

Versatility of Homodigital Islandized Lateral V-Y Flap for Reconstruction of Fingertips and Amputation Stumps

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ABSTRACT

Background: The primary goals of digital reconstruction are to preserve digital length and maintain full mobility of the digit. For long time lateral V-Y island flap had been used to reconstruct the fingertips. This study was designed to extend the versatility of islanded lateral V-Y advancement flap for reconstruction of the fingertip and amputation stumps.

Patients and Methods: Between December 2008 and March 2012, 116 patients (170 fingers) were treated with unilateral homodigital V-Y neurovascular island flap.

Results: 166 flaps survived, while partial flap loss occurred in 4 flaps. The flaps that suffered from partial loss were managed conservatively till complete healing with satisfactory coverage of the underlying bone. All patients were satisfied with the cosmetic and functional outcome of the surgery.

Conclusion: The homodigital V-Y neurovascular island flap is an ideal surgical option for reconstruction of fingertip injuries and amputation stumps, offering satisfactory functional recovery, and has acceptable patient satisfaction rates in terms of physical appearance and surgical outcome.

INTRODUCTION

The hand is prone to domestic and industrial trauma with fingertips being the most frequently injured portion of the hand [1]. A fingertip injury is any soft tissue, nail or bony injury distal to the insertions of the long flexor and extensor tendons of a finger or thumb [2].

Fingertip injuries are commonly seen by family and emergency physicians. Many of the cases are simple to treat and do not need specialized treatment by a hand surgeon. However, there are certain conditions where early intervention by a hand surgeon is warranted for better functional and aesthetic outcomes. They are often viewed as a relatively minor injury but their improper management can lead to considerable loss of skilled hand function. Fingertip injuries lead to significant morbidity affecting the occupational as well social activities. They account for approximately 10% of

all accidents reported in the casualty and two-thirds of hand injuries in children.

Fingertip injuries occur frequently because hands are used to explore surroundings. Common types of injuries include blunt or crush injuries to the fingernail creating subungual hematomas, nail root avulsions, and fractures of the terminal phalanx. Sharp or shearing injuries from knives and glass result in lacerations and avulsion types of soft tissue defects. Burns and frostbites commonly involve fingertips.

Though traumatic fingertip defect has relatively little effect on hand function, it still significantly affects the appearance of the hand, which produces a certain psychological stress in the patient, and it may even influence his or her working and living [3].

The approach to the management of fingertip injuries depends on many variables, including patient age, sex, hand dominance, profession, hobbies, finger involvement, location, depth, angle of the defect, nail bed involvement, status of the remaining soft tissue, co-morbid conditions and the characteristics of the fingertip defect [4].

The primary goals of digital reconstruction are to preserve digital length and maintain full mobility of the digit while providing adequate protective cover of the deeper vital structures with soft tissue and skin of good quality. The skin must not only be durable but of adequate sensibility for the normal function of that part of that particular digit. Over and above these functional aspects of reconstruction, it is necessary to remember that our hands are used as organs of expression and are also an integral part of our appearance.

Treatment of fingertip amputations is either surgical or conservative. The boundary between

surgical and conservative treatment depends on the extent of involvement of the pulp, nail, and bone. Various surgical methods are used for amputation injuries including simple revision amputation, full- or partial-thickness skin grafts, local flaps, distal flaps, kite flaps, and neurovascular island pedicle flaps [5,6,7].

Poorly managed finger-tip injuries and amputations have a shortened and/or stiff digit is usually disadvantaged functionally and cosmetically. In respect of the appearance, loss of the nail complex is a particular disadvantage, as is replacement of the digital skin by skin from elsewhere on the body which is different in colour, texture or thickness. For these reasons, we avoid terminalisation, encourage distal replantation or composite graft replacement, and also look to homodigital reconstruction whenever possible [8].

In contrast to adults, complete or partial avulsions heal extremely well in children especially before adolescence. In particular, the literature indicates that children younger than two years of age are very likely to demonstrate complete distal tip regeneration after amputation when managed without repair [9].

Homodigital reconstruction involves rearrangement of the soft tissues of the injured digit to achieve healing without seeking tissue for reconstruction from outside that digit [10,11,12]. This concept of reconstruction has definite advantages in meeting our goals of digital reconstruction. In particular, it reconstructs 'like with like' and avoids the creation of further scarring and morbidity elsewhere on the hand or body. While homodigital reconstruction is advantageous in these respects, the availability of donor tissues within an injured digit is obviously limited.

The amputated part is often not available or too badly damaged to replace. Tip injuries with only skin loss or those converted to this by minimal bone shortening can be treated with moist dressings and early mobilisation [13-16]. Where the bone exposure is more extensive, flap cover is necessary to maintain digital length. In a ragged injury with significant bone exposure, there may be ragged lengths of soft tissues adjacent to the amputation stump which are adequately vascularised and of sufficient size to provide bone cover: These "opportunistic flaps" can be used to convert the tip into a skin wound which can be healed by dressings. It is important when using this technique to ensure that the resulting reconstruction leaves a digital tip of good shape [8].

Where such opportunity for simple reconstruction of the digital tip does not exist, finger length can be maintained at that of the amputation by the use of flap reconstruction of the stump. The alternative of digital shortening may be expedient, for a variety of reasons, but is not a good operation in terms of hand function. Shortening permanently handicaps the digit, both by virtue of the loss of its length or affection of its function. The type of flap reconstruction which is appropriate depends on the extent and configuration of the digital loss.

The reconstructive methods for fingertips include, local homodigital advancement flaps including V-Y closure from ipsilateral or bilateral sides of the finger and volar advancement flaps [17-20] have been popular. Although these methods are very convenient, the major disadvantages are limited length of advancement and limited size of flaps. Cross-finger flaps [21,22] and thenar flaps [22-25] require a second-stage operation.

Other methods for repairing fingertip defects are antegrade neurovascular island flaps [26-29] and reverse-flow homodigital artery flaps [30-34] which require dissection or transection of the digital artery, sometimes longer and deeper dissection for the neurovascular bundle, and often skin grafting for donor defects. The free hemipulp flap, venous flap, [35,36] medial plantar perforator flap, and trimmed toe tip method [37,38] also require special microsurgical techniques.

In amputations which are oblique, the direction and degree of obliquity are also of significance to our choice of flaps. In transverse amputations beyond the mid-nail level and dorsal oblique amputations beyond the proximal nail fold, a Tranquilli-Leali [39] or Atasoy [18] flap works well.

In those palmar and sagittal oblique amputations which have a slope of 30 degrees or less, an alternative way to reconstruct the pulp defect is to use single pedicle lateral flaps. The earliest of these lateral flaps was described by Geissendörfer in 1943 [40]. This flap was subsequently popularised by Kutler [41]. It is vascularised by the small vessels beyond the trifurcation of the digital arteries. In our experience, these flaps only ever move significantly in the drawings in textbooks, and we no longer use them. More useful is the lateral flap described by Segmüller [42] and re-described by Biddulph [43]. Each lateral flap is raised as an island on its own neurovascular bundle and has a much bigger volume and reconstructive potential than the Geissendörfer/Kutler flaps. Originally, Segmüller raised the flaps only as far proximally as the DIP joint crease. Lanzetta et al. [44] described

the use of a modification in which the flap is extended back to the PIP joint.

In view of the homodigital reconstruction and on the bases of Lanzetta modification this study was designed to extend the versatility of islanded lateral V-Y flap. So that this flap was used for reconstruction of digital amputations at any level and finger-tip reconstruction.

PATIENTS AND METHODS

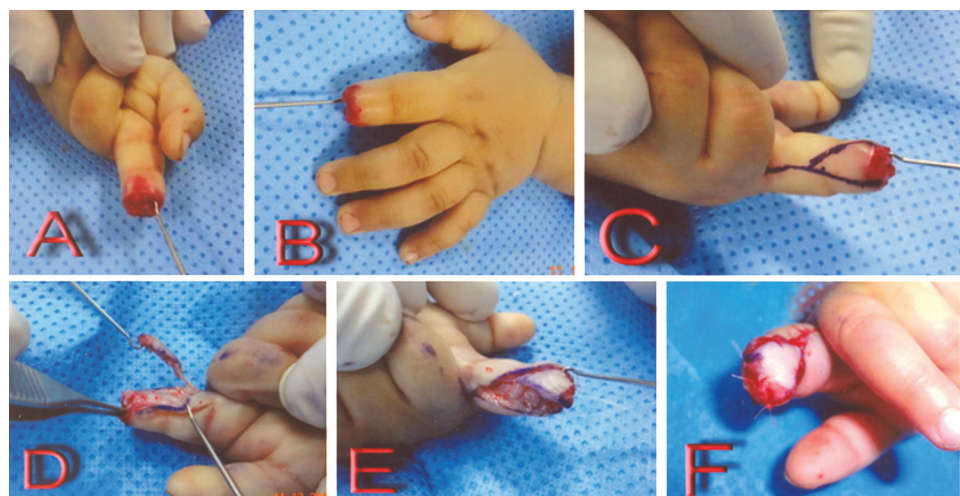
This technique was performed in two separate centers; Ain-Shams University Specialized Hospital, Cairo, Egypt and Al-Hada Armed Forces Hospitals, Taif, Saudi Arabia. Between December 2008 and March 2012, 116 patients (170 fingers) were treated with unilateral homodigital V-Y neurovascular island flap. This flap was used in four categories of injuries; finger-tip injuries with exposed bone (46 fingers), non replantable finger-tip amputations (69 fingers), amputations which are not suitable for replantation or with missed amputated part (50 fingers) and digital amputations with failed replantation (5 fingers). Ages at the time of presentation ranged from 1 to 67 years (mean: 26 years). The aetiologies of finger tip amputation included crush injury with heavy object, door trauma, and avulsion type. The injuries involved the index finger in 61 cases, the middle finger in 82 cases, the ring finger in 25 cases, and the little finger was affected in only 2 cases. The defect size ranged from 10mm x 6mm to 20mm x 12mm (mean 15mm x 10mm). In all cases, reconstruction was achieved using the unilateral homodigital V-Y neurovascular island flap. All 116 patients were invited for clinical review at an outpatient's clinic. Written records and photographic documentation of all patients were performed. Standardised assessment of outcome in terms of the defect size of the flap, the static two-point discrimination, total active motion (TAM) of the PIP and DIP joints,

time of return to daily activities and subjective assessment (satisfactory, good and very good) was completed.

Surgical technique:

The operation was carried out under general anaesthesia, with a pneumatic arm tourniquet applied and loupe magnification of 3X power. After wound debridement, the size and shape of the defect was measured. A V-shaped flap matching the defect size and orientated toward the volar surface on the contralateral side to the obliquity of the wound was marked (Fig. 1C). In cases with transverse (no obliquity) amputations in either index or little fingers, the designation of the flap is preferable to be done over the dominant bundle; ulnar one in the index and radial bundle in little finger. Incision is made along the periphery of the flap cutting only the skin. The incision is then extended mid-laterally to the base of the finger in a lazy S fashion exposing the digital neurovascular bundle. The elevation of the flap started distally and dorsally. The neurovascular pedicle was included in the flap by freeing it from Cleland's ligaments. The elevation continued in the palmar side with severing the Grayson ligament, allowing the bundle to be elevated off the tendon sheath (Fig. 1D). Care was taken to leave sufficient fat tissue around the neurovascular pedicle to ensure adequate venous drainage of the island. After complete dissection of the neurovascular bundle, the flap was advanced into the defect (Fig. 1E) and sutured with 4-0 absorbable sutures. The flap was advanced for up to 1cm in a V-Y fashion and there was no need to use skin grafts to cover additional residual defects (Fig. 1F). The sutures were removed on the 15th day postoperatively. After doing such large series, we found that arm tourniquet is much better the use of finger tourniquet in view of flap dissection, mobilization and inset without any undue tension.

Fig. (1): Steps of surgical technique. A & B- 18 months old baby with amputated terminal phalanx of the left index finger with a defect of 10 x 12mm. C- marking of the flap based on ulnar digital bundle. D- Elevation of the flap after dissection of the bundle. E- Flap is advanced to cover the amputated stump. F- Inset of the flap with direct closure of the donor site.



Postoperative follow-up:

All patients were followed-up for a mean of 9 (range: 3-22) months. The outcome was assessed for flap viability, tip/stump contour, recovery of sensibility, and TAM (subjective evaluation used only in patients older than 6 years at final follow-up). Patients and Parents were asked to rate their opinion as "satisfactory", "good" and "very good". They were also asked to assess any cold intolerance or pain and estimate the time taken till the finger was used for activities of daily life.

RESULTS

One hundred and sixty six flaps survived, while partial flap loss occurred in 4 flaps; primary healing was achieved within 2 weeks after operation. The flaps that suffered from partial loss were managed conservatively till complete healing with satisfactory coverage of the underlying bone. 116 patients were followed-up for an average of 12 months (range: 10-22 months). There were no complications such as flap congestion, haematoma or infection and no pain from neuroma. The average time interval before normal use of the hand for patients' daily activities was 5 weeks (range: 4-6). Stiffness developed in none of the digits treated.

Sensory testing with static two-point discrimination was difficult to evaluate in children under 6 years old and in small flaps. Thus, sensibility evaluation was performed only in older patients. The average static two-point discrimination of the flaps was 3.4mm (range, 3-4mm). The average TAM was 185° (range: 170°-200°). The flaps were characterized by rich blood supply, cold tolerance, suitable thickness and good texture. None of these flaps required thinning or any revisions. All patients were satisfied with the cosmetic and functional outcome of the surgery. TAM of the PIP and DIP joints, complications, static two point discrimination, time before normal use of the hand, objective outcome and subjective outcome of the long-term follow-up are analysed and their mean values were summarised in Table (1). The objective assessment

of the injured fingers regarding the TAM and two point discrimination was performed in 115 fingers which representing the first two categories [finger-tip injuries with exposed bone (46 fingers), non replantable finger-tip amputations (69 fingers)].

Illustrative case I:

A 42-year-old manual worker presented with right index and middle finger amputations following a crush injury. There was a 16 x 12mm and 19 x 14mm pulp defects respectively (Fig. 2A). The homodigital neurovascular island flap was used for reconstruction of the tip. The flaps were advanced for 12mm in a V-Y fashion and there was no need to use skin grafts to cover additional residual defects or donor sites (Fig. 2B). The wounds healed uneventfully and the flap survived completely (Fig. 2C). The length of the injured finger was preserved with subsequent preservation of the bony insertion of both flexor and extensor tendons and excellent tip contour with no neuro-matous pain. The patient was highly satisfied with the function and appearance of the reconstructed finger-pulps (Fig. 2D).

Illustrative case II:

26 years old mechanic technician subjected to gluttine amputation of the right middle finger at the level of the lanula (Fig. 3A,B). The same flap was used to reconstruct the tip stump aiming to preserve the remaining part of the distal phalanx. The postoperative course was uneventful and patients were followed-up for more than 12 months. The result was perfect in view of the functional and cosmetic aspects.

Illustrative case III:

Two years old Philippine girl presented with complete near-total pulp amputation of the right ring finger (Fig. 4A) with exposure of most of the distal phalanx (Fig. 4D). The pulp was reconstructed by the same technique aiming to reconstruct will padded and sensate pulp (Fig. 4B,C). Excellent result was achieved without any difference between injured finger and normal one (Fig. 4E,F).

Table (1): Mean values of objective and subjective assessment in long-term follow-up.

Digit	No.	Defect size (mm)	TAM (°)	Flap loss	S2PD (mm)	Period to normal use of hand (weeks)	Subjective assessment
Index	61	16 x 12	190	2	3	5	Very Good
Middle	82	18 x 13	180	2	4	6	Very Good
Ring	25	11 x 9	180	0	3	5	Very Good
Little	2	9 x 7	190	0	3	4	Very Good

No.: Number of digits involved in the study.

TAM for fingers = (Active PIP joint + DIP joint flexion) – (PIP joint + DIP joint extension deficit).

S2PD: Static two point discrimination.

Fig. (2): Illustrative case I: A- Preoperative amputation of two fingers. B- Intraoperative photo after coverage by V-Y island flaps. C- Two-week follow-up photo with viable flaps. D- Two-months follow-up. E & F- Four months post operative with excellent contour (simulating the normal pulp), full hand function (adequate flexion of profundus tendon), and extreme patient satisfaction.

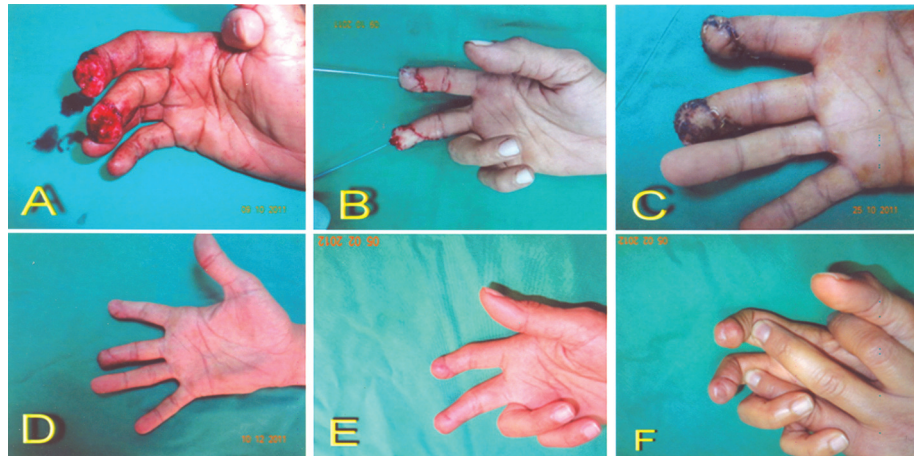


Fig. (3): Illustrative case II: A- Preoperative amputation of right middle finger. B- Dorsal view showing the level of amputation. C- One year follow up with excellent contour which couldn't be differentiated from the normal pulp of the adjacent digit. D- Dorsal view showing smooth long nail plate rather than trivial peak deformity (as there is no adequate bony support).

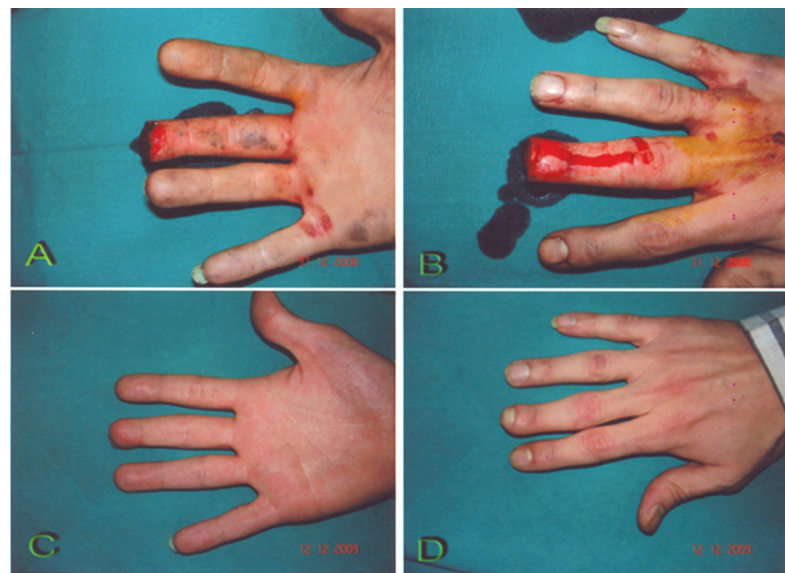
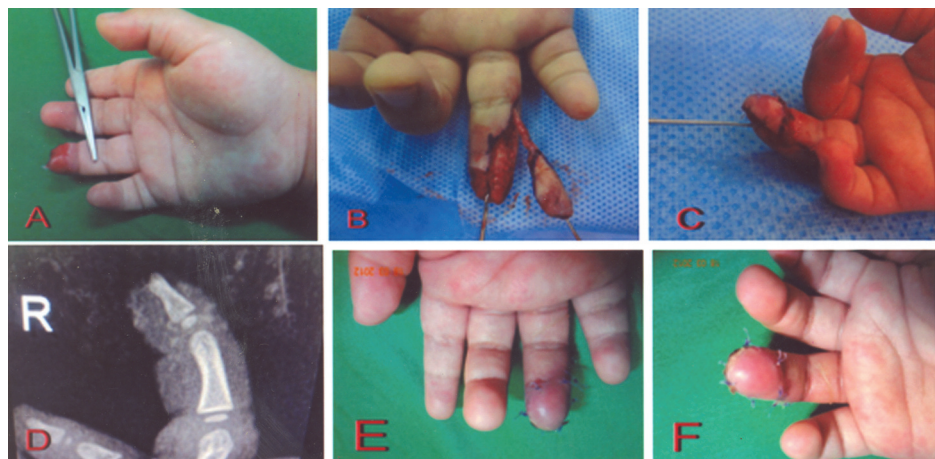


Fig. (4): Illustrative case III: A- Preoperative. B- Intraoperative with excellent mobilization of the flap. C- Flap inset with good vascularity. D- Plain X-ray showing no bone loss. E & F- Two weeks postoperative ensuring excellent reconstructed pulp.



DISCUSSION

Fingertip reconstruction is a complex and sophisticated surgical process. The surgeon is the most important factor in ensuring the quality and effectiveness of the surgery. The Goals of treatment of fingertip injuries include preservation of useful

sensation, maximizing functional length, preventing joint contractures, providing satisfactory appearance and avoiding donor disfigurement and functional loss [23].

Homodigital reconstruction involves rearrangement of the soft tissues of the injured digit to

achieve healing without seeking tissue for reconstruction from outside that digit [45,46]. This concept of reconstruction has definite advantages in meeting the goals of digital reconstruction. In particular, it reconstructs 'like with like' and avoids the creation of further scarring and morbidity elsewhere on the hand or body.

Revision amputation is certainly expeditious, and the functional results can be excellent. In some patients, preservation of digital length is more important than rapid recovery. In this situation, composite tissue (skin and subcutaneous tissue) reconstruction is usually required. The cross-finger flap and thenar flap are excellent options, but digital stiffness and proximal interphalangeal (PIP) joint contractures can result from the immobilization. In this article we extend the use of the islanded lateral V-Y advancement flap to include not only finger tip reconstruction but also the reconstruction of the stump of digital amputations at any level. A normal range of motion, preservation of digital length, normal sensation, and no cold intolerance were achieved.

Since discription of this flap in 1943 by Geisendörfer [40] / Kuttler [41] many modifications had been done till Lanzetta [44] et al., in 1995 when they extended the flap proximally till the PIP joint. In this article we extend the dissection further proximally than the PIP joint, this gives the flap much versatility and advancement potential. In all cases done in this series there is no need for the contra lateral flap.

In an application of free tissue transfer expertise on an extremely small scale, Lee and coworkers published a large series of fingertip defects that were reconstructed with pulp from the second toe [48]. In addition to the microvascular anastomoses, these flaps are neurotized by digital nerve coaptation to provide sensibility. Of the 854 flaps reported, only 3 were outright failures, and there was a minimal revision rate. The authors report that static 2-point discrimination averaged 8mm. This 2-point discrimination is similar to that seen with healing by secondary intention or with skin grafting. Those procedures, however, are not possible with exposed bone, whereas the toe pulp transfer is an option.

Lee's group has a large enough experience with free tissue transfer that the surgical times are reasonable. However, for most surgeons, the time required for free tissue transfer may be unreasonable for digital tip preservation.

The homodigital V-Y neurovascular island flap, which is based on the lateral digital bundle, would

be recommended as the flap of choice for covering digital pulp defects or amputation stumps. Satisfactory results have been achieved. None of the patients in this series were found to be intolerant to cold. Normal sensation was achieved in all patients. The average two-point discrimination at final follow-up was 4.5mm, which is comparable to normal individuals (4mm) [49]. Normal motion was well preserved. The average TAM was 185°, which is excellent compared with other study done by Lim in 2008 (177°) [50]. Thirty four fingers in our series developed mild nail peaking, and this deformity may develop because of inadequate bone support for the distal edge of the nail bed [51]. According to our experience, the functional and cosmetic result of this flap applied in children is far better than in adults, and this difference may be related with their increased capacity for growth and healing [52]. So this flap is considered to be the only available option with the least morbidity for reconstruction of fingertip defects with exposed bone in children.

The advantages of the homodigital neurovascular island flap applied in children (Fig. 4) include: Resurface fingertip with finger skin and pad virtually similar in appearance, texture, and sensibility as the skin that was lost; quick and simple to perform and without immobilization; it has the potential for the treatment of finger-pulp defect in a single-stage procedure; it avoids unnecessary trauma to otherwise uninjured digits; the donor site can be closed directly; the interphalangeal joints have recovered their total mobility and flexibility without any stiffness; reducing cost and time taken till the finger was used for daily activities.

In conclusion, the homodigital V-Y neurovascular island flap is an ideal surgical option for reconstruction of fingertip injuries and amputation stumps, offering satisfactory functional recovery, and has acceptable patient satisfaction rates in terms of physical appearance and surgical outcome.

REFERENCES

- 1- Chang J., Vernadakis A.J. and McClellan W.T.: Fingertip injuries. Clin. Occup. Environ Med., 5 (2): 413, 2006.
- 2- Murai M., Lau H.K., Pereira B.P. and Pho R.W.: A cadaver study on volume and surface area of the fingertip. J. Hand Surg., 22: 935, 1997.
- 3- Gaulke R.: Finger tip defect injuries. Orthopade, 29: 87, 2000.
- 4- Lister G.: Injury. In: Lister G. The hand: Diagnosis and indications. 3rd ed. Churchill Livingstone: Edinburgh, p. 121, 1993.

- 5- Li J., Guo Z., Zhu Q., Lei W., Han Y. and Li M.: Fingertip replantation: Determinants of survival. *Plast. Reconstr. Surg.*, 122 (3): 833, 2008.
- 6- Zhou X., Xu Y., Rui Y. and Yao Q.: Investigation of new classification and repair methods for fingertip traverse amputation. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi*, 22 (9): 1089, 2008.
- 7- Zhang X., Shao X., Ren C., Zhang Z., Wen S. and Sun J.: Reconstruction of thumb pulp defects using a modified kite flap. *J. Hand Surg. Am.*, 36 (10): 1597, 2011.
- 8- Elliot D.: Homodigital reconstruction of the digits: The perspective of one unit. *Indian Journal of Plastic Surgery*, 36 (2): 106, 2003.
- 9- Rosenthal L.J., Reiner M.A. and Bleicher M.A.: Nonoperative management of distal fingertip amputations in children. *Pediatrics*, 64: 1, 1979.
- 10- Mouchet A. and Gilbert A.: Couverture des amputations distales des doigts par lambeau neurovasculaire homodigital en ilot. *Annales de Chirurgie de la Main*, 1: 180, 1982.
- 11- Schuind F., Van Genechten F., Denuit P., Merle M. and Foucher G.: Homodigital neurovascular island flaps in hand surgery. A study of sixty cases. *Annales de Chirurgie de la Main*, 4: 306, 1985.
- 12- Foucher G., Smith D., Pempinello C., Braun F.M. and Citron N.: Homodigital neurovascular island flaps for digital pulp loss. *J. Hand Surg.*, 14B: 204, 1989.
- 13- Allen M.J.: Conservative management of finger tip injuries. *The Hand*, 12: 257, 1980.
- 14- Chow S.P. and Ho E.: Open treatment of fingertip injuries in adults. *J. Hand Surg.*, 7: 470, 1982.
- 15- Mennen U. and Wiese A.: Fingertip injuries management with semi-occlusive dressing. *J. Hand Surg.*, 18B: 416, 1993.
- 16- Lee L.P., Lau P.Y. and Chan C.W.: A simple and efficient treatment for fingertip injuries. *J. Hand Surg.*, 20B: 63, 1995.
- 17- Kutler W.: A method for repair of finger amputation. *Ohio State Med. J.*, 40: 126, 1944.
- 18- Atasoy E., Ioakimid E., Kasdan M.L., et al.: Reconstruction of the amputated finger tip with a triangular volar flap. *J. Bone Joint Surg. (Am.)*, 52: 921, 1970.
- 19- Evance D.M. and Martin D.L.: Step-advancement island flap for finger-tip reconstruction. *Br. J. Plast. Surg.*, 41: 105, 1988.
- 20- Venkataswami R. and Subramanian N.: Oblique triangular flap: A new method of repair for oblique amputations of the finger tip and thumb. *Plast. Reconstr. Surg.*, 66: 296, 1980.
- 21- Tempest M.N.: Cross finger flaps in the treatments of injuries to the finger tip. *Plast. Reconstr. Surg.*, 7: 205, 1952.
- 22- Smith J.R. and Bom A.F.: An evaluation of finger-tip reconstruction by cross-finger and palmar pedicle flap. *Plast. Reconstr. Surg.*, 35: 409, 1965.
- 23- Beasley R.W.: Reconstruction of amputated finger tips. *Plast. Reconstr. Surg.*, 44: 349, 1969.
- 24- Miller A.J.: Single fingertip injuries treated by thenar flap. *Hand*, 6: 311, 1974.
- 25- Melone C.P., Beasley R.W. and Carotens J.H.: The thenar flap: An analysis of its use in 150 cases. *J. Hand Surg. (Am.)*, 7: 291, 1982.
- 26- O'Brien B.: Neurovascular island pedicle flaps for terminal amputations and digital scars. *Br. J. Plast. Surg.*, 21: 258, 1968.
- 27- Macht S.D. and Watson K.H.: The Moberg volar advancement flap for digital reconstruction. *J. Hand Surg. (Am.)*, 5: 372, 1980.
- 28- Chen C.T. and Wei F.C.: Lateral-dorsal neurovascular island flaps for pulp reconstruction. *Ann. Plast. Surg.*, 45: 616, 2000.
- 29- Kim K.S., Yoo S.I., Kim D.Y., Lee S.Y. and Cho B.H.: Fingertip reconstruction using a volar flap based on the transverse palmar branch of the digital artery. *Ann. Plast. Surg.*, 47: 263, 2001.
- 30- Weeks P.M.: Local arterialized flap coverage of difficult hand defects preserving donor digit sensibility (Discussion). *Plast. Reconstr. Surg.*, 72: 858, 1983.
- 31- Lai C.S., Lin S.D. and Yang C.C.: The reverse digital artery flap for finger tip reconstruction. *Ann. Plast. Surg.*, 22: 495, 1989.
- 32- Kojima T., Tsuchida Y., Hirase Y. and Endo T.: Reverse vascular pedicle digital island flap. *Br. J. Plast. Surg.*, 43: 290, 1990.
- 33- Del Bene M., Petrolati M., Raimondi P., Tremolada C. and Muset A.: Reverse dorsal digital island flap. *Plast. Reconstr. Surg.*, 93: 552, 1994.
- 34- Niranjana N.S. and Armstrong J.R.: Homodigital reverse pedicle island flap in soft tissue reconstruction of the finger and the thumb. *J. Hand Surg. (Br.)*, 19: 135, 1994.
- 35- Yoshimura M., Shimada T., Imura S., Shimamura K. and Yamauchi S.: The venous skin graft method for repairing skin defects of the fingers. *Plast. Reconstr. Surg.*, 79: 243, 1987.
- 36- Kayikcioglu A., Akyurek M., Safac T., Ozkan O. and Kecik A.: Arterialized venous dorsal digital island flap for fingertip reconstruction. *Plast. Reconstr. Surg.*, 102: 2368, 1998.
- 37- Koshima I.: Distal thumb reconstruction with a great toe partial-nail preserving transfer technique (Discussion). *Plast. Reconstr. Surg.*, 101: 120, 1998.
- 38- Koshima I., Inagawa K., Urushibara K., Okumoto K. and Moriguchi T.: Fingertip reconstruction using partial-toe transfers. *Plast. Reconstr. Surg.*, 105: 1666, 2000.
- 39- Tranquilli-Leali E.: Ricostruzione dell'apice delle falangi ungueali mediante autoplastica volare pedunculata per scorrimento. *Infornistica e Traumatologia del Lavaro*, 1: 186, 1935.
- 40- Geissendörfer H.: Beitrag zur Fingerkuppenplastik. *Zentralblatt für Chirurgie*, 70: 1107, 1943.
- 41- Kutler W.: A new method for finger tip amputation. *JAMA*, 133: 29, 1947.
- 42- Segmüller G.: Modifikation des Kutler-Lappens: Neurovaskuläre Stielung. *Handchirurgie*, 8: 75, 1976.

- 43- Biddulph S.L.: The neurovascular flap in finger tip injuries. *The Hand*, 11: 59, 1979.
- 44- Lanzetta M., Mastropasqua B., Chollet A. and Brisebois N.: Versatility of the homodigital triangular neurovascular island flap in fingertip reconstruction. *J. Hand Surg.*, 20B: 824, 1995.
- 45- Mouchet A. and Gilbert A.: Couverture des amputations distales des doigts par lambeau neurovasculaire homodigital en îlot. *Annales de Chirurgie de la Main*, 1: 180, 1982.
- 46- Schuind F., Van Genechten F., Denuit P., Merle M. and Foucher G.: Homodigital neurovascular island flaps in hand surgery. A study of sixty cases. *Annales de Chirurgie de la Main*, 4: 306, 1985.
- 47- Foucher G., Smith D., Pempinello C., Braun F.M. and Citron N.: Homodigital neurovascular island flaps for digital pulp loss. *J. Hand Surg.*, 14B: 204, 1989.
- 48- Lee D.C., Kim J.S., Ki S.H., Roh S.Y., Yang J.W. and Chung K.C.: Partial second toe pulp free flap for fingertip reconstruction. *Plast. Reconstr. Surg.*, 121: 899, 2008.
- 49- Adani R., Busa R., Castagnetti C., Bathia A. and Caroli A.: Homodigital neurovascular island flaps with "direct flow" vascularization. *Ann. Plast. Surg.*, 38: 36, 1997.
- 50- Lim G.J., Yam A.K., Lee J.Y. and Lam-Chuan T.: The spiral flap for fingertip resurfacing: Short-term and long-term results. *J. Hand Surg.*, 33-A: 340, 2008.
- 51- Kumar V.P. and Satku K.: Treatment and prevention of "hook nail" deformity with anatomic correlation. *J. Hand Surg.*, 18-A: 617, 1993.
- 52- Yildirim S., Calikapan G.T. and Akoz T.: Reconstructive microsurgery in pediatric population-a series of 25 patients. *Microsurgery*, 28: 99, 2008.