Reconstruction of Fingertip Amputation: our Experience with the Hatchet Flap

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ABSTRACT

Background*: The hatchet flap is a single triangular flap with a partial bridge of the skin on one of its edges. It was used with success for defects on various parts of the body. The main objective of this study was to evaluate the effectiveness of this flap with fingertips.* ***Methods****: The study was conducted in Emergency Department, Cairo University hospital unit, during the period from January 2016 to June 2016. We recruited patients between 16 to 55 years who needed coverage of finger tip, with clean, sharp injury, presented during the first day of trauma. Patients were operated on using digital block anesthesia under finger tourniquet control and loupe magnification. For fingertip amputation, a triangular flap was planned obliquely toward the contra-lateral side of the defect with the tip point of the flap did not traverse the distal interphalangeal joint crease whenever it was possible. All cases have been followed up for three months for infection, hematoma, disfigurement, contracture and partial/complete flap failure.* ***Results****: Forty cases were thoroughly interviewed, investigated, treated and followed up over a three month period. Age ranged between 16-55 years with average age 30.87. Ninety-five percent of the cases were males (38 cases) while the rest were females, 90% were occupational according to the cause, and the rest were traumatic/household, according to Allen's classification the majority (37.5%) of cases showed amputation level class II. Only 3 cases (7.5%) did not have bone exposed. The index finger was the most injured in our study (35%). Fifteen (37.5%) cases showed postoperative infection. Nineteen (47.5%) cases got involved in the physical treatment/ occupational therapy. Thirty (75%) cases had numbness in the injured finger. Only 12 (30%) cases completely survived.* ***Conclusion****: Despite the ongoing publications about new flaps for fingertip reconstruction, there is a lack of evidence to support improved healing and function in a surgically reconstructed fingertip compared to conservative wound management. Controlled trials are surely needed to declare whether surgery is superior to secondary healing or not.*
Keywords: *Fingertips injury; Hatchet flap; fingertip amputation*

INTRODUCTION

A fingertip injury is any injury distal to the site of the long extensors or flexor tendons insertions in a thumb or a finger[1]. It can be crippling and affect all ages, especially the working-class adults and children. In adults, the injury is commonly due to an occupational activity like in the case of machines and hand tools[2]. In this case, it may account for more than the quarter of workload of emergency departments with more than 1% had one or more of his fingers amputated [3]. In children, fingertip injuries limit their activities as eating, schoolwork and playing; with long-term functional and aesthetic outcomes [4]. Most of the children injuries take place at home due to crushing by doors. [5]

The main objectives for the management of fingertip injuries are soft tissue coverage with preserving sensation, a painless fingertip and whenever possible to preserve the digit length [5]. Many options are offered to attain these objectives. They include primary repair, revision amputation, composite grafting, skin grafting and healing by secondary intention. [6]

Fingertip amputations are categorized into transverse and oblique. According to the amputation plane, the latter category is further classified into volar or dorsal. This classification helps in management which can be difficult due to the lack of locally available tissue, as seen in the case of volar oblique type [7]. Accordingly, each type of amputation has its management technique. Hence, plentiful reconstructive techniques for fingertips amputations have been described. [8-17]

Different classifications were used for fingertip amputations. One of them is Allen's classification (Figure 1) which showed the levels of fingertip amputations which are used for sharp amputations across the finger [18]. Another classification is that of Ishikawa's classification (Figure 2) where the fingertip is divided into zones based on the nail [19].

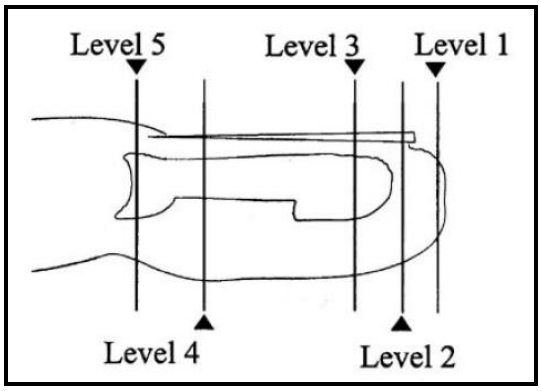

Fig 1: The Allen Fingertip Amputation Classification

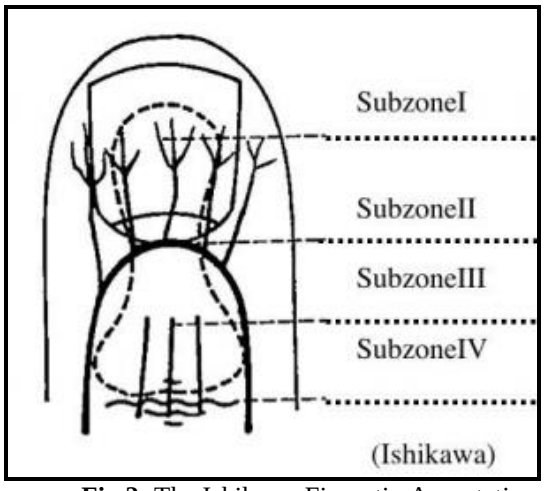

Fig 2: The Ishikawa Fingertip Amputation Classification

One of these reconstructive techniques is the hatchet flap which was described by Emmett in 1977. It is a single triangular shaped flap that has a partial skin bridge on one side [20]. It was used with great success in various parts of the body like facial defects, trochanteric pressure sores, ischial pressure sores and several other defects. [21-24]

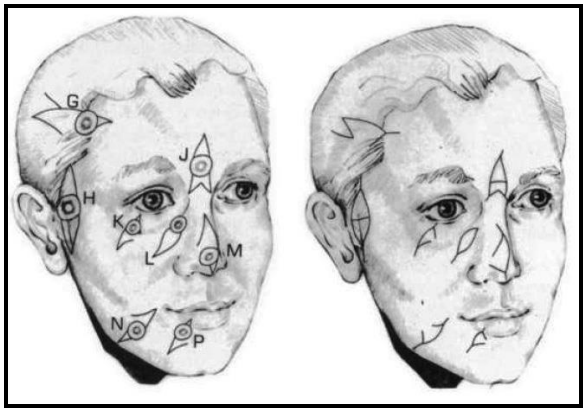

Fig 3: Original Emmet figure that describes the various triangular flaps, where hatchet flaps are K, N, P Quoted from Grabb encyclopedia of flaps. Chapter 97, 2007 [20]

According to the literature and the best of our knowledge, the application of hatchet flap for fingertips amputations has been reported previously in few studies. Also, it is a good alternative for management of both transverse and lateral oblique fingertips amputations and valuable for volar oblique amputations. Thus, the main objective of this study was to study the effectiveness of this flap in a prospective way presenting our experience with it in managing 40 cases in Kasr Al-Ainy University Hospital.

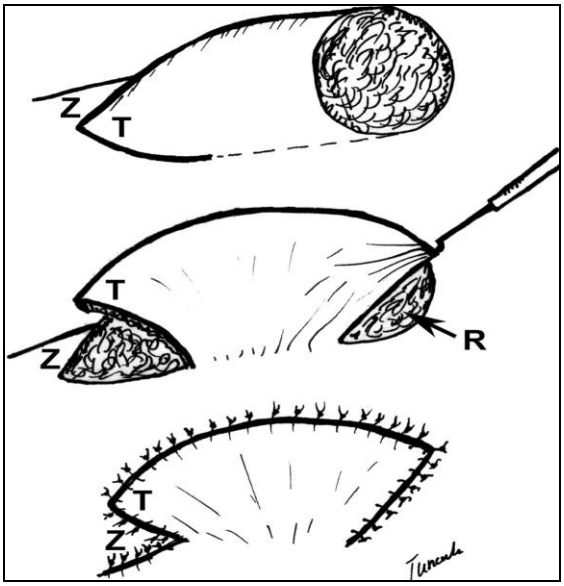

Fig 4. Conventional hatchet flap application and demonstration of the rotation advancement movement. *Z*, the optional Z-plasty flap; *T*, tail of the hatchet flap. (*Above*) The design of the flap. The *dotted line* indicates the part of the flap that is retained to serve as a skin paddle for pivoting. (*Center*) The mobilization and advancement of the flap. The raw surface marked as *R* indicates the theoretical area that will be covered following flap rotational movement. If rotation is the dominant movement, the tail (*T*) will inevitably be "kicked out" away from the skin paddle border. In these instances, the Z-plasty flap(*Z*) will be used fully to cover the donor area. (*Below*) The flaps sutured in place. [(31)]

Fig. 5. The patient in case 6. (*Above*) A dorsoulnar, oblique, distal phalanx amputation and the flap design. (*Below*, *left*) The flap is fully elevated based on one of the neurovascular bundles. (*Below*, *right*) Volar view at 15 months postoperatively. Note the inconspicuous scars. [(31)]

PATIENTS AND METHODS

This case series study was conducted in Emergency Department, Cairo University hospital unit, during the period from January 2016 to March 2016. This study was approved by the medical ethical review committee of Cairo University. The purpose of this study was clearly explained in the Arabic language to all subjects before their enrollment to the study, and an informed consent form was signed by and obtained from all of those enrolled.

The inclusion criteria: all patients with single or multiple fingertip amputation, age range from 10 to 60 years, who needed coverage of finger tip, with clean, sharp injury, presented during the first day of trauma.

Exclusion criteria included: patients with a previous scar in flap design, patients with previously burnt skin, patients with crushed fingers including the zone of the flap and patients with post-bite amputated tip, either human or animal bite, delayed presentation, ischemic tip, associated same finger fractures.

Procedure in details:

Patients were operated on using digital block anesthesia under finger tourniquet control and loupe magnification. For fingertip amputation, a triangular flap was planned obliquely toward the contra-lateral side of the defect with the tip point of the flap did not traverse the distal interphalangeal joint crease whenever it was possible.

After that, a full-thickness incision along the large edge of the triangle was undertaken. On reaching the tip of the flap, a back-cut incision was carried out for approximately one-third of the short edge. The flap was based on the ipsilateral neurovascular bundle, and it could be totally elevated, with special attention paid to preserve the small neurovascular branches while the contra-lateral neurovascular bundle was divided. However, when the restricted motion was adequate, these branches were preserved, which in turn would enhance the flap circulation.

Then, the raised flap was mobilized distally toward the fingertip, and its long edge was rotated and advanced across the defect on the pivot point located on the preserved skin paddle. After flap transposition, it was sutured by simple interrupted non-absorbable 5-0 sutures.

In addition, the donor area was closed using the V-Y principle where, whenever needed, a Z-plasty was introduced to facilitate closure. This was done whenever more rotation than advancement was needed as occurred only in two cases of our series.

Patients were followed up for the flap viability, infection, hematoma, disfigurement, contracture and partial/complete flap failure. The follow-up period was three months.

Outcome measures:

The primary outcome measure was the success of the flap in term of flap survival. Secondary outcome measures were preserved sensation and function

Statistical analysis

Descriptive statistical analyses were done where data were presented as (mean ± SD) or median (range) for continuous variables and as frequency & percent for categorical variables. All statistical tests were done using a significance level of 95%. A value of $P < 0.05$ was considered statistically significant. SPSS software (Statistical Package for the Social Sciences, version 20.0, SSPS Inc, Chicago, IL, USA) was used for the statistical analyses. Comparisons between groups were made using Chi-square or Phi-Cramer test for the categorical variables.

RESULTS

At the beginning of January 2016 till June 2016 where three months of follow up was conducted. Forty cases of fingertip amputation were examined and managed using this technique. In addition to management, we followed those cases over a three-months period after the first presentation and intervention to assess the outcome and any possible complications. Many cases were excluded out of our study because of incompliance from the side of the patient or due to refusal to get enrolled in the study.

Demographic data:

In this study, forty cases were enrolled and followed up postoperatively over a three month period. Age ranged between 16-55 years with an average age 30.87±10.17. Six (15%) cases were below the age of 20, sixteen (40%) cases 20-30 years, ten (25%) cases 30-40, six (15%) cases 40-50 and only 2 (4%) cases above 50. Ninety-five percent of cases (38 cases) were males while the rest were females. Three cases (7.5%) were

diabetic, 3 (7.5%) were hypertensive whereas, 28 (70%) were smokers. The baseline characteristics of subjects are shown in Table 1.

Characteristics of fingertips injury:

According to the cause of fingertips injury, ninety percent of cases were due to occupational trauma, and the rest were traumatic-household. Only 3 cases (7.5%) did not have bone exposed in the injury bed. The index finger was the most injured in our study (35%), followed by the middle and ring fingers, as shown in Table 1. Left-hand cases were 60%. Fourteen (35%) cases were contaminated cases upon admission. According to Allen's classification, 15 (37.5%) of cases showed amputation level class II. Only 2 (5%) cases had oblique injury line, while the rest (38= 95%) showed transverse injury.

Post-operative follow-up:

Fifteen (37.5%) cases showed postoperative infection, which was treated with systemic and local antibiotic according to culture and sensitivity. Nineteen (47.5%) cases of the 40 cases involved in the physical treatment/ occupational therapy recommended after the surgical intervention.

Ten (25%) cases showed a complete or partial return of sensation after a follow-up period of 3 months and 30 (75%) cases had numbness in the injured finger which did not subside during the follow-up period, as shown in Table 2.

The success of the Hatchet flap:

Flap survival was seen in twelve (30%) cases. Partial loss of the flap occurred in 20 (50%) cases, which showed areas of necroses or raw areas that were spontaneously closed by secondary intention during the follow-up period. Complete loss of the flap occurred in 8 (20%) of cases where complete loss of the flap took place during the study period. These cases were debrided and healed by secondary intention.

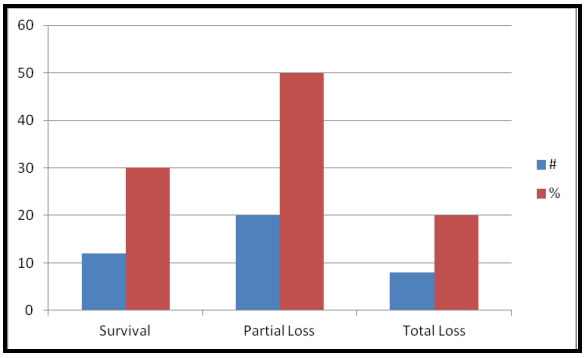

Fig 6: Flap survival/Loss number and percentage

Description of the survived flap cases:

Only 12 (30%) cases survived completely, six (50%) cases in each hand. Only 4 (33.33%) cases were not smokers, one (8.3%) case with controlled DM, while none had hypertension. Four (33.33%) cases were contaminated on admission. Only three (25%) of cases showed infection after the intervention. Six (50%) cases were involved in the PT/OT (physiotherapy/occupational therapy) program. Only three (25%) cases did not gain the sensation after 3-months of injury. Survived fingers were: two thumb fingers, four index fingers, five middle fingers and only one ring finger.

There was no significant difference (p-value > 0.05) between survived flaps and non-survived flaps as regards gender, smoking, DM, hypertension, the cleanliness of the wound, the level of injury, fingers affected, postoperative infection and postoperative PT/OT. However, there was a significant difference ($p < 0.001$) as regard postoperative sensation, as shown in Table 3.

Table 1: Baseline characteristics: demographics and fingertips injury characteristics

Demographics	
Age, years mean ± SD (range)	30.87 ± 10.17 (16-55)
Gender, n (%) male : female	38 (95%) : 2 (5%)
DM, n (%)	3 (7.5%)
Hypertension, n (%)	3 (7.5%)
Smoking, n (%)	28 (70%)
Fingertips injury characteristics	
Type, n (%)	
Occupational	36 (90%)
Traumatic	4 (10%)
Contaminated injury, n (%)	14 (35%)
Site, n (%)	
Right hand	16 (40%)
Left hand	24 (60%)
Finger Injured, n (%)	
Thumb finger	4 (10%)
Index finger	14 (35%)
Middle finger	11 (27.5%)
Ring finger	11 (27.5%)
Exposed bone in the injury bed, n (%)	37 (92.5%)
Oblique line, n (%)	2 (5%)
Transverse line, n (%)	38 (95%)
Amputation Level, n (%)	
Zone I	2 (5%)
Zone II	15 (37.5%)
Zone III	12 (30%)
Zone IV	11 (27.5%)

Table 2: Postoperative follow up data

	Results
Infection, n (%)	15 (37.5%)
Physical treatment/ occupational therapy n (%)	19 (47.5%)
Sensation; complete or partial n (%)	10 (25%)

Table 3: Survival data of the flap

	Survival flaps	**non-survival flaps**	**p value**
Numbers	**12**	**28**	
Gender			
male	11	27	0.515
female	1	1	
Smokers	4	8	0.521
DM	1	2	0.668
Hypertension	0	3	0.332
Clean	8	18	0.591
Level			
Zone I	1	1	0.887
Zone II	5	10	
Zone III	4	9	
Zone IV	2	8	
Finger			
Thumb	2	3	0.609
Index	4	11	
Middle	5	6	
Ring	1	8	
Postoperative infection	4	11	0.505
Postoperative PT/OT	6	13	0.554
Postoperative sensation	9	1	< 0.001

Fig 7: A case with complete survival of the flap; a) Pre-operative post-traumatic; b: Immediate post-operative; c) 1 week post-operative; d) 2 months post-operative

Fig 8: A case with partial loss of the flap; a) Pre-operative post-traumatic; b) 1 week post-operative; c) 1 month post-operative , left for healing by secondary intention

DISCUSSION

Fingertip amputations are very common injuries, and they account for 45% of all emergency department hand injuries. The middle finger is most commonly injured, followed by the ring fingertip, while thumb tip injury is least common. Fingertips injuries are classified as transverse or oblique (either dorsal or volar), according to the plane of amputation. Immediate repair is preferable for the best outcome. The management of these injuries can be challenging because of the lack of locally available tissue for reconstruction.

The hatchet flap for fingertip amputations, with its retained skin paddle, is a rotation advancement flap, although it is based on one of the neurovascular bundles. Thus, it is not a true direct-flow homodigital neurovascular island flap such as the triangular advancement or the step advancement flaps. However, the hatchet flap has certain advantages that deserve some attention. [25]

The hatchet flap has a very safe circulation because of the retained skin paddle along with the neurovascular bundle and, when compared with the original V-Y advancement flap, has an additional rotation motion that is advantageous for volar oblique lateral defects. The technique is similar to the oblique triangular flap described by Venkataswami and Subramanian except that the hatchet flap is usually based on the single neurovascular bundle located on the side of the major portion of the amputation. This is advantageous because the technique does not harm the intact side, on which the oblique triangular flap should be based, as was originally described. [26]

In general, rotation flaps usually provide adequate coverage; however, the arc of the mobile edge of the flap that introduces a residual scar on the side of the pulp is undesirable. The hatchet flap offers the same advantages as the rotation flap and, because smaller flap designs are possible, the resultant scar remains within the finger pulp. Besides, it can be totally elevated off its base, without compromising the vascular supply. This provides good distal reach that prevents immobilization in flexion. [16]

The volar advancement flap, which was initially described by Moberg [14] for thumb amputations and later by Snow [15] for fingers, is safe only for the thumb, with its good dorsal arterial supply. However, in the finger, the blood supply to the dorsal tissues distal to the proximal interphalangeal joint level is primarily through branches from the neurovascular bundles. Without preservation of at least some of these branches, ischemia of the portion of the finger from which the flap has been elevated may result. The hatchet flap, which is based on a single pedicle, prevents these complications, as one of the neurovascular bundles is left untouched during the procedure. [21, 27-28]

The hatchet flap is a simple, one-stage procedure, with a short operating time [21-23]. The most important benefit of the hatchet flap is that a rotational movement is ingrained in its original design along with a classic advancement. Despite the fact that finger skin is not as elastic as the skin of other parts of the body, the skin bridge still does not hinder the flexibility of the flap. The technique avoids a flap donor site that must be covered with a graft (along with its donor-site morbidity) and the adequate immobilization period required for graft take, which is unavoidable when local or homodigital neurovascular island flaps are preferred. [9, 29]

One advantage of the hatchet flap, in the transverse, dorsal oblique, and lateral oblique Ishikawa level I amputations, it usually remains within the boundaries of the distal phalanx. It will certainly extend to the middle phalanx (proximal phalanx for the thumb) when levels II, III, and IV are of concern. Second, it is imperative that a broad flap is designed when a pure volar oblique amputation is encountered. However, a smaller and more distally located flap may be used if there is some degree of lateralization of the amputation. It is probably very difficult to reconstruct pure volar oblique pulp defects larger than 2 cm with this flap. This length also designates the estimated maximal advancement for this flap. This method is obviously not a superior technique regarding every feature compared with other methods that use local tissues; however, it has some added advantages that may be beneficial in certain clinical situations. The major drawback of this flap arises when an original injury introduces redundant lacerations along the pulp where the flap will be planned. Another point to be stressed is that it is crucial to totally elevate the flap of the base to gain maximal mobilization so that undue tension on the distal suture line is prevented. This also

means that the flap has limited use when based on the subcutaneous pedicle which, along with the retained skin paddle, produces too much tension that prevents sufficient flap reach for distal coverage. Furthermore, a satisfactory rotational movement is gained only when total flap elevation is performed. [9]

This case series study attempted to show benefits of Hatchet flap in covering fingertip amputation cases that presented in Emergency Department of Kasr Al-Ainy University Hospital.

In our study, forty cases were thoroughly interviewed, investigated, treated and followed over a three month period. Age ranged between 16-55 years with average age 30.87. The majority of them were males and occupational according to the cause. The most prevalent amputation level according to Allen's classification was Zone II. Only a few cases did not have bone exposed. The index finger was the most injured finger in our study. Physical treatment/ occupational therapy were done in half of them. The majority of cases had numbness in the injured finger. Only 12 (30%) cases had completely survived flap. Partial loss of the flap occurred in 20 (50%) of cases closed by secondary intention during the follow-up period. Complete loss of the flap occurred in 8 (20%) which healed by secondary intention. There was no significant difference between survived flaps and non-survived flaps as regards gender, smoking, DM, hypertension, the cleanliness of the wound, the level of injury, fingers affected, postoperative infection and postoperative PT/OT. However, there was a significant difference as regard postoperative sensation which is more in the survived flaps cases.

One study on seven male patients with bilateral V–Y rotation advancement flap showed that index finger is the most prevalent; all cases were heavy smokers, three cases with amputation in zone II, and three others in zone III. All the patients were vaccinated for tetanus, and the injured hand's X-rays were taken before plastic surgery consultation. There was neither total nor partial flap loss. Patients had neither cold intolerance nor scar hypersensitivity. A stiffness of the PIP joint did not occur. No obvious hooked nail occurred in patients who have remaining nail matrix. Because flaps contain neurovascular bundle, there was no difference in sensation and perfusion between the finger's pre-operative and post-operative status. The result was satisfactory with painless pinching. [30]

Another study on nine patients, eight of them were males, completed their 1-year follow-up period. The thumb and middle fingers were affected in most of the cases. In general, the hatchet flap provided good protective padding and aesthetic contour for the fingers, and all incisions healed with inconspicuous scars. Cold intolerance developed in two patients. One patient complained of paresthesia at the amputation stump in the early postoperative period that resolved over time. Joint stiffness or hypersensitivity was not noted in any of the patients on late controls. Most patients could return to work or their normal routine in a period of approximately 4 to 6 weeks after the operation.[31]

Most studies available to review showed small sample size, hence lack the credibility and the strength, and the majority have almost 100% survival rate in a small sample size which raises a red flag about the results. One advantage of our study is that it has a good sample size (40 cases) compared to the previously mentioned studies with less than 10 cases.

Our humble study - though it had limited resources and many technical obstacles - has a reasonable strength due to its sample size even though with it did not have a considerable high survival rate (30%).

In addition, other studies still support the conservative treatment over the surgical intervention because first, conservative wound management with dressings and protective splints allows patients to avoid immobilization and donor site morbidity. Second, good results with near-normal sensibility, minimal cold intolerance, and tip durability are usually achieved. Finally, early return to work is possible, lowering the overall healthcare costs and burden on society. [32]

CONCLUSIONS

Finally, we conclude that despite the ongoing publication of new flaps for fingertip reconstruction, there is a lack of evidence to support improved healing and function in a surgically reconstructed fingertip compared to conservative wound management. Controlled trials are surely needed to distil the truth as to

whether surgery is superior to secondary healing or not.

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