



Clinical Results of Minor Upper Extremity Replantation and Revascularisation Patients in Comparison to the Literature: A Clinical Study

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Abstract

Objectives: To evaluate the minor upper extremity replantation and revascularisation cases and to compare the clinical results with those in the literature.

Materials and Methods: Our study covers upper extremity trauma repair operations of 35 fingers of 30 patients who received treatment in our clinic between 2008 and 2011 date. The total number of amputated fingers that underwent replantation was 15 (of 15 patients) while 20 fingers of 15 patients underwent revascularisation operation for amputated fingers. We have conducted a retrospective study of the early period results of patients, who have been followed for an average of 17 months (6 months - 3.5 years).

Results: The survival rate for replantation cases was 93.3%; this rate was 80% for revascularised fingers. The survival rate for zone 2 injuries was 66.6%; the survival rate for zone 3 injuries was 92.3%. The survival rate for guillotine type injuries was 100% of the; this rate was 68.8% for crush and avulsion type injuries. The evaluation of functional results based on Chen criterion and in terms of injury patterns has shown that 89.9% of guillotine-type incision patients showed very good results while 33.3% of the crush and avulsion type injury patients returned with very good results as 44.4% of these patients showed moderate results. The statistical evaluation of the functional outcomes of the distal parts showed better improvement in guillotine-type injuries compared to crush and avulsion type injuries.

Conclusions: Minor replantation and revascularisation operations are difficult and require various equipments. Our results are compatible with the literature in terms of the large replantation series.

Keywords: Replantation; Revascularization; Total-Subtotal Amputation.

Üst Ekstremitte Minör Replantasyon ve Revaskülarizasyon Yapılan Olguların Klinik Sonuçlarının Literatürle Karşılaştırılması: Klinik Bir Çalışma

Özet

Amaç: Üst ekstremitte minör replantasyon ve revaskülarizasyon uygulanan hastaların klinik sonuçlarının değerlendirilip literatür ile karşılaştırılması amaçlandı.

Gereç ve Yöntem: Kliniğimizde 2008–2011 tarihleri arasında üst ekstremitelerin’de travma sonucu total veya subtotal amputasyon oluşan 30 hastanın 35 parmağı ameliyat edildi. Total ampute 15 hastanın 15 parmağına replantasyon, ve subtotal ampute 15 hastanın 20 parmağına revaskülarizasyon yapıldı. Tedavi edilen tüm hastaların erken dönem sonuçları ile ortalama 17 ay (6 ay – 3.5 yıl) izlenen 28 hastanın 30 parmağı retrospektif olarak incelendi.

Bulgular: Erken dönem sonuçlar incelendiğinde, yaşama oranları; replantasyon yapılan parmaklarda %93,3, revaskülarizasyon yapılan parmaklarda %80 olarak saptandı. Zon iki seviyesindeki yaralanmalarda yaşama oranı %66,6 iken zon 3 seviyesindeki yaralanmalarda %92,3 idi. Giyotin tipi yaralanmalarda ise %100 yaşama oranı mevcut iken, ezilme- avülsiyon tipi yaralanmalarda %68,8 olarak bulundu. Yaralanma şekillerine göre fonksiyonel sonuçlar Chen kriterlerine göre değerlendirildiğinde, giyotin tipi kesi ile yaralanan olguların %89,9’unda çok iyi-iyi, ezilme ve avülsiyon tipi kesi ile yaralanan olguların %33,3’ünde çok iyi-iyi, %44,4’ünde orta sonuç bulundu. Yapılan istatistiksel değerlendirmede giyotin tipi kesilerle yaralanan olguların tedavi sonrası distal parçalarda yaşama oranları ve fonksiyonel sonuçlarının ezilme ve avülsiyon tipi yaralanmalara göre anlamlı olarak daha iyi olduğu bulundu.

Sonuç: Minör replantasyon ve revaskülarizasyon uygulamaları teknik olarak zor ve donanımlı ekip gerektirmektedir. Replantasyon sonuçlarımız literatürle uyumlu olup daha geniş serili çalışmaların gerektiği kaçınılmazdır.

Anahtar Kelimeler: Replantasyon; Revaskülarizasyon; Total-Subtotal Amputasyon.

INTRODUCTION

Hands are one of our most-used organs in everyday life. Inability to use hands for any reason greatly affects daily life as well as work life. Man recognises much of the substantial world through sense of touch. It is only by using our hands can we understand if an object priorly

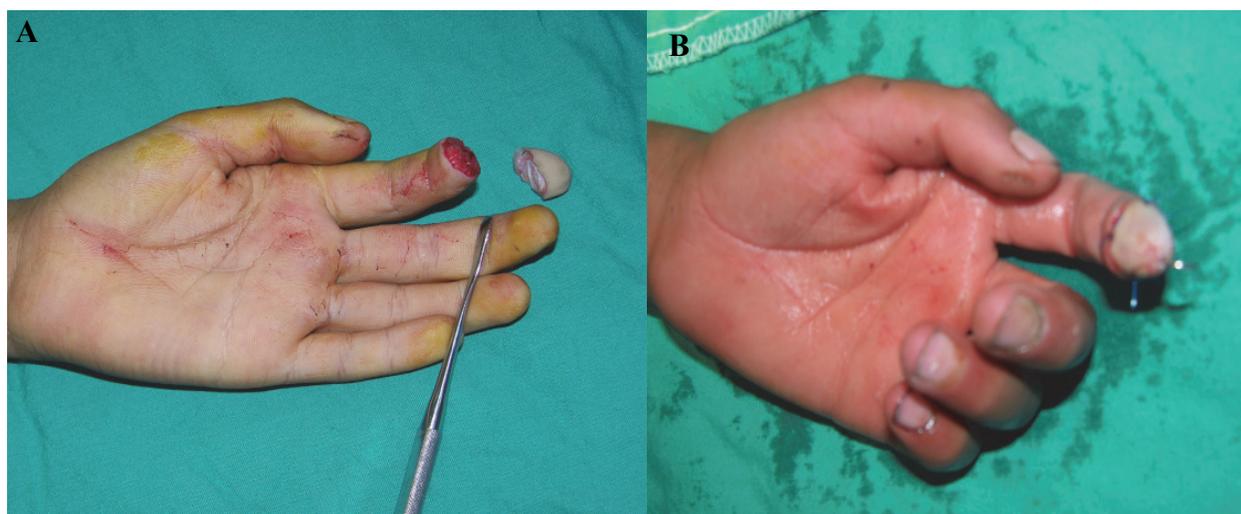
unknown to us is slippery, rough, sticky, elastic, or hard. Unfortunately, this valuable part of our body is faced with constant danger in everyday life. The most important of such risks are amputation injuries including rupture. Microsurgery, which refers to surgeries in which surgical field is magnified by using a surgery microscope and delicate surgical instruments are used, has been a groundbreaking development for surgical procedures.

Many surgeries which were formerly considered impossible before the introduction of microsurgery have now become routine interventions performed in many countries of the world (1). The possibility of repairing vessels with diameters smaller than 1mm along with restoring thin peripheral nerve fascicles with the help of microsurgical techniques have enabled partitioners to achieve successful replantations (rejoining severed extremities), one of physicians's historical aspirations, which has turned out to be an important development in medicine (2). While sewing amputated hands, arms, fingers, feet, etc. back restores bodily functions, the current techniques like replantation, revascularization, and reconstructions also give successful results in addition to amputation, the sole option for injuries like heavy fragmentation and avulsion in the past. The

present study aims to compare the literature with the results obtained by our retrospective analysis of patients who underwent minor upper extremity replantation and revascularization between 2008-2011 in our clinic.

MATERIALS and METHODS

Between March 2008 and June 2011, we operated 35 fingers of 30 patients patients due to total or subtotal amputation following upper extremity trauma. We performed physical examination for all the patients to evaluate the overall situation. We also investigated the presence of pathologies related to other systems that may have been affected in the same accident. We also evaluated the amputation stumps and distal parts of each patient (Figures 1A, 1B).



Figures 1A and 1B. (A) Guillotine-type total amputation; (B) Post-replantation image of the same patient.

We took two-sided radiographs showing both sections. The injured organs were then photographed and archived. According to the findings obtained and in accordance with the type of injury, cases with total amputation were taken to the operation room for replantation while patients with subtotal amputations underwent revascularization operation. The functional outcomes of patients were assessed according to the Chen criteria and level of injury (Table 1).

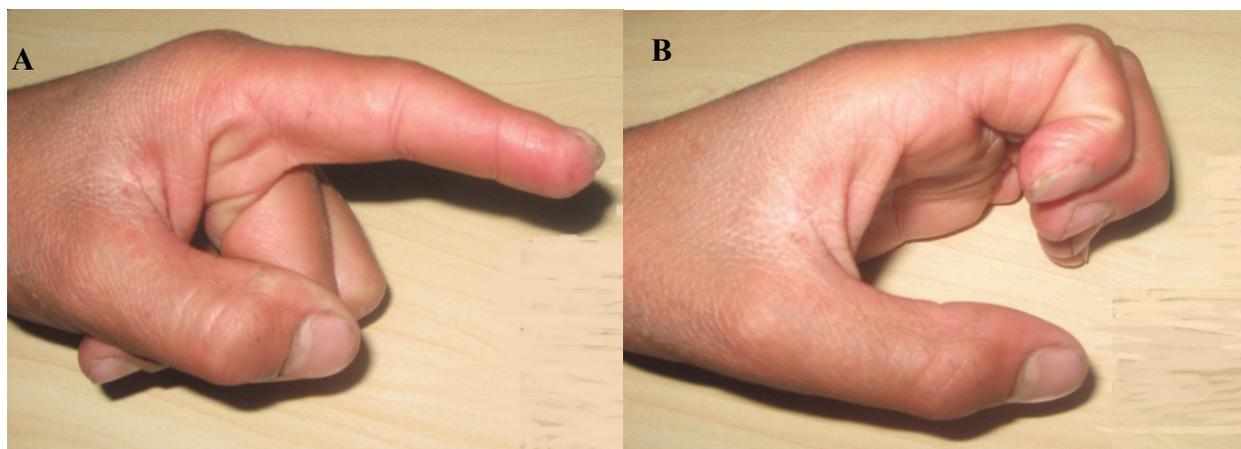
The patients underwent the most suitable surgical techniques: 12 patients who had an appropriate fasting period were operated under general anaesthesia while 18 patients were operated with axillary blockade. Using pneumatic tourniquet at the arm level, the injured extremity was washed at the proximal of the stump level; then we performed the exploration, debridement, and marking of the tissues. For the replantations, we followed the following procedure: exploration, marking neurovascular structure, debridement, bone shortening, bone fixation, extensor tendon repair of flexor tendon repair, artery repair, nerve repair, and repair and the

proposed order was complied with in the form of covering the wound (3). We performed bilateral incision in all replanting cases as we did so in the majority of the revascularized cases; we preferred unilateral midlateral incision in some cases.

In injury at the joint level, we performed primary arthrodesis in the proper position for the joint. For the flexor and extensor tendon repairs, we used 3-0, 4-0 PDS (polydioxanone) sutures with the modified Kessler technique in accordance with the level and thickness of the tendon. We repaired the lateral bands in zone 3 injuries (4). We administered the Pull-Out technique in some of the zone 2 flexor tendon repairs (5). According to the type of injuries in flexor tendon laceration in zone 3, we sometimes repaired one of the legs of flexor digitorum superficialis (FDS) and at times both legs. In some cases, we only repaired the flexor digitorum profundus (FDP) tendon. The unrepairable superficial flexor tendon tips were excised. Artery, vein, and nerve repairs were carried out by using a surgery microscope at 24x magnification (Figures 2A, 2B).

Table 1. Functional results of patients undergoing replantation and revascularisation.

No	Age	Level of injury	Type of injury	ROM (%)	Motor (M)	Sensual (S)	Results (Chen)
50		Zone-3	Guillotine	75	M4	S4	Very good
20		Zone-3	Crush	25	M2	S1	Bad
11		Zone-2	Guillotine	95	M5	S4	Very good
6		Zone-3	Guillotine	90	M4	S4	Very good
7		Zone-2	Crush	90	M5	S4	Very good
9		Zone-2	Crush	70	M4	S3+	Very good
34		Zone-3	Avulsion	35	M3	S3	Moderate
4		Zone-3	Guillotine	85	M4	S4	Very good
46		Zone-2	Guillotine	85	M4	S3+	Very good
20		Zone-3	Guillotine	85	M4	S3+	Very good
2		Zone-2	Guillotine	50	M3	S3+	Good
60		Zone-3	Crush	55	M4	S3+	Good
27		Zone-3	Guillotine	35	M3	S3	Moderate
17		Zone-3	Crush	30	M3	S2	Moderate
26		Zone-2	Guillotine	90	M5	S3+	Very good
23		Zone-3	Guillotine	85	M4	S3+	Good
27		Zone-3	Guillotine	80	M4	S3+	Good
38		Zone-3	Guillotine	65	M3	S3+	Good
13		Zone-3	Guillotine	60	M4	S3+	Good
46		Zone-3	Crush	40	M3	S3	Moderate
32		Zone-3	Guillotine	100	M5	S3+	Very good
35		Zone-3	Crush	10	M2	S1	Bad
32		Zone-3	Guillotine	35	M3	S3	Moderate
38		Zone-3	Crush	30	M3	S2	Moderate
8		Zone-3	Guillotine	60	M4	S3+	Good
22		Zone-3	Guillotine	55	M4	S3+	Good
29		Zone-3	Guillotine	50	M4	S3+	Good
23		Zone-3	Guillotine	60	M3	S3+	Good

**Figures 2A and 2B.** (A-B) Functional abilities in the latepost-operative period.

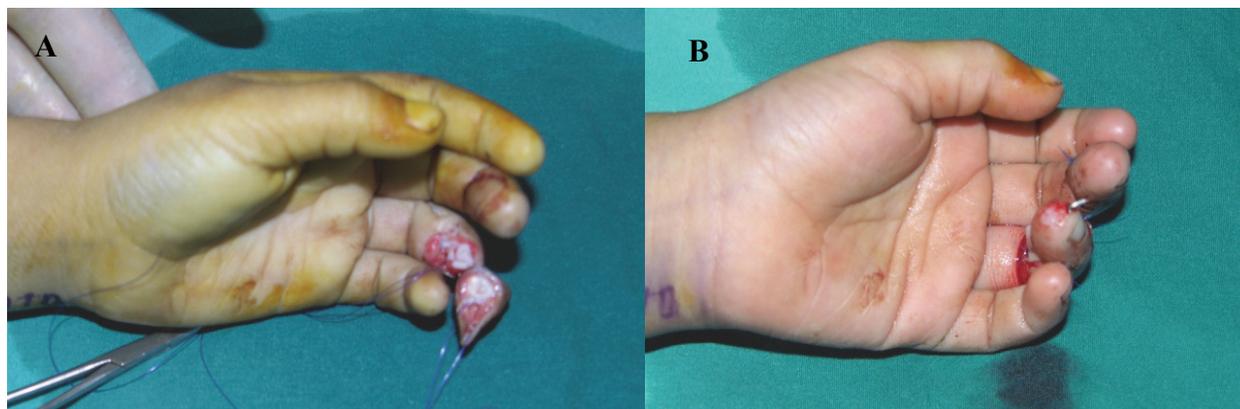
RESULTS

We performed replantation for 15 fingers and revascularization for 20 fingers of a total of 30 patients. 42.9% of the patients underwent replantation while 57.1% of the patients underwent revascularization surgery.

The average age of patients was 26 (2-60); 64% of the patients were between 21-40 years of age. According to the mechanism of injury, the patients with total and subtotal amputations were admitted due to the

following reasons: 16 fingers of 14 cases due to cuts from a variety of agricultural and construction machinery; 17 fingers of 14 cases due to injuries from sharp objects like ax, knife, chopper, and glass; 2 fingers of 2 patients due to finger sawmills incision. Injuries were on the right side in 18 (60%) patients and on the left side in 12 (40%) patients. In 19 (63.3%) of the patients the affected part was the dominant side.

As for the general evaluation, a total of 30 (85.7%) fingers were cured — 15 of the 14 (93.3%) replanted fingers; 16 of the 20 (80%) revascularized fingers — while the remaining 5 (14.3%) were lost (Figures 3A, 3B).



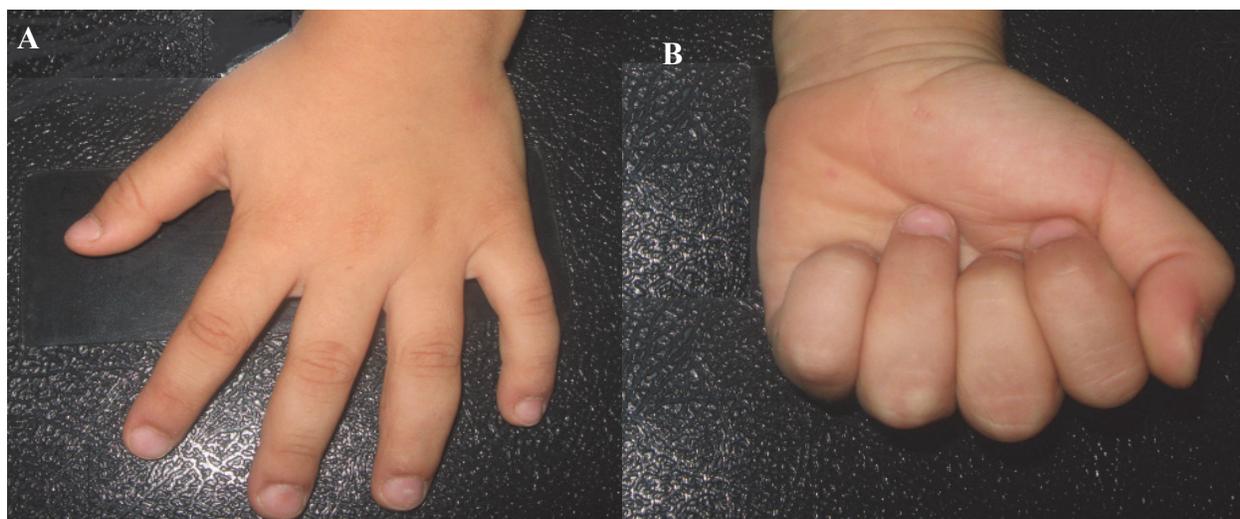
Figures 3A and 3B. (A) Subtotally amputated finger; (B) View of the finger after revascularisation.

In the evaluation for the level of injuries, we observed that 6 of the (66.6%) 9 fingers with zone 2 injuries survived while 3 (33.3%) of these fingers were lost; 24 of the (92.3%) 26 fingers with zone 3 injuries survived though 2 (7.7%) of these fingers were lost. The statistical analysis of the obtained ratios showed that there was a significant difference between the survival rates of zone 2 and zone 3 injuries ($p < 0.05$).

In the assessment for the type of injuries, we found out that all 19 of the (100%) 19 fingers with guillotine type injuries, 10 of the (66.6%) 15 fingers with crushing type injuries (though 5 (33.3%) of these fingers were lost), and 1 finger with avulsion type

injury survived. The statistical analysis of these ratios showed that there was a significant difference between crushing type amputations and guillotine type amputations ($p < 0.05$).

The assessment of whether distal parts were fully ruptured showed that 14 of the (93.3%) 15 fingers undergoing replantation survived while 1 (6.7%) of these fingers was lost; 16 of the (80%) 20 fingers undergoing revascularisation survived while 4 of these (20%) fingers were lost. The statistical analysis of the obtained ratios showed that there was a significant difference between replantation and revascularisation cases ($p < 0.05$) (Figures 4A, 4B).



Figures 4A and 4B. (A-B) Functional abilities in the latepost-operative period.

Evaluating functional outcomes of the operations according to Chen's criteria, we observed the following results: evaluation of the results according to level of injury: 10 (35.7%) of the 28 patients who underwent minor treatments showed very good results while another 10 (35.7%) showed good, 6 (21.4%) showed moderate, and 2 (7.2%) showed poor results. Evaluation

of the functional results according to injury patterns showed that 8 (42.5%) of the 19 guillotine type injury patients showed very good results while 9 (47.4%) had good, and 2 (10.6%) had moderate results; 2 (22.2%) of the 9 crush-avulsion type cases showed very good results as 1 (11.1%) had good, 4 (44.4%) had moderate, and 2 (22.2%) showed poor results. In the evaluation

according to the type of distal part rupture, of the 5 (35.7%) of the 14 replantation cases had very good results while 6 (42.9%) had good and 3 (21.4%) had moderate results; of the 14 revascularisation patients 5 (35.7%) showed very good, 4 (28.6%) had good, three (21.4%) showed moderate, and 2 (14.3) had poor results.

The statistical analysis of the results showed no significant relationship between the functional outcomes of revascularisation and replantation cases ($p>0.05$).

DISCUSSIONS

Success of replantation and revascularisation depends on discipline and order of the applied surgery. To reduce ischemic time in major vascular applications, there is a complete consensus on the necessity to perform vascular repair first (1, 6, 7).

Goldner and Urbaniak argue that use of tourniquet can alone help achieve a bloodless view and reduce blood loss and that is why artery repair should be performed first (8, 9). Biemer states that, if needed, both of the digital arteries in the fingers must be repaired using a graft; he further reports a 13.2% rate of thrombosis development in his series of 38 patients (10). Weiland, Goldner, and Urbaniak suggest administration of 3000-5000 IU of heparin intravenously applied in bolus during the operation in addition to the topical applications (11).

The evaluation of the survival rates of the distal parts according to types of injuries has shown that, guillotine type cuts have higher survival rates than crushing and avulsion type injuries. While Shenkler and Kleinert's overall survival rate in their series with 64 cases was 77%, the survival rate of their crushing and avulsion type injuries was 42% (12). Hamilton et al's series of 73 patients has reported a survival rate of 63% for crushing and avulsion type amputations (13). The same rate in Troums et al.'s study of 49 patients was 50% (14). In his report of a series of 149 patients, Scott has reported a survival rate of 79% for replantation cases and 97% for revascularisation cases, respectively (15). Blomgren et al.'s study has reported a survival rate of 71% in patients with replanted fingers and 92% for revascularisation cases (16).

In our series, the overall survival rate was 85.7%; the survival rate in guillotine type cuts was 100% while this rate was 68.7% in crush and avulsion type injuries. We think that the rates were higher in our study because we performed selective application in both guillotine type cuts and crushing and avulsion type amputations. One of the important factors affecting survival rate is the way the distal part is ruptured. In our series, we achieved a survival rate of 93.3% for replanted cases and of 80% in revascularized patients. We believe that our high success rates in replantation cases was a result the selective nature of our study as well as the anti-thrombosis treatment we administered after the operations.

Nerve repair technique in minor replantation or revascularisation operations is still a controversial issue.

Millesi, Goldner, and Urbaniak argue that the best method is the perineural (fascicles) repair technique (17). On the other hand, Snyder et al. claim that the perineural repair technique requires great deal of time and equipment; that suture line is not very durable against tension; and that, because suture materials placed into nerve may lead to formation of internal scars, epieneural neuroorrhaphy, rather than perineural repair technique, is the best repair technique (18). Akşamoğlu et al. argues that epiperineural neuroorrhaphy, which is similar to epieneural neuroorrhaphy, is the surgical method that saves time and helps fascicles improve in the expected direction (19). In the digital nerve repair of our patients, we adopted the epieneural repair technique suffused by Akşamoğlu et al. In this way, we both shortened operation time and achieved better functional results.

The duration for patients to return to work vary between 2-3 weeks to 6 months-1 year in various series. Kleinert, Morrison, Tamai, and Weiland have reported that the average time to return to work was in 5 months in their series (7, 11, 20). Urbaniak's series has reported that this period to be 2-3 months (9). Depending on the type and level of injury, the average time to return to work in our series was found to be 3,5 months. This is compatible with many of the series in the literature.

CONCLUSIONS

While minor replantation and revascularisation operations are technically difficult and require various equipments, results are gratifying. The most important factors affecting functional results are patients' age, amputation level, and mechanism of injury. Although success rates of replantation and revascularisation surgeries are fortunately increasing day by day, it is more important to prevent these injuries. For this, we believe that people should give importance to preventive medicine as much as they give importance to surgery.

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