Research Article

Utilization of First and Second Dorsal Metacarpal Artery Flaps for Reconstruction of Soft Tissue Defects of Thumb and First Webspace: Reproducible and Safe Options for Reconstruction

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Abstract

Background: Soft tissue reconstruction of thumb and first web-space requires robust and sensate flaps. First and second dorsal metacarpal artery flaps are excellent options for such cases. Variable survival and sensory restoration is reported due to different surgical techniques. We present our technique and outcome to help a novice surgeon safely and confidently utilize these flaps.

Methodology: This prospective case series was conducted from July 2017 to December 2019. Patients requiring thumb and first web space soft tissue reconstruction were included. Flap necrosis, hypertrophic scarring, two point discrimination and active range of motion were noted to assess outcome.

Results: A total of 17 patients were included, 11 (64.7%) underwent reconstruction with first dorsal metacarpal artery (FDMA) flap and 6 (35.3%) with second dorsal metacarpal artery (SDMA) flap. 7.7 ± 0.75 mm was the average two-point discrimination with FDMA flap and 8.0 ± 0.63mm with SDMA flap. 7 out of 11 (63.6%) developed sensory reorientation with FDMA flap and 2 (33.3%) out 6 with SDMA flap. Mean angle of donor index finger metacarpophalangeal joint (MCPJ) was 79.4° and 91.9° of proximal interphalangeal joint (PIPJ) when FDMA was utilized. Mean angle of index finger MCPJ was 80.2° and PIPJ 90.2,middle finger MCPJ was 81.7 and 98.5 at PIPJ when SDMA was utilized. Flap necrosis was not observed in any case.

Conclusion: First and second dorsal metacarpal artery flaps are sensate and robust options to reconstruct thumb and first web-space defects.

Received | 07-01-2023: **Accepted** | 26-02-2023

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Keywords | First dorsal metacarpal artery flap, Second dorsal metacarpal artery flap, Thumb reconstruction, first web space reconstruction.

Introduction

Thumb plays an important part in the functionality of hand. It has its independent specialized muscles and loss of thumb function results in loss of pinch grip and grasp.[1,2] For thumb to retain adequate function, it must have an adequate length, a reasonable range of motion and sensate stable coverage for tactile feedback needed for fine control.[3,4] Soft tissue of thumb requires special consideration, with each surface of thumb requiring tissue replacement with similar one.[4] First and second dorsal metacarpal artery flaps offer a durable and sensate option to reconstruct the thumb defects.[5,6,7,8] Although they are workhorse flaps for thumb soft tissue defects and first webspace reconstruction, a novice surgeon requires some surgical considerations to successfully plan and utilize them.[9] The degree of sensory restoration of the reconstructed area also varies, with many studies mentioning persistent cortical disorien-

tation.[10,11,12]

We present a case series describing the practical considerations and pitfalls when using these flaps for reconstruction of soft tissue defects of palmar surface of thumb and 1st webspace, based on our experience. We also present the outcome on the basis of wound healing and restoration of sensation. The objective is that our practical description may help a novice surgeon to safely utilize these flaps and relate the expected outcome to the patients in a confident manner.

Methodology

This study was conducted in Jinnah burn and reconstructive surgery center Lahore from July 2017 to Dec 2019. After obtaining permission from ethical review board, we included patients who required flap for reconstruction of soft tissue defects of the palmar surface of thumb and first webspace. Patients who required reconstruction of bony or tendon injuries, with extensive soft tissue defects requiring distant flaps were excluded. Patients with uncontrolled comorbid conditions were also excluded. All patients were assessed for suitability and were enrolled for the study after obtaining informed consent. Preoperatively planning in reverse was done, either first or second dorsal metacarpal artery flap was marked depending upon the dimensions and location of the defect. All perioperative data was recorded, and patient was followed post operatively. Flap necrosis was noted in immediate postoperative period. Sensation was evaluated at 6 months, by comparing static two-point discrimination to the contralateral normal side and determining sensory reorientation by patient's feedback. Hypertrophic scarring and active range of motion over index and middle finger metacarpophalangeal (MCPJ) and proximal interphalangeal joints (PIPJ) was also evaluated at 6 months.

Operative Technique:

All surgeries were performed in regional anesthesia or general anesthesia and under tourniquet control, applied after Esmarch maneuver. Loupe magnification of 2.5 x was used for entire procedure. Wound excision or release of contracture was done, and dimensions of the defect were noted. Flap was marked and planning in reverse was done. Post operatively scar care and active / passive range of motion was started in order to improve function of the hand.

Islanded First Dorsal Metacarpal Artery (FDMA) flap:

For first dorsal metacarpal artery flap doppler with 8 Mhz probe was used to mark 1st dorsal metacarpal artery at radial border of the 2nd metacarpal bone. Doppler signals are strong at its origin, at the base of first web space. Flap over proximal phalanx was marked, proximal to the first crease of proximal interphalangeal joint (PIPJ). The lateral markings were kept dorsal to the palmar / dorsal skin junction of the index finger. In case of thumb pulp defects, a v shaped skin extension was included in the skin island to incorporate it in the incision over interphalangeal joint (IPJ) of thumb. This prevented tightening of the tunnel over the interphalangeal joint (IPJ) as well as protected the small branches of the pedicle entering the flap at this level. An S-shaped incision was marked over the course of the first dorsal metacarpal artery.

Dissection of flap was started at distal and ulnar side, progressing proximally and radially, over the paratenon. Proximally over the dorsum of hand, S-shaped incision was given and thin skin flaps were raised on dermal plexus. The deep fascia was incised at the radial border of extensor digitorum communis (EDC) tendon of index finger and pedicle raised with a cuff of fascia around it. The first dorsal metacarpal artery branches have three terminal patterns and the ulnar most was taken with the flap, termed as FDMAu. The artery runs within the deep fascia of first dorsal interosseous, which was taken with the pedicle. Dissection over radial part of extensor hood was done with some part taken to preserve small terminal branches that supplied the flap. Dorsal branch of the digital nerve was divided and taken with the flap if flap was used to reconstruct pulp defects, where nerve was co-opted with digital nerve of the thumb. Proximal dissection was carried out till the origin of the pedicle.

A subcutaneous tunnel was created at the first web space and over the proximal phalanx of thumb, where skin was loose, but skin incision was given more distally, and v shaped skin extension of flap was incorporated to facilitate tension free closure. Full thickness skin graft (FTSG) from ulnar border of forearm was stitched over the donor site, reinforced with bolster. After insetting of flap, loose dressing was done and thumb was immobilized in 45° radial abduction and extension.

Islanded Second Dorsal metacarpal artery (2nd DMCA) flap:

Marking was done over the dorsum of first and second finger proximal phalanges not crossing the proximal crease of PIPJ and dorsal to the junction of palmar and dorsal skin, with the dimensions of the defect taken into

account. A lazy s incision was marked between second and third metacarpals to explore the second DMCA.

Incision was given over the dorsum of the hand. The skin flaps were raised on dermal plexus on radial and ulnar sides. Fascia was incised at the ulnar border of extensor indices proprius (EIP) tendon and radial border of EDC tendon of middle finger with division of the inter tendinous junction. The second dorsal digital nerve (DDN) and second DMCA travel within the deep fascia of second dorsal interosseous, which was raised together with a superficial vein to ensure adequate venous drainage. The skin paddles over phalanges were then raised as in the case of FDMA flap and pedicle was dissected over the extensor expansions and intermetacarpal ligament. We did not divide the tendon of index finger EDC and EIP and kept the pivot point before the pedicle entered deep to the tendons. In case the pivot point needed to be at the origin, there was the option of division of tendons and pedicle dissection proximally till the origin. Tunneling, flap in-setting and closure of the donor site was done as in the case of FDMA flap.

Results

A total of 17 patients were included, 9 (52.9 %) patients had post burn contractures or wounds and 8 (47.1%) presented with post traumatic wounds. In 11(64.7%) patients FDMA was used to reconstruct the defect whereas in 6 (35.3%) patients SDMA was used.

The mean two-point discrimination over the reconstructed site with FDMA flap was 7.7 ± 0.75 mm, compared to 3.64±0.50mm measured on the contralateral uninvolved side. In case of SDMA flap, the mean two-point discrimination was 8.0 ± 0.63mmas compared to 3.3 ± 0.52mm on the contralateral involved side.

Among the patients who underwent reconstruction with FDMA flap, 6 out of 8 (75%) developed sensory orientation in which nerve co-optation was done, while 1 out of 3 (33%) patients developed sensory reorientation without nerve co-optation. 2 out of 6 patients (33%) developed sensory reorientation who underwent reconstruction with SDMA flap. In this group, nerve co-optation was not performed on any patient.

The mean angle of flexion of donor index finger MCPJ was 79.4° vs 81.6° of contralateral side when FDMA flap was used. In these patients, mean angle of flexion at PIPJ was 91.9° vs 94.5 °. In SDMA flap cases, the angle of flexion of index finger MCPJ was 80.2° and PIPJ was 90.2° as compared to 82.3 and 92.8 of the contralateral side. The mean angle of flexion of middle finger

Table 1: *Summary of findings noted in the study.*

Gender	Age (Yrs)	Etiology	Soft tissue defect location	Flap	Flap Necrosis	Static two point discrimination flap (mm)	Static two point discrimination opposite side (mm)	Sensory reorientation
Male	20	Burn	First web	FDMA	None	8	4	Yes
Female	18	Burn	Dorsum of proximal phalanx	FDMA	None	9	4	No
Male	21	Burn	Defect over thenar eminence and 1st web	SDMA	None	7	3	Yes
Female	32	Burn	Pulp defect	FDMA	None	8	3	Yes
Male	37	Trauma	Pulp defect	FDMA	None	7	4	Yes
Male	30	Trauma	Amputation, stump at IPJ	FDMA	None	7	4	No
Male	13	Trauma	Amputation, stump at IPJ	FDMA	None	8	3	Yes
Male	47	Trauma	Pulp defect	FDMA	None	9	3	Yes
Female	20	Burn	First web	SDMA	None	9	3	No
Male	19	Burn	First web	SDMA	None	8	3	No
Male	29	Trauma	Pulp defect	FDMA	None	7	4	Yes
Female	25	Burn	First web	SDMA	None	8	3	No
Female	28	Trauma	Pulp defect	FDMA	None	7	4	Yes
Male	20	Burn	First web	SDMA	None	8	4	No
Female	15	Trauma	Amputation, stump at IPJ	FDMA	None	8	3	No
Female	23	Trauma	Defect over dorsum of MCPJ	FDMA	None	8	4	No
Male	11	Burn	First web	SDMA	None	8	4	Yes

MCPJ was 81.7 and PIPJ was 98.5 as compared to 84.3 and 100.8 compared to contralateral side. One patient developed hypertrophic scarring but was successfully treated with scar modulation therapy. Table 1 summarizes the findings of this study, and Figure 1 and 2 show the representative cases where first and second dorsal metacarpal artery flaps were used.

Figure 1: *A 30-year-old male laborer presented with amputation at Interphalangeal joint (IPJ). Defect was reconstructed with First Dorsal Metacarpal Artery Flap (FDMA).*

Figure 2: *A 21-year-old male sustained low voltage electric current injury. Reconstruction of 1st web space and adjacent area over thenar eminence was reconstructed using SDMA flap. Rest of the wounds were skin grafted and covered with ulnar artery perforator flap.*

Discussion

Use of the dorsal skin over fingers has evolved over the years as being two staged pedicled flaps to single staged is landed flaps. The dorsal skin provides sensate and robust flaps to reconstruct the defects up to the pulp of the thumb.[8,13] The vascular bases are also constant enabling reproducible and good results to be achieved. They are also easier to raise as compared to other sensate flaps and do no need microsurgical expertise.[8,14] First dorsal metacarpal artery flap has been extensively used for the reconstruction of thumb soft tissue defects.[15] As pointed in some studies Venous congestion can be a problem with FSMA flaps, with incidence as high as 11%.[5] We noted that the distal part of tunnel was always narrow when flap was used to reconstruct the pulp of thumb defects hence a v shaped extension of flap was taken proximally and adjusted over an incision given over ulnar aspect of inter phalangeal joint to release the tension over the pedicle. A cuff of soft tissue with the pedicle also improved the venous drainage and accounted for improved flap success rate. The second dorsal metacarpal artery flap when raised as islanded flap, with a cuff of soft tissue along the pedicle, but was used to reconstruct first web space and soft tissue defects of thenar eminence. The bi-paddle flap offered large skin islands to reconstruct two adjacent surfaces at first web space as pointed out by other authors.[7,8]

Scar complications were observed in one case only despite adequate post operative care. Post-operative loss in range of motion was also negligible due to the above-mentioned post-operative care, in addition to sparing of the skin over joints and raising islanded flaps. We observed increased incidence of sensory reorientation in FDMA flaps where nerve was coopted with the digital nerve of thumb. The increased incidence, i.e 63.6% as compared to less than 50% incidence, was maybe due to the nerve cooptation or because most studies failed to mention whether nerve cooptation was performed or not. Nevertheless, reorientation never affected the day-to-day function of the reconstructed thumb.[16,10] Feng et al have demonstrated that the division of superficial radial nerve and coaptation with sensory nerves at the recipient site improved two-point discrimination and sensory reorientation. But the transection of nerve which is in proximity with the vascular pedicle is a risky option, when compared to a little benefit when nerve is not transected. Nerve co-optation for SDMA is neither described nor have we attempted, as its reach is till the base of the thumb and first web space.

Our study clearly shows the advantage of neural co-optation, but due to a smaller number of cases, a

comparative study is needed to further emphasize the advantage of neural co-optation. This technique can be further explored in case of SDMA flap to evaluate the advantage in reconstructing the working surface of thumb. We further recommend research comparing these flaps with other flaps e.g., free toe pulp transfer over a longer follow up period to ascertain the pros and cons of each method of reconstruction.[17]

Conclusion

Sensate Flaps based on dorsal metacarpal arteries offer robust tissues to reconstruct the soft tissue defects and restore sensation of thumb. Increased flap success rate together with minimal donor site morbidity can be achieved through meticulous technique and good post-operative care.

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