

A Comparative Study of Cross Finger Flap with Thenar Flap for Finger Tip Reconstruction

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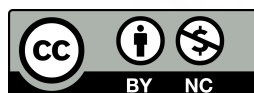
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ABSTRACT

Introduction: Fingertip injuries are common hand injuries ranging from simple laceration to larger defects with amputations. Different methods are used to reconstruct the affected finger. Cross finger flaps and thenar flaps are commonly used but it is difficult to select among these two flaps to reconstruct the finger in our settings.

Method: This is a time-bound prospective comparative study conducted in 14 months duration. The aesthetic (sensibility, appearance and function as subjective assessment) and functional outcomes (2 point discrimination and range of motion) were measured. Data were analyzed using SPSS version 21. Overall significance level was maintained at 'p' value < 0.05.

Results: There was female predisposition with average age of 34.66 years. The common mode of injury was crush injury with right hand most commonly involved hand and middle finger being commonly injured digit. On subjective assessment, the difference on rating scale on sensibility, function and appearance was not statistically significant among two groups. There were statistical significant differences in mean of static and moving 2 point discrimination among thenar flap and cross finger flap. . The mean active range of motion at three types of joint (MP, PIP, DIP) of finger were 97.660, 82.660 and 38.660 in thenar group and 88.330, 78.660 and 33.660 in cross finger group respectively which were not statistically significant.

Conclusion: Our study does not find any precise characteristics for the selection of thenar and cross finger flap based on aesthetic and functional outcomes in reconstruction of fingertip injury.

Keywords: Aesthetic; Flaps; Outcome; Reconstruction.

INTRODUCTION

Fingertip injuries are very frequent injuries of upper limb that may occur after thermal or traumatic accidents at any age groups.^{1,2} The pattern of injuries varies from simple laceration to soft tissue defects exposing vital structures. The fingers most commonly injured are middle finger followed by index, ring, little finger and thumb.³ The amount of soft-tissue loss, the integrity of the nail bed, and the age and physical demands of the patient should be considered when selecting a treatment method.⁷ The aim of fingertip defect reconstructions

is to provide a painless tip with good quality skin and adequate protective sensation, preserve the length, and prevent nail deformities.^{2,7} Different methods adopted for treatment of fingertip injury are secondary healing, semi-occlusive dressing, split thickness skin graft (STSG) and flap coverage.² The various native flaps used to reconstruct fingertip area are bilateral v-y flaps, cross finger flap, thenar flaps and island flaps.^{8,9} The thenar flap (TF) is most applicable to the index and middle fingers with significant pulp loss.¹⁰ The greatest advantage of

thenar flap is it provides glabrous skin of like nature with adequate sensation over a time period of 6 to 8 months and injuries to the adjacent finger can also be avoided.¹¹ Cross finger flaps (CFF) is a robust flap that uses dorsal skin of an adjacent finger to construct volar fingertip injuries in two stages thereby providing durable cover for volar oblique defects with exposed bone, tendon or joint when available local flaps are inadequate and preservation of length is essential.¹²

The management of fingertip injuries is complex and not without controversy as a variety of treatment options are available.¹³ However, in our context, choice between thenar and cross finger flaps is contended as no studies has been conducted regarding the differences in their clinical outcomes. Hence, the present study was conducted to compare the functional and aesthetic outcome of thenar flaps and cross finger flaps in fingertip reconstructions.

METHODOLOGY

This is the time bound, prospective comparative study conducted at Department of Burn, Plastic and Reconstructive Surgery, Bir Hospital and National Trauma Centre, Kathmandu, Nepal from November 2019 to January 2021. The study was conducted after getting approval from Institutional Review Committee and informed written and verbal consent were taken from each participants. The total subjects were 33 which were divided into 2 groups in non-randomized manner as per the choice of the patient, first group for thenar flap included 15 and second group for cross finger flap included 18. Inclusion Criteria for the study included Age group between 16 years – 60 years, Acute fingertip injuries with defects exposing bone or tendon, Transverse or oblique amputation distal to distal interphalangeal joint (DIP) joint and Paucity of soft tissue and more volar loss.

All routine pre-operative investigations including imaging were obtained prior to the surgical procedure. Patient were kept nil per oral as per guidelines: 2 hour for clear fluid like water, 4 hours for breast milk, 6 hours for formula milk, 8 hours for solid food. The patient will be taken into the operation room. The patients were kept in supine position and electrocardiogram (ECG), oxygen saturation (SpO2) and non-invasive blood pressure measurement were measured and baseline vitals were recorded. Intravenous drip were started with the appropriate size cannula and continued throughout the duration of surgery. 100% oxygen was administered through oxygen mask. The dimensions of flap required were determined by the size and shape of the fingertip defect and the flap design was based on the location and configuration

of the wound and defect pattern. Based on the site of amputation (involves the pulp or nail bed), plane of injury and the mechanism of injury or the level of injury, the fingertip injuries are classified. Allen classifications are based on the four types listed below.¹⁵

- Type 1: involves only the pulp
- Type 2: involves the pulp and nail bed
- Type 3: includes partial loss of the distal phalanx
- Type 4: injury proximal to the lunula

Operative Procedure

Cross Finger Flap: The finger adjacent to the injured finger was chosen as it was easiest to position as the flap donor (Fig 1 B & C). The template was used to select the optimal location and orientation of the flap, then the flap was marked on the dorsal aspect of middle phalanx of the adjacent finger. Incision was made through the skin and subcutaneous tissues extending it to paratenon overlaying the extensor mechanism. This layer was preserved. Then the flap was elevated between the paratenon and the subcutaneous tissue, beginning at the mid-lateral incision and progressing towards the opposite mid lateral hinge (Fig 1C). The flap was inserted the wound on the adjacent finger (Fig 1D). The flap was trimmed concentrically with the wound margin. Skin graft was taken from the ipsilateral medial arm and graft was secured with tie over bolster suture (Fig 1E).



Fig. 1. Surgical technique. A: Finger tip injury following road traffic accident; B & C: flap prepared from the adjacent finger; D: volar side of flap that remains pedicled by dorsomedial hinge; E: dorsal side after placement of graft

Wound was dressed with nonadherent paraffin gauze. Care was taken by placing soft dry gauze between all the fingers to prevent maceration. Fingers and palm were padded with cotton and dorsal pop splint applied. The hand was immobilized in intrinsic-plus position to prevent tension on the flap. The wound was inspected after 48 hours and suture removed on day 9-12. The finger were divided under local anesthesia and finger bandages was applied. Active physiotherapy was started after 3-5 days for both donor and injured finger.^{5,9,16}

Thenar Flap: A standard thenar flap was done by flexing the injured fingertip into the palm (Fig 2B). A proximal or distally based thenar flap, slightly larger than the fingertip defect was elevated at the level of the muscle fascia. The finger was flexed into the palm to rest in a relaxed position (Fig 2B). The corner of the digital defect was sutured to the edge of the donor defect in the palm with a 4-0 prolene suture to reduce tension on the flap. Donor defect was closed primarily with 4-0 prolene suture. The tourniquet was released and the blood supply to the flap determined by observation. To preserve adequate blood supply, the base of the flap was tried not to kink or fold. The thenar flaps were immobilized for 12-18 days using dorsal plaster or thermoplastic splint. Early active and passive range of motion was encouraged after flap was divided to prevent digital stiffness and to restore full thumb motion. Sensory re-orientation and desensitization instructions, scar massage and pressure garments were advised when necessary.^{5,7,9}

Subjective assessments were done by questionnaire mentioning sensibility, function and appearance. Patients were asked about the function, appearance and sensibility of hand after surgery and were given the options of “excellent”, “good”, “fair” and “poor”. Objective assessment for sensation was done by moving and static two-point discrimination (2 PD) test in both affected and unaffected hand. The result of this test was expressed in millimeter (mm).

Objective assessment for movements was observed by measuring the active range of motion of MP, PIP and DIP joints of the reconstructed finger as well as corresponding finger of the contralateral hand. Range of motion was measured with a standard hand goniometer and expressed in degree (0). Complications, secondary procedures (if done any) and sequelae in the post-operative period in all patients were recorded. The patients were followed up from 6 to 9 months.

Collected data were analyzed by means of statistical software such as SPSS (Statistical Analysis in Social Science) version 21. Overall significance level was maintained at ‘p’ value < 0.05 and T-test was performed. Analyzed data were presented in tables in the form of mean ± standard deviation.

RESULTS

Out of 33 surgeries performed for fingertip injuries, 13 were of males and 20 were of females (fig 1). The minimum age of patients was 16 and maximum was 58 with an average of 34.66±10.72 years (fig 2). Around 70% of patients were housewives and labourer/factory workers followed by in-service and school going students (fig 3).

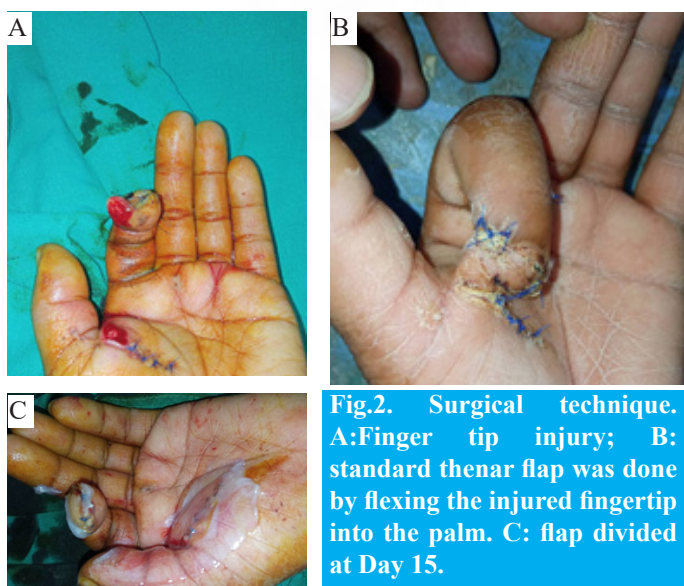


Fig.2. Surgical technique. A: Finger tip injury; B: standard thenar flap was done by flexing the injured fingertip into the palm. C: flap divided at Day 15.

Data collection were done by filling porforma containing the demographic details (age, sex, mode of injury, mechanism of injury, finger distribution), type of injury, duration of flap division, donor site morbidity, range of motion, sensation, appearances and, complications.

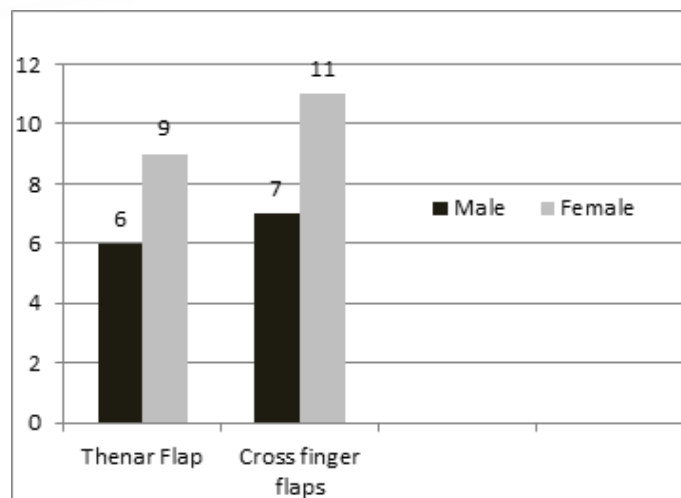


Fig 1. Gender Distribution of Participants

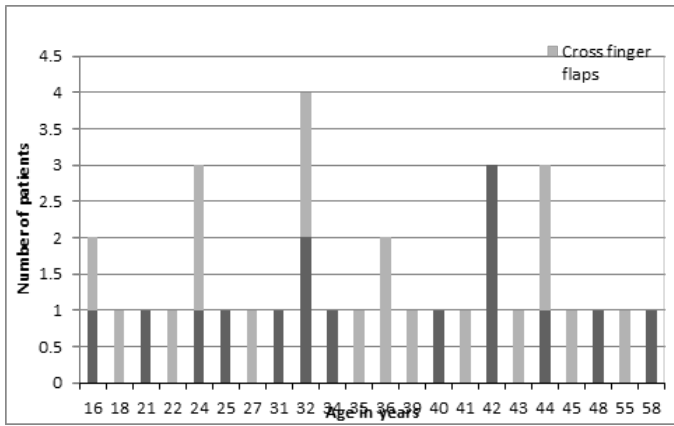


Fig 2. Age-wise Distribution of Participants

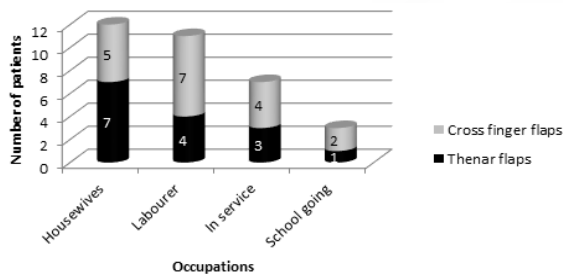


Fig 3. Occupation wise Distribution of Participants

The different modes of injuries are listed in table 1. The most common mode of injury was crush injury and least common was avulsion injury. The right hand was commonly involved with middle and ring fingers being most commonly injured (Table 2). Based on Allen classification of fingertip injuries, type 3 was most common followed by type 4 (Fig 4).

Table 1. Mode of Injury

Mode	Number of patients		Total
	Thenar Flap (TF)	Cross Finger Flap (CFF)	
Crush injury	5	9	14
Slicing injury	5	6	11
Clean cut amputation	3	2	5
Avulsion injury	2	1	3

Table 2. Hands and Fingers Injured

Group	Thenar flap (TF)		Cross finger flap (CFF)	
	Right hand	Left hand	Right hand	Left hand
Fingers				
Middle	5	2	3	2
Ring	2	1	5	2
Index	2	1	4	1
Little	1	1	0	1

Type of finger tip injury (Allen Classification)



Fig 4. Pie Chart Showing Type of Fingertip Injury

Out of 33 patients, 14 responded the sensibility of digits as excellent after surgery whereas 11 responded it as good. Poor sensibility was seen in 5 patients and fair with 3 patients. The subjective response as excellent was recorded by 11 and 14 patients on function and appearance whereas one and two of them rated it as poor function and poor appearance respectively (Table 3).

Table 3: Subjective Assessments (sensibility, function and appearance)

	Excellent		Good		Fair		Poor	
	TF	CFF	TF	CFF	TF	CFF	TF	CFF
Sensibility	8	6	4	7	1	2	2	3
Function	6	5	9	10	0	2	0	1
Appearance	8	6	6	8	0	3	1	1

In terms of objective assessment of sensation, the mean 2 point sensation was compared among each group and with contralateral side (Table 4). The mean static 2 point discrimination (2 PD) of reconstructed finger of thenar flap group and cross finger flap group were found to be statistically significant (p-value= 0.001) whereas mean of contralateral side static 2 point discrimination (2 PD) of thenar and cross finger flap were found to be not significant (p-value= 0.13). Similarly, the mean moving 2 point discrimination (2 PD) of thenar group and cross finger flap group, and mean of contralateral side moving 2 point discrimination (2 PD) of thenar and cross finger flap whereas were found to be not significant (p-value = 0.1 and p-value= 0.32 respectively). The comparison of mean of thenar flap and cross finger flap groups with their contralateral side mean was found significant (p-value= 0.01 and p-value < 0.0001 respectively).

Table 4: Objective Assessment: Sensation (2 point discrimination / 2 PD) (in mm)

	Static 2 PD		p-value	Moving 2PD		p-value
	TF	CFF		TF	CFF	
Flap side (Mean ±SD)	5.62±1.07	4.21±0.67	0.001*	3.74±0.65	3.42±0.29	0.1
Normal (Contralateral side) (mean ± SD)	3.06±0.61	2.75±0.52	0.13	3.03±0.63	2.82±0.52	0.32
P-value	<0.00001*	<0.00001*	-	0.01*	-	-

Regarding the objective assessment of active range of motion, the mean active range of motion was compared among each group (thenar flap group and cross finger flap group) and with contralateral side (Table 5). The mean MP, PIP and DIP joint motion in the reconstructed finger of thenar flap group were $97.66 \pm 5.30^\circ$, $82.66 \pm 6.77^\circ$ and $38.66 \pm 4.41^\circ$ compared to $101.66 \pm 3.08^\circ$, $88.33 \pm 3.08^\circ$ and $42.33 \pm 2.58^\circ$ in the non-affected contralateral side respectively. Similarly, The mean MP, PIP and DIP joint motion in the reconstructed finger of cross finger flap group were $88.33 \pm 11.12^\circ$, $78.66 \pm 6.67^\circ$ and $33.66 \pm 7.18^\circ$ compared to $95.66 \pm 5.62^\circ$, $86.33 \pm 4.80^\circ$ and $39.33 \pm 4.95^\circ$ in the non-affected contralateral side respectively. The differences in mean were not statistically significant.

male to female ratio was 0.65 and average age of patients was 34.66 years. The average age was 30.28 years and 29.3 years as reported in the study conducted by H Koch et al and Singh R et al respectively.^{18,19} The female preponderance in our study is in contrast with the study conducted by Saraf et al and Singh R et al in India which reported that there was male preponderance with ratio 1.5:1 and 3: 1 respectively.^{17,19} Thenar flap is preferred in females due to risk of scar visibility in cross finger flap but our study has not based on this factor only to minimize selection bias. However, our findings are consistent with the occupation as fingertip injuries were common in housewives during kitchen and other household activities followed by labourer involved in construction works and industries.

Table 5: Objective assessment: active range of motion

	TF		P-value	CFF		P-value
	Affected Digit	Contralateral Digit		Affected Digit	Contralateral Digit	
Mean MP joint motion (degrees ± SD)	97.66 ±5.30	101.66 ±3.08	0.98	88.33 ±11.12	95.66 ±5.62	0.99
Mean PIP joint motion (degrees ± SD)	82.66 ±6.77	88.33 ±3.08	0.99	78.66 ±6.67	86.33 ±4.80	0.93
Mean DIP joint motion (degrees ± SD)	38.66 ±4.41	42.33 ±2.58	0.85	33.66 ±7.18	39.33 ±4.95	0.99

There were few complications that include one marginal necrosis of flap and two developed wound infections developed in reconstructed finger in thenar flap group whereas, out of 18 cross finger flaps, two developed marginal necrosis and four developed wound infections. Marginal necrosis was managed conservatively and wound infection was managed with antibiotics and wound dressings. There was no complete loss of flaps in both cases.

Time taken from injury to operation theatre was ranged from 3 hours to 35 hours and time taken for operation with thenar flap ranged from 1.5-4 hours and cross finger flap ranged 2-5 hours. The time taken for division of finger in both cases ranged from 9 to 18 days. The movement of digits were mildly restricted in both injured and donor finger in both flap groups which eventually improves at follow up of 6 to 9 months. Similarly, pain in fingertip and numbness were complained by all 33 patients post-operatively. Out of 15 of thenar flaps, 6 complained of pain persisting for 2-4 weeks which eventually relieved after 4 weeks once physiotherapy started. Out of 18 of cross finger flaps, 9 complained of persisting pain in fingertip and donor area for 3-5

male to female ratio was 0.65 and average age of patients was 34.66 years. The average age was 30.28 years and 29.3 years as reported in the study conducted by H Koch et al and Singh R et al respectively.^{18,19} The female preponderance in our study is in contrast with the study conducted by Saraf et al and Singh R et al in India which reported that there was male preponderance with ratio 1.5:1 and 3: 1 respectively.^{17,19} Thenar flap is preferred in females due to risk of scar visibility in cross finger flap but our study has not based on this factor only to minimize selection bias. However, our findings are consistent with the occupation as fingertip injuries were common in housewives during kitchen and other household activities followed by labourer involved in construction works and industries.

Fingertip injuries were carefully evaluated for hands involved, mode and types of injuries. The study published in Indian journal of orthopedics showed crush injuries (32%) as commonest mode of injury and middle finger (25.3%) as commonly injured digit which is similar to our study findings (42.4% and 36.7% respectively).¹⁷ The fingertip of right hand was found to be commonly injured in the study conducted by Singh R et al (83.3%) and Ranganathan S et al (58.8%) which are similar to our study (66.7%) but both of their studies observed index finger (40% and 35.2% respectively) as most commonly injured finger.^{19,20} However, Zienowicz RJ et al mentioned that middle finger is the most vulnerable because it is the most distal and the last to be withdrawn in case of any trauma.²¹ According to Allen classification, type 1 and 2 injuries

DISCUSSION

In this study conducted on flap treatment of fingertip injuries, total patients were 33. The

may heal well by secondary intention and type 3 and 4 often requires flap coverage.^{15,22} Our study demonstrated that type 3 (54.5%) fingertip injuries was most common and type 4 (36.7%) was second most common whereas study conducted by Singh R et al reported type 2 (41.2%) as most common and type 4 (29.4%) as second most common fingertip injuries.¹⁹

On subjective assessment of aesthetic outcomes, around 80% and 72% patients rated good-excellent sensibility with thenar flap and cross finger flap respectively. On rating the function of reconstructed finger, 40% and 60% of patients reported function as excellent and good respectively in thenar flap group whereas 27.8% and 55.5% patients reported excellent and good function respectively in cross finger flap group. Similarly, 53.3% and 40% of them rated the appearance of reconstructed finger as excellent and good respectively in thenar group and 33.3% and 44.4% of them reported appearance as excellent and good respectively in cross finger flap group. The difference on rating scale was not statistically significant for sensibility, function and appearance among two groups which indicates that for fingertip injuries, thenar flap and cross finger flap have similar aesthetic outcomes in 6 to 9 months follow up. When there is bony exposure, soft-tissue coverage to restore finger pulp volume and sensation becomes essential.²³ As thenar flap provides good bulk with good aesthetic outcome, it is a good choice for reconstruction of the finger pulp.^{23, 24}

The functional outcome of flap was assessed by static 2PD and moving (dynamic) 2 PD along with range of motion at each joints of reconstructed digit. The mean static 2 PD and moving 2 PD was 5.62 mm and 3.74 mm in thenar flap reconstructed finger whereas it was 4.21 mm and 3.42 mm in cross finger flap reconstructed finger which is comparable to static 2 PD (5.6 mm) and moving 2PD (4.4 mm) reported by Sahu RK et al. and 5.6 mm and 3.3 mm reported by Dellon et al.^{7, 24} In our study the static 2PD and moving 2PD measured in mm were found to be greater in reconstructed finger than normal contralateral finger. The difference in mean in both static PD and moving PD among thenar flap group and cross finger flap group as well as in comparison to normal contralateral side were found to be statistically significant ($p < 0.00001$).

On analysis of hand function, active range of motion of MP, PIP and DIP joints measured in degree (°) for period of six to nine months were found to be lesser than the motion of normal contralateral digit in both thenar and cross finger flap groups. The mean active range of motion at three types of joint (MP, PIP, DIP) of finger were 97.660, 82.660 and 38.660 in thenar group and 88.330,

78.660 and 33.660 in cross finger group respectively. Our finding of MP joint was similar to Rinker et al (99.580) but the PIP and DIP joint motion were lesser than his study (92.40 and 50.410) but almost similar to results On analysis of hand function, active range of motion of MP, PIP and DIP joints measured in degree (°) for period of six to nine months were found to be lesser than the motion of normal contralateral digit in both thenar and cross finger flap groups. The mean active range of motion at three types of joint (MP, PIP, DIP) of finger were 97.660, 82.660 and 38.660 in thenar group and 88.330, 78.660 and 33.660 in cross finger group respectively. Our finding of MP joint was similar to Rinker et al (99.580) but the PIP and DIP joint motion were lesser than his study (92.40 and 50.410) but almost similar to results of Sahu RK et al (890 and 420).^{7,24} Though there was difference in active range of motion among groups, the difference was not found statistically significant.

The complications in cross finger flap reconstruction (33.3%) were more than in thenar flap reconstructed finger (20%). Marginal necrosis was managed conservatively and wound infection was managed with antibiotics and wound dressings. There was no complete loss of flaps in both cases. There was pain, numbness and difficulty in movement of both reconstructed fingers and donor fingers in both groups which gradually improves with physiotherapy. The complications were much more less than that reported by Koch et al and Al-Qattan MM et al in their studies.^{18, 27}

This study was successful in preserving the useful sensation, maximizing functional outcomes, providing satisfactory appearance and preventing the complications. However, no definitive distinction was observed in aesthetic and functional outcomes between thenar flap and cross finger flap reconstruction in fingertip injuries. Koch H et al mentioned that the cross finger flap is a reliable method in soft tissue reconstruction of the long fingers.¹⁸ However, our study showed outcome of thenar flap reconstruction is almost similar to outcome of cross finger flap reconstruction.

Study was conducted in single centre with small sample size. The follow up was done up to 9 months only. Hand aesthetic outcomes were solely based on patient reported rating. Few outcome instruments like Michigan Hand Outcomes Questionnaire, Vancouver scar scale, Buck-Gramcko Score could have been used for assessing hand aesthetics.²⁹ Hand function analysis was measured only with active range of motion. The study does not address the donor site morbidity in fingertip reconstruction which is a two-surgical steps.

CONCLUSION

Thenar flap and cross finger flap are commonly employed in treating fingertip injuries. The aesthetic and functional outcomes of thenar and cross finger flap on fingertip reconstruction showed no significant differences. The further study at multicenter with larger sample size and longer follow up is required before recommending whether thenar flap or cross finger flap is superior in reconstruction of fingertip injuries.

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