

Case Series

Neurotized first dorsal metacarpal artery flap for reconstruction of thumb defects: does it helps to improve sensory outcomes?

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ABSTRACT

Restoration of tactile sensation after reconstruction of a thumb pulp defect is important for hand function. We have evaluated the functional, sensory and aesthetic outcomes of neurotized first dorsal metacarpal artery (FDMA) flap in reconstruction of various soft tissue defects of the thumb. For a period of 18 months (January 2021 to June 2022), a total of 20 patients were considered for the study and divided into two groups that is neurotized (group A) and conventional (group B) FDMA flaps. One flap in each group underwent complete necrosis. Results were compared with patients treated by the conventional Foucher's FDMA flap without nerve repair. At the final follow-up, flap sensation was assessed using static two-point discrimination and Semmes-Weinstein monofilament (SWM) testing. The mean values for active range of motion, total time for procedure, average time to return to routine work and time period of cortical reorientation were statistically significantly different from the values in the control group (p value <0.05). 2-PD, SWM and cold severity score were found to be statistically non-significant. Neurotized FDMA island flap provides a stable, sensate and reliable option for sensory reconstruction of thumb pulp defects with earlier cortical reorientation that allows easier physical rehabilitation and earlier ability to return to previous work to the patients.

Keywords: Thumb pulp defect, First dorsal metacarpal artery, Radial sensory nerve, Island flap, Thumb degloving injury

INTRODUCTION

During the evolution what humans got is specialized function of thumb, which helps in grasping, opposing and other specialized functions. Soft tissue defects of thumb are very debilitating and can severely hinder hand function if not treated correctly. Thumb injuries have much more significant impact on the normal daily life activities than do other digits' injuries.¹ The significance of the thumb in its contribution to overall hand function cannot be overestimated. Indeed, the thumb contributes 40 to 50% of hand functioning. So, soft tissue defects of thumb must be provided with reliable, durable and sensate cover to ensure good functionality of the thumb.²

Reconstruction of complex soft tissue defects of the thumb with exposed underlying structures, is challenging to hand

surgeons because of limited local soft tissue availability.³ Conventionally, these defects can be resurfaced from secondary intention healing, free skin grafts, lateral triangular advancement flaps, Moberg advancement flap, sensate cross-finger flap, Littler's neurovascular island flap, first dorsal metacarpal artery (FDMA) flap, reversed radial forearm flap, distant flaps, and various free flaps from the 1st and 2nd toes and web space of the foot.⁴⁻¹⁰

The FDMA flap has an adequate and reliable blood supply, a wide rotation arch and minimal donor site morbidity, and allows unrestricted early rehabilitation activities. However, sensory restoration to the pulp has been unsatisfactory. An islanded sensate FDMA flap was demonstrated for the first time by Foucher and Braun in 1979.¹¹ One of the drawbacks of FDMA flap is that although it is a sensory flap, patients need a particular time

period for cortical reorientation of flap at the injury site. This time frame can be bothersome for some patients as they are not able to recognise sensory stimulus given at flap site. Usual time for this adaptation is 1-2 years. Also, thumb should have at least protective sensations, stereognosis and should be capable of recognizing textures and the character of objects by feel alone. This high level of sensitivity can now be re-established by modern surgical procedures that includes various nerve coaptations, sensory re-education, flaps that includes branches of dorsal digital nerves which are anastomosed with thumb digital nerve.¹²

CASE SERIES

For a period of 18 months (January 2021 to June 2022), 20 patients were considered for the study and divided into neurotized (group A) and conventional (group B) FDMA flaps. One flap in each group underwent complete necrosis. So, in each group, a total of 9 patients were included in the final study after taking written informed consent as per Helsinki declaration and institutional ethics committee approval. All patients were followed for a period of 12 months and evaluated for the occurrence of early post-operative complications in terms of flap necrosis, hematoma, infection, wound dehiscence and graft loss.

Neurotized FDMA flap

After the FDMA flap elevation, the terminal branch of radial sensory nerve supplying the flap was identified, isolated and transected proximally of about 2.0-2.5 cm length at the base of the flap to ensure tensionless coaptation. The remaining proximal nerve stump of the superficial radial nerve was buried in the interosseous muscle to prevent neuroma formation. The harvested island flap was transposed to the thumb pulp defect by gentle traction through a subcutaneous tunnel.

With the aid of high magnification loupe, the terminal branch of SRN in the flap was coapted to one of the digital nerves of the thumb using 10-0 nylon sutures. Coaptation of the dorsal radial sensory nerve to the thumb digital nerve in an end-to-end fashion can provide a better axonal regeneration pathway because of similar diameters. Then flap inset was completed and donor site was resurfaced with a full-thickness skin graft and secured with a tie-over bolster dressing (Figures 1 and 2).

Conventional FDMA flap

All procedures were same except nerve identification and coaptation (Figure 3).

A total of 18 patients were considered for the final study and divided into two groups that is neurotized (group A) and conventional (group B) FDMA flaps as one flap in each group underwent complete necrosis. Venous congestion was noted in one patient of group A which was

conservatively managed and flap survived. One patient in group B had partial graft loss at flap donor site which was secondarily healed.

Mean age of patients in group A was 36.8 years and 29.8 years in group B. Most of the patients were male in group A (67%) and group B (78%) (Figure 4).

Dominant hand was involved in 44% in group A and 56 % in group B. Machine cut injury was the most common mode of injury in both groups (56 % each) followed by road side accident (Figure 5). In group A, mean size of the defect was 2.7×2.5 cm and in group B, it was 2.6×2.5 cm. In group A, mean size of the FDMA flap was 2.9×2.8 cm and in group B, it was 2.9×2.6 cm.



Figure 1: Case example 1 (a) shows a case of crush injury of left thumb at level of IPJ, defect of size 2.9×2.5 cm after debridement; (b) and (c) FDMA flap marked and elevated with adipofascial island; (d) superficial radial nerve terminal branch supplying the FDMA flap identified and transected proximally; (e) nerve coaptation between superficial radial nerve terminal branch and ulnar digital nerve of thumb using nylon 10-0 sutures; (f) and (g) FDMA flap inset done and FTG placed at flap donor site; and (h)-(j) at 6 month follow up, showing a well settled FDMA flap and FTG at donor site. Patient also regained complete return of function.

In group A, mean time taken for completion of procedure was 2.7 hours which was more than in group B (mean - 2.1 hours) (p value <0.05). The mean length of hospital stay after the procedure was 7 days in group A and 7.2 days in group B. Mean time taken to return back to previous work was 3.0 months in group A and 4.5 months in group B (p value <0.05).

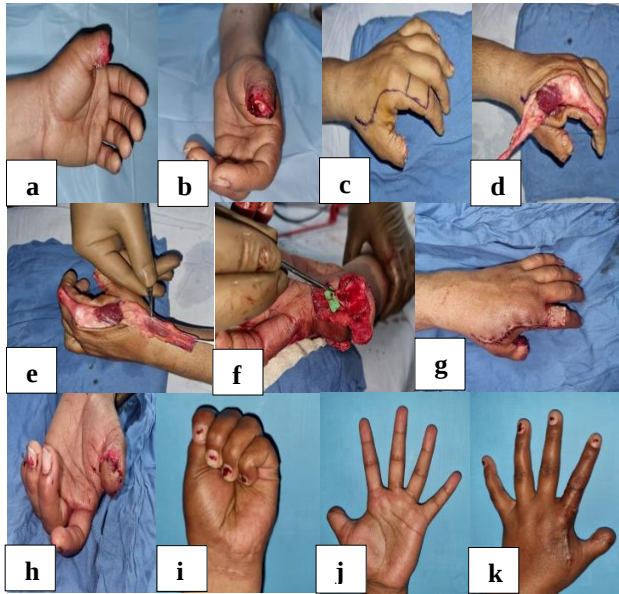


Figure 2: Case example 2 (a) and (b) Images of thumb defect with exposed bone at IPJ level; (c) marking of FDMA flap after debridement with lazy-S type of incision; (d) FDMA flap harvest; (e) and (f) demonstrate the coaptation between terminal dorsal branch of superficial radial nerve supplying the FDMA flap and ulnar digital nerve of thumb with nylon 10-0 sutures; (g) and (h) FDMA flap inset at thumb defect with donor site covered with FTG taken from wrist crease of the involved hand; and (i)-(k) 6 months post-surgery, shows a well settled FDMA flap and FTG at flap donor site with regain complete active range of motion at thumb and index fingers.

In group A, the mean 2-PD was 9.2 mm (7-14) as compared to opposite thumb which was 4.6 mm (3-6). In group B, mean 2-PD the thumb pulp was 10 mm (8-13) as compared to opposite normal thumb which was 4.8 mm (4-6). By comparing between these two groups, Neurotized FDMA flap group has average 2-PD of 9.2 mm as compared to conventional FDMA group which has 10 mm (p value >0.05) as shown in Table 1.

In the group A, 6 of 9 flaps achieved SWM sensitivity scores of 2.84-3.61 and in group B, 5 of 9 flaps achieved scores of 2.84-3.61. Based on the Modified American Society for surgery of the hand guidelines for stratification of 2PD, we obtained “good” 2 -PD grading in 8 patients and “fair” grading in 1 patient of group A as compared to 6 patients who achieved “good” grading and 3 patients of “fair” grading in group B. 7 patients in each group had CISS of 0 out of 100 and 2 patients had CISS of 10 out of 100. All patients in both groups had “mild” grading under CISS grading scale. At 12 months follow up period, 8 patients in group A were able to achieve complete cortical reorientation at a mean time period of 6.1 months and in 1 patient cortical reorientation was incomplete. Similarly, in group B, cortical reorientation was incomplete in 2 patients and was complete in rest of the 7 patients at a mean time period of 10.1 months (Figure 6).



Figure 3: Case example 1, shows a case of bike chain avulsion injury just distal to IPJ, (a) and (b) thumb defect of size 2.8x2.5 cm after debridement; (c) FDMA flap marking according to the size of defect, straight line shows doppler marking and course of FDMA; (d) FDMA flap elevation with adipofascial island; (e) FDMA flap inset after making subcutaneous tunnel, FTG placed at flap donor site; and (f)-(h) at 6 month follow up, showing a well settled FDMA flap and FTG at flap donor site and complete return of function.

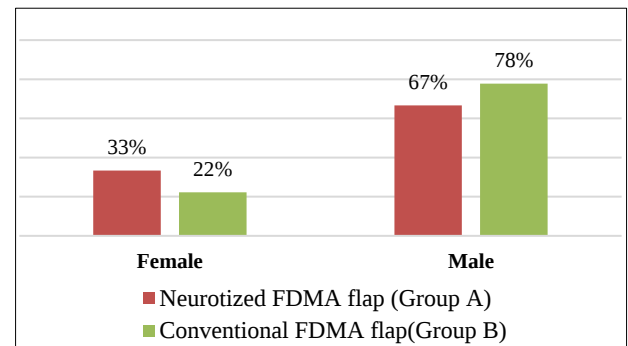


Figure 4: Gender distribution.

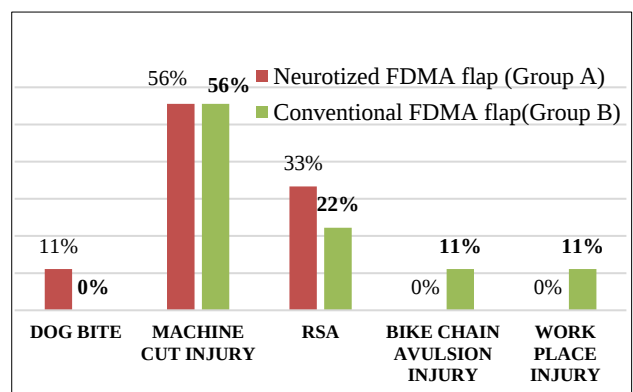


Figure 5: Mechanism of injury.

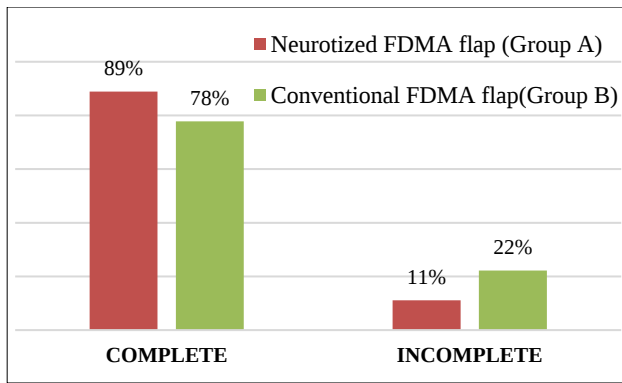


Figure 6: Cortical orientation.

Table 1: The different variables and comparison between two groups.

Variables	Neurotized FDMA flap (group A) (mean)	Conventional FDMA flap (group B) (mean)	P value
Age (years)	36.8±9.22	29.8±15.9	1.000
Defect size (cm)	2.7×2.5	2.6×2.5	0.207
Flap size (cm)	2.9×2.8	2.9×2.6	0.105
Follow up (months)	14.2	10.7	0.124
AROM(PIPJ)	99.44°	100.44°	<0.05
MCPJ	77°	78°	<0.05
Static 2-PD (mm)	9.2 (7-14)	10 (8-15)	0.253
SWM scores	6/9	5/9	0.240
Cortical reorientation (months)	6.1±0.835	10.1±2.268	<0.05
CISS	0/100 (7) 10/100 (2)	0/100 (7) 10/100 (2)	1.000
Satisfaction score (MHQ)	4.9±0.5	4.1±0.5	1.000
Pain (VAS)	0.2	0.3	0.624
Kapandji score	8.7	8.6	0.624
Total procedure time (hours)	2.7±0.26	2.1±0.25	<0.05
Average time to return to work	3.0±0.354 (months)	4.5±0.417 (months)	<0.05

DISCUSSION

The finger and especially the thumb, are the most important organs of tactile sensibility. The FDMA flap offers a reliable option for covering complex thumb defects because it has a constant vascular anatomy and easy dissection. Neurotized FDMA flap has average 2-PD of 9.2 mm as compared to Conventional FDMA which has

10 mm (p value >0.05). Muyldermans et al reported mean static 2-PD over the FDMA flap was 10.57 mm while Ravada et al observed a mean static two-point discrimination was 9.3 mm.^{13,14} Ege et al used 21 Foucher's flaps for thumb reconstruction and had an average static 2-PD of 10.8 mm.¹⁵ In another study, Ghoraba et al reported that mean static two-point discrimination was 10.4 mm.¹²

Various authors reported their modifications of FDMA flap in which one of the nerves supplying the flap was isolated and used for anastomosis with proper digital nerves of the thumb for improvement of flap sensory outcomes.¹⁶⁻¹⁸ Zhang et al reported the modified FDMA flap, including both dorsal branches of the proper digital nerve (DBPDNs).¹⁷ Neurorrhaphy between the DBPDN and the proper digital nerve was performed in both sides in all cases. The mean static 2PDs in the radial and ulnar distal portions of the flaps used to reconstruct the thumb tips were 5 mm (range, 4-8 mm) and 6 mm (range, 4-8 mm), respectively. Keramidas et al used a sensory dorsal island flap, including one DBPDN in 21 digits, which resulted in an average static 2PD of 13 mm in the flaps.¹⁹ Pan et al and Zhao et al used the sensory flap from the homodigital dorsum of the digit, with one neurorrhaphy between the DBPDN and PDN. In those flaps, the average static 2PDs were 7.6 and 8.0 mm, respectively.^{20,21}

At 12 months follow up period, 8 patients in group A were able to achieve complete cortical reorientation at a mean time period of 6.1 months and in 1 patient cortical reorientation was incomplete. Similarly, in group B, cortical reorientation was incomplete in 2 patients and was complete in rest of the 7 patients at a mean time period of 10.1 months (p value <0.05). This finding supports study done by Feng et al in which the average duration of cortical reorientation in the preservation group and the transection (of terminal branch of superficial radial nerve) group was 11 months (6-24 months) and 3 months (1-5 months), respectively.¹⁶ Ravada et al reported that cortical reorientation was complete in 45% of patients and also observed that the least period needed for reorientation was 11 months.¹⁴ Muyldermans et al and Delikonstantinou et al both reported that 2 years period was needed for complete reorientation.^{13,22}

In present study, variables like age, gender, hand dominance, defect and flap size, timing of reconstruction, length of stay, 2-PD scores, SWM scores, CISS score, satisfaction score, pain score, Kapandji score, mean follow up time were found to be statistically non-significant (p value >0.05). However, mean operative time, active range of motion across the joints, time interval for return back to normal routine activities and time period for achieving cortical reorientation of flap were found to be statistically significant (p value <0.05). Inability to achieve cortical reorientation can interfere with patients' daily activities. However, it can be corrected surgically with a neurotized FDMA flap with nerve coaptation.

Compared with the traditional FDMA flap, neurotized FDMA flap has a reliable blood supply for the dorsal terminal branch of the superficial radial nerve, satisfying postoperative recovery of finger pulp sensation which allows the sensation to be localized in the thumb and improve cortical reorientation. Also, wound repair and reconstruction of finger pulp sensation are completed in the operation at once.

CONCLUSION

To achieve better clinical outcome, we recommend repair of thumb pulp defects using a neurotized FDMA flap in which the first dorsal digital branch of the superficial radial sensory nerve is transected and coapted with one of the proper digital nerves of thumb at the defect site. Even though the ultimate sensory outcomes may not be clinically different, the significant improvement in cortical reorientation of neurotized flap after superficial branch of radial nerve division is enough to warrant use of this technique, as it would potentially improve rehabilitation outcomes and minimize required cognitive remapping. The neurotized FDMA flap represents a useful and reliable procedure for thumb pulp reconstruction with satisfactory flap sensation, appearance, and satisfactory function, with acceptable donor site morbidity. A longer follow up period on a larger group of patients may be required for better evaluation of the aesthetic and functional outcomes of this flap.

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