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A Comparative Study between Two Types of Heterodigital Flaps and Volar Advancement Flap in Reconstructing Thumb Soft Tissue Defects

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ABSTRACT

Management of soft tissue defects of the thumb represents challenge for plastic surgeons regarding techniques, cosmetic and functional results, aiming at restoration of functioning thumb with non-painful, sensate and durable coverage. This study was conducted to evaluate the role of three types of local flaps used for reconstructing soft tissue defects of the volar aspect of the thumb; the volar palmar advancement flap, the heterodigital neurovascular island flap and the first dorsal metacarpal artery flap.

Methods: 34 cases of soft tissue defects of the volar aspect of the thumb were included in the study, divided into three groups, each group representing a flap used. The 1st group represented palmar volar advancement flap reconstruction. The 2nd group represented heterodigital neurovascular island flap reconstruction and 3rd group represented 1st dorsal metacarpal flap reconstruction.

Results: twelve patients (35.3% - 1st group) treated with volar advancement flap showed the best outcome both functionally and cosmetically with neither significant complications nor donor site morbidity. Eight patients (23.5% - 2nd group) treated with heterodigital neurovascular island flap showed stable coverage with good protective sensation. However the operation is lengthy with meticulous dissection. Complications included partial flap loss and donor site morbidity. Fourteen patients (41.2% - 3rd group) treated with 1st dorsal metacarpal artery flap showed stable skin covrage. Although the timing is less than 2nd group, protective sensation is poorer. Complications included partial flap loss and donor site morbidity.

Conclusion: Volar palmar advancement flap is more superior in terms of sensation and cosmetic results for defect size of 1-2cm. It has no significant donor site morbidity. Heterodigital neurovascular flap-although technically demanding with considerable time-is ideal in reconstructing large thumb soft tissue defects providing it with good protective sensation. First dorsal metacarpal artery flap is less favorable in terms of protective sensation and cosmetic results.

INTRODUCTION

The thumb plays an important role in hand function. Daily tasks involving pinch, grip, grasp and precise handling are more easily accomplished with an opposable thumb. Loss of thumb diminishes much of the hand abilities and function (Bueno & Wilhelmi, 2007). Soft tissue injuries of the hand frequently require flap coverage, either to preserve structures or even to facilitate later reconstruction (Soutar & Tanner, 1984).

The goal of thumb reconstruction is to restore a sensate and non-tender thumb tip, with stable thumb joints. The thumb should be of adequate length to resist the forces of the fingers, correct in posture with a wide adductor space (Heitman & Levin, 2002).

An ideal reconstruction of the thumb "would replace like with like", restoring both function and appearance. Opposition, the hallmark of "thumbness", necessitates length, stability, strength and mobility, exactly how important each of these factors becomes will vary depending on the needs of the patient (Manketlow et al., 1984), (Vikki, 1998).

This work presents a comparative study between volar palmar advancement flap, heterodigital neurovascular island flap and first dorsal metacarpal artery flap in soft tissue reconstruction of volar thumb defects regarding sensation, technical ease, complications, donor morbidity and aesthetic outcome.

PATIENTS AND METHODS

This work included 34 patients, with soft tissue defects of the thumb that presented and managed at Kasr Al-Aini Hospital (Cairo University) department of plastic surgery, between 2012 – 2014. All patients in this study were acute post-traumatic cases.

Cases were divided into three groups, group I included cases in whom volar palmar advancement flap was performed, group II included cases in whom heterodigital neurovascular island flap was performed and group III included cases in whom first dorsal metacarpal artery flap was performed.

In our study the surgical technique used to perform volar thumb advancement skin flap (Moberg Flap) included performing Longitudinal mid-lateral (mid-axial) incisions on each side (radial and ulnar sides) of the thumb. The volar skin with its subcutaneous tissue and both neurovascular bundles were elevated from the underlying tendon sheath of the flexor pollicis longus, and the flap was dissected and raised at the level of the flexor tendon sheath from distal to proximal. It was elevated to the flexion crease of the MP joint, the flap was advanced distally and sutured into the nail or the nail bed.

Postoperatively a dorsal plaster splint with thumb spica was applied, immobilizing the wrist in neutral position and the thumb in slight flexion, to relieve any tension on the skin sutures. Active thumb flexion was instituted immediately postoperatively and active extension exercises encouraged when the splint was discontinued in 10 days.

The surgical technique used to perform neurovascular (Littler) Flap included elevation of the flap along the ulnar border of the tip of the middle finger on its neurovascular bundle, dissection up into the palm, it was then tunneled for thumb reconstruction. The skin island was outlined on the ulnar aspect of the middle finger according to the defect pattern. An incision was then made along the ulnar lateral border of the finger and continued into the palm in a zigzag fashion. The dissection was performed under loupe magnification and tourniquet control, the digital artery, vein and nerve were easily identified in the finger, the skin island isolated and dissected off the underlying tissue, the flap was elevated from distal to proximal. In the web space between the middle finger and ring finger, the arterial branch of the common digital vessel to the radial side of the ring finger was isolated, divided and ligated. The common digital nerve was split to preserve the innervation to the radial side of the ring finger, while keeping the branch to the ulnar side of the middle finger with the vascular pedicle during this proximal dissection. A tunnel was then made to the proximal end of thumb defect and the neurovascular flap pulled through it, inset and sutured without tension. The donor site was closed using a skin graft.

Surgical technique used for performing dorsal metacarpal artery flap (Kite Flap) included a skin flap from the dorsum of the proximal phalanx of the index finger based on the dorsal metacarpal artery after the pulsations of the radial artery were checked against the second metacarpal bones at the angle between the tendon of extensor pollicus longus and the bone.

Flap elevation proceeded from distal to proximal without prior pedicle dissection. The skin island on the proximal phalanx of the index finger was incised and elevated, leaving the well-defined extensor paratenon intact. At the level of the metacarpal neck, a perforator constantly present, is coagulated or ligated. A zig-zag or lazy S incision was extended along the ulnar half of the first dorsal interosseous muscle to identify the first dorsal metacarpal artery and its associated vena comitants. The dissection included the ulnar half of the deep fascia over the dorsal surface of the first dorsal interosseous muscle to be included in the flap. The flap was then rotated to reach defects on the volar aspect of the thumb. In order to avoid first web space contracture, the skin over this space should not be included in the skin island. Pedicle dissection was done under loupe magnification, starting with elevation of the thin skin flaps on both sides of the zig-zag or lazy S incision. Among the visible superficial dorsal veins, those that had the same course with the pedicle were preserved and incorporated to the pedicle with a cuff of superficial subcutaneous layer, inclusion of at least one or more superficial dorsal veins in the pedicle would increase venous outflow and help avoid postoperative flap congestion. The first dorsal metacarpal artery and associated venae comitants were located deep in the first dorsal web space and adherent to the ulnar half of dorsal surface of the first dorsal interosseous muscle. During the radial to ulnar elevation of the deep muscle fascia across the ulnar half of the muscle, the first dorsal metacarpal artery readily comes into vision. The periosteum at the dorsal radial edge of the second metacarpal bone representsthe deep ulnar limit of pedicle elevation and dissection in ulnar direction was stopped at that level. The pedicle included the interosseous fascia with the three branches of the first dorsal metacarpal artery, the superficial veins, the superficial radial nerve and its accompanying artery. Finally, the harvested island flap was tunneled to the defect. Split thickness skin graft was used to close the donor defect.

RESULTS

This work included 34 patients, (33 males and one female; mean age 25.9 SD± 6years), with soft tissue defects of the volar aspect the thumb (mean surface area 2.04cm^2).

Cases were divided into three groups, group I included 12 cases in whom volar palmar advancement flap was performed, group II included 8 cases in whom heterodigital neurovascular island flap was performed and group III included 14 cases in whom first dorsal metacarpal artery flap was performed. The mean follow-up period was 2 months.

Twelve cases (35.3%, mean age 26.8 years) were subjected to volar palmar advancement flap (Table 1). The mean operative time was 81±SD 14min. This flap was easily performed when the defect size is not more than 2cm-not beyond the distal half of terminal phalynx. Reported complications included flexion deformity in case with large defect and three cases of delayed wound healing. All patients restored good protective sensation and were satisfied with the results.

Eight cases (23.5%, mean age 24.8 years) were subjected to heterodigital neurovascular flap reconstruction (Table 1). The mean operative time was 277±SD 14min. Timing should be considered when performing this flap. Although patients regained protective sensation to the thumb, cortical training to refer the sensation to the recipient area was needed. Partial flap loss was encountered in one case and stiffness in interphalangeal joints of donor finger in another case.

Fourteen cases (41.2%, mean age 26.1 years) were operated upon using first dorsal metacarpal artery flap reconstruction (Table 1). The mean operative time was 223±SD 12min. Although inclusion of sensory branches of the radial nerve while dissecting the flap has improved flap sensibility, the quality of sensation remained less than those in the second group. Moreover, cortical interpretation still required training. Complications included partial flap loss in one case and stiffness of donor finger interphalangeal joints in another case.

Cosmetic disfigurement assessed by patient satisfaction was recorded in a case of volar palmar advancement flap (8.3%), in one case of heterodigital neurovascular flap (12.5%), and in two cases of first dorsal metacarpal flap (14.3%).

Assessment of outcome of different flaps used in reconstruction was done according to the following criteria: Coverage stability, restoration of sensation and function, cosmetic appearance and donor site closure (Table 2).

Table (1): Demographic data, defect characteristics and perioperative criteria of patients.

Case #	Age (years)	Gender-	Defect area-cm^2	Bone involvement	Reconstructive method	Operative time (min.)	Protective sensation		Patients satisfaction	Complication
							Recipient	Donor		
1	21	M	2.6	+	Heterodigited neurovascular island flap	300	++	–	++	–
2	23	M	3	+		285	++	–	++	–
3	30	M	3.4	+		280	+	–	+	–
4	19	M	2.6	–		290	++	–	+	PFL
5	25	M	2.4	–		275	+	–	++	–
6	25	M	2	–		260	+	–	+	
7	22	M	2.4	–		270	++	–	+	Stiffness of donor
8	32	M	3	+		260	+	–	+	–
9	32	M	3	–	First dorsal metacarpal artery flap	240	+	–	++	–
10	31	M	2.4	–		230	+	–	+	PFL
11	30	M	2.6	+		250	+	–	+	–
12	21	F	2.6	+		220	++	–	++	–
13	38	M	2.8	–		210	+	–	+	–
14	41	M	2.2	+		230	+	–	++	Joint stiffness
15	26	M	3	+		220	++	–	+	–
16	25	M	3.4	–		230	+	–	++	
17	21	M	2	–		220	+	–	++	–
18	20	M	2	–		210	+	–	+	–
19	22	M	2.4	–		240	+	–	+	–
20	31	M	2.8	+		210	++	–	++	–
21	19	M	2	+		220	+	–	++	–
22	20	M	1.6	+		210	+	–	+	–
23	31	M	1.2	–	Volar palmar advancement flap	110	+++	NA	++	–
24	30	M	1.5	–		110	+++	NA	+++	DWH
25	35	M	1.4	–		90	+++	NA	++	
26	34	M	1.2	+		70	+++	NA	+++	DWH
27	37	M	1.9	–		80	+++	NA	+++	DWH
28	20	M	1.5	–		80	+++	NA	++	–
29	18	M	2	+		75	+++	NA	++	FD
30	26	M	1.4	+		70	+++	NA	++	–
31	23	M	1.3	–		75	+++	NA	+++	–
32	28	M	1.2	–		70	+++	NA	+++	–
33	29	M	1.4	–		80	+++	NA	++	–
34	20	M	1.2	–		80	+++	NA	+++	–

DWH: Delayed wound healing. FD: Flexion deformity. PFL: Partial flap loss. NA: Not applicable.

Table (2): Assessment of the outcome of different types of flaps used in reconstruction.

Flap type	Coverage stability	Restoration of sensation	Restoration of function	Cosmetic result	Donor morbidity
Volar palmar	75%	88.8%	83.3%	91.7%	0%
Heterodigital	100%	100%	100%	87.5%	12.5%
Dorsal metacarpal	92.9%	64.3%	85.7%	85.7%	7.1%

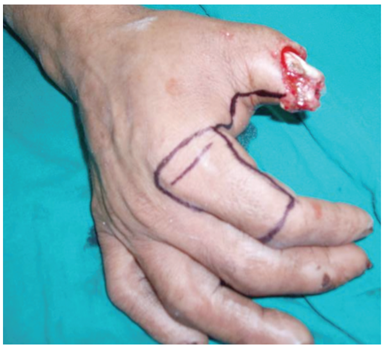

Fig. (1-A): Preoperative view of a male patient, 33 years showing the design of the first dorsal metacarpal artery flap.

Fig. (1-B): Flap inset.

Fig. (1-C): Recepient site coverage.

Fig. (1-D): Flap fixed to the defect.

Fig. (1-E): Full thickness skin graft for donor site.

Fig. (1-F): Final appearance of the flap and the skin graft.

Fig. (2-A): First dorsal interosseous flap elevation, the deep fascia over the first dorsal interosseous muscle is included in the flap.

Fig. (2-B): Postoperative photo.

Fig. (3-A): Heterodigital neurovascular island flap elevation.

Fig. (3-B): Flap inset.

Fig. (3-C): Final appearance of the same patient.

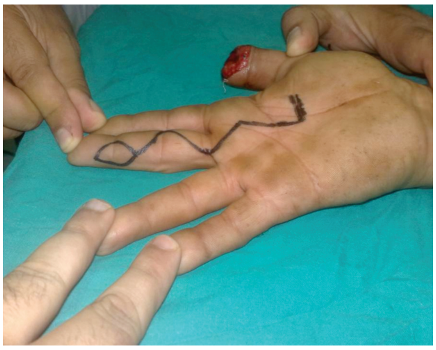

Fig. (4-A): Heterodigital neurovascular flap design.

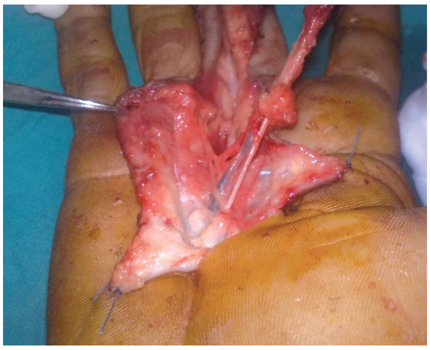

Fig. (4-B): Flap elevation in the same patient.

Fig. (4-C): Flap inset.

Fig. (5): Heterodigital neurovascular flap elevation.

Fig. (6-A): Volar palmar flap design.

Fig. (6-B): Volar palmar flap elevation.

Fig. (6-C): Volar palmar flap inset.

Fig. (7-A): A case with volar thumb soft tissue defect.

Fig. (7-B): Volar palmar flap design in the same patient.

Fig. (7-C): Flap advancement to thumb tip.

Fig. (7-D): Flap covering the defect.

DISCUSSION

Defects of the thumb usually occur because of failure of closure of post-traumatic wounds (Davalbhakta & Niranjan, 1999). Soft tissue defects of the thumb frequently require flap coverage [12].

The working surface of the thumb is best replaced with tissues that are glabrous as it is hairless, has fine sensibility and good pseudomotor function for tactile gnosis. When possible, tissue should be from the same hand or the thumb itself and transferred as a local flap.

Hallock, [5] mentioned that the use of local flaps for thumb reconstruction avoids the complexity of the microsurgical tissue transfer, allows earlier mobilization of the hand and digit than distal flaps.

Borbly, [1] mentioned the following advantages of the axial pattern flaps over the random pattern flaps; wider arc of rotation, greater dimensions, more bacterial resistance, no need for a delay procedure and have a known vascular pedicle allowing for distal replacement so it can be used for areas away from the zone of injury. The identification of the vascular pedicles offered tremendous possibilities for wound coverage and defect reconstruction [11].

In this work, the heterodigital neurovascular island flap (Littler's flap) was used in eight cases. The flap was reliable, with good vascular and sensory supply, and provided thumb reconstruction in a single stage. This meets what Braun 1979, mentioned. This flap offered good results in terms of cosmetic appearance due to skin match and excellent results in terms of restoration of sensation as the digital nerve was preserved in the flap. On the other hand, the flap dissection required longer duration than the other flaps.

The first dorsal metacarpal artery flap was done in fourteen cases. The flap was reliable, with good vascular supply, and provided thumb reconstruction in a single stage. Postoperatively, one partial flap loss occurred, another patient had stiffness in the proximal interphalangeal joint of the index (donor finger), good cosmetic results were achieved in 85.7% of the cases, the skin at the index finger dorsum didn't match well with the skin at the volar thumb surface.

The mean result of the two point discrimination test in cases who performed Littler's flap, was 4mm, while the mean result of this test in cases who performed first dorsal metacarpal flap, was 8 mm, hence, Litter's flap was found to be better than first dorsal metacarpal flap as regard to sensation, probably Littler's flap was better in terms of sensation because the flap contains a well defined sensory nerve that is the digital nerve, on the other hand, the first dorsal metacarpal artery flap has poor nerve supply as it contains the ramifications of the superficial radial nerve.

Volar palmar advancement flap was done in twelve cases. The flap was reliable, with good vascular and sensory supply, and provided thumb reconstruction with well padded skin, free from tender scars in a single stage with no donor site morbidity, this flap was sufficient to cover defects up to 1.5-2cm of the volar surface of the thumb, otherwise a flexion deformity may occur and release incision should be performed at that time at the base of the flap. The resulting secondary raw area may be left for secondary healing or skin graft applied.

In Conclusion:

Soft tissue defects of the volar aspect of the thumb should be reconstructed with local flap coverage whenever possible. They provide stable and durable skin of good quality. Protective sensation with varying degrees can be restored according to the flap type. Accordingly, the volar advancement flap is superior to other flaps for defects up to 2cm. For larger defects, the heterodigital neurovascular island flap is ideal and better than the first dorsal metacarpal flap especially when sensory requirements are high.

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