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Araştırma

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Neurovascular Heterodigital Island Flap for Digital Pulp Defect Reconstruction: 58 Case Series

Parmak Pulpa Defektlerinin Nörovasküler Heterodijital Ada Flebi ile Rekonstrüksiyonu: 58 Vakalık Seri

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ABSTRACT

Aim: Our study aims to report the neurovascular heterodigital island flap reconstruction for finger pulp defects.

Patients and Methods: This study included 58 patients presenting to our clinic with pulp defects between 2014 and 2022. The average age of the patients was 26 years (20 - 56 years). Injuries were Allen type 2 for 18 patients, type 3 for 33 patients, and type 4 for 7 patients. Pulp defects were caused by crush injury (n:42) and sharps injury (n:16).

Results: None of the flaps administered to the participating patients developed any total loss. Three patients developed partial loss in the distal flap. Six patients were found to have superficial tissue infection. Two patients were found to have hyperpigmentation and hyperesthesia. While one patient with Allen type 3 pulp defect was detected to have 10 degrees of flexion contracture in the distal interphalangeal (DIP) joint and 5 degrees of flexion contracture in the proximal interphalangeal joint, three patients were found to have 5 degrees of flexion contracture only in the DIP joint. While the mean static two-point discrimination of the pulp-administered flap was 5.2 mm (3-8 mm) it was 3 mm on the contralateral side. The mean Semmes-Weinstein monofilament test was 3.18 g (2.96 – 4.7 g) in the pulp administered flap and 2.92 g in the contralateral side.

Conclusion: Reconstruction of pulp defects with neurovascular heterodigital island flap is a reliable treatment option with satisfactory functional and sensory outcomes.

Key Words: Hand trauma, fingertip reconstruction, heterodigital island flap, local arterialized flap.

ÖZ

Amaç: Çalışmamızın amacı el parmak pulpa defekti olan hastalarda nörovasküler heterodijital ada flebi ile pulpa rekonstrüksiyonu sonuçlarımızı bildirmektir.

Patients ve Metod: Kliniğimize 2014-2022 yılları arasında pulpa defekti ile başvuran 58 hasta (42 erkek, 16 kadın) çalışmaya dahil edilmiştir. Hastaların yaş ortalaması 26'dır (20-56 yaş). Hastaların 18 tanesi Allen tip 2, 33 tanesi Allen tip 3 ve 7 tanesi Allen tip 4 yaralanmalardı. Pulpa defektleri crush yaralanma (n:42) ve kesici alet yaralanması (n:16) ile meydana gelmişti.

Bulgular: Çalışmaya dahil edilen hastalara uygulanan fleplerin hiçbirisinde total kayıp gelişmemiştir. Üç hastada flep distalinde kısmi kayıp gelişti. Hastaların 6 tanesinde yüzeyel doku enfeksiyonu görüldü. Donör saha morbiditesi olarak 2 hastada hiperpigmentasyon ile birlikte günlük hayatını etkilemeyecek şekilde hiperestezi tespit edildi. Allen tip 3 pulpa defektli olan 1 hastada distal IP (interphalangeal) eklemde 10 derece fleksiyon kontraktürü ile birlikte PIP eklemde 5 derece fleksiyon kontraktürü tespit edilirken, 3 hastada sadece distal IP eklemde 5 derece fleksiyon kontraktürü tespit edildi. Flep uygulanmış olan pulpaların ortalama statik 2 nokta diskriminasyonu 5,2 mm (3-8 mm) iken karşı tarafta ortalama 3 mm idi. Ortalama Semmes-Weinstein monofilament testleri flep uygulanmış olan pulpada 3.18 g (2.96 – 4.7 g) iken karşı tarafta 2.92 g idi.

Sonuç: Akut el yaralanmaları sonrası oluşan pulpa defektlerinin nörovasküler heterodijital ada flebi ile rekonstrüksiyonu fonksiyonel, estetik ve duyusal anlamda tatminkar sonuçlara sahiptir.

Anahtar Kelimeler: El travması, parmak ucu replantasyonu, fingertip reconstruction, heterodigital ada flebi, local arterli flep.

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Introduction

Pulp defect of the digit is a common condition in acute hand injuries often resulting in permanent damage to the pulp and potential loss of finger function. The Allen classification stands as the most widely used system for categorizing pulp defects.[1] This classification indicates that type 1 injury includes only the pulp; type 2 injury includes pulp and nail bed; type 3 injury indicates partial loss of the distal phalanx, and type 4 injury indicates injuries proximal to the lunula. Various techniques such as skin graft, pulp flaps such as Atasoy and Kutler flaps, pedicled homodigital/heterodigital island flaps, and free flap repair have been previously described.[2,3] These techniques are frequently used as a single-session reconstruction option in clinical practice.[4] The goal of reconstruction pulp defects is to address functional and sensory losses by creating a cosmetic pulp contour with high quality skin covering. The choice of treatment may vary based on the surgeon's experience, sociocultural factors and available resources.[5]

This retrospective study aims to present the sensory, functional and surgical outcomes of reconstruction using a neurovascular heterodigital island flap for digital pulp defects resulting from acute hand injury.

Patients and Method

All the procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. This study was approved by the Ethics Committee of the University Hospital (decision no: 781).

The study included 58 patients (42 males, 16 females) out of 124 patients who presented to our clinic with digital pulp defects due to acute hand injury between 2014 and 2022. The average age of the patients was 26 years (range:20-56 years). The exclusion criteria were as follows: presence of two or more finger injuries, diagnosis of microangiopathy due to diabetes mellitus, and peripheral vascular disease. Injury classification included Allen type 2 for 18 patients, type 3 for 33 patients, and type 4 for 7 patients (Table 1). Pulp defects were caused by crush injuries in 42 patients and sharp injuries in 16 patients. Thirty-four patients had thumb injuries, 9 patients had second finger injuries and 15 patients had third finger injuries. The average size of the pulp defect was 15 x 28 mm (range:12x22-24x35 mm). Patients with sharps injuries (n=16) underwent an operation on the same day, and patients with crush injuries (n=42) underwent an operation after preparation for reconstruction, involving intermittent debridement and antibiotic treatment, typically on the fifth day on average (range:2-10 days).

***Surgical Technique**:* All the patients underwent surgery under general anesthesia with the application of a tourniquet. The initial stage involved debridement of the recipient site in crush injury patients. The defect and the finger flap donor site were identified. The flap was neurovascularly elevated and freed up to the common digital artery and nerve dissection site. A Bruner-type incision was performed up to the recipient finger with tissue defect site, and the bed of the pedicle was prepared. The flap was transferred to the recipient finger with the pedicle, and flap setting was performed. In all patients, the donor site was repaired with full-thickness skin graft from the inguinal region. All the patients were hospitalized for an average of 48 hours (24-72 hours) for circulatory monitoring and administered antibiotic therapy.

Statistical Analysis

IBM SPSS V25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was used for the statistical analysis of the study. Before statistical analyses, Shapiro Wilk/ Kolmogorov Smirnov tests were run to determine whether or not continuous variables were normally distributed according to categories. Descriptive characteristics were expressed in number (n) and percentage (%) for categorical variables and mean, standard deviation, and median for continuous variables by using the appropriate measures of central tendency. Independent sample t-test/Mann-Whitney U test was run for the mean/median comparison of two independent groups. The statistical significance was assessed at a significance level of $p<0.05$.

Results

None of the flaps administered to the participating patients developed total loss. Partial loss on the distal side of the flap was observed in three patients. One patient with partial loss achieved secondary recovery while two

Table 1. Table of patients' demographics

Allen classification	Number of people	Males/Females	Age
TIP II	18	12/6	26(20—50) years
TIP III	33	25/8	27(20-56) years
TIP IV	7	5/2	25(20-33) years

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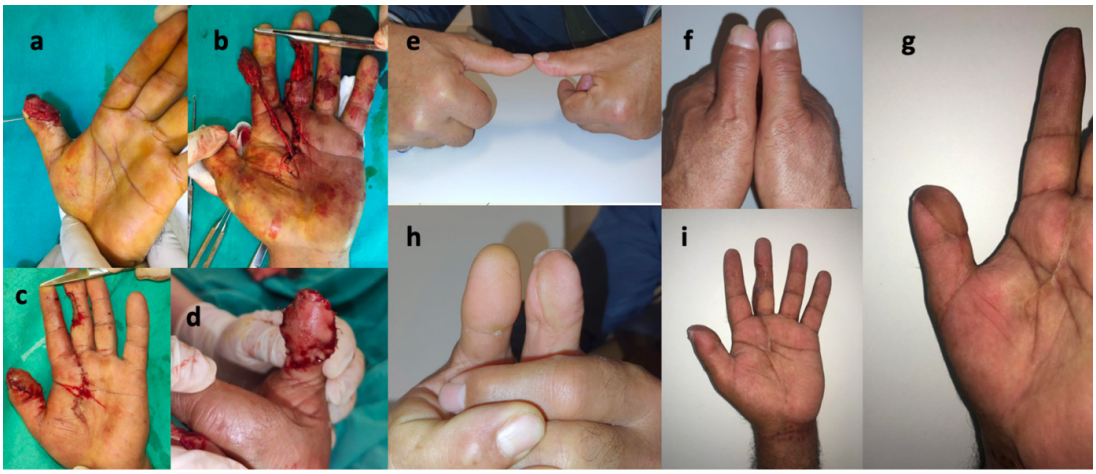

Figure 1. 45 years old male patient a) Left hand thumb Allen type 2 sharp injury b) Raise of neurovascular heterodigital island flap form third finger radial side c,d) Postoperative view e,f,g,h,i) Postoperative 6th month view.

other patients administered additional repair with a partial thickness skin graft. Superficial tissue infection was identified in six patients, and recovery was achieved with parenteral antibiotics. Two patients exhibited hyperpigmentation and hyperesthesia that did not affect their daily lives (Figure 1).

The patients were followed up for an average of 12 months (range:6-23 months). In the last follow-up, finger interphalangeal (IP) joint ranges of motion were compared to those of the contralateral fingers. One patient with Allen type 3 pulp defect was detected to have 10 degrees of flexion contracture in the distal IP joint and 5 degrees flexion of contracture in the proximal IP joint and 3 patients were found to have 5 degrees flexion contracture only in the distal IP joint ($p>0.05$). The rest of the patients achieved a full range of motion. In two patients with wide pulp tissue defect with Allen type 2 injury, pincher nail deformity was detected while hook nail deformity was identified in 2 other patients only. Sensory examinations of the flaps were conducted using the static two-point discrimination test and Semmes-Weinstein monofilament test comparing them with the contralateral finger. The mean static two-point discrimination of the pulps where the flap was applied was 5.2 mm (range:3-8 mm) on the flap side and it was 3 mm on the contralateral side. The mean Semmes-Weinstein monofilament test was 3.18 g (range:2.96-4.7 g) on the flap side and 2.92 g on the contralateral side ($p<0.05$).

Discussion

This study, reporting results of reconstruction of pulp defects using a neurovascular heterodigital island flap in patients with finger pulp defects, achieved favorable outcomes with low complication rates and high patient satisfaction. An evaluation of the patients, particularly in terms of sensory, functional, and aesthetic aspects, showed that two-point discrimination and DIP range of motion values were at a satisfactory level.

Pulps of the thumb, second and third fingers play a crucial role in functions requiring fine skills, such as squeezing and pinching. Consequently, injuries affecting these areas necessitate the preference for neurovascular flaps.[6] The literature has presented various flap alternatives for pulp defects; Atasoy, Kutler, free foot pulpa flap and Moberg are advantageous techniques in terms of the use of a single operation site and short surgery duration.[2,3,7] However, conventional procedures like these come with certain disadvantages. These flaps are limited in size and may not be suitable for large defects. They are the best options in defects with a pulp advancement requiring 10 to 15 mm size, yet complication rates increase in case of more advancement requirements. The most common complications include flap loss, sensation loss, residual pulp dystrophy, hook nail deformity, and flexion contracture in the distal IP joint.[8] In our study, up to 24x35 mm tissue defects were successfully reconstructed and yielded satisfactory results.

Reverse homodigital flap is a favorable reconstructive technique, yet its applicability is limited to small volar and tip defects. Free sensate flaps harvested from various regions such as the thenar, hypothenar, and flexor aspects of the wrist serve as excellent options for larger defects. More recently, innovative techniques, including toe-to-thumb and wrap-around flap, have gained widespread application. However, the utilization of free microvascular flaps is at times constrained due to extended operation time, heightened skill requirements, and potential donor site morbidity.[6,7]

The neurovascular heterodigital island flap was initially described by Littler.[9] After free flaps, it stands out the best alternative, particularly for large pulp defects. Flaps up to 3.5 cm in length can be raised for substantial volar and dorsal finger tissue defects.[10] No specific complica-

tions have been reported for neurovascular heterodigital island flap. Although the literature has indicated a small number of various complications in previous studies, Lai et al. identified total flap necrosis in two cases out of 52 reconstructed fingers.[12] Pham et al. reported no instance of total necrosis in their patients.[10] Similarly, the present study, also reported no total flap necrosis in any patients, but partial flap loss was noted in three patients.

While one of the patients who had partial loss had secondary recovery with dressing follow-up, two patients were additionally administered repair with partial thickness skin graft. Pham et al. reported a two-point discrimination between 6.2 mm on average in patients who underwent neurovascular island flap.[10] Chi et al. also reported that it ranged from 7 to 13 mm in patients who underwent radial artery superficial perforator branch free flap for digital injury reconstruction.[13] The mean two-point discrimination level was 5.2 on average in our study. The mean Semmes-Weinstein monofilament tests were 3.18 g (2.96 - 4.7 g) on the pulp administered flap and 2.92 g on the contralateral side. Flexion contracture is another complication reported in the literature. While one patient with Allen type 3 pulp defect in our study had 10 degrees of flexion contracture in the distal IP (interphalangeal) joint and 5 degrees of flexion contracture in the proksimal IP joint, three patients had 5 degrees of flexion contracture only in the distal IP joint. A full range of motion was achieved in the other patients. This complication is considered to be caused by excessive tension of the neurovascular pedicle especially in large defects. Other complications reported in the literature are hyperpigmentation, hyperesthesia, and contour deformity in the donor site.[10] As donor site morbidity, two patients in our study had hyperpigmentation and hyperesthesia that did not affect daily live.

If a repairable vessel is present, replantation can always be considered as an option.[11] When replantation is not possible, reconstruction should be planned. Advantages of heterodigital neurovascular island flap include simultaneous reconstruction of the soft tissue and providing excellent sensory and aesthetic restoration at the recipient site. Drawbacks of this technique encompass the necessity to sacrifice a digital artery from a donor digit, potentially leading to a temporary reduction in arterial flow and causing mild numbness of the dorsal surface of the phalanx.

The limitation of the study is that the absence of a control group impedes the analysis of comparative results. However, the low complication rate of the surgical technique and surgeon's experience may reduce the likelihood of errors in the conclusion.

Conclusions: Reconstruction of pulp defects following acute hand injuries with neurovascular heterodigital island flap has shown satisfactory outcomes in terms of functional, aesthetic and sensory improvement. Further studies are necessary to assess these results with a larger sample size and to compare them with other techniques.

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