Defying standard criteria for digital replantation: A case series

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ABSTRACT

INTRODUCTION: There is much controversy regarding the current indications and contraindications for digital replantation.

PRESENTATION OF CASE: Three patients with absolute contraindications for digital replantation according to classical criteria are presented (Case 1: multilevel amputation of the hand and fingers; Case 3: avulsion of the thumb; Case 4: index amputation proximal to the insertion of the flexor digititum superficialis). In addition a patient with a very distal digital amputation (Case 2), whose indication for replantation is controversial is also presented. In all cases, the patients were replanted and showed good functional and aesthetic results.

DISCUSSION: Most authors advocate that the classical indications for replantation have been validated by experience, are predicated on the potential for long-term function, and should be followed in most if not all cases. However, some surgeons have been adopting a more liberal attitude with good results.

CONCLUSION: The clinical cases presented in this paper suggest that the standard criteria for digital replantation should not be followed rigidly but instead should be regarded as a general guide.

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1. Introduction

Since the first successful digital replantation was performed in Japan in 1968, much has been written on this topic.1,2 Digital replantation is frequently requested in many trauma centers all over the world.1,3,4 However, it is widely accepted that replantation is not always the best option in the case of a severed finger.5 In fact, there is much controversy regarding the indications and contraindications for digital replantation.1,3–8 To make matters worse, most individual surgeons never gain extensive personal experience in this field.7,8 For example, a recent epidemiologic study in the United States of America estimated that only a few hospitals perform digital replantation procedures regularly, and only approximately 2 percent execute more than 10 replantations each year.7,8 In addition, on the one hand, bold but unfruitful trials at replantation are very likely to result in litigation.5 On the other hand, a recent review on litigation in the realm of hand replantation in a major trauma center revealed that most patients that had filed claims did so because the attending physician decided not to replant the severed part.5

To facilitate the decision making process, several authors have proposed a list of indications and contraindications for digital replantation that are largely followed (Table 1).1,3,5,9 In this paper, the authors present 4 clinical cases of patients that were replanted despite these contraindications, with good viability, function and cosmesis of the replanted segments.

2. Presentation of cases

In all patients, radiographs of both the amputated parts and the hands were obtained at admission in the emergency department. In the operating theatre, the amputated segments were cleansed with 500 ml of sterile lactated Ringer’s solution mixed with 80 mg of gentamicin. These segments were then carefully debrided under the microscope, and their vessels and nerves identified and tagged with a 8/0 nylon suture.

After bony fixation, the extensor tendons were repaired with two horizontal mattress sutures of 3-0 Nylon. The flexor tendons were repaired with 3-0 Nylon using the Tajima suture method.10–12 Arteries and veins were repaired only after observing normal intima under high-power magnification. Vascular defects were bridged by interposition vein grafts. Before arterial anastomoses were performed, blood flow was confirmed from the proximal artery. Vessels were sutured using interrupted sutures of 9-0, 10-0 or 11-0 nylon, depending on the vessel’s size. Nerves were repaired under...
Table 1

<table>
<thead>
<tr>
<th>Indications</th>
<th>Contraindications</th>
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<tbody>
<tr>
<td>Thumb amputation</td>
<td>Single digits proximal to the insertion of the flexor digitorum superficialis (Zone II) – particularly in the index or small fingers</td>
</tr>
<tr>
<td>Multiple digits</td>
<td>Severe crush, avulsed or mangled parts</td>
</tr>
<tr>
<td>Hand amputation through palm</td>
<td>Multilevel amputations</td>
</tr>
<tr>
<td>Hand amputation (distal wrist)</td>
<td>Prolonged warm ischemia time</td>
</tr>
<tr>
<td>Any part in a child</td>
<td>Severely arteriosclerotic vessels</td>
</tr>
<tr>
<td>Finger distal to the insertion of the flexor digitorum superficialis tendon (Zone I)</td>
<td>Multiple trauma to other regions*</td>
</tr>
<tr>
<td></td>
<td>Severe comorbidities*</td>
</tr>
</tbody>
</table>

* Relative contra-indications.

the operating microscope with interrupted epineural sutures of 8-0, 9-0 or 10-0 nylon, after fascicular alignment was confirmed.

In all patients 40 mg of enoxaparin given subcutaneously and 100 mg of aspirin given enterally were administered in the operating room and once a day for the following 14 days.

2.1. Clinical Case 1 – multilevel amputation (Fig. 1)

A 59-year-old right-handed male sustained a double amputation of his left hand with an electric saw (Fig. 1A and B). There was amputation of the ring and small fingers at the distal metacarpal level and amputation of the ring finger at the distal part of the middle phalanx. Replantation of the two segments was performed in sequence from proximal to distal by the second author (M.M.C.). The bones were fixed with Kirschner wires. One artery and two veins were repaired for each finger. Palmar digital nerves were repaired, as well as the extensor tendons and the flexor digitorum profundus tendons. The ischemia time was 2 h for the proximal segment and four and a half hours for the distal segment. Since the end of the surgery the replanted segments remained well perfused (Fig. 1C and D). The patient was discharged home 7 days after surgery. Kirschner wires were removed after 6 weeks. After that, the patient moved to another part of the country and stopped coming to the clinic. In addition, he did not attend any more physiotherapy treatments. 7 years after surgery, the patient returned to the clinic (Fig. 1E and F). He presented rigidity in the involved joints, but had an overall acceptable functional and cosmetical result (Video). The patient used his hand in all daily living activities and was satisfied with the end result.

Fig. 1. Mangled left hand with amputation of the ring and small fingers at the distal metacarpal level and amputation of the ring finger at the distal part of the middle phalanx. The amputated segments were replanted with good functional and aesthetic results. (A) Palmar aspect of the amputated portion of the hand with double amputation of the ring finger; (B) Posterior aspect of the amputated stump; (C) Immediate postoperative appearance of the dorsal aspect of the replanted segments; (D) Immediate postoperative appearance of the volar aspect of the replanted segments; (E and F) Dorsal and volar aspects (respectively) of the hand 7 years after surgery, showing complete viability and adequate healing of the amputated segments.
2.2. Clinical Case 2 – Distal phalanx partial amputation (Fig. 2)

A 40-year-old right-handed female suffered an amputation of the distal portion of the distal phalanx of her left index finger, corresponding to a type IV amputation according to Allen’s classification13 (Fig. 2A). Osteosynthesis was performed with a Kirschner wire, and an artery, a vein and branches of the palmar digital nerves were repaired under the microscope (Fig. 2B). The ischemia time was 4 h. The replanted part survived uneventfully. 1 year after surgery, she showed good function and cosmesis of the replanted segment (Fig. 2C and D).

2.3. Clinical Case 3 – avulsion of the distal phalanx of the thumb (Fig. 3)

A 60-year-old right-handed male, with an history of smoking 30 cigarettes per day for the previous 40 years, suffered an avulsion of the distal phalanx of his right thumb in an industrial machine accident (Fig. 3A). Concurrently, he had also sustained a comminuted fracture in the subcapital region of the second metacarpal bone with bony shortening. The amputated segment of the thumb was fixated with two Kirschner wires. The two palmar arteries were anastomosed using two vein grafts (each around 4 cm in length) taken from the volar aspect of the forearm; a single venous anastomosis in the dorsum of the thumb was performed using a 5-cm long vein graft taken from the same region; the two palmar digital nerves were repaired, as were the extensor pollicis longus and the flexor pollicis longus tendons. The ischemia time was 5 h. The fracture on the second metacarpal bone was reduced and immobilized with an external fixator. The severed phalanx survived uneventfully (Fig. 3B). The hardware was removed at 6 weeks. 2 months after the accident, the patient showed a functionally and aesthetically acceptable result, using his thumb in his daily life activities (Fig. 3C–F).

2.4. Clinical Case 4 – amputation of the index finger proximal to the insertion of the flexor digitorum superficialis tendon (Fig. 4)

A 50-year-old right-handed lady with a smoking history of 20 cigarettes per day during the previous 33 years sustained multiple cutting/crushing injuries to her right hand with a lawn-mower (Fig. 4A). These injuries included amputation of the index finger at the proximal phalanx level. The index finger presented additional injuries, especially at the level of the distal phalanx. The patient adamantly expressed her wish to have her finger replanted, even after being explained that function would most likely be compromised if that option was pursued. Osteosynthesis was performed with 2 crossed Kirschner wires. The extensor tendons and the flexor digitorum profundus tendon were sutured. Under the microscope the two palmar digital arteries, the palmar digital nerves and one dorsal vein bridged by a 4 cm-long vein graft from the dorsum of the hand, were repaired (Fig. 4B). The ischemia time was 4 h. Part of the distal phalanx and part of the medial aspect of the proximal phalanx of the index finger suffered skin necrosis, mandating fingertip revision and a skin graft coverage of the proximal phalanx. 6 months after surgery the patient could flex the interphalangeal joints as well as the metacarpal-phalangeal joint of the index finger (Fig. 4C and D). She was able to use that digit in her daily activities, including writing, and she was satisfied with the end result.

3. Discussion

Most authors argue that the classical indications for digital replantation have been validated by experience, are predicated on the potential for long-term function, and should be followed in most if not all cases.19,11 Table 1 indicates the most often cited criteria for digital replantation. However, some surgeons have been adopting a more liberal attitude and try to replant most fingers.16,14–16 For example, successful replantations after avulsion amputations or amputation of small parts of fingers are ever more performed with resort to the liberal use of veins grafts, free flaps, including venous arterialized flaps, with arteriovenous fistulas, and...
sometimes with temporary ectopic replantation of the amputated segment before transfer to the original location, when the amputation stump is too dirty or too damaged for immediate orthotopic replantation. All these options as well as the increasing microsurgical and supermicrosurgical expertise of many surgeons have allowed to replant many digits and digital parts that would be deemed unsalvageable in the past. Therefore, the traditional indications and contraindications for digital replantation mentioned in classical textbooks are being increasingly challenged in many medical centers.

In this paper we have presented three patients with absolute contraindications for digital replantation according to classical criteria (Case 1: Multilevel amputation; Case 3: Avulsion of the thumb; Case 4: Index replantation proximal to the insertion of the flexor digitorum superficialis). Moreover, we presented a patient with a distal digital amputation (Case 2), whose replantation is controversial. In all cases, the patients fared well functionally and aesthetically, and were pleased with the final result.

Classically, in patients with multilevel amputations in the same limb, it is recommended either to close the amputation stump or to replant only the most proximal segment. Notwithstanding, in Asia several upper limb multilevel replantations have been described. In 2008, Cavadas described for the first time in Europe a bi-level hand amputation, similar to the one we present in Case 1. As far as we could determine, this is the second description of the kind outside Asia.

Distal digital replantation, as the one described in Case 2, is not routinely performed because it is a technically challenging procedure requiring supermicrosurgical skills. Moreover, several studies suggest completion amputation at this level guarantees a similar functional outcome with a faster return to daily activities. The risk of replantation failure with the subsequent need for a secondary revision surgery, longer surgery time, a prolonged hospital stay, longer time off from work, and higher costs further deter surgeons to perform distal digital replantation of this kind. Finally, the loss of function caused by a missing fingertip is generally perceived to be insignificant. However, several of these arguments have been questioned lately. For example, a recent metanalysis showed a similar survival rate in distal digital replantation and more proximal replantation, particularly in centers in Asia where these procedures are performed routinely. Furthermore, the one study designed to compare the results of distal finger replantation and those of revision amputation, showed that replantation provided not only the best appearance, but also a better functional outcome.

Avulsion amputations, as the one depicted in Case 3, are usually considered contraindications for replantation. In fact, in several large series a significant part of avulsed thumbs is
considered non-replantable.\textsuperscript{23,24} Additionally, when replantation is attempted, significant inferior success rates are reported with avulsion injuries compared with clean-cut amputations.\textsuperscript{8,25} However, several authors believe that when possible, replantation of avulsed thumbs should be tried, recurring to vein grafts if needed, since the thumb is the single most important digit and its structure and function cannot be fully replicated by any other means.\textsuperscript{11,12,26}

Concerning single finger amputations, as the one presented in Case 4, there is a large consensus in the literature that in adults replantation of a single finger other than the thumb proximal to the insertion of the flexor digitorum superficialis should not be performed.\textsuperscript{1,3,5,11} This is due to the almost invariably poor results observed in the long run, particularly rigidity that hampers the movement of the remaining fingers.\textsuperscript{1,3,5} This is especially true in the case of index finger amputation, as the brain tends to exclude this digit and substitutes the middle finger for thumb-middle finger pinch.\textsuperscript{3,5} However, several authors have reported cases similar to the one we described with good results in intelligent and well-motivated people.\textsuperscript{11}

4. Conclusion

The 4 clinical cases presented in this paper illustrate that the standard criteria for digital replantation should not be followed rigidly but instead should be regarded as a general guide.\textsuperscript{3} In this way, patients who do not meet the standard criteria for digital replantation can still be offered the possibility of replantation, provided they are willing to accept the risks, costs and time off work, and that surgeons have reasons to believe that the end result for that particular patient will be better with replantation than with simple stump revision with or without a flap.\textsuperscript{3}

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**Ethical approval**

Written informed consent was obtained from the patients for publication of these case reports and accompanying images. Copies of the written consents are available for review by the Editor-in-Chief of this journal on request.

**Author contributions**

Diogo Casal played a major role in the treatment of the patients described, in addition to collecting and analysing the data, and writing the manuscript.

Manuel Macenino Gomez played a major role in the treatment of the patients described, in addition to collecting and analysing the data, and writing the manuscript.

Paula Antunes participated in the treatment of the patients described, as well as in the data collection and analysis, and in the writing and editing of the final manuscript.

Henrique Candeias participated in the treatment of the patients described, as well as in the data collection and analysis, and in the writing and editing of the final manuscript.

Maria Angélica Almeida played a major role in the in treatment of the patients described, as well as in the data collection, and in the editing of the final manuscript.

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References


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