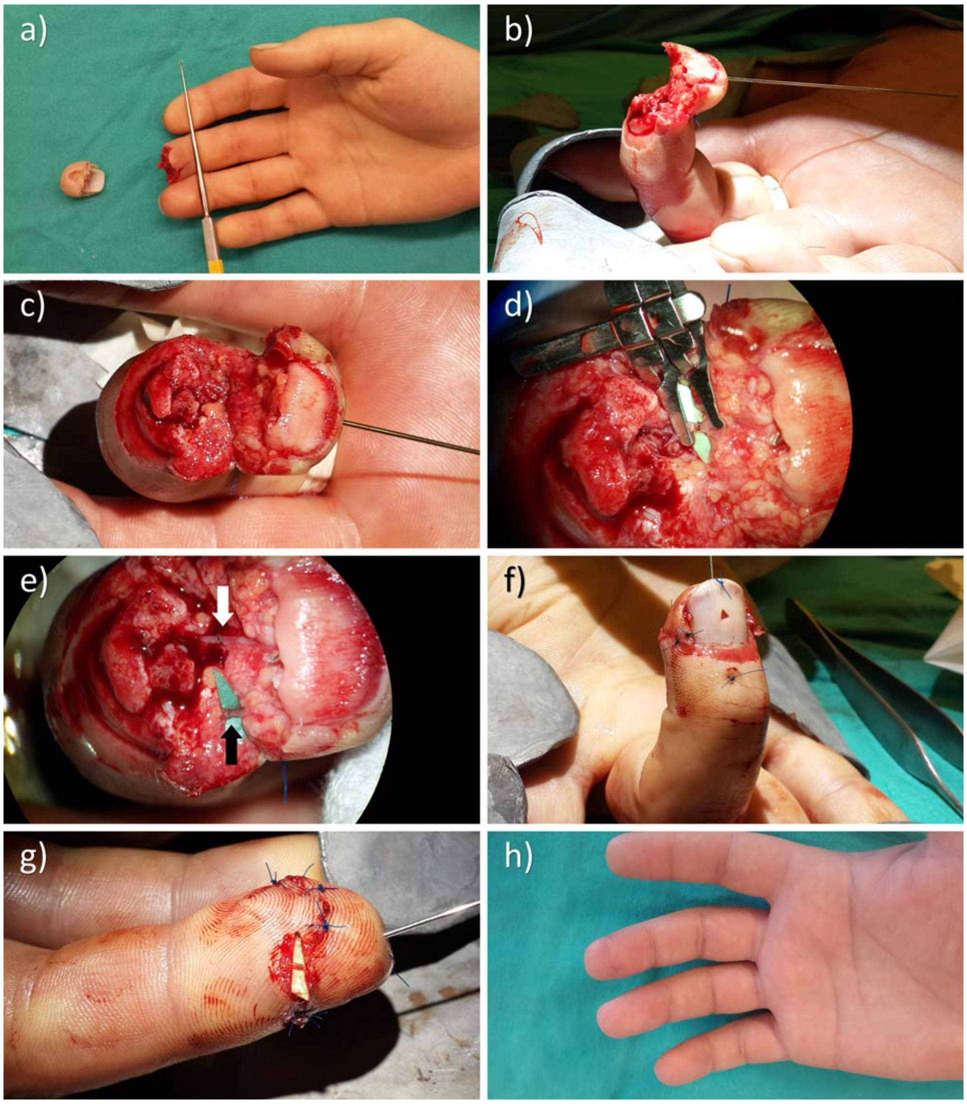

*Figure 1. (a) A 37-year-old male patient had a transverse Tamai Zone I amputation of the middle finger. The vessels were tagged and prepared. (**b**) K- wire was passed from the amputated part. Volar skin was repaired without bone fixation. The K wire's length and skin sutures were adjusted to obtain the best exposure with least tension and the amputated part was retracted to volar side using the volar skin as a hinge. The weight of the K-wire stabilized the exposure. (**c**) Wide exposure of the anastomosis sites was obtained. (**d**) The exposure was wide enough to place a microvascular clamp if needed. (**e**) The arterial repair was completed (white arrow). A subcutaneous volar vein was repaired without the need for a microvascular clamp (black arrow). (**f**) The bone was fixed and lateral skin and nail bed repair was performed and nail plate was fixed with sutures. (**g**) A previously tagged subdermal volar vein was repaired lastly from volar side. (**h**) The result at the six month.*

proximal stump, the hand was positioned by lead hand in supine position and the uninjured fingers were fixed with lead hand (Figs. 1a and 1b). A K- wire was passed to the amputated part only. The volar skin was repaired first as a hinge and the exposure was obtained from dorsal side (Fig. 1b). The exposure was wide enough to use microvascular clamp and approximator (Figs. 1c and 1d). The structures were repaired from volar to dorsal before bone fixation. As the repairs came dorsally the number of volar skin sutures were increased or the K- wire was manipulated to obtain the best exposure with least tension. Subcutaneous volar vein was repaired by dorsal approach (Fig. 1e). After completing the repairs by dorsal approach the amputated segment was reduced carefully and the K- wire was passed to proximal bone. Lateral skin and nail bed repair was performed and nail plate was fixed with sutures (Fig. 1f). If a previously tagged subdermal volar vein would be repaired than the sutures were taken from the volar skin and the subdermal volar vein was repaired from volar side (Figs 1 g and 1 h).

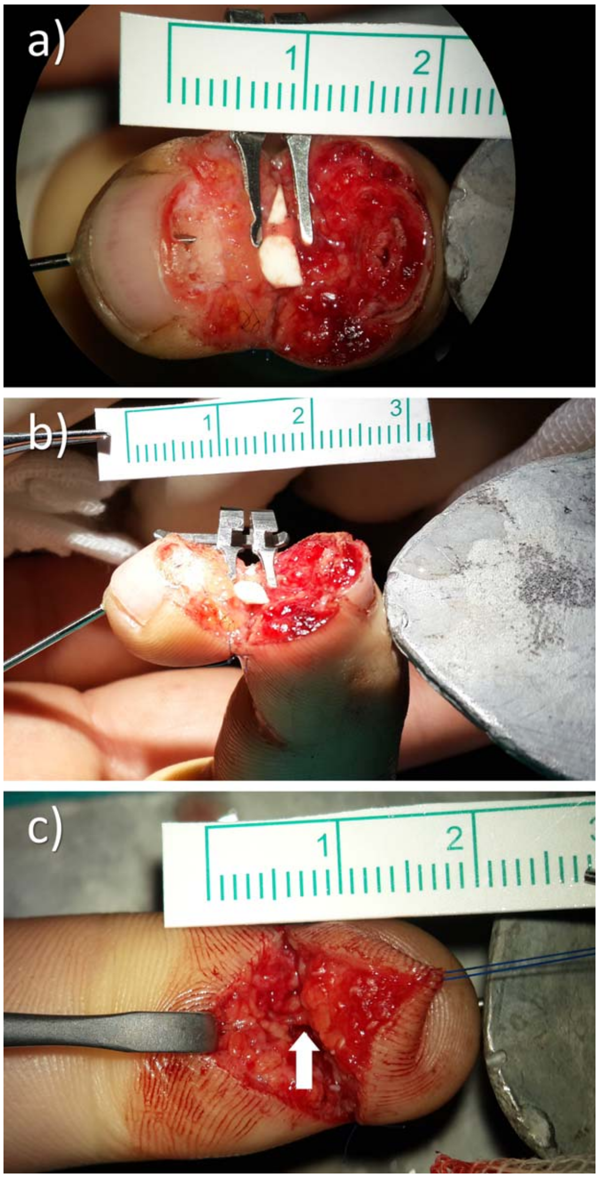

*Figure 2. (a) The middle finger was amputated at the left hand of an 18-year-old male patient. The exposure of arterial repair in dorsal approach was about 2 cm without need for an assistant to retract soft tissues or without stay sutures. (**b**) Lateral view of the same patient. The cross section of cleft for vascular repairs was like a semicircle providing a better exposure without soft tissue interruption. (**c**) The volar approach to the same finger's arterial repair site (white arrow) resulted in a 1 cm exposure with the cross section being like a "V". Stay sutures and retraction of soft tissues by an assistant were needed to maintain exposure.*

In patients who needed vein grafting, vein grafts were harvested from thenar area or volar wrist depending on the size of the vessels. Vein grafting and nerve repairs were also performed by dorsal approach.

In order to compare the exposures of dorsal and volar approaches objectively, in three patients with transverse amputations, the replantations were performed by dorsal approach by measuring the width of exposures from dorsal approach. After completing the replantations by dorsal approach with bone fixation and nail bed repair, the volar skin sutures were taken and the arterial repair sites were exposed again for the same fingers by volar approach. Again the widths of exposures by volar approach were measured for comparison in these three patients (Fig. 2).

We tried to compare the exposures between dorsal and volar approaches also in oblique amputations. In some volar oblique amputations in which anastomosis sites were distal to the skin amputation level, it was so difficult by volar approach even to see the tagged vessel ends for repair when the bone is fixed (Fig. 3). In volar approach although the bone fixation approximated the vessel ends it also brought the thick pulp tissue that precluded exposure of the repair sites in such cases. However, these vascular repairs were performed comfortably by dorsal approach. Normally these cases were either vein grafted or skin incisions were performed to the small amputated part to reach the vessel repair sites or more simply composite grafted. Dorsal approach enabled replantation without vein grafting or skin incision in such cases.

In some dorsal oblique replantations in which the artery to be repaired was dorsal to the main axis of bony phalanx. It was nearly impossible to reach the repair sites by volar approach to compare the exposures between two approaches (Fig. 4).

Dextran 40 intravenous infusion 10 ml/kg/day was started during operation and continued for four days. If bleeding was too much infusion was stopped before four days. Oral acetylsalicylic acid 300 mg/day was started in the first day and continued until third week. Oral pentoxifylline 3×400 mg/day was started in the first day and continued until third week. Enoxaparin 60 mg/day was started during operation and continued until discharge. All dosages were arranged in children according to weights.

RESULTS

We measured and compared the exposures of volar and dorsal approaches in three patients with transverse amputations for the same replanted finger (Figs. 2a and 2c). The measurements in the first patient were 2 cm for dorsal approach and 1 cm for volar approach. The measurements in the second patient were 2.2 cm for dorsal approach and 1.2 cm for volar approach. The measurements in the third patient were 2.4 cm for dorsal approach and 1.3 cm for volar approach. Dorsal approach provided 2 times wider exposure in the first patient, 1.83 times wider exposure in the second patient and 1.84 times wider exposure in the third patient. Moreover the

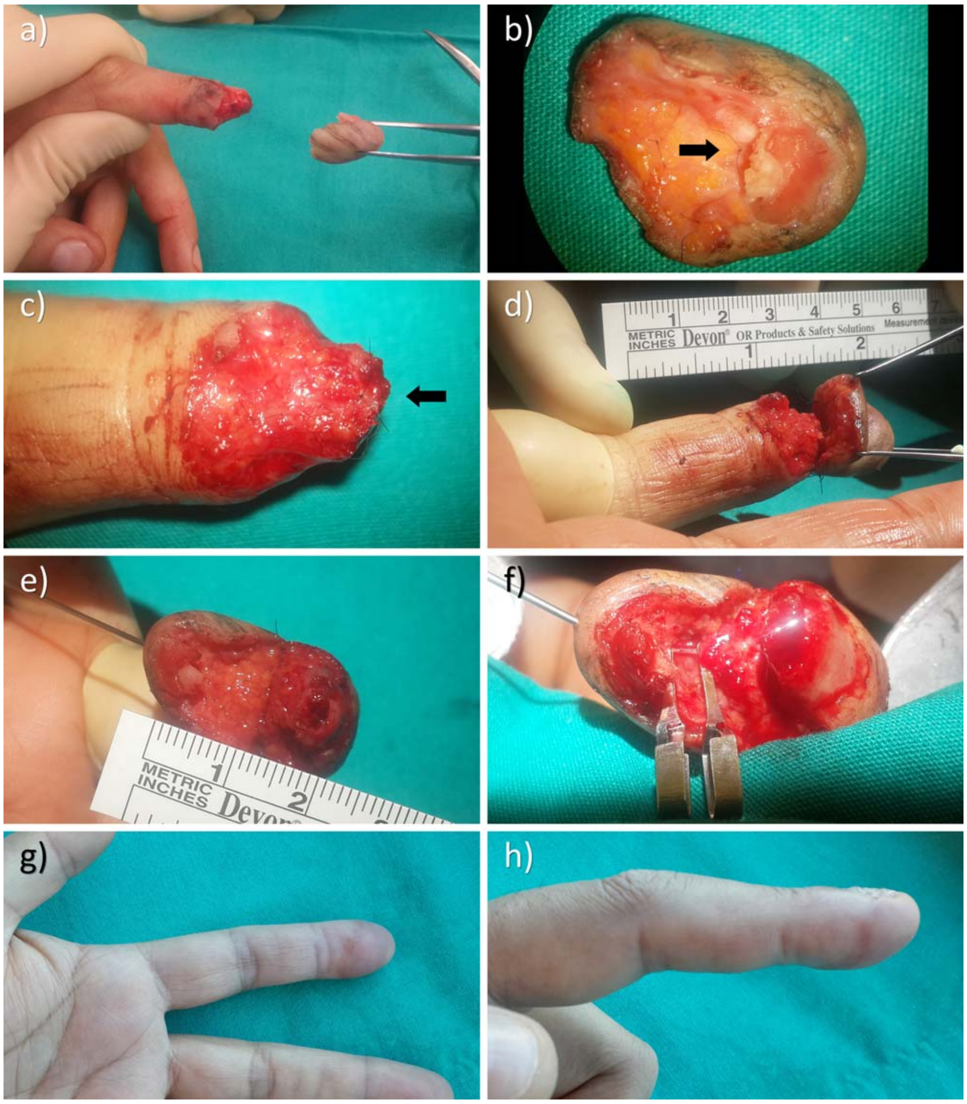

*Figure 3. (a) Volar oblique amputation of index finger caused by a crush avulsion injury in a 32-year-old female patient. (**b**) The artery (black arrow) was in the deepest location of amputated finger and was away from the skin edge. Two subcutaneous veins were also tagged. (**c**) The artery at the tip of stump was tagged (black arrow). (**d**) After temporary bone fixation it was not possible even to see the tagged vessel ends by volar approach with maximum retraction of skin providing about 1 cm cleft. (**e**) The exposure by dorsal approach was 2 cm. (**f**) The artery at the stump was first mobilized with a periosteal flap and the anastomosis was performed comfortably by dorsal approach. (**g**, **h**) The result at tenth week.*

cross section of cleft between skins edges was "V" shaped in volar approach having the repairs at the narrowest bottom of "V" (Fig. 2c). However, the cross section of cleft in dorsal approach was like a semicircle providing a better exposure without soft tissue interruption that prevents suture handling and vision (Fig. 2b).

Totally, 23 fingers survived and 2 fingers were lost despite revision surgeries (92% success rate). One artery was repaired in all patients. All arteries, subcutaneous, lateral, and dorsal veins were repaired by dorsal approach, only subdermal volar veins were repaired by volar approach. It was not possible to repair any vein in 9 patients, 1 vein was repaired in 6 patients, 2 veins were repaired in 5 patients and 3 veins were repaired in 5 patients. The results of patients are summarized in Table 1.

External bleeding was performed in 14 patients. Nine of them were patients without venous repairs and 5 of them were patients with venous repairs who still had immediate external bleeding due to poor quality of venous repairs. External bleeding was started immediately after operation without waiting for the signs of congestion. A tangential excision of epidermis was performed by scalpel in a 3 mm^2 to 5 mm^2 area of replanted fingertip without a true incision like harvesting a thin small split thickness skin graft. This exposed the dermal vessels. Bleeding was obtained by abrading the area by a dry gauze or by the tip of a needle.

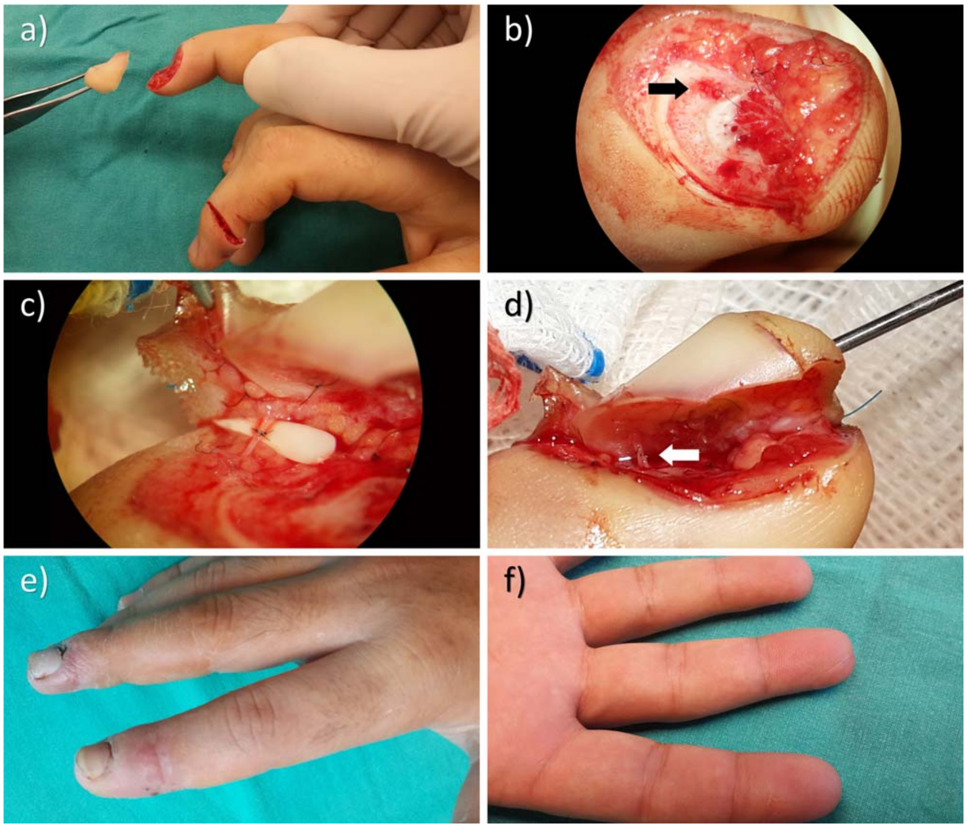

*Figure 4. (a) Middle finger was amputated in a dorsal oblique type of guillotine injury in a 20-year-old male patient. (**b**) The artery to be repaired was tagged (black arrow) within the nailbed dorsal to the bony phalanx. (**c**) A lateral vein was repaired first by dorsal approach. (**d**) The artery (white arrow) was repaired within the nailbed by dorsal approach before bone fixation. One could not reach this artery by volar approach to compare the exposures especially when the bone was fixed. It would be difficult even by dorsal approach after bone fixation. Performing the anastomosis before bone fixation enabled this repair. (**e**) The result at seventh week. (**f**) The result at sixth month.*

Bleeding was maintained by applying diluted heparin soaked gauze to the de-epithelized area. The interval of bleeding was 2 hours for the first and second day after replantation. In the third day if the color of bleeding was bright red in three consecutive bleedings than we increased the interval to 4 hours and if the colour of bleeding was bright red in three consecutive bleedings in any day then we increased the interval to 6 and then to 8 hours. In any day if the color of bleeding got darker red in three consecutive bleedings then we decreased the interval. Usually we reached to 8 hours of interval by the fifth or sixth day. The mean duration of external bleeding was 6.8 days in 14 patients (range, 6–8 days). Before discharge we kept the patient 24 hour without external bleeding to see if any sign of congestion occurs.

Vein grafts were used for arterial repair in 3 patients. Two of these patients had primary vein grafting due to crush injury of the artery. One of them had secondary vein grafting due to arterial thrombosis at the second day in the revision surgery. Vein grafts were harvested from thenar area in two patients and from volar wrist in one patient. Nerve repair was possible in seven patients. Nerve repairs were also performed by dorsal approach. The mean operation time was 190 min (range 55 min−270 min, excluding revision and secondary surgeries). The mean hospitalization period was 7.7 days (range, 6–10 days). The mean time off work was 10 weeks for 22 patients (range 6–12 weeks, including a failed case, three patients were excluded because they were children including the other failed case). The mean follow up period was 13 months (range 6–28 months excluding failures). After discharge the patients were seen every other day for the first week and after one week the patients were called back for dressing change in every 3 or 4 days before physiotherapy starts. All patients had controls before starting to work after physiotherapy and called back for the third, sixth, and twelfth months of replantation. Six patients had nail deformity 5 of them were Tamai zone I replantation and one of them was Tamai zone II replantation with damage to germinal matrix. Four patients had pulp atrophy three of them were crush and one was crush avulsion type injury.

Three patients had restriction in distal interphalangeal joint range of motion. Two of them were Tamai zone II replantation and one was Tamai zone I replantation. One patient had arthrodesis of distal interphalangeal joint.

CASE REPORTS

Case 1

A 32-year-old female patient presented with a crush avulsion amputation of index finger of her left hand (Patient number 19 in Table 1). The Tamai Zone I amputation occurred in an industrial injury that was caused by a band rotating on a high speed wheel (Fig. 3a). The pulp was amputated in a volar oblique direction with a small bone fragment of tip of distal phalanx (Fig. 3b). The vessels were tagged in the amputated part and in the stump (Figs 3b and 3c). It was not possible to expose the arterial repair site by volar approach after temporary bone fixation for comparison of the dorsal and volar exposures (Fig. 3 d). The replantation was performed by dorsal approach (Figs. 3e and 3f). One artery and one vein were repaired with 11/0 suture material. It was not possible to repair any nerve. The operation time was 200 min Dextran 40 intravenous infusion 10 ml/kg/day was started during operation and continued for four days. Oral acetylsalicylic acid 300 mg/day was started in the first day and continued until third week. Oral pentoxifylline 3x400 mg/day was started in the first day and continued until third week. Enoxaparin 60 mg/day was started during operation and continued until discharge. She did not have signs of congestion or arterial insufficiency in the postoperative period and she was discharged at the end of first week without any complication. After discharge she was seen every other day for the first week and after one week she was called back for dressing change in every three or four days before physiotherapy starts. The K-wire was extracted at the end of fourth week and physiotherapy started at fifth week. She started working 10 weeks after operation (Figs. 3g and 3h). She had no pulp atrophy or nail deformity when she was seen in her 6th month control.

Case 2

A 20-year-old male patient had a guillotine amputation of middle finger of his right hand. The injury was caused by a punch metal slicer (Patient number 2 in Table 1). The slicer amputated the nailbed with some radial side of pulp in a dorsal oblique direction (Figs. 4a and 4b). The artery to be repaired was within the nailbed just dorsal to the distal phalanx (Fig. 4b). One artery and one lateral vein were repaired with 11/0 sutures (Figs. 4c and 4d). It was not possible to repair any nerve. The operation time was 180 min. He had no complications during postoperative period Dextran 40 intravenous infusion 10 ml/kg/day was started during operation and continued for four days. Oral acetylsalicylic acid 300 mg/day was started in the first day and continued until third week. Oral pentoxifylline 3x400 mg/day was started in the first day and continued until third week. Enoxaparin 60 mg/day was started during operation and continued until discharge. He did not have signs of congestion or arterial insufficiency in the postoperative period and he was discharged at the end of first week without any complication. After discharge he was seen every other day for the first week and after one week he was called back for dressing change in every three or four days before physiotherapy starts. The K-wire was extracted at the end of fifth week and physiotherapy started at sixth week (Fig. 4e). He started working ten weeks after operation. He had no any late complication and he was satisfied with the result when he was seen in his sixth month control (Fig. 4f).

DISCUSSION

Decision of replantation in a distal finger amputation may be difficult because there are many options to reconstruct the stump other than replantation. When the amputated part is not replanted, distal finger amputations can be repaired by bony shortening and primary repair, skin or composite grafts, local or regional, flaps. However these techniques have drawbacks, such as non-aesthetic appearance, the need to shorten the finger, persistent pain, hypersensitivity, cold intolerance, paresthesia, soft tissue atrophy, absence of nail or nail deformity, joint stiffness, and decreased grip power. Some of these techniques also require a second operation with donor site morbidity. Goldner et al. listed the advantages of replantation in distal finger amputations as: it is a single stage procedure providing a good soft tissue coverage, good sensibility without painful neuroma, good range of motion in the affected joints, preservation of nail and finger length, cosmetically pleasing and satisfying the patient.[7] Hattori et al. compared 23 distal finger replantations with 23 amputation closures and found that replantation not only provides the best appearance but also the best functional outcome.[1] The existence of paresthesia and cold intolerance were not statistically different between the 2 groups, but pain in the affected fingers was more frequent in the amputation closure group (2 patients in the replantation group, 14 patients in the amputation closure group). Disabilities of the Arm, Shoulder, and Hand score of the successful replantation group was statistically better.[1] Distal finger replantations has become a routine operation in many hand surgery clinics due to its advantages over other reconstruction methods.

Sebastin SJ and Chung KC in their systematic review of the outcomes of replantation of distal digital amputation including 30 studies with 2273 distal replantations found the mean survival rate as 86%.[8] Pulp atrophy was found in 14% of patients and nail deformity was seen in 23% of the patients.[8] They concluded that the common perception as distal replantation is associated with little functional gain is not based on scientific evidence and review of the 30 studies proved high success rate with good functional outcomes.

Pulp atrophy is believed to occur mostly in patients with crush amputations and with postoperative vascular complications.[9] Our 4 cases with pulp atrophy (17%, excluding failures) were crush and crush avulsion type amputations. Hahn et al. in their large series of distal replantations found pulp atrophy in 10% of the patients and recommended to anastomose as many veins as possible to minimize soft tissue atrophy.[10]

Nail deformity is another complication after distal finger replantation. Nishi et al. studied nail regeneration in 48 replanted digits.[11] They observed that replantation at the level of sterile matrix showed near-normal nail regeneration if there is minimal postoperative circulatory disturbance. However replantation with injury to germinal matrix, resulted in more problems with nail growth. We had nail deformity in 6 patients (26% excluding failures). Five of them were Tamai zone I replantations and one of them was Tamai zone II replantation. All of them had crush and crush avulsion type amputations proving that the type of injury also affects the result of nail growth additional to zone of injury.

Nerve repairs should be performed in distal finger replantations if possible. We could repair digital nerves in seven patients. However, nerve repair is not an essential repair that must be performed in all distal finger replantations because protective sensation returns irrespective to nerve repair status. This was confirmed by many studies presenting good sensory recovery without nerve repair in distal finger replantations.[12−14] Nerve recovery is believed to be good because of the short distance the regenerating terminal branches of the purely sensory digital nerves have to travel to reach the distal targets. Additionally, the phenomenon of adjacent and spontaneous neurotization may play a role especially in younger patients.[13]

Distal finger replantations are technically demanding operations. The vessel sizes are so small that needs patience and skill for repair. The distal transverse palmar arch is formed by anastomose of two digital arteries at the level of flexor tendon insertion to the distal phalanx. Three or sometimes more vessels branch from the distal transvers palmar arch to supply the pulp with the central ones having the largest diameter. These radiating arterial branches may have a diameter $0.8 - 0.3$ mm[2]. The vein diameters are more variable. 63% of the fingers may have a vein of 0.8 mm or larger at the level of eponychium. At the level of distal tip there is an equal mix of veins 0.5 mm or larger and 0.4 mm or smaller.[3] These fragile, thin vessels need delicate manipulation and have no tolerance to tightness in repair. Moreover, a good exposure and a comfortable space are needed to perform the fine anastomoses.

Classically the distal finger replantations are performed from volar site. The routine sequence is: bone fixation, nail bed repair, tendon (if needed) and nerve repair (if possible), arterial and venous repairs. Mostly arterial repairs and some venous repairs are done by volar approach. An assistant or stay sutures are needed to retract the skin and thick pulp tissue obscuring a clear view in volar approach. The small artery is in the deepest location just over the periosteum. The amputated part is so small that it is difficult to perform long distal incisions to expose the repair sites. The narrow cleft is not enough for applying microvascular clamps and approximators in most cases. Retracting the pulp tissue and skin to increase the exposure takes the vessel ends apart from each other and puts additional tension on repair sites.

Dorsal approach with above mentioned technique helps in overcoming these technical difficulties. Dorsal approach was first proposed by Foucher and Norris for distal thumb replantations in 1992.[4] Without giving details and discussing the technique they mention dorsal approach in only one sentence that "Due to the difficulty encountered by patients in maintaining the prone position, in other very distal thumb amputations the vascular bundle was repaired via a dorsal approach, thereby producing a very deep and narrow field of vision through the operating microscope."

Morrison and McCombe in their epic review on digital replantation in 2007, named dorsal approach for distal replantations as "open book technique".[5] They state the technique and its usefulness in only one sentence that "The use of an 'open-book' technique of palmar skin closure, digital nerve, and artery anastomosis from a dorsal approach and then skeletal fixation before dorsal repair can simplify the replant". They refer to the study of Foucher and Norris without giving details or discussing the advantages.

Scheker and Becker in their review article on distal finger replantation in 2011 were the first ones detailing the technique and depicting the technique with figures of patients.[6] They did not refer to the study of Foucher and Norris and called dorsal approach as "open book technique of Morrison and McCombe". Only three cases were presented and two of them were performed by dorsal approach one by volar approach. The two cases performed by dorsal approach were oblique amputations of pulp. Although they mention some about the sequence of the technique they do not discuss the details and advantages of dorsal approach.

These three studies are the only ones we could reach in the literature about dorsal approach.

In dorsal approach the vessels are repaired before bone fixation. The advantages of this kind of repair was discussed in the study of Sabapathy et al.[15] In distal replantations they repaired the nail bed without fixating the distal phalanx and performed the vascular repairs by volar approach. The authors believe that vascular repair in such cases is facilitated by stabilization of the amputated part by nail-bed repair alone. They stated that this provides a certain degree of flexibility, which allows for easier placement of clamps in the limited space available. This flexibility is an important issue that we benefit in dorsal approach. Dorsal approach enabled repairs that possibly could not be performed by volar approach especially when the bone was fixed.

Although rarely emphasized in the literature we believe that using dorsal approach in distal finger amputations has numerous advantages over volar approach:

First of all no assistant or sutures are needed for retraction of skin and pulp tissue as needed in volar approach.

There is no need for skin incisions to expose the repair sites. It provides a wider exposure that facilitates easy microvascular clamp and approximator usage that is difficult in volar approach. Our objective measurements of exposures for the same fingers proved that dorsal approach provided near two times wider exposures compared to volar approach.

Since the bone is not fixed during repair, it provides flexibility to the vessels and soft tissue. The tension of vessels can be adjusted by adding volar skin sutures and K-wire manipulation. The advantage of repairing the vessels before bone fixation has been documented.[15]

All distal finger replantations are amenable to this approach but main advantages are seen in oblique amputations because the anastomosis sites are distal or proximal to the pulp skin edges depending on whether it's volar or dorsal oblique respectively. Repair of deep seated artery from volar site is so difficult in oblique amputations because retraction of the skin to see the tagged vessel ends, takes the stumps apart from each other. Skin incisions or forced retraction tightening the repair are needed for volar approach in such situations. However it is so easy to perform the replantation by dorsal approach in oblique amputations without retraction or skin incisions. We replanted 16 oblique amputations and none of them had skin incisions.

Lastly and most importantly the quality of all repairs increases due to lack of tension and wide exposure.

CONCLUSION

Distal finger replantation is a technical challenge and dorsal approach with its above mentioned advantages may help in overwhelming the technical difficulties. We used dorsal approach in 25 cases with different types of distal finger replantations and believe that it is easier to perform distal replantations by dorsal approach compared to classical volar approach.

REFERENCES

1. Hattori Y, Doi K, Ikeda K, Estrella EP. A retrospective study of functional outcomes after successful replantation versus amputation closure for single fingertip amputations. J Hand Surg A 2006;31: 811–818.
2. Strauch B, de Moura W. Arterial system of the fingers. J Hand Surg A 1990;15:148–154.
3. Smith DO, Oura C, Kimura C, Toshimori K. The distal venous anatomy of the finger. J Hand Surg A 1991;16:303–307.
4. Foucher G, Norris RW. Distal and very distal digital replantations. Br J Plast Surg 1992;45:199–203.
5. Morrison WA, McCombe D. Digital replantation. Hand Clin 2007; 23:1–12.
6. Scheker LR, Becker GW. Distal finger replantation. J Hand Surg Am 2011;36:521–528.
7. Goldner RD, Stevanovic MV, Nunley JA, Urbaniak JR. Digital replantation at the level of the distal interphalangeal joint and the distal phalanx. J Hand Surg [Am] 1989;14:214–220.
8. Sebastin SJ, Chung KC. A systematic review of the outcomes of replantation of distal digital amputation. Plast Reconstr Surg 2011; 128:723–737.
9. Hattori Y, Doi K, Sakamoto S, Yamasaki H, Wahegaonkar A, Addosooki A. Fingertip replantation. J Hand Surg Am 2007;32: 548–555.
10. Hahn HO, Jung SG. Results of replantation of amputated fingertips in 450 patients. J Reconstr Microsurg 2006;22:407–413.
11. Nishi G, Shibata Y, Tago K, Kubota M, Suzuki M. Nail regeneration in digits replanted after amputation through the distal phalanx. J Hand Surg [Am] 1996;21:229–233.
12. Ozcelik IB, Tuncer S, Purisa H, Sezer I, Mersa B, Kabakas F, Celikdelen P. Sensory outcome of fingertip replantations without nerve repair. Microsurgery 2008;28:524–530.
13. Faivre S, Lim A, Dautel G, Duteille F, Merle M. Adjacent and spontaneous neurotization after distal digital replantation in children. Plast Reconstr Surg 2003;111:159–165.
14. Wong C, Ho PC, Tse WL, Cheng S, Chan DK, Hung LK. Do we need to repair the nerves when replanting distal finger amputations? J Reconstr Microsurg 2010;26:347–354.
15. Sabapathy SR, Venkatramani H, Bharathi RR, Sebastin SJ. Distal fingertip replantation without skeletal fixation. J Reconstr Microsurg 2005;21:11–13.