

Functional and Results from Nail Lengthening with the Eponychial Folding Procedure Reconstruction of the Fingertip Amputation

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Purpose: Fingertip amputation usually involved soft tissue, bone, and nail. Various local flaps reconstruct only soft tissue volar pulp dose not restore nail length after fingertip amputation. To overcome this problem “The Eponychial Folding Procedure” lengthens the nail plate and restore a good appearance of the nail apparatus was employed. The purposes of this study were present the outcomes of nail salvage by Eponychial Folding Procedure combined with several local flaps following fingertip amputation.

Methods: In the period between January 2018 and October 2019 at Samutsakorn Hospital. 30 cases of fingertip amputation with nail bed defects underwent pulp reconstruction with different local flaps depending on the geometry of the amputated digit tip. We increased nail bed exposure by creating 4-6 mm parallel incision at distal eponychium. The eponychium flap was elevated then fold proximally to expose more nail matrix, thereby effectively lengthening the exposed nail bed. The outcomes for fingertip appearance, nail length, and nail bed area at pre and postoperative treatment were evaluated. The finger’s range of motion (ROM) was compared to the contralateral uninjured fingers as control. The paired t test was employed for $\alpha < .05$ considered statistically significant

Results: There were 25 patients (5 patients were affected 2 fingers) with mean age of 31 (18-51 years). The procedures were performed initial injury and secondary treatment after consequence previous operation, neither pulp reconstruction nor eponychial flap loss occurred. The visible nail increased 5.78 mm (4-7mm), nail bed area was enlarged 60% (25-150%). All patients were satisfied with the appearance and function of the reconstructed fingertips.

Conclusions: Fingertip amputation with nail bed involvement should be reconstructed not only volar soft tissue but considered the nail as well. Eponychial folding Procedure combined with different local flaps provided for the aesthetic and functional restoration of the fingertip amputation, both initial injury and its consequence.

Keywords: Fingertip amputation, Eponychial Folding Procedure

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Introduction

Fingertip injuries are common in acute hand injury⁽¹⁾. An injury can damage any part of the fingertip pulp, bone, and nail. Reconstruction of the fingertip requires attention to both aesthetic and functional outcomes. Several techniques including shortening with primary closure skin graft, and local or distant flaps usually replaced only the pulp⁽²⁾. The nail is important not only for cosmetic appearance but also distal grip. Nail bed are specialized tissue and attempt to replace with skin or dermal graft are unpredictable⁽³⁾. The Eponychial Folding Procedure⁽⁴⁾ is an option to increase nail bed exposure. We have implemented a technique for nail bed reconstruction that can be used at the same time as pulp reconstruction, with aim of achieving both cosmetic and functional restoration. In this study we present our clinical experience with

application “The Eponychial Folding Procedure” for nail bed restoration combined with several technique for pulp reconstruction at the same time of the fingertip injury.

Patients and Methods

30 consecutive cases of fingertip amputation with nail involvement underwent pulp reconstruction with different local flap and nail lengthening by Eponychial Folding Procedure, excepted 1 case (NO.14) was performed by nail fold recession. There were 25 patients (5 patients affected 2 fingers, 2 patients were recorrected after consequence initial operation), 15 men and 10 women, average age of 31 years (range 18-51 years), 9 Thai and 16 foreign. The fingertip injured was classified according Allens system⁽⁵⁾ (Type 1 injuries are those involving the pulp only. Type 2 injuries consist of injury to the pulp and nail bed. Type 3 injuries include distal phalangeal fracture with associated pulp and nail loss. Type 4 injuries involve the lunula, distal phalanx, pulp, and nail loss) (Table 1).

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Table 1 Eponychial Folding Procedure in patients.

Patient	Sex/Age(yr)	Mechanism of Injury	Injured finger	Allens Classification	Flap Type (Pulp)	Nail Bed Size, cm ²		Follow up time	Remark
						Preoperatively	Postoperatively		
1	M/37	Crush	R/Ring	3	composite	0.5	0.7	12	
2	M/18	Cut	L/Ring	3	V-Y	0.6	0.82	16	
3	F/23	Crush	R/Index	4	HNV	0.63	0.95	10	nail deviation
4	M/25	Crush	L/Ring	4	V-Y	0.7	1.2	8	
5	M/21	saw	R/Index	2	RHNV	0.5	0.8	6	
6	M/19	consequence	R/Ring	3	V-Y (oblique)	0.5	1	12	
7	M/31	Cut	R/Index	3	V-Y	0.8	1.155	12	
8	F/28	Crush	L/Index	3	V-Y	0.6	1	18	
9	M/37	Cut	L/Index	4	Composite	0.63	0.9	8	
10	F/36	Crush	R/Index	4	HNV	0.8	1	10	
11	F/19	Crush	L/Long	4	HNV	0.5	0.8	12	nail deviation
12	F/25	Crush	L/Index	3	V-Y	0.6	0.9	12	
13	M/41	Crush	R/Index	3	HNV	0.7	0.9	12	
			R/Long	3	V-Y	0.6	0.9	12	
14	M/29	Saw	R/Index	4	RHNV	0.7	1	10	
15	M/38	Crush	L/little	3	V-Y	0.5	0.9	10	
16	M/31	Crush	R/Index	4	HNV	0.56	1	8	
17	F/20	Crush	L/Ring	3	X finger	0.7	1	10	
18	M/30	Saw	R/Ring	4	X finger	0.52	0.9	14	
			R/Long	3	V-Y	0.63	1	14	
19	M/26	Saw	L/Long	4	X finger	0.6	1	16	naifold recession
			L/Index	4	X finger	0.6	1.05	16	
20	F/27	Crush	R/Index	3	X finger	0.5	0.8	10	
			R/Long	4	X finger	0.5	0.8	10	
21	M/51	consequence	L/Index	3	X finger	0.7	1	10	dystrophic nail
22	M/43	Cut	L/Ring	4	X finger	0.5	1.25	12	
23	F/49	Cut	L/Long	3	Thenar	0.6	1.2	14	
24	M/41	Crush	R/Ring	4	X finger	0.5	1	10	
25	F/30	Crush	R/Ring	3	Composite	0.63	1	12	
			R/Long	3	V-Y	0.6	0.9	12	

HNV, homodigital neurovascular island flap. RHNV, reverse homodigital neurovascular island flap X finger, cross finger flap Case NO. 19 Used eponychial recession⁽¹⁶⁾ instead of eponychial folding technique⁽⁴⁾.

Case NO. 3, 11, 21 present nail deformity.

Operative technique

Digit-specific radiographs were performed to show associated phalangeal fractures. All cases underwent nail salvage by Eponychial Folding Procedure. Pulp reconstruction was created with different local flaps according to the angle geometry of the amputated digital tip⁽⁶⁾, including composite flaps⁽⁷⁾, V-Y advancement flaps⁽⁸⁾, homodigital neurovascular island flaps⁽⁹⁾, reverse homodigital neurovascular island flaps⁽¹⁰⁾, cross finger flaps⁽¹¹⁾, and thenar flaps⁽¹²⁾.

Eponychial folding Procedure⁽³⁾ was operated by a parallel longitudinal incision as wide as the residual nail width. The eponychium flap was delicately lifted and fold proximally, fixed the eponychium flap with half buried mattress suture at medial and lateral edge (Figure 1). At this point effectively lengthening the exposed nail bed. If the nail plate is detached or destroyed, the sterilized remaining part of the nail plate or artificial (polypropylene) plate is reset and fixed.

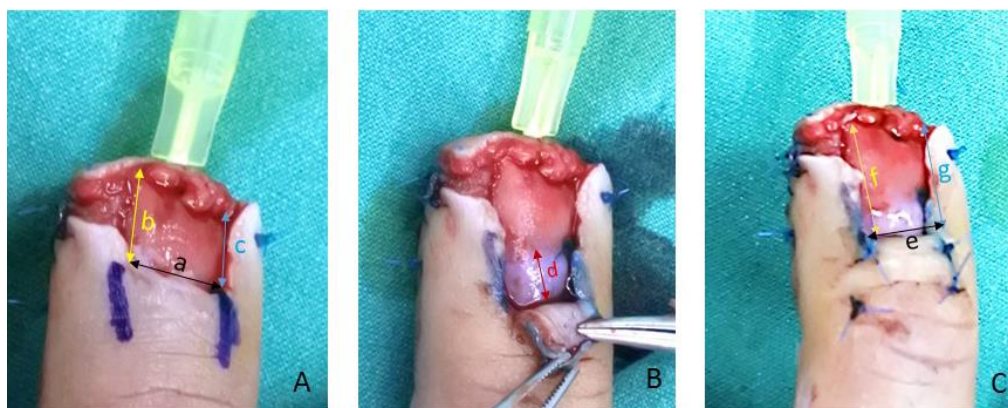


Fig. 1 Eponychial Folding Procedure. **(A)** The longitudinal incision of both sides of the eponychium as wide as the residual nail width, trapezoid area calculated by $\frac{1}{2}(b+c)*a$. **(B)** Eponychial flap was elevated (d =residual nail length). **(C)** Postoperative view, folding of the eponychium and fixation with half-buried horizontal mattress sutures, postoperative area $\frac{1}{2}(f+g)*e$.

Outcome measurement and statistical analysis

We evaluated outcomes for fingertip appearance, total active motion (TAM) of the fingers, and patient's satisfaction with hand function. We measured nail bed size using a ruler and calculated trapezoid's nail bed area, the goniometer was used to determine the total active finger motion. The contralateral uninjured finger was used as control. We employed pair *t* test to test for significant joint mobility with $\alpha < .05$ considered statistically significant.

Results

Table 1 lists patients' data. All acute injury were operated within 12 hours of injury, the consequence 2 cases were sent 2 weeks after previous treatment. The mean follow up period was 12 months (range, 6-18 months). The eponychial flap and pulp flaps survived in all patients. Compared with preoperative residual nail, the postoperative residual nail length increased by 5.78 mm (4-6mm), nail bed area was enlarged 60.02% (25-150%). All of them reported returning to activities in 8 weeks and to work in 12 weeks. The mean motion TAM were not significantly difference to the same digit on the opposite hand $\alpha < .05$, $t(29)=1.66$, $p=.107$. Donor site scar and skin discoloration were seen in all cases of cross finger flap group, V-Y flap and Thenar flap scar group less than Neurovascular island flap group. Nail deformities were reported in 3 cases; No. 2, 11 nail deviation after 12 months follow up but finally the patient accept no any further procedure. Nail surface usually improved within 6 months, 1 case had nail dystrophy after 6months. Finally, 23 patients were satisfied, whereas 2 patients (No. 2, 11) neutral, all patients have no further operation.

Case Report

Case 1 (NO.19)

A 26-year-old male patient presented with left Index and long fingertips amputation, with large

volar oblique pulp loss, and classified as Allens III. Reconstruction was performed at the time of injury. Both index and long finger were operated with cross finger flap, we employed The Eponychial Folding Procedure index finger compare with only pulp reconstruction long finger. Clinical evaluation at 12-month shows nearly full ROM all fingers with satisfactory result (Figure 2).

Case 2 (NO.6)

A 19-year-old male presented with the right ring finger injury, the patient had been treated 2 weeks earlier, dry gangrene flap and nail bed. After careful surgical cleaning, a decision was made to use the Eponychial Folding Procedure for nail salvage combined with oblique V-Y Flap for pulp reconstruction (Figure 3).

Case 3 (NO.14)

A 29-year-old male with transverse defect in pulp and $\frac{3}{4}$ nail bed loss of the right index finger, crush injury. Reconstruction was performed at time of injury. The Eponychial Folding Procedure combined with reverse homodigital neurovascular island flap for pulp reconstruction (Figure 4).

Case 4 (NO.23)

A 49-year-old female crush injured with volar oblique pulp loss, Allens IV. Despite the residual nail available, almost the whole nail matrix was exposed. The Eponychial Folding Procedure and the thenar flap reconstruction, respectively (Figure 5).

Case 5 (NO.11)

A 19-year-old female crush injured with transverse pulp loss, Allens IV. The Eponychial Folding Procedure combined with reverse homodigital neurovascular island flap for pulp reconstruction (Figure 6). Postoperative nail deformity was shown.



Fig. 2 (A-B) Volar and dorsal aspect of the left hand shown. (C-E) Eponychial Folding Procedure was done at index finger, whereas nail recess technique (detach subcutaneous tissue under skin and retract eponychial proximally) was performed at index finger. (D) residual nail bed length of index after eponychial flap was raised. (H) Visible nail length of the long finger after nailfold recession compare with eponychial folding index finger. (F-G) Cross finger flap was performed from dorsal long finger to index finger, (F-J) Cross finger flap were used for pulp reconstruction index and long fingers, split thickness skin graft was applied to coverage donor site. (K-M) follow up 12-month shows nearly full ROM with satisfactory result.



Fig. 3 (A, B) Dry gangrene fingertip volar pulp and nail bed of the ring finger, almost total gangrene of the nail. (C, D) Eponychial Folding Procedure was done to salvage nail bed. (D, E) Oblique V-Y flap remedied pulp loss. (F, G) Postoperative views after reconstruction. (H, I) Follow up 6 months after treatment.



Fig. 4 (A, B) Left index finger with transverse defect pulp loss, Allens III. (C, D) Reconstruction was performed with reverse homodigital neurovascular island flap combined with Eponychial Folding Procedure. (E-G) The size of the nail and contour of the pulp 12 months later.



Fig. 5 (A, B) Left long fingertip amputation with small nail bed remnant, volar oblique pulp loss. (C-E) Eponychial Folding Procedure was performed for nail salvage. (F) Thenar flap was employed for pulp reconstruction. (G, H) The size of nail and the contour of the pulp was almost the same as uninjured part with inconspicuous scar.

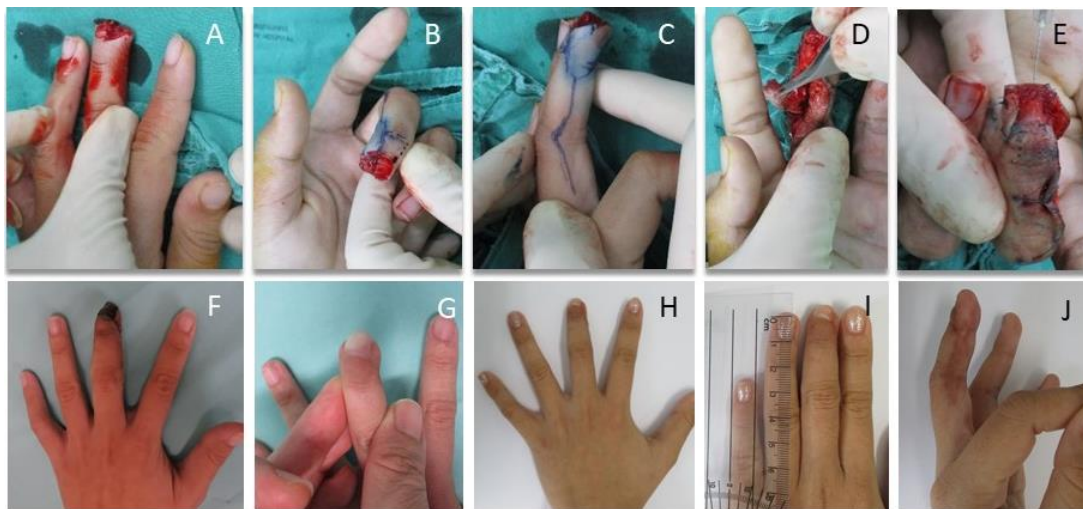


Fig. 6 (A-C) Left long fingertip amputation with small nail bed remnant, transverse pulp loss. (C-E) Homodigital neurovascular island flap was performed simultaneously with Eponychial Folding Procedure. (F) Postoperative 1 month. (G) 6 months after injury shown deviated hook nail. (H-J) 1 year nail shape appears better, patient finally accepted deformity without further treatment.

Discussion

During fingertip reconstruction, both appearance and function should be consideration. Although there are several local flaps to remedy an injured digital pulp, the fingernail is often overlooked⁽²⁾. Various surgical techniques have been developed to reconstruct the nail bed, nail bed graft from amputated part, from adjacent finger, and great toe⁽³⁾. Nonvascularized is used with risk of failure and require the presence distal phalanx to provide bone support. More difficulties microsurgical reconstruction free osteoonychocutaneous flap⁽¹³⁾ harvested from great toe or second toe, this technique is not simple, high cost, and not always accept by the patient.

Some authors suggested that if less than 0.5 cm or less than half of the original nail bed remains, the nail bed should be ablated⁽¹⁴⁾. In normal finger, the nail plate should protrude from the eponychium by at least 0.2 cm for a precise grip and good appearance⁽¹⁵⁾.

To optimize the outcome of the reconstruction, we employed nail salvage by Eponychial Folding Procedure. The dorsal skin of nail fold cover most germinal matrix and nail plate, the residual nail bed 0.4-to 0.6-cm-long can be exposed and effectively enlarged to look more acceptable. In our studied the eponychial flap was raised and fold proximally increase visible nail bed length 5.78 mm (4-6 mm), nail bed area was enlarged 63% (35-150%), we can preserve finger which nail more than 0.2 cm or lanula intact safely. Compared with nail lengthening technique described by Bakhach⁽¹⁶⁾ (the rectangle flap was exteriorized, eponychium sliding and folding proximally increased visible nail bed area)⁽¹⁷⁾, Xing⁽¹⁸⁾ reported nailfold recession in acute injury

lengthened 0.3-0.4 cm. nail bed length and enlarged 38 to 100%, without flap complication. Both nail lengthening techniques were powerful preserving fingertip amputation which nail bed less than 0.2 cm.

The Eponychial Folding raised the flap and folding directly may comfortable than recession nail fold, which must precisely remove the middle skin then slid distal flap proximal to adjust nail bed area. In our series pulp loss less than 1 cm or dorsal oblique geometry, the Tranquilli-Leali may be disturb blood supply eponychium folding flap, the modified Atasoy V-Y flaps⁽⁸⁾ more satisfy (Figure 3). We employed homodigital neurovascular (HNV) or reverse homodigital neurovascular (RHNV) island flap when pulp loss between 1-1.5 cm, the aesthetic result of RHNV⁽¹⁰⁾ is better than HNV in our series (Figure 4). In case of defect larger than 1.5 cm was treated by cross finger flap⁽¹¹⁾, large amount tissue was available from the flap, the usual and double cross finger flap work well, nearly full ROM without complication (Figure 2). The thenar flap⁽¹²⁾ was tried in 2 cases of the long finger with good results (Figure 5). Although objective functional data, such as from 2-point discrimination or Jepsen tests, were not obtained for our patients, patients' sensation in Homodigital neurovascular island flap and V-Y flap group were better than Thenar and Cross finger flap group, all can used their affected digit in activities of daily living. Flap optioned was not only sensation but also the nail shaped result later, too small amount of soft tissue with tension may caused deformity later, such as case No.11 may resulted from too small flap and pedicle design, the RHNV flap had less tension than HNV flap, and we have no any nail deformity. Our study had many cross finger flap cases because some cases had vascular compromise after Neurovascular

flap was raised, the procedure was converted to Cross finger flap immediately. Some cases had double digits with large volar defect for example case report 1, RHNV pair digits may be jeopardized the cross finger flap may be safely consideration.

Nakanishi⁽¹⁹⁾ and co-workers compare Tanmai Zone I Fingertip amputation reconstruction using digital artery flap with microsurgical replantation, 2 procedures were comparable regarding postoperative daily activities of daily living and performance. The Eponychial Folding Procedure may improve outcomes the local flaps regard to nail salvage. In our series most cases were foreign patients, Burma people. From October 2019 there had been pandemic covid 19, and protest in Myanmar. Our obstacle not only communication problem but also contact examination was limited, sensation may not perfectly reported from our study. Many patients circling back, so clinical course was limited in our studied. There is insufficient evidence to determine the best treatment method for composite defects of the fingertips. To date, there have been no prospective, randomized clinical trials to evaluate one method versus another. Future studies should develop and use standard methods for evaluating both subjective and objective results.

Conclusion

Fingertip amputation with critical nail bed loss, the Eponychial Folding Procedure collaborate well with different local flaps, either acute situation or consequence after injuries. The final result not only on the proper and precise use of the technique but also its combination with appropriate procedure for pulp reconstruction.

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การรักษาผู้ป่วยปลายนิ้วขาดด้วยการผ่าตัดเพิ่มขนาดฐานเล็บร่วมกับการปลูกถ่ายเนื้อเยื่อบริเวณปลายนิ้ว

เทพรักษา เหมพรหมราช, พบ

วัตถุประสงค์: ศึกษาผลการผ่าตัดรักษาผู้ป่วยปลายนิ้วขาดด้วยการผ่าตัดเพิ่มขนาดฐานเล็บ ร่วมกับการปลูกถ่ายเนื้อเยื่อบริเวณปลายนิ้วในการผ่าตัดรักษาครั้งเดียวกัน

วิธีการศึกษา: ผู้ป่วยปลายนิ้วขาดจำนวน 30 นิ้ว ที่มารับการรักษาที่โรงพยาบาลสมุทราศรตั้งแต่ มกราคม 2561 ถึง ตุลาคม 2562 ได้รับการผ่าตัดรักษาด้วยการเพิ่มขนาดฐานเล็บด้วยวิธีมีวนผิวหนังที่ปกคลุมฐานเล็บ (*Eponychial Folding Procedure*) ร่วมกับการย้ายเนื้อเยื่อมาปิดปลายนิ้วด้วยวิธีการต่างๆ (*different local flaps*) โดยเก็บข้อมูลลักษณะปลายนิ้วที่ขาด พื้นที่ฐานเล็บ ก่อนและหลังการผ่าตัดรักษา พิสัยการเคลื่อนไหวของนิ้วหลังการรักษาเทียบกับข้างปกติ ความพึงพอใจผลการรักษาของผู้ป่วย

ผลการศึกษา: ผู้ป่วยจำนวน 25 ราย (30 นิ้ว) มี 5 บาดเจ็บ 2 นิ้ว, 2 ราย (2 นิ้ว) เคยได้รับการผ่าตัดรักษามาก่อน ไม่มีการสูญเสียเนื้อเยื่อที่มาปลูกถ่ายและเนื้อเยื่อบริเวณฐานเล็บ ความยาวของเล็บเพิ่มขึ้นเฉลี่ย 5.78 มม. (4-7 มม.) พื้นที่ฐานเล็บเพิ่มขึ้นเฉลี่ย ร้อยละ 60 (ร้อยละ 25-150) พิสัยการเคลื่อนไหวของนิ้วไม่ต่างกับข้างปกติอย่างมีนัยสำคัญทางสถิติ ผู้ป่วยทุกรายพอใจกับรูปร่างนิ้วและการทำงานหลังผ่าตัดรักษา

สรุป: การผ่าตัดรักษาผู้ป่วยด้วยการเพิ่มขนาดฐานเล็บในผู้ป่วยปลายนิ้วขาดที่มีการบาดเจ็บของเล็บร่วมด้วย ให้ผลการรักษาที่ดี สามารถทำร่วมกับการปลูกถ่ายเนื้อเยื่อด้วยเทคนิคต่างๆ ได้เป็นอย่างดี
