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Digital artery perforator flaps: an easy and reliable choice for fingertip amputation reconstruction

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Objective: The aim of this study was to evaluate the use and efficacy of digital artery perforator (DAP) flaps in fingertip reconstruction.

Methods: From 2007 to 2011, 7 fingers of 5 patients (4 male, 1 female) underwent fingertip reconstruction with extended DAP flaps following traumatic fingertip amputation. Average flap size was 4.25 cm^2.

Results: All flaps survived except one case in which partial skin necrosis was observed and treated with wet-dressing. Donor sites were closed with full-thickness skin grafting in 5 and primarily in 2 fingers. We did not observe hypersensitivity or cold intolerance in repaired fingers.

Conclusion: The DAP flap is a reliable, free-style perforator flap that can be used for all types of fingertip injuries.

Key words: Digital artery perforator flap; fingertip, reconstruction.

Replantation is the primary option for amputation in terms of preserving function of the finger and obtaining a better cosmetic result.[1] When microsurgical fingertip replantation is not applicable, various fingertip reconstructions can be used, such as V-Y flap closure from unilateral, bilateral or volar side of the finger.[2,3] In case of larger defects, the thenar, hypothenar and cross-finger flaps are more suitable to reconstruct the fingertip rather than V-Y flaps.[4-8] Normograde neurovascular island flaps and reverse-flow homodigital artery flaps can be evaluated as a next reconstruction step.[8] Free venous flap, free hemipulp and trimmed toe tip methods are other reconstructive options for fingertip amputation, but they require an advanced microsurgical procedure and can be evaluated as last choice alternatives.[9-11] None of these techniques can be an alternative for each other and selection of the reconstruction technique should be done depending on the size of defect, its location, injury type, patients' medical condition and expectation, and decision of the surgeon. Digital artery perforator (DAP) flap is another technique for fingertip reconstruction. This flap and its utility for fingertip reconstruction was described by Koshima et al.[12] The DAP flap artery originates from the digital artery in the lateral aspect of the finger and these small branches perforate the thin fascia and adipose tissue. Therefore, instead of digital artery branches, they are named as digital artery perforators by Koshima et al.

In our study, we aimed to evaluate the use and efficacy of DAP flaps in fingertip reconstruction.

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Table 1. Demographical, surgical and follow-up data of the patients.

Patient	Age (yr)	Sex	Injury	Defect	Flap size (cm)	Donor site closure	Semmes-Weinstein test results (6 months after surgery)	Semmes-Weinstein test results of the contralateral normal finger
1	16	Male	Home accident	Left little finger	2.0x1.0	Skin graft	3.22-3.61	1.65-2.83
2	60	Male	Industrial accident	Left long finger	4.0x2.0	Skin graft	3.84-4.31	3.22-3.61
3	22	Male	Industrial accident	Right index, long and ring finger	2.0x1.0	Primary closure	3.22-3.61	1.65-2.83
4	21	Male	Industrial accident	Right index finger	3.5x2.0	Skin graft	3.84-4.31	1.65-2.83
5	19	Female	Home accident	Left ring finger	2.5x1.0	Skin graft	3.22-3.61	1.65-2.83

Patients and methods

Seven fingers of 5 patients (4 male, 1 female) were reconstructed between years 2007 and 2011 via DAP flaps. The average age of the patients was 27.5 (range: 16-60) years. Three patients had fingertip amputations due to industrial accidents; other two cases were domestic accidents. None of the patients had a comorbid injury. Bone segment exposition was observed in all cases. Reconstructions were performed under local anesthesia and loupe magnification.

Digital artery perforator flap method is especially recommended for transverse fingertip injuries where the bone is exposed. The contralateral side of the finger is advised for elevation in cases of lateral oblique fingertip injury with bone exposure.

Digital artery perforator flaps were elevated from the less injured sides of the fingers, avoiding the dominant sides where possible. The designed flaps were elevated superficial to the digital artery and nerve. Most of the distal DAPs were preserved as a pedicle and the flap was rotated 180° around the pedicle to restore the fingertip (Fig. 1).

Flap sizes ranged from 2.50 to 8 cm^2 (average: 4.25 cm^2) (Table 1). Donor sites were closed with full-thickness skin grafts in five fingers and with primary closure in other two fingers. Full-thickness skin grafting was preferred to prevent direct compression of the pedicle. Flaps were checked to confirm the blood supply by refilling testing.

Bulky dressings were employed after the operation. Short-arm splints were used for those patients who had a donor site closure with full-thickness skin graft.

Semmes-Weinstein monofilament sensory testing was performed. Cold intolerance was rated subjectively by the patients with regard to normal daily use (none, slight, moderate, and severe). Active range of motion was also measured in reconstructed fingers.

Case 1 was a 16-year-old male had a fingertip amputation of his left little finger with bone exposure, caused by an exercise machine accident. He also had a nail and nail bed injury (Fig. 2a). Replantation could not be performed because of the severe extent of injury and loss of

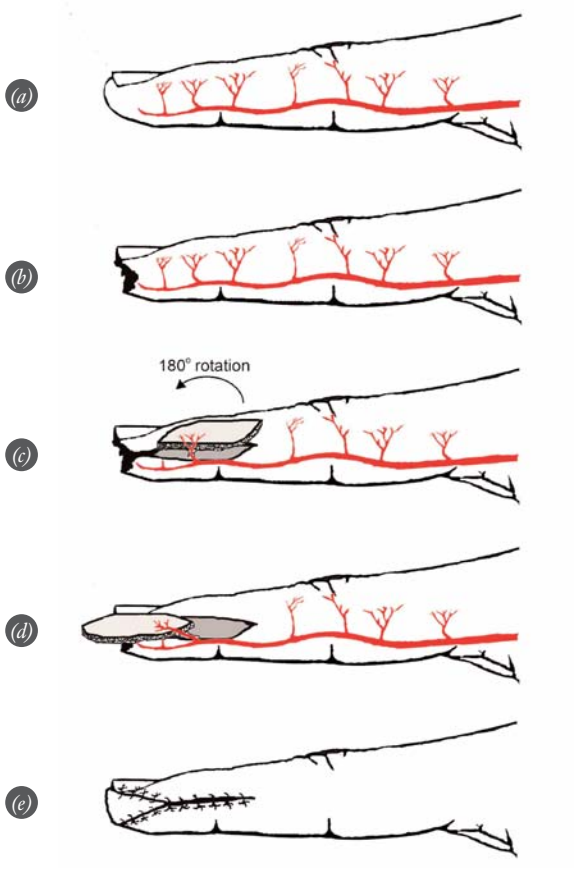

Fig. 1. Schematic illustration of the DAP flap. **(a)** Uninjured finger and anatomy of the digital artery. **(b)** Amputation of the fingertip. **(c)** Elevation and 180° rotation of the DAP flap. **(d)** Advancement of the flap. **(e)** Closure of the defect and donor sites. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

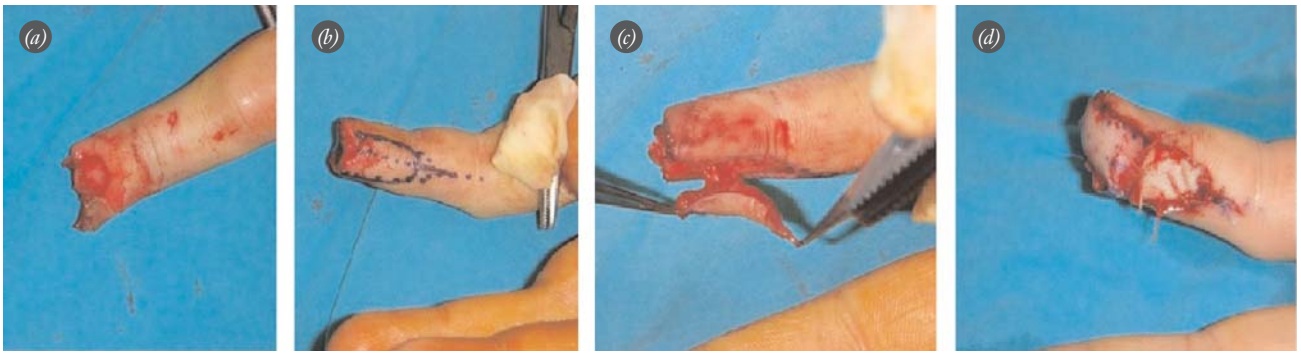

Fig. 2. Images from Case 1. **(a)** Amputation of the left hand little finger caused by an exercise machine accident. **(b)** A 2×1 cm DAP flap was designed from the ulnar mid-lateral side of the finger. **(c)** DAP flap was elevated superficial to the digital artery. **(d)** Flap was rotated 180° around the perforator and placed over the open wound site. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

the amputated part. Injury of the radial side of the finger was more severe, therefore a 2×1 cm DAP flap was designed from the ulnar mid-lateral side of the finger (Fig. 2b). A mid-lateral incision proximal to the designed flap was elongated with exploration of the ulnar side of the digital artery. DAP flap was elevated superficial to the digital artery. Dissection was done from proximal to distal. All digital artery perforators were identified and most of the distal perforators were preserved whereas the proximal perforators were sacrificed (Fig. 2c). Flap was rotated 180° around the perforator and adapted to the defect. Loose separated polypropylene 5/0 sutures were used to fix the flap. Donor site was repaired with full-thickness skin graft harvested from the volar side of the wrist (Fig. 2d). At the end of the follow-up period, the flap survived completely and the donor site healed properly (Fig. 3).

Case 2 was a 60-year-old man suffered from crush amputation of his left hand long finger due to a press machine accident (Fig. 4a). Because of the age of the patient and crush type of injury, there was no replantation indication. As the bone exposed defect area was large, a 4×2 cm DAP flap was designed from the radial side of the long finger (Fig. 4b). The DAP flap was elevated from proximal to distal direction (Fig. 4c), rotated 180° around the perforator and adapted to the fingertip. Donor site was reconstructed with full-thickness skin graft harvested from the volar side of the wrist (Fig. 4d). Skin necrosis or contracture was not observed at the end of follow-up period (Fig. 5).

Results

Except for the partial skin necrosis in one case, rest of the flaps survived completely. This case required debridement and secondary healing. After the completion of the wound healing, scar contracture was seen and this caused about 10° extension loss at the distal interphalangeal (DIP) joint. Grafts for donor site defect were adapted properly and graft failure was not observed. Average recovery period was 15 days.

Semmes-Weinstein test values of three patients were 3.22-3.61, meaning 'diminished light touch' and other two patients' values read 3.84-4.31, meaning 'diminished protective sensation' at the 6th month follow-up. (Table 1).

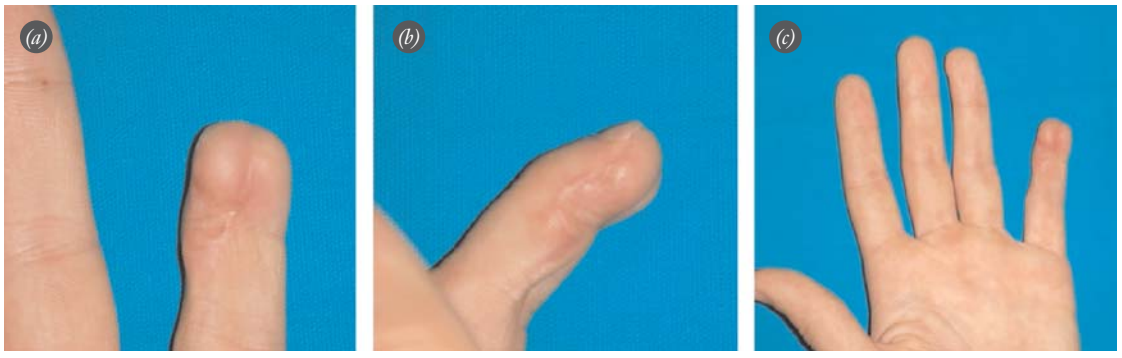

Fig. 3. Postoperative 10th month images from Case 1. Views of the finger from the **(a)** close-up volar, **(b)** radial, and **(c)** volar sides. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Fig. 4. Images from Case 2. **(a)** Amputation of the left hand long finger due to press machine accident. **(b)** As the bone exposed defect area was large, a 4x2 cm DAP flap was designed from the radial side of the long finger. **(c)** The DAP flap was elevated from proximal to distal direction. **(d)** Flep was rotated 180° around the perforator and adapted to the fingertip. Donor site was reconstructed with full-thickness skin graft harvested from the volar side of the wrist. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

Average follow-up time was 32 (range: 6 to 72) months. No patients showed hypersensitivity or cold intolerance during the follow-up period and flaps recovered with well sensation.

Discussion

Fingers are of great importance in terms of functionality and aesthetic. Partial or total loss of finger affects the person both functionally and psychologically. Microsurgical replantation is the gold standard for the reconstruction but may not be possible in all cases.

The basic goal of any type of finger reconstruction is to maintain digital length and volume, minimize aesthetic loss and preserve finger function.[1] Various finger reconstruction techniques have been reported for cases when replantation is impossible.[1-14] Bilateral, unilateral or volar V-Y advancement flaps can be used as a stump closure method. Limited length is the major disadvantage of this technique.[2,3] In case of larger defects, that cannot be repaired with V-Y advancement flap, the cross-finger, thenar and hypothenar flaps can be used.[4,5] These manipulations require a two-stage operation.[3] Between two operations, patients must use a short-arm splint for approximately 3 weeks. The major disadvantage of splint usage is joint stiffness.[6,7]

Normograde neurovascular island flaps and reverse-flow homodigital artery flaps are other methods for repairing fingertip defects. Direct-flow neurovascular island flaps have better results in terms of sensitivity, constant and reliable, direct blood flow without sacrificing a major artery. Therefore, this technique makes the direct-flow neurovascular island flaps more favorable than reverse-flow flaps.[15,16] In reverse-flow flaps, the blood supply comes from the contralateral digital artery and have higher flow insufficiency rates.[15] It requires dissection and transection of the major digital artery and has higher probability of venous insufficiency.[15] When direct-flow flap is possible, the choice of reverse-flow is not clear.[16] The free hemipulp, venous flap and trimmed toe tip methods are also used for fingertip reconstruction, but require special microsurgical techniques.[8-10]

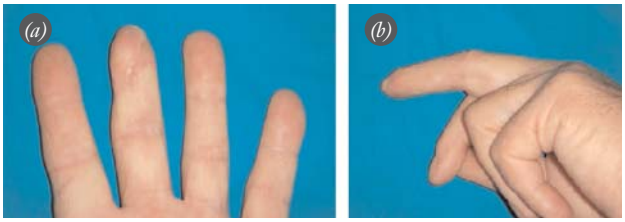

Fig. 5. Postoperative 2nd year images from Case 2. Views of the finger from the **(a)** volar and **(a)** ulnar sides. [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

The DAP flap has normograde flow and does not require digital artery transection. Small DAPs nourish the flap and both the digital artery and nerve are preserved. The preservation of the digital artery allows for the use of the vessel at the recipient artery in any secondary free flap fingertip reconstruction, such as second toe transfer.[11,12] The reverse-flow homodigital artery flap design is similar to DAP flap, however, the reverse-flow flap requires transection at the proximal level of the digital artery and the flap is elevated more distant from the defect area. These are the main disadvantages of the reverse-flow flap.[15]

The DAP flap has normograde flow and elevated from the area close to tip defect.[1,12] The flap can be elevated under loupe magnification and finger tourniquet. Elevation of the flap requires less invasive surgery and the flap circulation is reliable. The operation time is shorter than other reconstructive techniques that require microsurgical practice. During the elevation of the flap, the subcutaneous tissue around the perforator must be preserved; the venous drainage of the flap is established by this subcutaneous tissue. Protection of the subcutaneous tissue around the perforators signifi-

cantly reduces the possibility of the following venous drainage problem. In some cases, perforator cannot be found during dissection, the surgeon can elevate the flap over the most distal uninjured subcutaneous tissue. The probability of nourishment of the flap from this subcutaneous tissue is not uncommon, making the DAP flap more reliable than other neurovascular island flaps.[1,12]

The indication of DAP flap includes all cases of fingertip amputations with the bone exposed. The disadvantages of the method include limited flap size, risk of pincushion effect, and arterial inflow instability.[1] The flap can be designed 2x1 cm in size if the donor site is repaired primarily.[1,12,17] The size limitation can be solved with the use of the adipofascial DAP flap.[1] The pincushion effect is a common risk in the island flaps. When the pincushion effect is severe and causes patient discomfort, Z-plasty can be performed. Blood flow insufficiency is also a concern with perforator flaps. Three important points should be considered to avoid this problem; the first one is to design a flap larger than defect, second is to cover the priority wound partially, and the third is to avoid pedicle kinging when rotating flaps. Tension of free donor site closure is also important in terms of prevention of the compression effect on the pedicle.

We performed the extended form of DAP to reconstruct the larger fingertip defects with bone exposure. Thick flaps that contain both skin and subcutaneous tissue prevent tenderness on the fingertip. Flaps were designed in larger than routinely used size, so the donor site defect was repaired with full-thickness skin graft. No healing problem was detected at donor sites, except in one patient with a 10° flexion contracture at the DIP joint level.

In conclusion, the DAP flap is a reliable, free-style perforator flap that can be used for all types of fingertip injuries.

Conflicts of Interest: No conflicts declared.

References

1. Mitsunaga N, Mihara M, Koshima I, Gonda K, Takuya I, Kato H, et al. Digital artery perforator (DAP) flaps: modifications for fingertip and finger stump reconstruction. J Plast Reconstr Aesthet Surg 2010;63:1312-7.
2. Atasoy E, Ioakimidis E, Kasdan ML, Kutz JE, Kleinert HE. Reconstruction of the amputated finger tip with a triangular volar flap. A new surgical procedure. J Bone Joint Surg Am 1970;52:921-6.
3. Evans DM, Martin DL. Step-advancement island flap for finger-tip reconstruction. Br J Plast Surg 1988;41:105-11.
4. Tempest MN. Cross-finger flaps in the treatment of injuries to the finger tip. Plast Reconstr Surg (1946) 1952;9:205-22.
5. Smith JR, Bom AF. An evaluation of finger-tip reconstruction by cross-finger and palmar pedicle flap. Plast Reconstr Surg 1965;35:409-18.
6. Miller AJ. Single finger tip injuries treated by thenar flap. Hand 1974;6:311-4.
7. Melone CP Jr, Beasley RW, Carstens JH Jr. The thenar flap – An analysis of its use in 150 cases. J Hand Surg Am 1982;7:291-7.
8. O'Brien B. Neurovascular island pedicle flaps for terminal amputations and digital scars. Br J Plast Surg 1968;21:258-61.
9. Lai CS, Lin SD, Yang CC. The reverse digital artery flap for fingertip reconstruction. Ann Plast Surg 1989;22:495-500.
10. Niranjan NS, Armstrong JR. A homodigital reverse pedicle island flap in soft tissue reconstruction of the finger and the thumb. J Hand Surg Br 1994;19:135-41.
11. Koshima I, Inagawa K, Urushibara K, Okumoto K, Moriguchi T. Fingertip reconstructions using partial-toe transfers. Plast Reconstr Surg 2000;105:1666-74.
12. Koshima I, Urushibara K, Fukuda N, Ohkochi M, Nagase T, Gonda K, et al. Digital artery perforator flaps for fingertip reconstructions. Plast Reconstr Surg 2006;118:1579-84.
13. Uysal A, Kankaya Y, Ulusoy MG, Sungur N, Karalezli N, Kayran O, et al. An alternative technique for microsurgically unreplantable fingertip amputations. Ann Plast Surg 2006;57:545-51.
14. Chen SY, Wang CH, Fu JP, Chang SC, Chen SG. Composite grafting for traumatic fingertip amputation in adults: technique reinforcement and experience in 31 digits. J Trauma 2011;70:148-53.
15. Kayalar M, Bal E, Toros T, Sügün ST, Özaksar K, Gürbüz Y. The outcome of direct-flow neurovascular island flaps in pulp defects. Acta Orthop Traumatol Turc 2011;45:175-84.
16. Kayalar M, Bal E, Toros T, Özaksar K, Sügün ST, Ademoğlu Y. The results of reverse-flow island flaps in pulp reconstruction. Acta Orthop Traumatol Turc 2011;45:304-11.
17. Suzuki S, Koshima I. Digital artery perforator flap for reconstruction of fingertip after resection of melanoma *in situ*. Hand Surg 2011;16:395-8.