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REPLANTATION OF THE FROSTBITTEN AMPUTATED DIGITS AND EVENTFUL POSTOPERATIVE COURSE: CASE REPORT

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ABSTRACT
Very little is written about replantation of frostbitten amputated parts due to exposure to very low temperature for extended periods. In this case report the amputated parts were placed directly on an ice pack and exposed the cold during transportation. This caused frostbite of the amputated parts. The replantation of frostbitten amputated digits was performed successfully but the postoperative course was eventful in which it was similar to that of frostbite injury including delayed dermal circulation and late vascular compromise. When these clinical manifestations were encountered frostbite treatment were applied to the digits and surgical debridement was reserved for late period. On long term follow- up both fingers were viable but resulting in partial tip tissue losses. In this case report author present replantation of frostbitten amputated digits, treatment approach and discuss the possible mechanism that cause eventful postoperative course.
Keywords: Frostbite, replantation, amputation

DONMUŞ AMPUTE PARMAKLARIN REPLANTASYONU VE POSTOPERATİF YAŞANAN SIKINTILAR

ÖZET
Uzun süre çok düşük dereceli ısı maruziyetine bağlı olarak donmuş olan amputadların replantasyonu ile ilgili çok az sayıda yazı mevcuttur. Bu olgu sunumunda amputadlar buz paketi üzerine konularak transport süresince soğuğa direkt maruz kalmışlar ve bu nedenle donmuşlardır. Donuk amputadların replantasyonu başarılı olarak uygulanmış, ancak postoperatif dönemde donuk hasarına benzer biçimde dermal dolaşımın gecikmesine bağlı sıkıntılar yaşanmıştır. Karşılaşılan bu durum karşısında parmaklara donuk tedavisi uygulanmış ve cerrahi debridman daha sonraya bırakılmıştır. Uzun süreli takipte her iki parmağın da yaşadığı, ancak tipte parsiyel doku kaybı olduğu izlenmiştir. Bu olgu sunumunda donmuş ampute parmakların replantasyonu, tedavi yaklaşımı sunulmuş ve postoperatif dönemde yaşanan sıkıntılar tartışılmıştır.
Anahtar Kelimeler: Donuk, replantasyon, amputasyon

INTRODUCTION

Various factors that influence the success of digital replantation, including the level of the amputation, type of injury, ischemia time, age, sex, blood transfusion and viscosity, have been described in the literature in great detail.[1-6] However, very little is written about the replantation of the frostbitten amputated digits and the effect of frostbite on replantation surgery.[7,8] Frostbite is an injury that results from exposure to temperatures that are low enough to cause crystal formation in exposed tissue.[9] Frostbite develops when the tissue is exposed to low temperatures (below-2 °C) for more than 1 hour.[9] In our case, the etiology of the frostbite was inappropriate preparation of the amputated digits for the transportation, where digits were placed directly on the ice pack and exposed the cold more than 7 hours.

In this report we present a case of replantation of the frostbitten amputated digits, which was followed by a complicated postoperative course. Also effect of the frostbite injury on the microcirculation of replanted digits is discussed.

CASE REPORT

This patient was a 21-year- old male. He sustained a complete amputation of his left thumb and index finger while using a hatchet while working in a kitchen. Immediately after the injury the patient was transferred to a local hospital which had no microsurgery facility. The surgeon of district hospital performed the first aid treatment and transferred the patient to our hospital. The patient arrived in our department 7 hours after the injury. The left thumb was amputated through the interphalangeal joint level and the index finger was amputated at the proximal mid phalangeal level. Both were guillotine type amputations (Fig-1). When the amputated parts were examined it was observed that these fingers were frozen solid. Amputated digits had been wrapped with moistened gauze but were placed directly on ice packs at the district hospital. Digits were exposed the cold (-2°C) for more than 7 hours. This caused frostbite of the amputated parts. Following the exploration, fingers were placed in ringer lactate solution Operation was done under general anesthesia with a two team approach. With the use of operating loupe the amputated digits were debrided carefully, nerves and vessels were identified and tagged with sutures. Thereafter appropriate bone trimming and shortenings were performed and then with one intramedullary K- wire bony fixation was performed. The ulnar digital artery of

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Figure 1: (A) Appearance of the amputated digits and left hand. **(B)** Appearance of the hand immideately after the replantation. Although thumb circulation restored immediately, dermal circulation did not restored in the index finger.

the thumb was anostomosed first and Dextran 40 at a rate of 35cc/hr was begun immediately after the arterial anastomoses were completed and continued for 5 days. The circulation was restored within minutes indicated by bleeding from the dorsal veins. This was followed by anastomoses of the radial digital artery and the dorsal vein. Later debridement and bony fixations were performed by the same manner on the index finger. First, ulnar digital artery of the index finger was anastomosed. Although a normal patency test, the circulation was not restored in the digit. This was followed by anastomosis of the radial digital artery, however circulation was still not restored although prior to the anastomosis there was adequate bleeding from the arteries with flawless surgical technique and a normal patency test. Even after an hour wait period there was no circulation, which was attributed to the frosbite injury. Later dorsal veins of the index finger were anastomosed followed by digital nerve and tendon repair in both digits. Although there was good circulation to the thumb a small piece of nail was removed to achieve better venous drainage and for monitorization. External heat with a lamp was applied immediately after the surgery.

Postoperative course of each operated finger was quite different from each other. The day after surgery circulation of the thumb was perfect, however, there was blister formation at the dorsal aspect of the amputated part. Color, temperature, and capillary refill as well as bleeding from nail plate were good. Doppler flow meter showed normal blood flow. However, at the index finger there was no capillary refill. The finger appeared yellowish white and was cold. Doppler flow meter showed no cutaneous blood flow. There were no changes at index finger except the color of the digit, which turned from yellowish- white to blue-gray, till the end of the second week and it was still hard (Fig-2). However blister formation extended distally on the dorsal aspect of the thumb and the color turned darker, bleeding from the nail plate was perfect but there was superficial infection on the replanted thumb. On postoperative day 16 the thumb circulation was compromised and bleeding from nail plate ceased and gradually the skin of the replanted thumb became dusky except the dorsal aspect of the thumb where the blister formed. Then a debridement was performed on the dorsal aspect of the thumb and viable tissue was observed on this part. During the next several days the color of the index finger gradually turned blue-gray to mottled, deep red and cyanotic and color changes extended proximally. However, consistently the index finger became edematous, softened and superficial blisters formed dorsally. At the end of the third week the skin slough was removed on the dorsal part of the index finger and surprisingly underlying tissue was completely viable on the index finger. Then we decided to treat expectantly and applied local wound care to the both fingers with vaseline gauze. During the fourth week the dorsal aspect of the index finger spontaneously epitelized and the volar aspect of the index finger gradually softened and a superficial blisters formed. At the end of fourth week, the skin slough on the volar aspect of the index finger was removed and the eschar tissue on the volar aspect of the thumb was partially debrided. Surprisingly, we encountered viable tissues on both fingers and decided to continue the wound care. We gave up the debridement and reserved it for late treatment. Except the tip of the digits where partial black eschar tissue formed, especially more on the thumb, replanted digit spontaneously epitelized leaving a patchy desepitelized area. The patchy desepitelized areas were grafted however graft take was 50% and eschar tissue was persistent at the tip of both fingers at the end of sixth week. We followed the patient for another 6 weeks with wound dressing. At the end of the postoperative 3 months we decided to debride the eschar tissue and close the wound with a local flap. During the operation the eschar tissue was superficial and came out easily leaving a small wound at the tip of fingers (Fig-3). These wounds spontaneously epitelized in the next 10 days leaving a small atonic wound at the tip of fingers. During the next 3 months the postoperative course was normal but the skin of replanted part was a little bit fragile and showed hypopigmentation. On radiographic examination the bone looked normal. At the end of the postoperative 12 months the patient had a light sensorial loss on the replanted parts he was able to use his fingers.

DISCUSSION

There were only a few articles about the replantation of frostbitten amputated parts due to exposure to very low temperature for extended periods.[7,8] Since the authors of

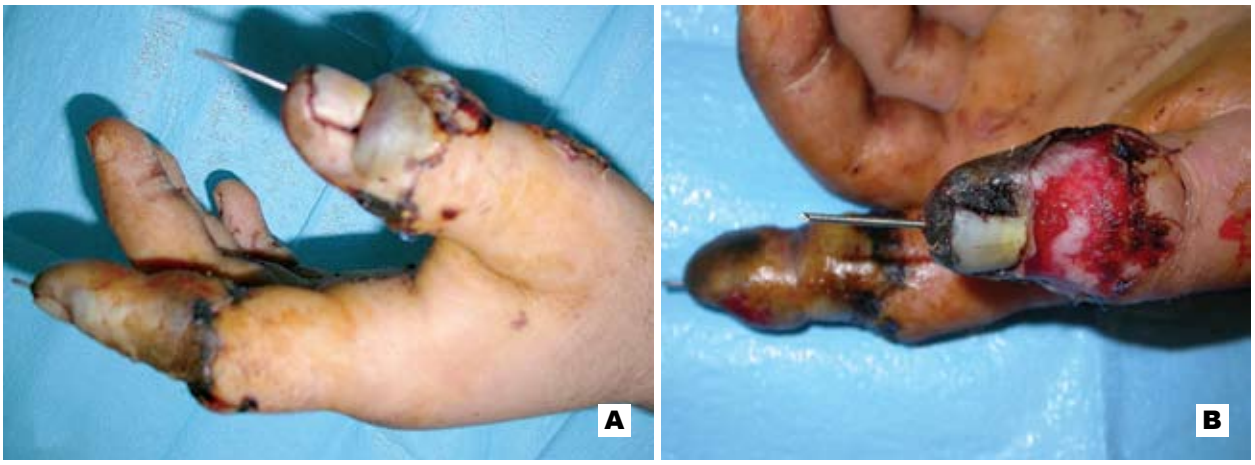

Figure 2: (A) Postoperative day14, the thumb circulation was perfect but the blister formed dorsal aspect of the digit, extended distally. In index finger, there was only color changes. **(B)** On postoperative day 16 the skin of the thumb became dusky and circulation was compromised. After the debridment of the dorsal aspect of the thumb viable tissue was observed.

these articles lived in frigid zone of China some of the amputated digits presented in the frozen state. In their series 17 digits of 11 cases were exposed to extremely cold temperatures and these digits were successfully replanted. Sixteen of the digits survived. However they gave very little information about the postoperative course of these fingers.

In our case the amputated parts were placed directly on an ice pack and exposed cold more than 7 hours. This caused a frostbite of the amputated parts. Following the replantation of the frostbitten digits, the postoperative course was similar to that of frostbite injury such as edema formation, presence of cyanosis, vesicles or bullea formation, delayed dermal circulation, vascular compromise and finally black, hard and consistently dry eschar formation. However, on long term follow-up both fingers were viable except the partial tip tissue loss where there was persistent eshcar formation.

Frostbite represents a spectrum of injuries where the severity ranges from irreversible cellular damage to reversible changes seen after rewarming.[9] The pathophysiology of frostbite involves various factors that lead to direct and indirect injury.[9-11] The freezing of tissues leads to formation of extracellular and intracellular ice crystals which cause direct cellular injury whereas the second type of damage involves indirect vascular injury believed to be caused by post thaw arterial vasoconstriction and microcirculatory damage leading to disordered vascular flow.[9-11] Direct endothelial damage due to freezing allows platelets to adhere to microfibril, the basement membrane and collagen.[12] This induces platelet trombaxene A2 synthesis - Prostanoids, thromboxane and prostaglandin- which are believed to play a role in microcirculatory collapse of frostbite injury.[12,13] The literature gives strong evidence that frostbite injury is largely caused by this microcirculatory collapse.[13-16] Microcirculatory damage results in tissue edema, hemorrhage, progressive thrombosis, circulatory stasis, ischemia, and eventual necrosis of the tissues.[9,11] In clinical practice the end result of microcirculatory damage could be seen as dermal ischemia and skin necrosis in 2-4 weeks after the frostbite injury. We believe that the vascular compromise seen in the thumb at the end of second week was the result of progressive dermal

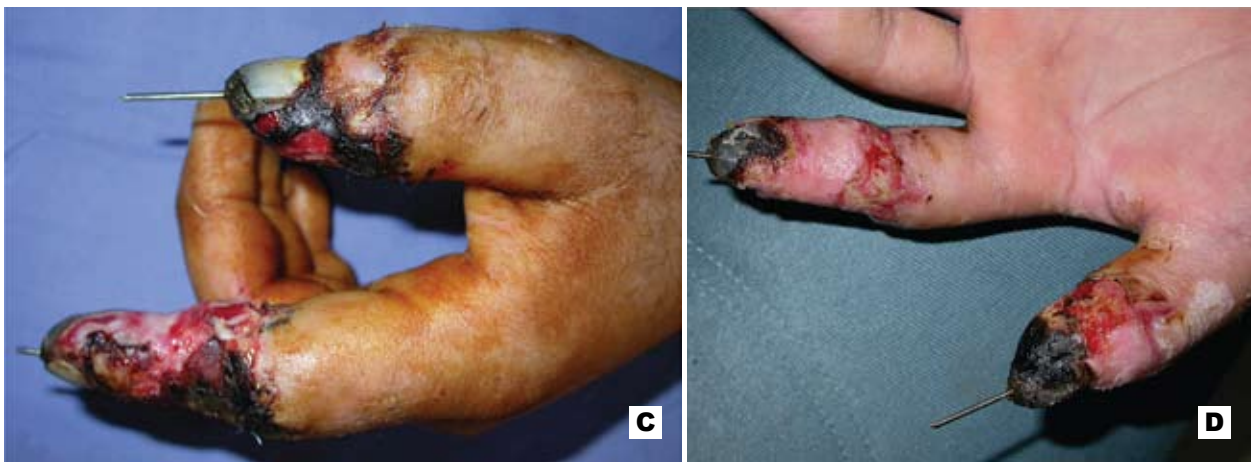

Figure 2: (C) During the next several days consistently index finger became little edematous, softened and superficial blisters were formed dorsally and volarly. After removal of the skin slough, surprisingly, viable tissue was observed on the index finger. **(D)** Except the tip of the digits where partial black eschar tissue formed, open wounds spontaneously epitelized leaving a patchy desepitelized area at end of the forth week.

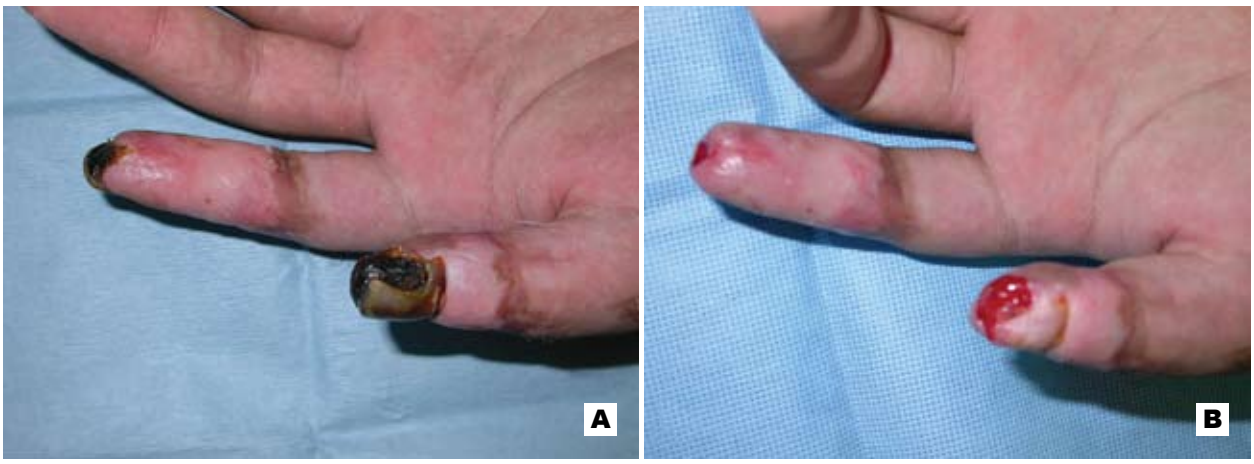

Figure 3: (A) Appearance of the replanted digits on postoperative 3- months. The replanted digits spontaneously epitelized, however, the eschar tissue was persistent at the tip of the fingers. **(B)** Appearance of the digits after debridement; the eschar tissue was superficial and came out easily leaving a small wound on the tip of fingers, which spontenously epitelized in next 10 days leaving a small atonic wound.

ischemia due to frostbite injury rather than anastomosis failure due to thrombosis. It was reported that the highest risk of critical thrombosis following finger replantation is in the first 3 days after surgery[5] and late failures (1 week after replantation) following replantation are infrequent.[6]

Although dermal circulation was restored in the early period in the thumb the postoperative course of the index finger was quite different from that of the thumb. In the index finger, dermal circulation was restored very late. In one of the articles that was about replantation of frostbitten amputated digits it was reported that the circulation of the frostbitten replanted finger was restored 17 hours after the surgery.[8] In our case this period was longer than that of their cases. This was probably due to different factors. In index finger time elapsed from rewarming to the replantation was longer than that of the thumb and this may be due to more endothelial cell damage than that of the thumb. It was shown that the endothelial cell injury begun during freezing and extending through early reperfusion.[14] This may explain excessive endothelial cell damage which leads to excessive microcirculatory collapse. In addition to this, prostanoids, thromboxane and prostaglandin, which were released into the systemic circulation after the thumb replantation, might be in high concentrations and this could be responsible for the deterioration of cutaneous circulation of the index finger which was replanted hours later than thumb. Other than this, neutrophil- endothelial cell adherence and neutrophil-neutrophil aggregation was also believed to cause microvascular damage in frostbite injury.[17,18] It may be speculated that previously stimulated neutrophil –following the thumb replantation- could deteriorate the neutrophil-endothelial cell interactions and neutrophil – neutrophil aggregation in the index finger which results in excessive microcirculatory collapse. Probably all these events could explain the delayed cutaneous circulation of the index finger.

Another question that should be answered is that although cutenous circulation was not restored in the early period, how did the index finger stayed viable? In Sumner's study it was shown that most of the capillaries were thrombosed and blood flow was maintained only from artery to vein through arterio-venous communications.[19] Thus while blood may continue to flow through the larger arterioles and venules, the tissues were not nourished. Since than we could not detect any cutaneous circulation in the early period while there

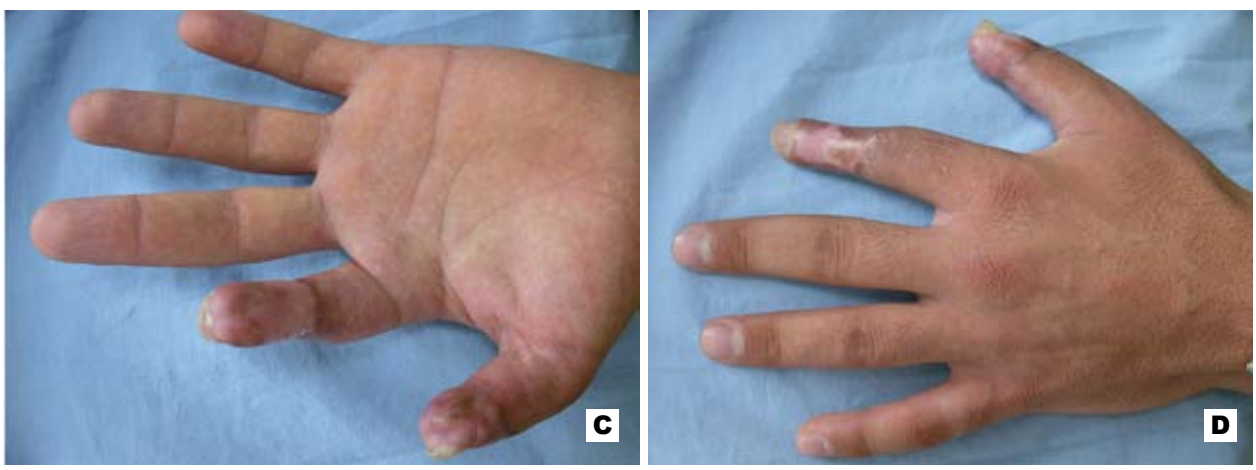

Figure 3: (C,D) Appearance of the replanted digits on postoperative 9- month.

was flow through the larger arterioles and venules. With time the waste products that caused this decrease in the systemic circulation and cutaneous circulation was restored but leaving patchy areas of necrosis.

All these events show similarity with that of secondary thrombosis.[20] Also there is a similarity between clinical signs of secondary thrombosis and that of our patients such as skin graft loss, eshcar formation, and superficial infection. Weinzweig and Gonzalez[20] discussed secondary thrombosis, a phenomenon that leads to a spectrum of reversible or possibly irreversible damage to flap tissue ranging from segmental ischemia to complete loss of the free flap or replanted digit. Vascular compromise was detected between 4 hours to 6 weeks postsurgery. They proposed that formation and showering of microemboli may lead to occlusion or shutting down of the microcirculation and called this phenomenon secondary thrombosis. Similar observation was reported by Zook et al. that a significant number of thrombi and emboli observed after thawing on microcirculatory observation of frostbite injury.[12] It appears that frostbite induces secondary thrombosis. The risk factors were identified that predisposes to secondary thrombosis including delayed lower extremity microvascular reconstruction, established infection, use of vein grafts, refractory vasospasm, hypercoagulable states, advanced arteriosclerosis, and intravenous drug use. Frostbite could be considered as another preoperative risk factor that predisposes to secondary thrombosis. In our case we believe that partial loses of the replanted digit was due to the secondary thrombosis and main risk factor for this was the frostbite injury rather than anastomosis failure due to thrombosis.

Frostbite of amputated digits is quite rare clinical situiation. It should also be known that replanted digits might show similar clinical signs of frostbite injury during the postoperative period. If these clinical manifestations are encountered frostbite treatment should be applied to the digits and surgical debridement should be reserved for late period.

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