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RESEARCH ARTICLE

Modified First Dorsal Metacarpal Artery Flap to Prevent Venosus Congestion: Retrospective Analysis of 37 Cases

Burak Yasar, Hasan Murat Ergani
Department of Plastic, Reconstructive and Aesthetic Surgery, Health Sciences University, Ankara Bilkent City Hospital, Ankara, Turkey

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Abstract

Introduction: First dorsal metacarpal artery flap (FDMAF) is thin, pliable, sensate flap which is useful in the restoration of the contour and sensation of the thumb. Although FDMAF stands out with many positive aspects, venous congestion and related flap losses are frequently reported in the literature. In this study, we evaluated the clinical results of our modification, which prevents venous congestion and facilitates the inset of the flap to the defect area, with retrospective patient analyzes. We aimed to share surgical anatomy, surgical technique, tips and key points to get good results.

Methods: Between May 2016 and December 2019, 37 patients (32 males, 5 females) with thumb defects were included in the study. All patients were evaluated for flap size, defect size, sensory return, two-point discrimination (2PD), operation time, metacarpophalangeal (MCP) and interphalangeal (IP) range of motion.

Results: All 37 flaps survived complately. Venous congestion was not observed in the other flaps. Semmes-Weinstein sensory test score: 4,36 (range, 3,84-5,1) in the flap, 4,62 range, 3,9-4,92) in the donor site. Mean two-point discrimination (2PD): 8.8 mm (range, 7-22 mm) in the flap, 12 mm in the donor area (range 10-14 mm). MCP range of motion of the operated thumbs was 82o (range, 70o-86o) and IP range of motion was 84o (range, 15o-88o).

Conclusion: Modified kite flap is technically simple, and the learning curve is fast, even it may be performed with local anesthesia. Also it is a useful, reliable and sensory option for the thumb reconstruction. Our clinical results are encouraging.

Correspondence Address: Beytepe mah. Orhan Gazi Bulv. Güneşpark Evleri, No: 19/30, Çankaya 06500 Ankara - Türkiye **Phone:** +90 506 662 37 36 **e-mail:** burakys@gmail.com

Introduction

Thumb defects frequently arise as a result of avulsion trauma. For superficial defects, skin grafts can often suffice as a treatment option. However, when bone and tendon exposures are involved, more intricate reconstruction methods become necessary. In thumb reconstruction, various techniques can be employed, such as Littler's neurovascular island flap, small free flaps, or sensory cross finger flaps. The restoration of the thumb pulp and sensory function is crucial for achieving optimal hand functionality. Therefore, the first dorsal metacarpal island flap (FDMAF) stands as a favorable choice for reconstructing thumb defects.[1-4]

The FDMAF is a thin, pliable, and sensate flap that proves valuable in restoring both the contour and sensation of the thumb pulp.[5] However, despite its numerous positive aspects, the literature frequently reports cases of venous congestion and associated flap losses.[4,6-9] Multiple studies have highlighted the occurrence of venous congestion in approximately 40% of flaps.[7] Preventing venous congestion becomes crucial in order to avoid partial flap losses, minimize hospitalization duration, and reduce the need for additional surgical interventions.

The primary objective of this study was to assess the clinical outcomes of our modification, designed to prevent venous congestion and enhance the successful insertion of the flap into the defect area. We conducted a retrospective analysis of patients to evaluate the effectiveness of our approach. Additionally, we aimed to share insights on surgical anatomy, surgical technique, as well as essential tips and key points that contribute to achieving favorable results in the procedure.

Materyal and Methods

This study received approval from the Ankara City Hospital Ethics Committee (number E2-23-4185) before its commencement. Between June 2016 and December 2019, a total of 37 patients (32 males and 5 females) with thumb defects were included in the study. The mean age of the patients was 34 years, with an age range spanning from 16 to 64 years. All cases involved either avulsion injuries (n = 26) or crush injuries (n = 11). The evaluation of each patient encompassed various factors, including defect size, flap size, sensory outcome, two-point discrimination (2PD), operation time, as well as the range of motion in both the metacarpophalangeal (MCP) and interphalangeal (IP) joints. It is worth noting that the operations and subsequent patient follow-ups were conducted by the same surgical team throughout the study.

Surgical Technique

The operations for FDMAF can be performed under local or general anesthesia with tourniquet control. No premedications used in all case before surgery. The patient is positioned supine on the hand table with the arm in abduction. Operation starts with debridment of the defect. The flap size is decided according to the size of the defect area. The dorsum of the second finger serves as a reference for flap design. Radial lateral of the flap must be on the midradial axis line because first dorsal metacarpal artery branch is located at the dorsoradial side of the second finger. Ulnar side of the flap can be determined by the required flap size. If a large flap required flap can be extended till the midulnar line serves as the ulnar lateral border. The entire dorsum of the second proximal phalanx can be harvested as a flap.

To prevent joint contractures, the authors does not recommend extending the distal portion of the proximal interphalangeal joint line. In the author's modification, the proximal part of the flap is planned in a V-shaped pattern as equilateral triangle. However, a vertical incision is made to relieve the tunnel neck at the proximal part of the defect. The lenght of the vertical incision should be equal to side lenght of equilateral triangle. The equilateral portion of the flap must precisely fits into vertical incision line (Figure 1). If it is not fits well, vertical incision line can ve lenghten. As a result, Due to the vertical incision, tunnel mouth widens by the side lenght of equilateral triangle which prevents vascular compression within the tunnel. This modification helps reduce venous congestion and its associated complications. Also this modification is the advanced version of authors venosus congestion preventing modification which presented in the First International Congress of Occupational Accidents, Hand Injuries and Amputations.[10]

Flap dissection begins from the distal ulnar lateral side, following the appropriate markings. The dorsal digital nerve and its radial branch are included in the flap with approximately 1 cm of remnant length. The radial branch of the nerve is subsequently coapted to the digital nerve stump in the defect area. The paratenone is not preserved in this region due to the

close proximity of the pedicle to the paratenon on the radial lateral side of the metacarpophalangeal joint. A lazy-S incision is made from the proximal end of the flap to the anatomical snuff box. During the elevation of the skin flaps, only the skin tissue is dissected, while the subcutaneous tissue and subcutaneous veins are included in the flap pedicle. This step is crucial in preventing the occurrence of venous congestion. The fascia of the first interosseous muscle is included proximally in the flap. The pedicle is dissected up to the radial artery (Figure 2). Subsequently, a subcutaneous tunnel is created between the thumb defect and the artery. It is important for the tunnel to be wide enough to prevent pedicle compression. To relieve the neck of the tunnel and prevent pedicle compression, a vertical incision is made on the distal portion of the tunnel. The planned proximal V-shaped part of the flap is then positioned in this area.

Lastly, the defect at the donor site on the dorsum of the second finger is reconstructed using a full-thickness skin graft harvested from the ulnar forearm.

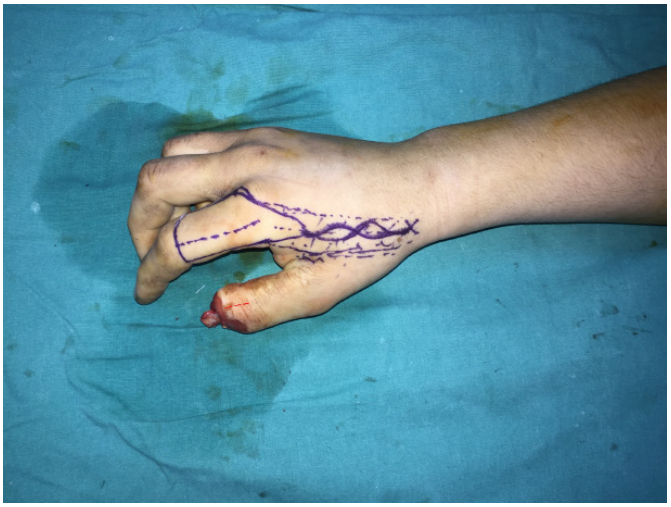

Figure 1:Skin markingd of modified FDMAF. Red dashed line: The tunnel neck at the proximal of the defect is relieved by this vertical incision. That maneuver is very important to prevent venous congestion.

Figure 2:Flap dissection. Interosseos muscle fascia included to protect pedicle and support venous drainage.

Results

All 37 flaps in the study demonstrated complete survival, except for one flap that showed partial necrosis distally. In this particular case, satisfactory results were achieved through wound debridement and secondary wound healing. No instances of venous congestion were observed in the remaining flaps, and there were no reports of graft lysis at the donor site and there were no other wound healing problems such as infection and dehiscence.

The average operation time for flap dissection was 56 minutes, with a range of 50-80 minutes. It is noteworthy that all flap dissections were performed using loupe magnification, ensuring precision and accuracy during the procedure.

The mean follow-up period for the patients was 13,4 months, ranging from 5 to 20 months. At the last control of cases, all flaps exhibited good skin color and tissue compliance. Also donor site condition was acceptable as observed in Figure 3, 4, and 5.

There were no reports of pain in the donor site or recipient site scars. However, nine patients (24%) experienced cold intolerance in the flap, while three patients (8%) reported hypersensitivity to the flap. These are important

Figure 3: Postoperative 18 months. No deplession at the donor site. Flap is well healed, no contour deformity.

Figure 4:Postoperative 18 months. Full abduction and extension of MCP joint.

considerations in the assessment of patient outcomes and potential post-operative complications.

The Semmes-Weinstein sensory test scores for the flap were recorded as 4,36, with a range of 3.84 to 5.1, while the scores for the donor site ranged from 4,62 to 3,9-4,92. This indicates a relatively preserved sensory function in both the flap and donor site areas.

The mean two-point discrimination (2PD) was measured as 8,8 mm in the flap, with a range of 7-22 mm. In the donor area, the 2PD was 12 mm, ranging from 10 to 14 mm. These measurements reflect the ability to discern finer tactile stimuli and suggest a reasonably good sensory recovery. The mean defect size was 2,4 x 2,9 cm, ranging from 1,9 x 2,1 cm to 2,7 x 3,2 cm. The size of the flaps used for reconstruction had a mean measurement of 2,6 x 3,2 cm, with a range of 1,9 x 2,3 cm to 2,9 x 3,6 cm. These dimensions indicate the adequacy of the flaps in covering the thumb defects.

In terms of range of motion, the metacarpophalangeal (MCP) range of motion for the operated thumbs averaged 82 degrees, with a range of 70 to 86 degrees. The interphalangeal (IP) range of motion averaged 84 degrees, ranging from 15 to 88 degrees. These values indicate satisfactory mobility in the operated thumbs, contributing to functional hand movement.

Discussion

The reconstruction of tendon and bone exposed defects in the thumb presents challenges due to the limited availability of surrounding tissues. The primary objective of thumb reconstruction is to preserve thumb length and restore sensation. Various surgical options, including local, regional, and free flaps, are available for this purpose.

Littler's neurovascular island flap is a sensory flap commonly used for thumb reconstruction, typically harvested from the ulnar lateral of the third or fourth finger.1 However, this flap has certain limitations, such as its suitability for smaller defects and the sacrifice of one of the digital arteries. Additionally, it may pose challenges in terms of cortical learning.

The V-Y advancement flap is another option for reconstructing defects up to 1,5 cm in size. However, it is not a sensory flap, meaning it does not provide restoration of sensation. On the other hand, the Moberg flap can be used for larger defect reconstruc-

tions. It is important to note that during flap elevation, there is a risk of circulatory disorders and necrosis in the dorsal skin and nail bed due to damage to the dorsal nourishing veins. Furthermore, this flap may lead to flexion contracture of the interphalangeal joint, which should be considered in the surgical planning.[11]

Each of these flap options has its advantages and limitations, and the choice of technique depends on the specific characteristics of the defect and the patient's individual needs and goals.

In authors own practice, the innervated cross-finger flap is not a preferred due to the requirement of a two-stage operation and the potential for joint stiffness, particularly in elderly patients. Despite providing acceptable sensation in the thumb, these factors make it less favorable in our clinical practice.3

Similarly, the dorsoulnar thumb flap, as described by Brunelli, is not recommended by the authors due to its lack of sensory return and the absence of natural dimples in the webs. These factors make it a less ideal choice for thumb reconstruction.[12]

Regarding small free flaps, such as partial toe transfers, they are not considered as the first choice in our authors practice. Many patients are reluctant to sacrifice their big toe for the procedure, and the operation itself requires complex microvascular techniques. This complexity contrasts with the relative simplicity of the FDMAF procedure.

The FDMAF, with its wide rotation arc and innervation from superficial radial nerve branches, is the primary choice for thumb defect repair in our clinical practice. It offers technical simplicity and a fast learning curve, and can even be performed under local anesthesia. There are techniques with expanding FDMAF with a skin bridge to pivot point of the flap. [13] However skin bridge technique reduces venos congestion, donor site scar at the dorsum of the hand is expands with the skin bridge. Also a vertical scar at the junction of the first web space can lead to skin contracture at late onset. Aesthetically dorsum of the hand is important.[14] In our current study dorsal scar of the hand limited with the donor site and pedicle dissection area. As a limitation of our study, patients did not score aesthetic outcomes of operation. Comperative studies with large number of patients recommended.

In our study, the mean two-point discrimination (2PD) was 8,8 mm, within the range of 7-22 mm. This is consistent with the literature, where 2PD measurements typically average around 9-10 mm.[14] Günay et all found 15 mm of mean 2PD in their FDMA flap study with classical flap elevation. We think that our better 2PD results are associated with our modification which provides no pedicle compression. One case in our study demonstrated 22 mm of two-point discrimination, which can be attributed to the patient's hypersensitivity and noncompliance. Also patients need to improve cortical reorientation for proper sensation of the thumb in local sensate flaps such as heterodigital neurovascular island flap.[16] Cortical reorientation process can differ induvisually.

In our series, mean flap size was 2,6 x 3,2 cm which is same with literature. When harvesting local flaps from the hand, there is always size limitations cause of uniqe and fonctional anatomy of the hand. Similar to other local flaps in the hand, FDMAFs are constrained by size limitations. These flaps are capable of extending distally to the PIP joint and proximally to the metacarpophalangeal joint. In an effort to address this limitation, El-Khatib reported extended first dorsal metacarpal artery neurovascular island wrap-around flap, which demonstrated successful outcomes.[9] It should be kept in mind that our modification can be used in extended FDMAF too. Nonetheless, it should be noted that this particular procedure may be accompanied by an increased risk of donor-site morbidity.

Overall, the FDMAF technique has shown promising results in terms of sensory outcomes and patient satisfaction in our study, aligning with the existing literature in this field.

One limitation of the study is that we did not apply the cold intolerance questionnaire to patients who reported cold intolerance. This could have provided additional insight into the prevalence and severity of cold intolerance among the study participants.

Most patients in the study had satisfactory thumb metacarpophalangeal (MCP) and interphalangeal (IP) joint range of motion. It is thought that our V-shaped modification provided adequate tissue to recipient site. Also our equilateral triangle extention of flap acts as a 60 degrees of Z-plasty and that prevented any joint contracture.

In our study, only one flap (2,7%) experienced venous congestion and partial necrosis. It was determined in the postoperative period that this patient had trauma at the flap donor site, which was believed to be the cause of the congestion and necrosis. Si-

milar studies by Zhang et al.[6] Couceiro and Sanmartin[7], and Satish et al[8]. also reported cases of partial necrosis in their respective series. However, El-Khatip[9] reported no flap necrosis despite the presence of venous congestion in all of their cases. When comparing our study to the existing literature, our findings showed significantly less venous congestion compared to other case series. This may be attributed to the modifications made to the flap, such as the V-shaped proximal flap and the vertical incision that releases the tunnel through which the pedicle passes, allowing the flap tail to fit precisely in this line.

Overall, our study highlights the favorable outcomes and low incidence of venous congestion and necrosis associated with the FDMAF procedure, particularly when considering the modifications made to enhance flap survival.

Conclusion

Based on the results of the study, it can be concluded that the new kite flap modification is a technically simple and easily learnable procedure. It offers several advantages, including the ability to perform it under local anesthesia and its reliability in providing sensory reconstruction for the thumb.

The clinical outcomes of the patients who underwent this procedure in our study were encouraging, with high flap survival rates, satisfactory range of motion, acceptable sensation, and minimal complications such as venous congestion and necrosis. These findings suggest that the kite flap modification can be considered as a valuable option for thumb reconstruction, providing reliable results and sensory restoration. The simplicity of the technique and the fast learning curve make it an attractive choice for surgeons. However, it is important to consider individual patient factors and preferences when selecting the most appropriate reconstruction option. Further research and comparative studies may help to establish the long-term effectiveness and advantages of the Kite flap modification in thumb reconstruction.

References

1. Yıldırım AR, İğde M, Tapan M, Öztürk MO, Yaşar B, Ünlü RE. Littler Flap: A reliable option in soft tissue defects of different fingers. Cumhur Med J. Published online 2016. doi:10.7197/cmj.v38i4.5000180330
2. Connors KM, Kurtzman JS, Koehler SM. Successful Use of WALANT in Local and Regional Soft Tissue Flaps: A Case Series. Plast Reconstr Surg Glob Open. 2023 Jan 13;11(1):e4756. doi: 10.1097/GOX.0000000000004756
3. Woon CYL, Lee JYL, Teoh LC. Resurfacing hemipulp losses of the thumb: The cross finger flap revisited: Indications, technical refinements, outcomes, and long-term neurosensory recovery. Ann Plast Surg. 2008;61(4):385-391. doi:10.1097/SAP.0b013e3181640873
4. Zhang X, Shao X, Ren C, Zhang Z, Wen S, Sun J. Reconstruction of thumb pulp defects using a modified kite flap. J Hand Surg Am. 2011;36(10):1597-1603. doi:10.1016/j.jhsa.2011.06.033
5. Sherif MM. First dorsal metacarpal artery flap in hand reconstruction. I. Anatomical study. J Hand Surg Am. 1994;19(1):26-31. doi:10.1016/0363-5023(94)90220-8
6. Zhang X, Shao X, Ren C, Zhang Z, Wen S, Sun J. Reconstruction of thumb pulp defects using a modified kite flap. J Hand Surg Am. 2011;36(10):1597-1603. doi:10.1016/j.jhsa.2011.06.033
7. Couceiro J, Sanmartín M. The Holevich flap revisited: a comparison with the Foucher flap, case series. Hand Surg. 2014;19(3):469-474. doi:10.1142/S0218810414970090
8. Satish C, Nema S. First dorsal metacarpal artery islanded flap: A useful flap for reconstruction of thumb pulp defects. Indian J Plast Surg. 2009;42(1):32-35. doi:10.4103/0970-0358.53003
9. El-Khatib HA. Clinical experiences with the extended first dorsal metacarpal artery island flap for thumb reconstruction. J Hand Surg Am. 1998;23(4):647-652. doi:10.1016/S0363-5023(98)80050-6
10. Yasar B. Venous Congestion Preventive Kite Flap Modification in Reconstruction of Thumb Defects: Retrospective Analysis of 19 Cases, International Congress on Occupational Ac-

cidents, Hand Injuries and Amputations, 2019
11. Baumeister S, Menke H, Wittemann M, Germann G. Functional outcome after the Moberg advancement flap in the thumb. J Hand Surg Am. 2002;27(1):105-114. doi:10.1053/jhsu.2002.30921
12. Terán P, Carnero S, Miranda R, Trillo E, Estefanía M. Refinements in dorsoulnar flap of the thumb: 15 cases. J Hand Surg Am. 2010 Aug;35(8):1356-9. doi: 10.1016/j.jhsa.2010.05.016
13. Aggag AM, Aboel-Hasan WS, Abdel-A-al M. A Comparison of Outcomes of Reconstruction of Palmar versus Dorsal Defects of the Thumb Using a First Dorsal Metacarpal Artery Flap with a Cutaneous Bridge Segment. J Hand Surg Asian Pac Vol. 2022 Apr;27(2):313-319. doi: 10.1142/S2424835522500278
14. Park JA, Lee SH, Hwang SJ, Koh KS, Song WC. Anatomic, histologic, and ultrasound analyses of the dorsum of the hand for volumetric rejuvenation. J Plast Reconstr Aesthet Surg. 2021 Jul;74(7):1615-1620. doi: 10.1016/j.bjps.2020.11.017
15. Günay AE, Tatlisu K, Çavuş M, Kahraman M. Mid-Term Results of the First Dorsal Metacarpal Artery Flap for Thumb Defects. J Hand Surg Asian Pac Vol. 2022 Oct;27(5):834-838. doi: 10.1142/S2424835522500801
16. Wang H, Yang X, Chen C, Wang B, Wang W, Jia S. Modified Littler flap for sensory reconstruction of large thumb pulp defects. J Hand Surg Eur Vol. 2018 Jun;43(5):546-553. doi: 10.1177/1753193417754191