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Immediate Reconstruction of Distal Thumb Amputations Using Reverse Homodigital Dorsoradial Flap and the Amputated Part of the Phalanx

Başparmak Distal Uç Ampütasyonlarının Revers Homodijital Dorsoradial Flep ve Falanksın Ampüte Kısmı Kullanılarak Erken Rekonstrüksiyonu

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ABSTRACT

Aim: The contribution of the thumb to hand function is indisputable. Treatment after an amputation injury should be aimed to restore the length, sensation, function and appearance of the thumb. This study aimed to present the surgical details and clinical outcomes of the reconstruction of the distal thumb amputations with a reverse homodigital dorsoradial flap using the amputated phalanx as a graft in heavy-duty workers, where functional gains are more prominent than appearance.

Materials and Methods: Eight patients who underwent reconstruction using reverse homodigital dorsoradial flap and the amputated part of the distal phalanx due to traumatic amputation at the distal thumb, between 2016 and 2019, were evaluated retrospectively in this study. At the final follow-up, static two-point discrimination, key pinch strength, interphalangeal joint range of motion and Quick Disability of the Arm, Shoulder, and Hand score were measured.

Results: Patients were analyzed. They had a mean age of 42.25 (range, 34-52) years and a mean follow-up of 20.4 (range, 16-24) months. At the final follow-up, the average static two-point discrimination was 7.5 (range, 6-9) mm. The mean injured side key pinch forces was 93% compared to the opposite side (range, 76-110%). All patients returned to their jobs.

Conclusion: It was concluded that the reconstruction of the thumb distal tip amputations with the reverse homodigital dorsoradial flap using the amputated phalanx should be considered as an alternative to other reconstruction methods in patients with low aesthetic expectations, or irreversible damage to the nail bed.

Keywords: Thumb, amputation, reconstructive surgery

ÖZ

Amaç: Başparmağın el fonksiyonlarına katkısı tartışılmazdır. Ampütasyon sonrası uygulanacak olan tedavi, başparmağın uzunluğunu, hissini, işlevini ve görünümünü eski haline getirmeyi amaçlamalıdır. Bu çalışmada, fonksiyonel kazanımların estetik görünümden daha önemli olduğu ağır işlerde çalışan ve başparmak ampütasyonu ile başvuran hastaların tedavisinde, ampüte falanksın greft olarak kullanılarak ters homodijital dorsoradial flep ile rekonstrüksiyon uygulamalarımızın klinik sonuçlarının değerlendirilmesi amaçlandı.

Gereç ve Yöntem: Bu çalışmada 2016-2019 yılları arasında distal falanksın travmatik ampütasyonu nedeniyle ters homodijital dorsoradial flep ve distal falanksın ampüte kısmı kullanılarak rekonstrüksiyon uygulanan sekiz hasta retrospektif olarak değerlendirildi. Son takipte statik iki nokta ayrımı, çimdikleme gücü, interfalangeal eklem hareket açıklığı ve Hızlı Kol, Omuz ve El Sorunları anket skoru ölçüldü.

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Bulgular: Hastaların yaş ortalamaları 42,25 (dağılım 34-52) yıl idi. Ortalama takip süresi 20,4 (dağılım, 16-24) aydı. Son takipte, ortalama statik iki nokta ayrım ortalaması 7,5 (dağılım, 6-9) mm idi. Karşı taraf ile yüzdelik olarak karşılaştırılan çimdikleme güç ortalamaları %93 olarak saptandı (dağılım, %76-110). Tüm hastalarımız önceki işlerini fonksiyonel kayıp yaşamadan devam ettirebildiler.

Sonuç: Başparmak distal uç ampütasyonlarının, ampüte falanks greft olarak kullanılarak ters homodijital dorsoradial flep ile rekonstrüksiyonunun, estetik beklentisi düşük veya tırnak yatağında geri dönüşümsüz hasar olan hastalarda diğer rekonstrüksiyon yöntemlerine alternatif olarak değerlendirilmesinin uygun olacağı sonucuna varıldı.

Anahtar Kelimeler: Başparmak, ampütasyon, rekonstrüktif cerrahi

INTRODUCTION

In the treatment of thumb amputations, replantation is considered as the best treatment method. Although many patients have the chance for replantation, some patients do not have arterial and venous structures suitable for replantation, especially in amputations distal to the interphalangeal (IP) joint level. Many reconstruction methods have been described for the treatment of distal thumb amputations when replantation is not possible[1].

Treatment of the amputations distal to the IP joint with reconstruction methods is still controversial. Many factors affect the decision on treatment. In addition to some factors such as the type of injury, patient-related factors and expectations (age, occupation, socioeconomic level, cultural habits of the patient), the surgeon's experience also determines the treatment option[1-5].

For the distal amputations involving the phalanx of the thumb, in order to achieve better functional and aesthetic results, transfer from toe to thumb is one of the most effective reconstructive treatments. This technique allows to achieve the length and sensibility of the thumb and an aesthetic appearance[1,2,5,6]. Another reconstruction method in which the amputated part of the distal phalanx and the nail bed is used as a graft with flaps has been performed for many years[7-10].

The most important point that determines the favorable outcome of the applied treatment for the patients is to decide which treatment method should be chosen in the first place. After a good evaluation of the patients, the treatment should be decided after being informed about the treatment options that can be applied in line with their expectations and needs[6,11].

This retrospective study aimed to present the surgical details and clinical outcomes of the reconstruction of the distal thumb amputations with a reverse homodigital dorsoradial flap using the amputated part of the distal phalanx as a graft in heavy-duty workers where functional gains are more prominent than appearance.

MATERIALS AND METHODS

Eight patients who underwent immediate reconstruction using reverse homodigital dorsoradial flap and the amputated part of the distal phalanx due to traumatic amputation at the distal thumb, between 2016 and 2019, were retrospectively evaluated in this study. The study was approved by the University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital of Local Ethics Committee (protocol no: 2718, date: 10.03.2020).

All of the patients were male and their mean age was 42.25 years (range 34-52 years). Our study group consisted of patients who had no previous hand injury, worked in heavy industry, and had type 1c amputation injuries according to the Merle classification[6,12]. Patients treated with replantation or one of the other treatment options were excluded from the study.

At the final follow-up, static pinch force was measured with key pinch grip using a pinch gauge (Baseline Pinch Gauge, Alimed Corp., Dedham, MA, USA) and the percentage was determined by comparing with the contralateral side. Range of motion of the IP joint was measured clinically with a goniometer. Functional evaluation was performed using the Quick Disabilities of the Arm, Shoulder, and Hand (DASH) score and patients were asked to evaluate their satisfaction with thumb functions subjectively, as excellent, good, fair, or poor. Sensorial return was evaluated by a static two-point discrimination test. Bone healing was evaluated radiologically. Patient data and surgical details are summarized in Table 1.

Surgical Technique

Detailed interviews and briefings were held with all patients, including the treatment options that could be applied in line with their expectations. The type of anesthesia to be applied was decided by the anesthesiologist after the evaluation of the patients. All patients underwent surgery within the first 8 hours after injury.

Firstly, the injury was examined in terms of whether it was suitable for replantation or not. In patients who were not suitable for replantation, the reconstruction procedure was continued. All operations were performed under a pneumatic tourniquet inflated without using an esmarch bandage. Surgical loop magnification was used.

Soft tissues and the nailbed around the amputated phalanx were excised. Then, the amputated part was placed in the stump

and fixed with a K wire (Figures 1, 2). Before determining the flap dimensions, the required pedicle length was calculated by marking the pivot point in the middle third of the proximal phalanx. Subsequently, the flap sizes required for distal phalanx covering were measured and flap was drawn. The incision and lifting of the flap started from the proximal to the distal direction (Figure 3). The sensory collateral branch of the radial nerve, which was located close to the artery, was included in

Figure 1. Distal amputation of thumb

Figure 2. After soft tissues and the nailbed around the amputated phalanx were excised and fixed with a K wire to the stump

Figure 3. Required flap size drawn and dissection

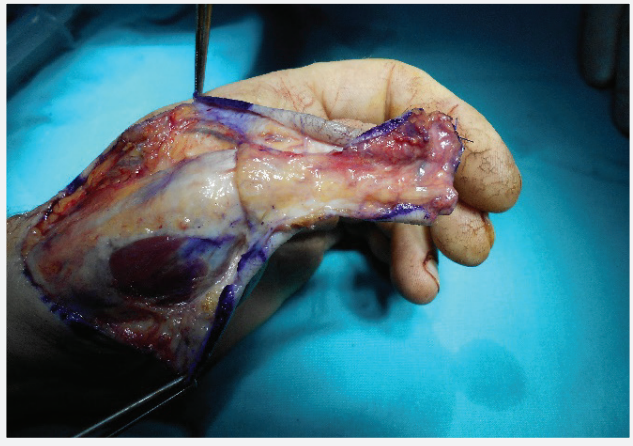

Figure 4. Flap lifting with the sensorial branch

Table 1. Patient data and surgical details

	Age (years)	Side of injury	Type of injury	Amputation level of distal phalanx	Donor site closing
Case 1	43	L	Avulsion amputation	Middle third	Primary
Case 2	48	R	Crush amputation	Base	FTSG
Case 3	38	L	Compression and pulling amputation	Middle third	FTSG
Case 4	52	L	Compression and pulling amputation	Middle third	FTSG
Case 5	45	R	Avulsion amputation	Middle third	FTSG
Case 6	34	L	Compression and pulling amputation	Base	FTSG
Case 7	40	L	Crush amputation	Middle third	FTSG
Case 8	38	R	Chain injury	Middle third	FTSG

FTSG: Full thickness skin graft, L: Left, R: Right

the flap. The skin incision was continued superficially along the pedicle line. Sufficient space was reserved for the pedicle to settle. The flap was lifted from the proximal to the distal direction. The pedicle was raised as wide as possible (Figure 4). At this stage, the tourniquet was opened and hemostasis was achieved. The distal wound was closed with the flap. A full-thickness skin graft was taken from the volar side of the wrist. The pedicle was covered with a full-thickness skin graft. The flap donor site was closed with a full-thickness skin graft or primary closure (Figure 5). Appearance of the thumb at the last control is shown in Figure 6.

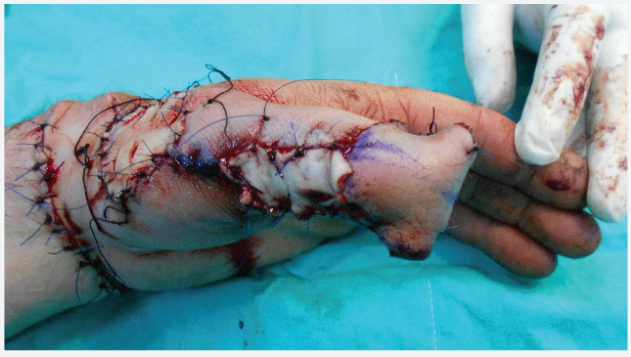

Figure 5. Phalanx was closed with the flap and donor area closed by skin greft

Figure 6. Appearance of the thumb at the last control

Postoperative Care

Postoperatively, a thumb spica splint (the wrist and thumb in neutral position, allows for finger motion) was applied. Oral antibiotics and analgesics were prescribed and the patients were discharged on the first postoperative day. The wound was checked weekly. Plaster splint was terminated in the 3rd week and aluminum finger splint was used to start wrist and metacarpophalangeal joint movement. The K wire was removed at an average of 5 weeks (range, 4-8 weeks) postoperatively. After the removal of the K wires, all patients were referred to rehabilitation. All patients were followed for at least 16 months.

RESULTS

The mean follow-up was 20.4 (range, 16-24) months. The dominant hand of all patients was the right side. Left thumb of 5 patients and right thumb of 3 patients were injured.

In the postoperative period, soft tissue infection developed in 2 patients at the thumb tip wound. Treatments with local debridement, wound care and antibiotic therapy were performed under outpatient clinic conditions. The K wire which was under the skin of a patient was removed with local anesthesia. No patient developed donor site complications and all flaps survived.

At the final follow-up, the mean Quick DASH score was 2.55 (range, 0-6.8). The mean static two-point discrimination was 7.5 (range, 6-9) mm. The operative side key pinch forces were 93% on average compared to the opposite side (range, 76-110%). The mean range of motion of the IP joint was 65^0 flexion and 3.75^0 extension. Bone resorption was observed in three of eight patients (37.5%). Five patients evaluated the

Table 2. The results of the distal thumb reconstruction

	Two point discrimination (mm)	Key pinch strength (% of contralateral side)	QuickDASH score	Range of motion (interphalengeal joint) (flexion/extension)
Case 1	6	90	0	65 / 10
Case 2	9	110	2.3	70 / 0
Case 3	7	85	4.5	60 / 5
Case 4	9	76	6.8	55 / (-5)
Case 5	7	100	4.5	65 / 5
Case 6	8	85	0	70 / 10
Case 7	7	88	0	70 / 5
Case 8	7	110	2.3	65 / 0
Average	7.5	93	2.55	65 / 3.75

Quick DASH: Quick Disabilities of the Arm, Shoulder, and Hand

final functional state of their thumbs as excellent and three patients as good. All patients returned to their jobs. One of the patients complained of pain with percussion and cold intolerance. The surgical results are summarized in Table 2.

DISCUSSION

Approximately 1% of all trauma admissions to the emergency department are amputation injuries and about 69% of all amputations are finger and thumb amputations[13]. Amputation of the thumb can cause up to 40% loss of hand function[14,15]. As a result of injuries, surgeons have focused on regaining this lost function and many methods have been defined over the years for thumb repair or reconstruction[6]. Following the first thumb replantation successfully performed by Komatsu and Tamai[16] in 1968, with the developments in microsurgery, more successful results started to be obtained over time and accordingly, the expectations of the patients increased[17,18].

The thumb is uniquely positioned to perform grasping and pinching movements due to its anatomical position in the hand. In order not to lose this functionality after amputation, durability, sensation, stability, length, and mobility should be gained with treatment. In parallel with patient expectations, aesthetic appearance should not be ignored[15,18].

Amputations involving 1/3 of the thumb, distal to the IP joint, are referred to as the "compensated amputation zone" in the literature. In distal amputations, functional loss can be tolerated more easily than proximal amputations, and for this reason, it is not always necessary to reconstruct the length. It is often sufficient to provide soft tissue coverage without causing further shortening. Secondary healing, full thickness skin grafts, advancement flaps and other homodigital or heterodigital flaps may be preferred depending on the condition of the injury[4,6,18-20].

Although thumb distal amputations are more tolerable, functional and aesthetic deficiencies may occur, especially in injuries with bone loss close to the IP joint. In order not to encounter unfavorable results in people with high aesthetic and functional expectations, treatment should be decided according to patient condition. In such cases, replantation should be preferred first, and in cases where replantation is not possible, treatment with reconstructive methods should be planned[1,5,6,11,18].

Thumb injuries occur in many patients at work. The majority of these patients are manual workers. Grip strength and pinch ability are important for their job and also finger sensation is very important to prevent re-injury[1,5]. The patients in our study were all manual workers. For this reason, it was important not to lose their functional and tactile skills. Replantation was not attempted in any patient, since the amputated part was not suitable for replantation. Reconstruction was performed with a homodigital dorsoradial flap using the amputated phalanx as a graft. Our main aim in realizing this method was to protect the thumb's length as much as possible and to ensure the sensitivity of the thumb tip.

Reconstruction of the distal thumb using a free great toe flap is considered to have functional and aesthetically pleasing results. Many great toe transfer techniques have been described for the distal thumb reconstruction[5,6,21-25]. On the contrary, the necessity of distal thumb reconstructions is still controversial and some of the surgeons have concern about performing such a complicated surgical procedure[2-6,23,26]. Moreover, the risk of free flap failure is the primary reason that the patients do not accept this surgery. Prolonged hospital stay and risk of donor foot functional impairment are among the reasons mentioned[27]. None of the patients in our study group had a hospital stay longer than 24 hours, they had no complaints about the donor site, and necrosis did not develop in any flap.

In another reconstruction method in which the amputated part of the distal phalanx and nail bed are used as grafts, it is aimed to provide revascularization of the dead bone and nail bed with flaps. Good results have been reported in the literature regarding this method that can restore length and appearance. In reconstructions with this method, many different flap techniques have been used to provide revascularization[7-10]. The reason we prefer a reverse homodigital dorsoradial flap is that it contains a sensory branch, it can be taken wide enough to cover the entire bone surface, it does not affect the other fingers, and the donor site can be easily restored[28,29].

Bone resorption is one of the complications that can be seen in reconstructions with avascular bone grafts. Dubert et al.[30] reported that bone resorption developed in all patients in the treatment results of distal tip amputations, which they used amputated nail bed and bone as a graft with homodigital neurovascular anterograde island flap[30]. In this study, cold intolerance was seen at the rate of 67%. Han et al.[9] published the results of distal thumb reconstruction using the amputated part of the thumb with the homodigital dorsoulnar flap. In this method, the amputated nail bed and phalanx were used together as graft for reconstruction and they included the periosteum in the flap to support revascularization to prevent the development of resorption. They reported minimal bone graft resorption according to the 6-month follow-up[9]. In this study, they reported a two-point discrimination mean of 9.9 mm. In our study, bone resorption was seen in three patients of eight (37.5%) and the mean two-point discrimination was 7.5 mm.

Yang et al.[21] reported that bone resorption developed in all 15 patients in the free great toe wrap-around flap method, in which they used bone graft from the iliac crest. As a result of this study, they stated that the probability of bone resorption

increased with longer graft use[21]. The expectations of the patients in our study were not for appearance, but for not experiencing functional loss. Volume of the distal phalanx of the thumb was larger than the other fingers and we have concluded that the probability of bone resorption would be high if the phalanx is used as a graft in thumb injuries where the distal phalanx is amputated close to the level of the IP joint. Based on these, we decided to debride all soft tissues including the nail bed from the amputate phalanx and enclose the bone graft completely with the flap to increase the bone revascularization. The purpose of choosing such an application was to minimize the development of bone resorption. However, bone resorption developed in three of our patients. The phalanx amputation levels of these patients were very close to the IP joint level, so they were reconstructed with a longer phalanx graft. Despite some length loss due to bone resorption over time, the patients did not have any functional complaints while doing their job.

Aesthetic appearance is important among the gains of distal thumb reconstructions. Del Piñal et al.[5] evaluated cosmetic results with visual analog scores in patients who underwent reconstruction with free great toe transfer and achieved an average score of 9.5 (range, 8-10)[5]. To improve aesthetic results, the nail bed must be reconstructed. However, functional outcomes were much more important than aesthetic concerns in our patients. Consequently, we could not perform this because we aimed to cover more bone surfaces with vascularized tissue instead of reconstructing the nail bed. None of our patients complained about their aesthetic appearance. Also, the patients were informed before the surgery that the nail beds would be irreversibly removed at the surgery.

In the evaluations of our patients at their last follow up, all of them were able to return to their pre-injury works. All flaps survived and necrosis was not seen. The mean Quick DASH score was 2.55. Five patients subjectively evaluated the final functional state of their thumbs as excellent and three patients as good.

Study Limitations

The main limitations of our study are the small sample size, retrospective design, and lack of control groups.

CONCLUSION

It was concluded that the reconstruction of the thumb distal tip amputations with the reverse homodigital dorsoradial flap using the amputated phalanx should be considered as an alternative to other reconstruction methods in patients with low aesthetic expectations, or irreversible damage to the nail bed.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Şişli Hamidiye Etfal Training and Research Hospital of Local Ethics Committee (protocol no: 2718, date: 10.03.2020).

Informed Consent: Consent form was filled out by all participants.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: N.C., Ö.F.K., Concept: N.C., M.K., Ö.F.K., H.M.Ö., Design: N.C., M.K., Ö.F.K., H.M.Ö., Data Collection or Processing: N.C., M.K., Ö.F.K., Analysis or Interpretation: N.C., M.K., Ö.F.K., H.M.Ö., Literature Search: N.C., M.K., Ö.F.K., Writing: N.C., M.K., Ö.F.K.

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