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Original Article

V advancement eversion flap for fingertip injury: Preventing ischemia and hook-nail deformity

Jung Eun Lee[a], Sihun Kim[a], Jieun Kwon[b], Young Ho Lee[c,*]

[a] Department of Orthopedic Surgery, Gachon University Gil Medical Center, Incheon, Korea
[b] Department of Orthopedic Surgery, Ehwa Womans University College of Medicine, Ehwa Womans University Mokdong Hospital, Seoul, Korea
[c] Department of Orthopedic Surgery, Seoul National University College of Medicine, Seoul National University Hospital, Seoul, Korea

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ABSTRACT

Introduction: Traumatic fingertip amputation is the most common type of upper extremity injuries. The V-Y advancement flap is a reliable method for reconstructing fingertip defects, but it is associated with complications such as hook-nail deformity and suture site ischemia. Here, we describe our modifications to V-Y advancement flap technique, termed as "V advancement eversion flap" and review the outcomes of this procedure in 21 patients with fingertip amputation.

Methods: This was a retrospective review of 21 consecutive patients with fingertip injury who were treated surgically using the V advancement eversion flap technique at a single trauma center between 2006 and 2019. We analyzed the age, injury location and mechanism, Allen classification, injury geometry, and objective and subjective clinical outcomes.

Results: Twenty-three fingertip amputations with defect sizes greater than 1.0 cm^2 from the tip to lunula were included in this study. The mean age of the patients was 43.6 years (range, 24–65 years). The average follow-up period was 20 months (range, 12–37

* Correspondence author: Young Ho Lee, M.D., Ph.D., Department of Orthopedic Surgery, Seoul National University College of Medicine, Seoul National University Hospital, 101 Daehakro, Jongno-gu, Seoul 03080, South Korea, TEL: 82-2-2072-0894; FAX: 82-2-764-2718.
E-mail address: orthoyhl@snu.ac.kr (Y.H. Lee).

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months). The average wound healing time (apparent epithelization) was 29.4 days (range, 14-41 days). At the final follow-up, all flaps had healed uneventfully without noticeable hook-nail deformity. In the static two-point discrimination test, the mean value was 4.61 mm in the injured finger. Patient ratings of the outcomes were "excellent" in 18 and "good" in 5 cases.

Conclusion: The V advancement eversion flap technique, when properly designed and executed in fingertip amputation cases, can minimize morbidity and result in successful wound healing without flap necrosis and hook-nail deformity.

Introduction

Traumatic amputation of the fingertip is the most common type among upper extremity injuries, and various management techniques have been described in the literature including secondary wound healing, primary closure, bone shortening with closure, skin grafting, and a wide variety of neurovascular flaps.[1-3] Regardless of the methods used, the ultimate goal of fingertip amputation treatment is to achieve functional and aesthetic reconstruction of the defect. Moreover, restoring the functional length and sensory features, providing durable coverage, and preventing pain and contracture are essential steps.[1,3] However, owing to insufficient evidence regarding the superiority of one technique over the others, surgeons must choose the most appropriate type according to their technical abilities and preferences. The V-Y advancement flap has been a reliable method to reconstruct fingertip defect, since it was first reported in 1935 by Tranquilli-Leali and popularized by Atasoy in 1970.[4,5] However, the major drawback of this technique is the potential risk of flap ischemia and hook-nail deformity due to suture line tension.[1,6-10] To address such complications, several authors have introduced modifications to V-Y plasty.[11-17] This study describes our modification to the V-Y advancement flap, called "V advancement eversion flap," and reviews the outcomes of this procedure for fingertip amputation in 21 patients.

Patients and methods

The author's institutional review board approved the retrospective chart review of these cases. The study period was from January 2006 to February 2019, and 21 consecutive patients (15 men and 6 women; 23 fingertip amputations) with fingertip injury treated operatively using the same procedure by a single surgeon (LYH) in our trauma center were reviewed. All patients with fingertip defects of more than 1.0 cm^2 from the tip to lunula were included in this study. Microsurgical replantation was not feasible in all patients. The mean age of the patients was 43.6 years (range, 24–65 years). The average follow-up period was 20 months (range, 12–37 months). The injury mechanisms were crushing with or without avulsion in 15, amputation with sharp laceration in 4, and human bite in 1 case. One injury occurred on the thumb, 4 on the index finger, 8 on the middle finger, 7 on the ring finger, and 3 on the little finger. All finger injuries were classified according to Allen classification with type 1 involving pulp loss only, type 2 involving pulp and partial nail loss, type 3 consisting of pulp and nail loss along with partial loss of the distal phalanx, and type 4 involving pulp and nail loss with partial loss of the distal phalanx through the germinal matrix. There were 1 case of type 1, 15 of type 2, and 7 of type 3 in this study. Type 4 injuries were excluded from this study. The injury pattern was transverse type in 8 patients, dorsal oblique type in 12 patients, and mild volar oblique

Table 1
Patient summary.

Patient	Sex/Age (yr)	Injured finger	Allen type	Injury shape	Injury mechanism
1	F/54	Rt. Ring	2	Dorsal oblique	Crush with avulsion
2	F/62	Rt. Ring	2	Dorsal oblique	Crush with avulsion
3	F/48	Lt. Ring	1	Transverse	Sharp laceration
4	M/29	Rt. Index	2	Dorsal oblique	Crush with avulsion
5	M/50	Rt. Ring	2	Dorsal oblique	Crush with avulsion
6	M/65	Rt. Little	3	Dorsal oblique	Crush with avulsion
7	M/49	Rt. Middle	3	Transverse	Human bite
8	F/38	Lt. Middle	2	Mild volar oblique	Crush with avulsion
9	F/27	Lt. Middle	2	Dorsal oblique	Crush with avulsion
10	F/34	Rt. Ring	2	Transverse	Crush with avulsion
11	M/55	Lt. Ring	2	Transverse	Sharp laceration
12	M/24	Rt. Middle	2	Transverse	Crush with avulsion
13	M/60	Rt. Index	3	Transverse	Crush with avulsion
14	M/67	Lt. Thumb	2	Dorsal oblique	Crush with avulsion
15	M/37	Lt. Middle	3	Mild volar oblique	Sharp laceration
16	M/26	Rt. Ring	2	Transverse	Crush with avulsion
17	M/52	Lt. Index	2	Dorsal oblique	Sharp laceration
18	M/61	Lt. Little	3	Dorsal oblique	Crush with avulsion
19	M/27	Rt. Middle	2	Dorsal oblique	Crush with avulsion
20	M/26	Rt. Middle	2	Dorsal oblique	Crush with avulsion
21	M/26	Rt. Ring	2	Transverse	Crush with avulsion
22	M/63	Rt. Index	3	Mild volar oblique	Crush with avulsion
23	M/63	Rt. Middle	3	Dorsal oblique	Crush with avulsion

Yr, year; F, female; M, male; Rt, right; Lt, Left

type in 3 patients, although cases nearly similar to the transverse type were included according to the surgeon's preference (Table 1).

Surgical technique

The procedure was performed under digital block or general anesthesia using a tourniquet. The fingertip wound was cleaned with irrigation and debridement. The remnant nail plate and bed were trimmed adequately to avoid excess nail bed projection and to provide subsequent contour of the pulp. The flap base was designed to be larger than the nail bed to provide sufficient support to the nail bed. No bone shortening procedures were performed. Depending on the size and obliquity of the defect, a palmar V advancement flap was designed in the manner described by Atasoy.[4] The flap was adequately mobilized and advanced 5 mm to 10 mm distally without tension. The lateral and medial ends of the flap base were apposed to the corresponding edges of the nail by horizontal mattress sutures. Tight closure between the nail bed and distal flap causes a hook-nail deformity by creating tension between the pulp and hyponychium, thereby pulling the nail bed downward. To avoid this problem, the nail bed was buttressed upward, and a horizontal mattress stitch was used to maintain eversion of both edges of the nail bed and flap base. In addition, the number of sutures was minimized to two or three to ensure tension-free closure. If the nail was partially avulsed or located on the laceration margin, a stitch was applied through the nail. The consequent donor site defect was exposed and allowed to heal by secondary intention, instead of suturing with the Y pattern. When associated fractures of the distal phalanx were present, reduction and fixation with a longitudinal or crossed Kirschner wire (K-wire) were additionally performed. Finally, the tourniquet was deflated, and perfusion of the flap was confirmed (Figures 1, 2).

Post-operative management

Occlusive dressing was applied and post-operative dressing change was performed every other day for 3 to 4 weeks, until wound epithelialization was apparent. Thereafter, stitch out was performed, and the wound site was exposed. After discharge, the patients were taught to perform their own

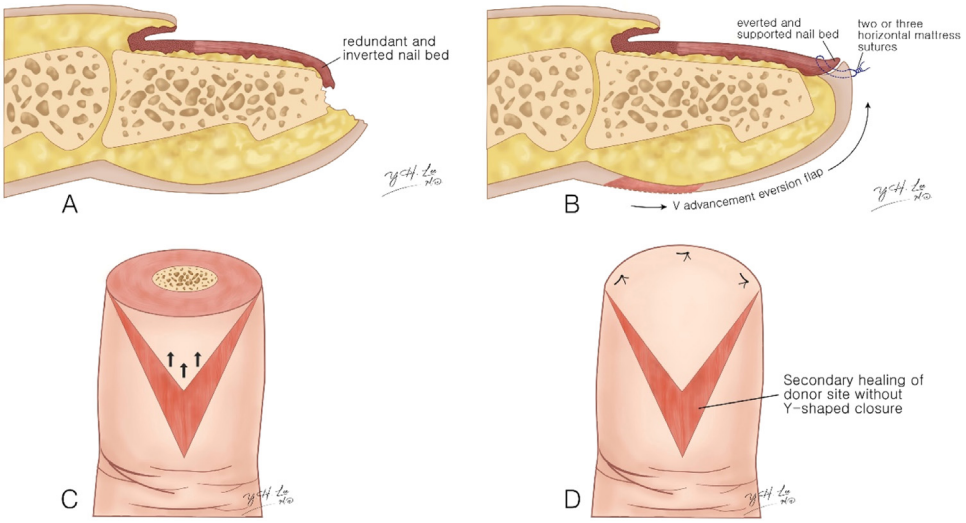

Figure 1. Schematic illustration of V advancement eversion flap procedures.
Illustrations created by Y.H. Lee, M.D., Ph.D. (Corresponding author)
A. Fingertip injury with distal phalanx fracture and redundant, inverted nail bed
B. V advancement flap with nail bed eversion and buttress via horizontal mattress sutures
C. Mobilization of the flap distally in the injured finger
D. Securing of flap base with horizontal mattress sutures and secondary healing of the donor site without the Y-shaped closure

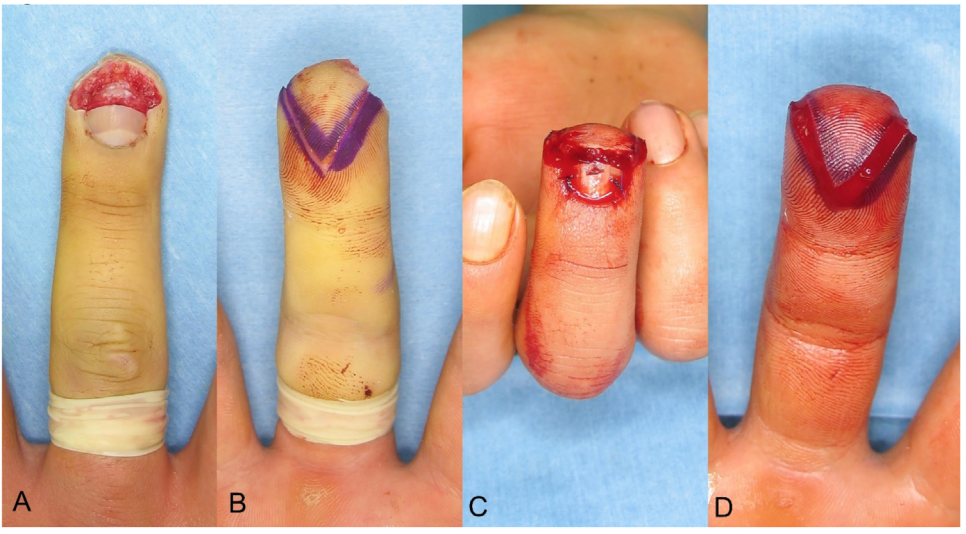

Figure 2. Surgical procedures of V advancement eversion flap for fingertip injury of a 26-year-old male (patient 20*).
A. The remnant nail plate and nail bed were trimmed adequately to avoid excess nail bed projection
B. Flap was designed and incisions were subsequently performed.
C. The flap was adequately mobilized and advanced distally in a tension-free manner. Three horizontal mattress sutures were placed to secure the flap base and support nail bed
D. After flap advancement and suturing, the donor site defect was exposed and allowed to heal via secondary intention
* Patient 20, patient number 20 in Tables 1 and 2

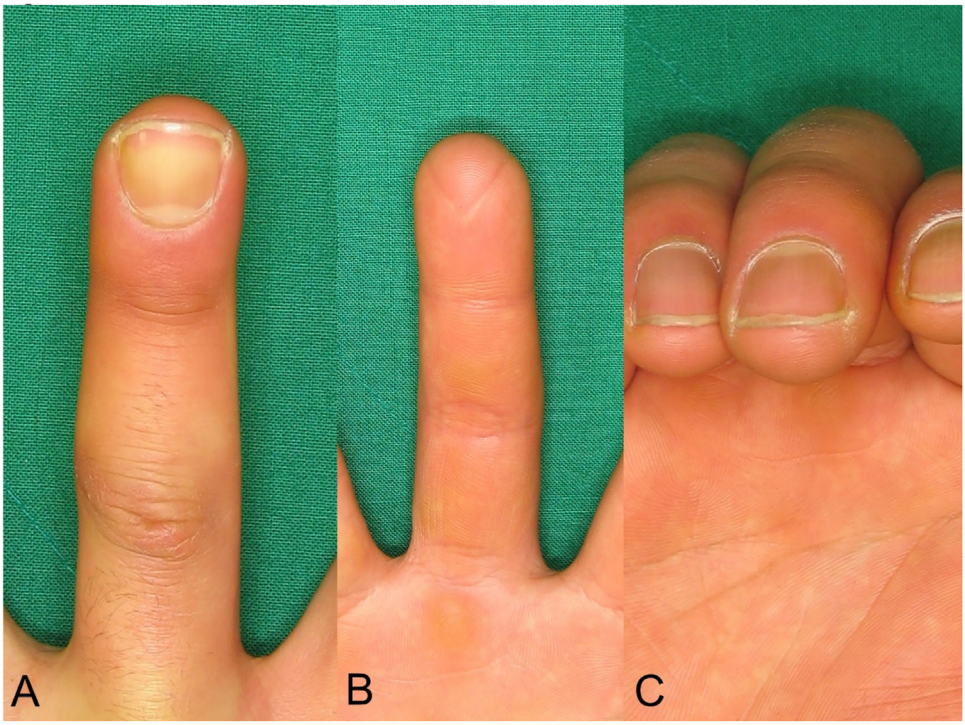

Figure 3. Post-operative 6-month Photos of V Advancement Eversion Flap for Fingertip Injury of a 26-year-old Male (Patient 20*).
A. Dorsal view
B. Volar view
C. Axial view showing a nearly normal pulp contour and nail appearance
* Patient 20, patient number 20 in Tables 1 and 2

sterile dressing changes. In case of K-wire insertion owing to associated distal phalanx fracture, the K-wire was removed in the outpatient clinic approximately 4 weeks post-operatively after radiologic confirmation of the union. Gentle active exercises involving all adjacent joints were performed in the first week post-operatively. One patient (Case 5) showed an associated tendinous mallet finger deformity in the affected finger. To preserve flap vascularity and apply adequate compression, a K-wire was inserted to maintain the distal interphalangeal joint in extension and was removed 8 weeks post-operatively. After wound healing, the patients were taught desensitization exercises using friction massage.

Assessment of the results

All patients underwent objective and subjective assessments at 6 and 12 months, routinely, and at the final follow-up. The objective outcomes included sensitivity testing using the static two-point discrimination test (STPD test; Disk-Criminator™, North Coast Medical Inc., Gilroy, USA) and the Semmes–Weinstein monofilaments test (SWM test; Touch-Test™ Sensory Evaluator 20 Piece Full Kit, North Coast Medical Inc., Gilroy, USA). The scores of the STPD test were categorized in the following three groups: 1) normal, 1 mm to 5 mm; 2) fair, 6 mm to 10 mm; 3) poor, 11 mm to 15 mm.[18] The scores of the SWM test were categorized into the following five groups: 1) 1.65 to 2.83 as normal sensibility; 2) 3.22 to 3.61, diminished superficial sensibility; 3) 3.84 to 4.31, diminished vital sensibility; 4) 4.56 to 6.65, absent vital sensibility; and 5) more than 6.65, as not testable.[19] The range of motion (ROM) of the distal interphalangeal joint, scar contracture, and various nail deformities, including

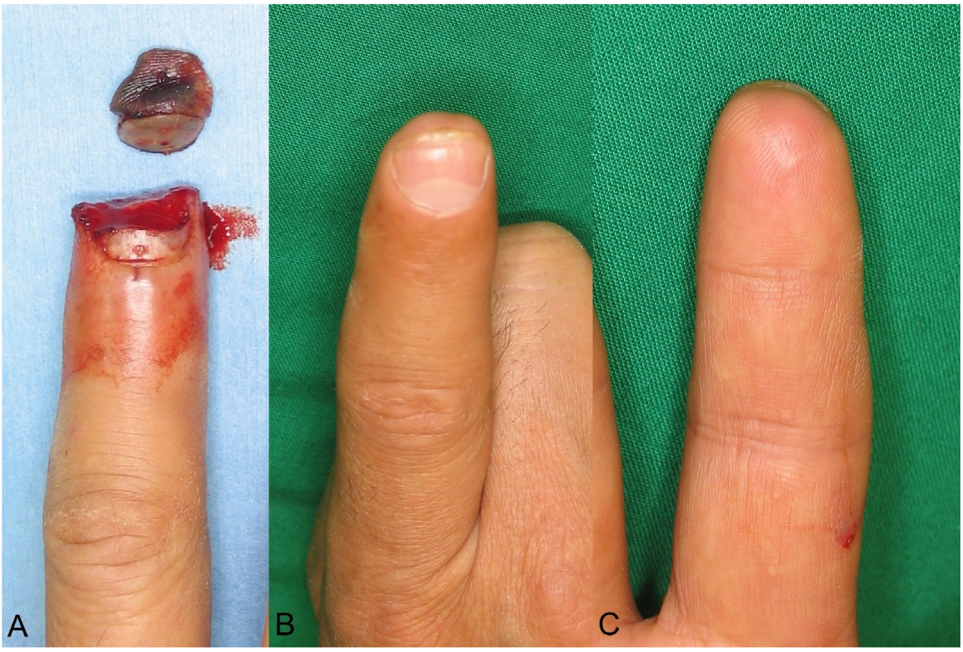

Figure 4. V advancement eversion flap for fingertip injury of a 61-year-old male (patient 13*).
A. A 60-year-old male, with right index finger amputation
B,C. Post-operative 6-month photographs showing good pulp contour with mild short nail deformity
* Patient 13, patient number 13 in Tables 1 and 2

hook-nail deformity, was also assessed. In our study, we recorded and considered noticeable hook-nail deformity in the measurement when the total nail surface in the lateral view exceeded 25%. The subjective outcomes were evaluated based on the patients' report of dysesthesia (spontaneous pain, "cold intolerance," hyperesthesia, or hypoesthesia) and their subjective ratings of outcome as "excellent," "good," "fair," or "poor."

Results

The mean patient age was 43.6 years (range, 24–65 years). The average follow-up period was 15 months (range, 12–37 months). All operations were performed within 24 hours after the injury, except for one patient who underwent a revision surgery 6 days after the initial surgery at another hospital. Wound healing time, defined as the time when apparent epithelization occurred, was an average of 29.4 days. (range, 14-41 days). At the final follow-up, all flaps healed uneventfully. In the objective evaluation with the SWM test, 15 patients recognized the 2.83 monofilament (0.07 g), 6 recognized the 3.61 monofilament (0.4 g), and 2 recognized the 4.31 monofilament (2 g).

In the STPD test, the mean value was 4.61 mm in the injured finger. None of the patients developed noticeable hook-nail deformity. However, seven patients had residual short nails and two patients had mild nail ridges. Almost full ROM of the distal interphalangeal joint of the injured finger was observed in all patients except for one patient (Case 5), who had a mild extension lag of approximately 15° owing to combined tendinous mallet finger injury. In subjective outcomes, various degrees of dysesthesia, including cold intolerance, were reported in most patients for some time after surgery. However, these symptoms improved at the final follow-up. Most patients were satisfied with the results. Patient ratings of the outcomes were "excellent" in 18 and "good" in 5 (Table 2).

Table 2
Summary of results.

Patient	FU period (months)	Wound healing time (days)	STPD (mm)		SWM (g)		Nail appearance	Dysesthesia	Patient satisfaction
			Injured finger	Opposite finger	Injured finger	Opposite finger			
1	23	40	6	5	3.61	2.83	Short nail	None	Excellent
2	17	23	5	4	2.83	2.83		None	Good
3	22	29	4	3	2.83	2.83		None	Excellent
4	15	26	4	4	2.83	2.83		None	Excellent
5	22	33	5	5	3.61	3.61	Short nail	None	Excellent
6	12	20	7	6	4.31	3.61	Mild nail ridge	None	Excellent
7	24	28	4	4	2.83	2.83	Short nail	None	Excellent
8	18	41	4	3	2.83	2.83		None	Good
9	19	34	3	3	2.83	2.83	Short nail	None	Excellent
10	14	29	5	4	2.83	2.83		None	Excellent
11	21	30	4	4	2.83	2.83		None	good
12	14	28	3	3	2.83	2.83		None	Excellent
13	31	29	3	3	2.83	2.83	Short nail	None	Excellent
14	15	22	3	2	2.83	2.83		None	Excellent
15	13	14	4	4	2.83	2.83		None	Excellent
16	19	21	5	4	3.61	3.61		None	Excellent
17	15	27	6	4	3.61	3.61		None	Excellent
18	16	34	6	5	3.61	3.61	Short nail	None	Good
19	21	41	4	4	2.83	2.83		None	Excellent
20	16	35	5	4	2.83	2.83		None	Excellent
21	21	37	4	4	2.83	2.83		None	Excellent
22	37	27	6	5	4.31	3.61	Short nail	None	Excellent
23	37	28	6	5	3.61	3.61	Mild nail ridge	None	Good

FU, follow-up; STPD, standard two-point discrimination test; SWM, Semmes–Weinstein monofilament test.

Discussion

For reconstruction of distal finger amputations, V-Y plasty has been widely used with little or no modification.[1,2] Although the V-Y advancement flap may have advantages of simplicity and reproducibility, discrepancies among studies still exist.[9,10,12-14,17,20,21] In the classic V-Y advancement flap technique, the main problem appeared to be the strain caused by the suture line, which leads to complications such as flap ischemia and hook-nail deformity.[1,6-10] To overcome these disadvantages, we modified the V-Y advancement flap based on two previously well-known principles. First, if the fingertip injury is small, with less than 1.0 cm^2 of soft tissue loss, healing via secondary intention is believed to result in superior sensory, cosmetic, and functional recovery.[1] Second, provided that the nail bed is supported and does not overlap with the tip of the distal phalanx, hook-nail deformity will not develop.[1,7,8,22]

When performing a V-Y advancement flap procedure, most surgeons believe that closure of the flap apex into a Y pattern must be performed as the name implies. Although the flap may survive when the donor site defect is sutured primarily in the Y pattern, the neurovascular structure will be disturbed because of the contraction caused in the pulp. We believe that healing the donor site defect using secondary intention can minimize pulp contraction, and therefore, prevent the ischemic stress applied to the neurovascular structure. Sequelae such as cold intolerance, sensory impairment, and dysesthesia are considered common complications of all fingertip amputations, regardless of the treatment method.[1,2,9,10] However, our study showed excellent subjective outcomes, in that the expression of such symptoms gradually subsided, and the patients were eventually satisfied with the final results. The study showed that relieving stress on the neurovascular structure by applying a minor modification to the healing method of the donor site defect leads to reduced complications when reconstructing the fingertip after traumatic amputation.

Hook-nail deformity occasionally develops as a complication after V-Y advancement flap or from trauma regardless of the treatment approach. Interestingly, the V-Y advancement flap is also one of the treatment modalities for hook-nail deformity.[6-8] Hooking of the nail occurs due to tight closure of fingertip amputation or loss of bony support under the nail bed, which leads to curving of the matrix in a volar direction. To avoid this, the redundant nail bed folded over the tip of fractured phalanx must be trimmed back to the distal end of the bone. Additionally, the distal flap and nail bed must be sutured with laxity and a small number of ties, and the nail bed must be supported to maintain wound eversion. In our study, when the nail bed was significantly longer than the bone, it was trimmed back to the level of the bone adequately. However, in the dorsal oblique-type injury, we did not perform a bone shortening procedure, but instead, a K-wire support or bone graft was applied to support the remnant nail bed. Hook-nail deformity may also occur due to a lack of support for the nail bed.[6-8] Hyponychium is a plug of keratinous material, and the pulp is fibro-fatty tissue that is stabilized by fibrous septa extending from the dermis to periosteum of the distal phalanx.[6] A distal flap base consisting of these tissues provides sufficient support to the nail bed. Moreover, the eversion and elevation in the nail bed created by sutures provide sufficient support to prevent hook-nail deformity. Lastly, allowing the donor site to heal via secondary intention without using a Y-shaped closure prevents the additional downward tension created by the Y suture, thereby preventing hook-nail deformity. Although our study lacks a control group, a comparison with relevant research provides compelling insights. In 2022, Franke et al. reported a significant 64% incidence of hook-nail deformity in patients with fingertip injuries treated using V-Y flaps, despite their assessment relying on self-reported results provided by patients during telephone interviews.[9] Similarly, in 2019, Haehnel et al. reported similar long-term result in children with V-Y flaps.[10] In their study, the measurement of hook-nail deformity is represented as a percentage of the total nail surface in the lateral view. The study reports the incidence of hook-nail deformity in 50% of the patients, noting that the deformity affected more than 30% of the nail surface in the lateral view. In our study, we recorded and considered noticeable hook-nail deformity in the measurement when the total nail surface in the lateral view exceeded 25%. Interestingly, none of the patients developed noticeable hook-nail deformity.

In brief, using the V-Y method, the V advancement eversion flap covers the defect by advancing the flap without damaging the neurovascular structure, and the consequent defect of the donor site is healed by secondary intention without manipulation. Furthermore, tension-free horizontal mattress sutures between the nail bed and distal flap provide adequate support and maintain eversion of the nail bed, thereby, preventing hook-nail deformity. The technique presented is very similar to the one published by Thoma et al. in 2010.[17] However, they presented the case of only one patient with a follow-up period of 1 month and did not address the issue of nail deformity. To avoid suture line tension in the nail bed, several authors have advocated their own modification of the V-Y advancement flap. Foo et al., in 2012, described a modified version of the V-Y advancement technique in which the flap is pinned to the donor site and then left untouched to heal by secondary intention.[12,13] They reported that all seven patients obtained satisfactory fingertip and nail contour. Hassanpour et al., in 2011, reported a purse-string suture technique without any sutures in the nail bed that achieved reduction in the number of hook-nail deformities.[14] They also pointed out that the main causes of hook-nail deformity are underlying bone support, nail bed suture, and tight closure of the tip of the amputation. However, in their study, the donor site was covered by primary closure in 24 cases, secondary intention in 11 cases, and skin graft in 6 cases. However, no differences in results were observed according to the donor site management.

This study introduced a modification to the traditional V-Y advancement flap method and found that secondary-intention healing along with supported and everted nail bed with tension-free horizontal mattress sutures reduced the incidence of complications of pulp stricture and hook-nail deformity. The result was successful as all participants reported functional and cosmetic restoration of the amputated fingertips and were satisfied with their results.

However, this study has some limitations. First, this study may have been biased due to its retrospective nature and lack of a control group. Second, the study lacks an objective means to show subjective satisfaction with the results. Tools such as “The Disabilities of the Arm, Shoulder, and Hand Questionnaire” may have strengthened this study. Although we excluded cases with defect sizes less than 1.0 cm^2, the specific defect size and flap advancement length were not measured; therefore,

we could not provide the specific guidelines for surgical indication of the modified V advancement eversion flap. The study may lack objectivity as patient selection and modification of surgical technique were solely based on the surgeon's experience and insight. Although our study included only transverse and dorsal oblique types, the indication for use of this modified technique is not limited to dorsal oblique or transverse-type injuries. It can be applied to mild lateral oblique or mild volar oblique-type injuries, if performed by an experienced surgeon.

Conclusion

The modified V advancement eversion flap technique, when properly designed and executed in fingertip amputation, can effectively minimize the risk of flap ischemia and facilitate favorable wound healing without flap necrosis and hook-nail deformity.

Role/Participation in manuscript authorship: All authors contributed to the conception, analysis, interpretation, drafting, and revision of the manuscript.

Conflict of interest: The authors have on competing interest to declare.

Financial Disclosure Statement: The authors have no financial interest to declare in relation to the contest of this article

Institutional Review Board(IRB) approval: This study was approved by the institutional review board of Gachon University Gil Medical Center (Identification code: GAIRB No. 2020-197). All procedure were followed in accordance with the ethical standards of the responsible committee on human experimentation (international and national) with Helsinki Declaration of 1975, as revised in 2008.

References

1. Kakar S. Digital amputations. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, Cohen MS, eds. *Green's Operative Hand Surgery*. Philadelphia: Churchill Livingstone; 2017:1708–1752.
2. Lee DH, Mignemi ME, Crosby SN. Fingertip injuries: An update on management. *J Am Acad Orthop Surg*. 2013;21:756–766.
3. Lemmon JA, Janis JE, Rohrich RJ. Soft-tissue injuries of the fingertip: Methods of evaluation and treatment. An algorithmic approach. *Plast Reconstr Surg*. 2008;122:105e–117e.
4. Gharb BB, Rampazzo A, Armijo BS, et al. Tranquilli-Leali or Atasoy flap: An anatomical cadaveric study. *J Plast Reconstr Aesthet Surg*. 2010;63:681–685.
5. Atasoy E, Ioakimidis E, Kasdan ML, et al. Reconstruction of the amputated finger tip with a triangular volar flap: A new surgical procedure. *J Bone Joint Surg Am*. 1970;52:921–926.
6. Sommer NZ. Perionychium. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, Cohen MS, eds. *Green's Operative Hand Surgery*. Philadelphia: Churchill Livingstone; 2017:318–337.
7. Dumontier C, Gilbert A, Tubiana R. Hook-nail deformity: Surgical treatment with a homodigital advancement flap. *J Hand Surg Br*. 1995;20:830–835.
8. Strick MJ, Bremner-Smith AT, Tonkin MA. Antenna procedure for the correction of hook-nail deformity. *J Hand Surg Br*. 2004;29:3–7.
9. Franke JD, Kraft LT, Mailey BA. Atasoy Flap Fingertip Reconstruction: Long-term patient-reported outcomes in male laborers. *Plast Reconstr Surg Glob Open*. 2022;28(11):e4599 10.
10. Haehnel O, Plancq MC, Deroussen F, et al. Long-Term outcomes of Atasoy flap in children with distal finger trauma. *J Hand Surg Am*. 2019;44(12):1097.e1–1097.e6.
11. Lee SM, Rahman MF, Thirkannad S. Combination V-Y advancement flap and composite graft for reconstruction of an amputated fingertip. *Hand Surg*. 2012;17(1):145–149.
12. Foo TL, Wan KH. Modification of VY flap to preserve fingertip contour. Hand *(NY)*. 2012;7(4):388–390.
13. Foo TL, Wan KH, Chew WY. Safe and easy method to preserve fingertip contour in VY-plasty. *Tech Hand Up Extrem Surg*. 2012;16(2):95–97.
14. Hassanpour SE, Hosseini SN, Abdolzadeh M. Purse-string suture as a complementary technique with conventional flaps in repairing fingertip amputation. *Tech Hand Up Extrem Surg*. 2011;15(2):94–98.
15. Chung SR, Foo TL. Crescent flap for fingertip reconstruction. *Hand Surg*. 2014;19(3):459–461.
16. Hwang E, Park BH, Song SY, et al. Fingertip reconstruction with simultaneous flaps and nail bed grafts following amputation. *J Hand Surg Am*. 2013;38(7):1307–1314.
17. Thoma A, Vartija LK. Making the V-Y advancement flap safer in fingertip amputations. *Can J Plast Surg*. 2010;18(4):e47–e49.
18. Dellon AL, Mackinnon SE, Crosby PM. Reliability of two-point discrimination measurements. *J Hand Surg Am*. 1987;12(5 Pt 1):693–696.
19. Weinstein S. Fifty years of somatosensory research: from the Semmes-Weinstein monofilaments to the Weinstein Enhanced Sensory Test. *J Hand Ther*. 1993;6(1):11–50.
20. Jackson EA. The V-Y plasty in the treatment of fingertip amputations. *Am Fam Physician*. 2001;64(3):455–458.

21. Bang H, Kojima T, Hayashi H. Palmar advancement flap with V-Y closure for thumb tip injuries. *J Hand Surg Am.* 1992;17(5):933–934.
22. Kumar VP, Satku K. Treatment and prevention of “hook-nail” deformity with anatomic correlation. *J Hand Surg Am.* 1993;18(4):617–620.