FINGERTIP RECONSTRUCTION WITH THE "SHARK MOUTH" INCISION THENAR FLAP: Analysis of Outcomes in Pediatric Patients

Manuel García Aríz MD[a]
Antonio Otero López MD[a]
Ernesto R. Otero López MD[a]
Beatriz García MD[a]
Pablo A. Marrero Barrera MD[a]*
Samuel Fernández MS[a]

[a]Department of Orthopedic, UPR School of Medicine, Puerto Rico Health Science Center.
*Corresponding author: Pablo A. Marrero Barrera MD - University of Puerto Rico, Medical Sciences Campus, Department of Orthopedics PO Box 365067, San Juan, Puerto Rico 00936-5067. E-mail: Pablitomarrero@gmail.com.

ABSTRACT

The thenar flap technique is a time-tested method of fingertip reconstruction that has been criticized due to possible finger flexion contractures and unsightly donor site scars. Functional outcome data on thenar flaps on the pediatric population is poor in the medical literature. Method: In this retrospective chart review we acquired information from sixteen patients who underwent a "Shark Bite" incision thenar flap reconstruction. Results: Patients ranged in age from 0-17 years. Time to division ranged from 16-30 days. All 16 patients' affected finger ROM were measured in DIP, PIP and MCP joints and compared with corresponding finger on contralateral hand. A questionnaire measured subjective satisfaction in: sensibility, appearance, and function. Fingertip sensation was preserved in both affected finger and donor site. The most persistent patient complaint involved fingertip contour, were most patients rated it as "Fair"(43%) and "Good"(56%). After statistical analysis of the data we found no statistical difference in range of motion (ROM) between affected finger and the same finger on the contralateral hand on both PIP and MCP joints (p=0.08, 0.06 respectively). Conclusions: The "Shark Mouth" incision thenar flap is an effective strategy for fingertip reconstruction. The results demonstrate this technique has excellent functional and aesthetic results and is not associated with flexion contractures, excessive sensibility or pain in the pediatric population.

Index words: ***fingertip, reconstruction, shark, mouth, incision, thenar, flap, outcome***

INTRODUCTION

The fingers serve a crucial role in the functioning of the hand. They are an organ of manipulation and sensation and are wrapped with countless sensory nerve endings, which account for sensation of pain and an extremely sharp two-point discrimination. The skin covering the pulp of the finger is very durable and has a thick epidermis with deep papillary ridges. It consists of fibrofatty tissue that is stabilized by fibrous septa extending from the dermis to the periosteum of the distal phalanx. Unfortunately, the most common injuries of the hand are fingertip injuries. These are injuries that occur distal to the insertion of flexor and extensor tendons (1). These injuries could be as insignificant as a fingertip fracture with no significant displacement or soft tissue injury, at which point treatment is conservative, or could be as severe as fingertip amputation with loss of distal fragment. In the latter case, even though preservation of the nail, length and keeping a good appearance is important, the primary goal of treatment would be to maintain good, strong, durable and sensate skin with no fingertip pain. Considerable dysfunction can occur when a painful fingertip excludes the use of a digit, or even the hand from use. It is crucial to maintain sensation in fingertips as not only does it help guide the finger along surfaces and aid in the overall functioning of the whole hand, but it serves as a defense mechanism and protective sensation.

Treatment of fingertip injuries should be individualized to each specific wound's characteristics. Various methods of treatment are possible, including allowing wound to heal by secondary intention, shortening of the bone and primary closure, skin grafting and coverage with a local and regional flap. It is important to know whether there is loss of skin and pulp tissue and the size of the defect. Also knowing whether there is exposed bone, bone loss or fracture of the distal phalanx tip is important for choosing the appropriate treatment. Primary closure of injury usually suffices for injuries with no skin or tissue loss. For those injuries with loss of skin or pulp tissue with no exposure of bone, both skin grafting and allowing the wound to heal by

secondary intention are appropriate treatments. Several authors have reported few complications and high patient satisfaction with the latter method (2,3), specifically for wounds no larger than 1 cm2. Larger wounds, however, when treated non-operatively heal with a thin layer of epithelium that is relatively fragile and could be over-sensitive to the point of being irritating and disabling to patients. Also, injuries that involve exposed bone and tissue loss almost never have enough tissue to close primarily, and treatment by secondary intention after shortening exposed bone below exposed tissue is associated with an unacceptable incidence of nail plate deformities (1). In these cases the application of full thickness skin graft should be considered. Full thickness skin grafts tend to contract less than split-thickness grafts, are more durable and less tender, and achieve better sensibility than split grafts (4).

One possible option for obtaining full coverage of a fingertip injury is implementation of a thenar flap. Thenar flaps are very advantageous in fingertip injuries with extensive tissue loss since they can provide a three-dimensional reconstruction that contains similar skin to the original skin of the finger, has extensive sensory endings, and is functional, durable, and aesthetically pleasing. The caveats of flap design are described by Beasley and Melone (5-7) and state that the flap should be placed high on the thenar eminence, based laterally, and adjacent to the metacarpophalangeal joint crease. Placing the incision too close to the mid-palm has been associated with debilitating donor-site tenderness (7). The thenar flap can be used for fingers two to five, although problems may arise in thick hands were the 4th and 5th distal digits could have difficulty comfortably reaching the thenar eminence. Rinker described that in a study with 15 patients who underwent thenar flap reconstructions of fingertip injuries, 75% reported good or excellent results in terms of sensibility, function and appearance (8). Dellon (9) reported a small case series of five patients with thenar flaps who had excellent sensory recovery. Barbato et al (10), also reported a case series of 20 patients, who also underwent thenar flap reconstruction, and also resulted with excellent sensory recovery.

All the studies previously mentioned show that the thenar flap is effective for sensory recovery of affected digit; however, functional outcome data is scarce in medical literature. The technique has been criticized due possible flexion contractures of the proximal interphalangeal joint due to the mandatory digit flexion. Barbato (10) reported in his thenar flap case series a 25% rate of PIP flexion contracture requiring extension splinting after flap division, but Rinker reports no significant flexion contractures observed in his case series. He did however notice a measured decrease in DIP joint motion of 13° compared to the contralateral side that was statistically significant (8).

Recently, in the University of Puerto Rico School of Medicine, pediatric orthopedic surgeons have been implementing a modification to the thenar flap techniques currently described, specifically the shape of the incision and flap. This new technique, termed "Shark Mouth" incision thenar flap, has given excellent functional, sensory and aesthetic results in this institution. In this retrospective chart review we acquired information from 16 medical records of patients ages 0-17 years old, who underwent "Shark Mouth" incision thenar flap reconstruction by two different surgeons after traumatic amputation at the level proximal to the middle portion of the nail bed with loss of the pulp and exposure of bone from 2005-2011. The purpose of this study was to review the experience of two pediatric surgeons with the "shark mouth incision" thenar flap for composite fingertip reconstruction. An objective assessment of sensory recovery and range of motion was performed to confirm the approach in pediatric fingertip injuries in the future. The main focus is to provide the best care, in the adequate timeframe, and avoid unnecessary or avoidable complications. Also, we wish to provide the orthopedic community with a procedure that has a small learning curve and excellent results.

MATERIAL & METHODS

Institutional Review

The present study was categorized as expedite and received the approval of the participating institution's Institutional Review Board for research involving human subjects. This approval was given prior to beginning data collection.

Study Design

This is a retrospective study studying the medical records of pediatric patients ages 0-17, who underwent thenar flap fingertip reconstruction with "shark mouth" incision of distal 2nd, 3rd and 4th distal fingertip injuries. Patients underwent surgical treatment by two separate pediatric orthopedic surgeons at the University Pediatric Hospital with follow-up at the Puerto Rico Trauma Center. A data sheet was created to organize information extraction. This information included demographic data, mechanism of injury, type of injury, timeline which included time to flap division, complications that may have developed, and physical examination findings, specifically range of motion of PIP, DIP and MP joints, and grip strength.

Participants

Inclusion Criteria

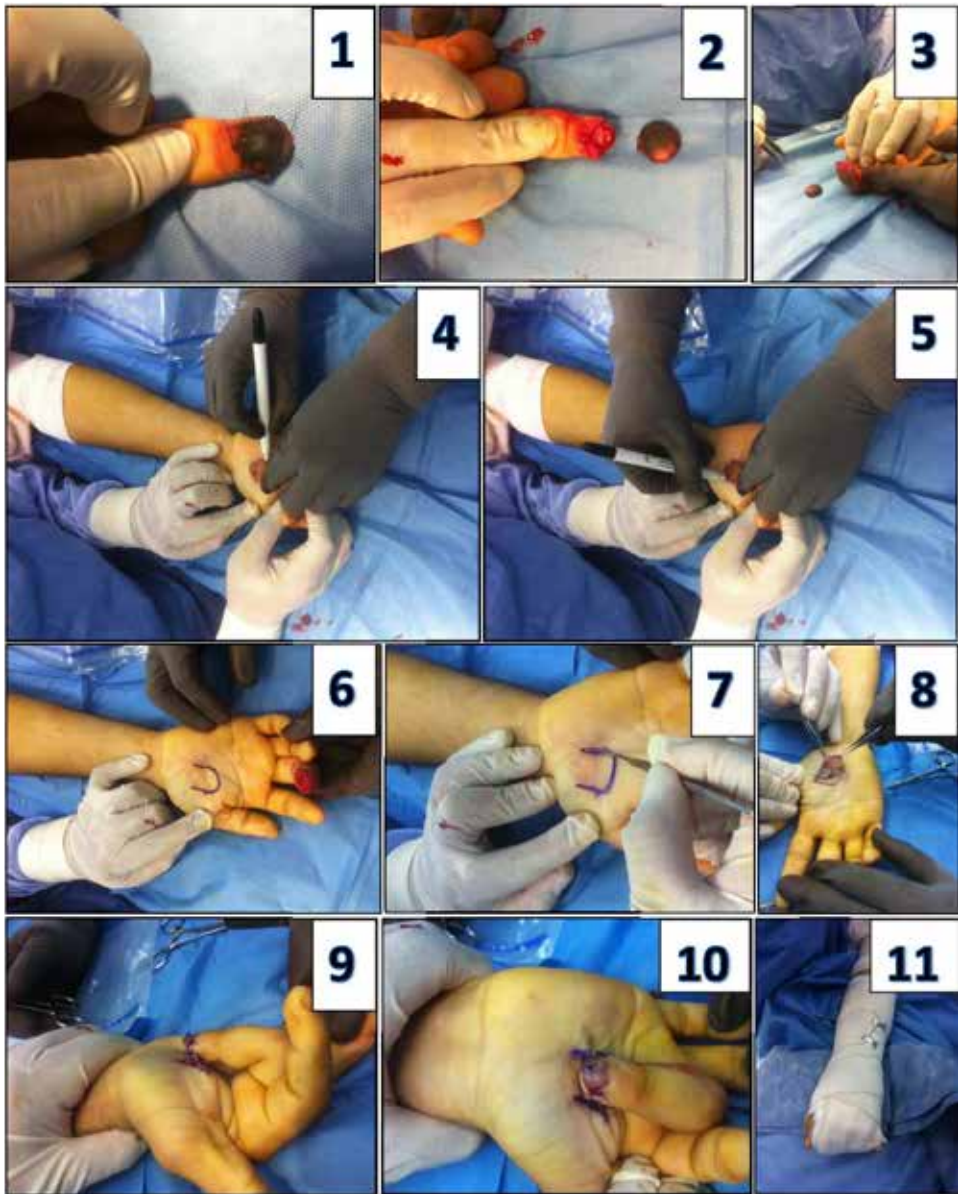
- Male and Female Patients
- 0 to 17 y/o
- Suffered traumatic amputation at the level proximal to the middle portion of the nail bed, with loss of the pulp and exposure of bone in index, long and middle fingers and underwent thenar flap reconstruction with at least 6 months of follow up

Exclusion Criteria

- Patients older than 17 years old
- Multiple digit amputation

- Patients who underwent other flap reconstruction or completion of amputation

Figure 1: Illustration demonstrating steps to follow to perform the “Shark Mouth” incision thenar flap.



Procedure/Operative Technique (see Figure 1)
The donor site was found by taking the tip of the injured finger and placing it against the thenar eminence. Two parallel lines are traced along the lateral and medial borders of the affected finger. The finger is then raised and the two lines are joined distally by a curved line (concave towards fingers and convex proximally) creating an angle greater than 60° between straight and curved lines. The wound is incised following the sketched lines. The tip of the wound incised is elevated and is sutured to the respective dorsal and volar fingertips and to each other along the lateral margins (see Figure 2). This method effectively advances the edges of the donor defects to one another. The hand is immobilized with the thumb in palmar abduction and the MP joint of the affected finger flexed to minimize flexion at the PIP joint. Plaster is added to the dressing along the dorsal aspect of the finger to act as a splint and maintain that position. A thumb Spica is then placed over the dressing to complete immobilization. The digit is left attached to the donor site for approximately three weeks, and the flap is then divided. This can be accomplished by injecting local anesthesia. Skin flap is approximated in the finger with 3-4 sutures and the donor site is closed (see Figure 3). An active range of motion program is initiated for both the affected finger and thumb. Cautious wound hygiene is maintained along with dressing changes to decrease risk of wound infection and graft failure. Patients and parents are instructed on proper maintenance of cast and dressings; especially on bathing techniques utilizing plastic bags to cover the cast and prevent ideal conditions for infection. After 15 days after graft division, sutures are removed. Patients were followed up for at least 6 months (Figure 4) to assess function and any possible complication.

Sensory Assessment
Objective sensory assessment was made by the surgeon at follow-up clinics performing pinprick and light touch to verify adequate sensory nerve regeneration. Average follow up time was 14 months post flap division. Semmes Weinstein Monofilament test and two-point discrimination were not performed. Patients were subsequently given a questionnaire that surveyed their opinions in terms of sensibility, color, pain, appearance, and general motion. Patients were asked to rate each category as poor, fair, good or excellent, depending on how they perceived each outcome.

Data Analysis
Data gathered was analyzed utilizing descriptive statistics and a Wilcoxon Signed Rank Test to compare between affected digit ROM and corresponding finger on contralateral hand.

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RESULTS

We identified 150 records with distal fingertip injuries. Of these, 37 were excluded by age and 86 did not undergo thenar flap graft. Of all records reviewed, we found 27 fingertip injuries that had thenar flap technique with "shark mouth" incision performed. Of these, 2 patients denied participation, and 9 were unable to be contacted, leaving a final population sample of sixteen patients who fit the inclusion criteria for this study. There were 14 males (87.5%) and 2 were females (12.5%), ranging in age from 0-17 years old with a median age of 9.8 years. Three fingers were affected, with 9 cases involving the index finger (56%), 3 involving the long finger (19%), and 4 involving the ring finger (25%). The mechanisms were mostly restricted to some kind of door crushing the fingertip, being interior door the most common observed mechanism of injury (56%), followed by exterior door (18%) (see Table 1).

Time from injury to reconstruction ranged from 12-48 hours. Time to division ranged from 12 to 30 days with a mean of 19.6 days. No infections were recorded and length of finger was successfully preserved in all cases. Both fine and gross sensation, as well as temperature and pain were preserved in affected finger and donor site in all cases, as recorded in follow-up clinics after subsequent division of flaps. Revision was not necessary in any of the sixteen cases reviewed and there were no reported complications.

Range of motion (ROM) was measure in degrees in PIP, DIP, and MP joints in both affected finger and corresponding finger on the contralateral hand. MP joint mean ROM was 100.3° in flexion with a standard deviation of 2.2°, PIP recorded at a mean of 89° with a standard deviation of 4.6°, and DIP had a mean of 39.7° with a standard deviation of 7.9° (see Table 2). ROM of corresponding finger on non-affected extremity was a mean of 102 ± 5.8° at MP joint, 100 ± 5.5° on PIP joint, and 55 ± 5° for DIP joint. A Wilcoxon Signed Rank Test revealed no significant differences in ROM between PIP (p=0.08) and MP (0.06) joints when compared to mean ROM of the corresponding digits PIP and MP joints of contralateral hand (Table 3). DIP ROM, however, showed to be significantly less (p = <0.001) than corresponding joint on contralateral hand. On follow-up, there were no functionally significant flexion contractures or thumb adduction contractures.

All 16 patients answered the questionnaire. All 16 patients reported resulting sensibility, pain and general motion in affected finger and donor site as good or excellent. Two patients (12%) reported fair results in color of skin on donor site and graft, and 14 (88%) reported good or excellent results in this category. Six patients (43%) reported fair results in fingertip contour, while 10 patients (57%) reported contour to be good or excellent. No patients reported poor results in any category (see Table 4).

Table 1: Demographic Patient Data.

Patient	Gender	Age	Finger	Mechanism	Days to Division	Follow up (Months)
1	M	8	R Index	Door (I)	19	13
2	M	16	L Long	Door (E)	15	14
3	M	13	L Index	Window	16	12
4	F	8	L Index	Door (I)	23	13
5	M	10	R Index	Door (C)	26	15
6	M	9	L Ring	Door (I)	30	13
7	M	2	R Ring	Door (I)	21	13
8	M	11	L Index	Door (I)	18	14
9	M	8	R Index	Window	20	12
10	M	9	R Index	Door (E)	17	14
11	F	2	L Long	Door (I)	12	15
12	M	16	L Ring	Door (C)	17	15
13	M	8	L Long	Door (E)	21	12
14	M	15	R Index	Door (I)	24	13
15	M	10	L Ring	Door (I)	18	12
16	M	12	L Index	Door (I)	16	13

Table 2: Range of Motion Distribution.

Patient	MP ROM (degrees)	PIP ROM (degrees)	DIP ROM(degrees)
1	100	90	30
2	100	80	40
3	95	90	25
4	100	95	55
5	100	90	40
6	100	90	30
7	100	90	35
8	105	85	40
9	100	95	40
10	105	85	45
11	100	90	40
12	100	90	55
13	100	80	40
14	100	95	40
15	100	90	40
16	100	90	40

Table 3: Mean Range Of Motion Per Joint.

	Affected Digit	Contralateral Digit	P-Value
Mean MP Joint	100.31+/- 2.2	102 +/- 5.8	0.06[a]
Mean PIP Joint	89.06+/-4.55	93+/-5.5	0.08[a]
Mean DIP Joint	39.69+/-7.85	55+/-5	<0.001[a]

a =Wilcoxon Signed Rank Test

Table 4: Questionnaire: Patient Subjective Data/ Satisfaction.

Category	Poor	Fair	Good	Excellent
Sensibility (DS)	0	0	2 (12%)	14 (88%)
Sensibility (AF)	0	0	2 (12%)	14 (88%)
Color (DS)	0	2 (12%)	10 (63%)	4 (25%)
Color (AF)	0	2 (12%)	12 (76%)	2 (12%)
Pain (AF)	0	0	3 (19%)	13 (81%)
Contour (AF)	0	6 (43%)	9 (56%)	1 (1%)
General Motion	0	0	2 (12%)	14 (88%)

DISCUSSION

Fingertip injuries can produce composite loss of fingertip pulp and tactile skin. The skin on the palmar aspect of the finger is specialized in that it has many more nerve endings that in other parts of the body and allow fine sensation. Extensive loss of palmar fingertip skin must be replaced with a flap of similar

Figure 2: Suturing of the thenar flap to distal fingertip defect of third finger.

composition that allows restoration of fine sensation as well as maintain original fingertip function. Aesthetic appearance is secondary to the previous goals but is nonetheless important to maintain patient satisfaction and self-esteem. The results of this study show that the thenar flap done with the "Shark Mouth" incision is effective for treating these types of injuries. This is reflected in the questionnaire results were 100% of patients reported good or excellent results in sensibility of affected finger and donor site, pain, and general motion. Overall, patients reported satisfactory results in terms of fingertip appearance after reconstruction. 88% of patients believed that the flap color match with original fingertip color was good or excellent. Contour, however, was the category that received the worst results, reflected by 6 patients (43%) who reported fair results in this aspect; nonetheless, the majority of patients (57%) believed that the shape of the reconstructed fingertip was good or excellent. The fact that no patients reported poor results in any category speaks favorably about this technique.

Barbato (10) reported in his thenar flap case series a 25% rate of PIP flexion contracture requiring extension splinting after flap division. The results of this study show no clinically significant contractures of the

Figure 3: Post flap division and closing of flap donor site.

Figure 4: Healed fingertip and donor site.

digits. Both MP and PIP joints of affected finger showed no statistically significant loss of ROM when compared to corresponding finger on the unaffected hand, showing only a 2° and 4° loss of ROM respectively. There was an average loss of ROM in affected DIP joints of 15° that reached statistical significance; however, the cause of this loss of motion cannot be attributed to this technique. The specific cause for these differences in DIP motion is unknown and could have been easily caused by initial distal phalanx injury. Rinker (8) had similar results, finding no significant difference in MP and PIP joints compared to contralateral hand and statistically significant reduction in ROM in DIP joints of affected finger.

Weaknesses of this study include a low number of participants and the unavailability of two-point discrimination and Semmes-Weinstein monofilament testing sensory assessments. If a higher number of patients were found, differences in ROM of affected digits' PIP and MP joints could have reached statistical significance. Future studies will aim to be prospective in nature, find a larger population and include more specific neurological/sensory testing on patients with the "Shark Mouth" incision thenar flap and compare them to current data on other commonly used composite graft techniques for distal fingertip injuries.

The "Shark Mouth" incision thenar flap is an effective strategy for fingertip reconstruction. The results demonstrate that this technique has excellent functional and aesthetic results and is not associated with flexion contractures, excessive sensibility or pain in the pediatric population. The technique is an excellent procedure with a small learning curve and will most likely provide the patient with a fully functional recovery.

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RESUMEN

La técnica del colgajo tenar es un método de reconstrucción de la punta del dedo de la mano que ha sido cercenada por la posible ocurrencia de contracturas en flexión así como cicatrices no estéticas en el sitio donante. Método: En este análisis retrospectivo se adquirió información de 16 expedientes médicos de pacientes a los cuales se le realizó una reconstrucción de colgajo tenar tipo "Shark Bite" por dos cirujanos de nuestra institución. Los pacientes sostuvieron una amputación traumática a nivel proximal de la parte media del lecho ungal con pérdida de la pulpa y exposición ósea entre los años 2005 y 2011. Resultados: El rango de edad fue de 0-17 años. El tiempo de división del colgajo fluctuó entre 16 y 30 días. El arco de movimiento del dedo afectado fue medido en las articulaciones DIF, PIF Y MCF y comparado con el dedo correspondiente en la mano contralateral. A base de un cuestionario se midió la satisfacción del paciente en cuanto a sensibilidad, apariencia y función. La sensación de la punta del dedo se preservó tanto en el dedo afectado así como en el sitio donante. La queja principal de los pacientes incluía la forma residual del dedo donde los pacientes la catalogaban de adecuada (43%) y buena (56%). En el análisis de la data no se encontró diferencia estadística con arco de movimiento entre el dedo afectado y el contralateral en las articulaciones PIF y MCF (p=0.08, 0.06). Conclusión: El colgajo tenar tipo "Shark Mouth" es una estrategia efectiva para la reconstrucción de la punta del dedo. Los resultados demuestran que esta técnica provee una función y una apariencia excelente y no está asociada a contracturas de flexión, sensibilidad excesiva o dolor en la población pediátrica