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Management of amputated digits

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Abstract

Traumatic digit amputations account for 1% of all trauma admissions and are an important cause of morbidity in young, working people. It is essential that patients are worked up appropriately and referred promptly to a specialist unit for consideration of replantation. This review summarises the acute management of a patient presenting to the emergency department with an amputated digit. It discusses the assessment, initial management in the emergency department, how to make the decision to replant and operative steps.

Key words: Amputated digits; Hand surgery; Microsurgery; Replantation; Trauma

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Introduction

In 2015–16, hand injuries made up 20% of the 22.9 million attendances to emergency departments in the UK (Warwick et al, 2017). Traumatic digit amputations make up a significant proportion of these injuries, with figures reported of up to 1% of all trauma admissions (Win and Henderson, 2014). They tend to occur in young, working people, for whom both the physical and emotional impact can be devastating (Bastidas et al, 2011). It is essential that patients are worked up appropriately before prompt referral to a specialist plastic surgery or hand unit for consideration of replantation. Replantation is the reattachment of a totally amputated part that aims to restore function and appearance of the affected digit, but it is worth noting that this is not always clinically viable. This is in contrast to the term 'revascularisation', which describes the repair of a devascularised but incomplete amputation. All patients with amputations where the amputated part is available, should be referred to a specialist hand surgery unit.

Assessment and acute management

Table 1 outlines the key points of the initial assessment and management of a patient presenting with an amputated digit to the emergency department. Such patients may well have other associated injuries that must not be overlooked on clinical assessment so initial management should follow Advanced Trauma Life Support (ATLS) guidelines. Amputation results in associated peripheral vascular injury with the potential for life-threatening exsanguination. Haemorrhage control should be with moist, non-adherent dressings and localised direct pressure: attempting to clamp or tie off vessels will only hinder any repair effort (Win and Henderson, 2014). Arterial tourniquets can be lifesaving in the event of severe, uncontrollable haemorrhage and may be required if direct pressure alone is insufficient. Prolonged tourniquet use has significant local (effect of direct pressure and ischaemia byproducts on distal tissues) and systemic (thromboembolic events, rhabdomyolysis, acidosis, hyperkalaemia, arrhythmias and shock) risks attached (Richey, 2007).

A focused history should identify the timing and mechanism of injury and how the amputated digit has been stored. Both the mechanism and timing are important to aid management decision making: digits that have suffered crush or avulsion injuries are unlikely to be suitable for replantation because of the significant damage to the neurovascular pedicles. Digits are more resistant to ischaemia than other body parts because of the absence of muscle. Reports have demonstrated they can tolerate 12 hours of warm ischaemia (measured from amputation time to start of cold preservation or revascularisation) or 24 hours of cold ischaemia (stored appropriately at 4 °C) before replantation (Woo et al, 2015). A past medical history for any patient with a hand injury should include hand dominance, occupation and hobbies, in addition to comorbidities, smoking status and last oral intake.

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Table 1. Initial assessment of a patient in the emergency department presenting with an amputated digit	
History of injury	Time of injury
	Mechanism of injury
	Storage of amputated digit since injury
Past medical history	Hand dominance
	Occupation
	Hobbies
	Comorbidities
	Medication including allergies
	Smoking status
	Last oral intake
Examination of patient	Advanced Trauma Life Support (ATLS)
Examination of stump	Number of digits involved
	Which digit(s) are involved
	Level(s) of injury
	Favourable injury – guillotine
	Unfavourable injury – mangled, crushed or avulsed
	Specific signs – red streak or ribbon signs
Investigations	Baseline blood tests
	Radiographs of hand and amputated digit

Figure 1. Preoperative photographs taken in the emergency department of a clean-cut non-dominant thumb amputation at the mid-proximal phalanx level.

Examination of the stump and part should identify the level and type of amputation: was it a clean cut or is the part mangled, avulsed or crushed? An avulsed digit may have structures dangling from the part. The 'red streak' sign describes bruising over the neurovascular pedicle along the lateral border of the digit (Maricevich et al, 2011). This represents haemorrhage from the vascular branches tearing off the digital artery and is a sign that replantation is unlikely to be successful (Maricevich et al, 2011). The 'ribbon' sign is also a poor prognostic indicator and describes a corkscrew-like appearance to the protruding vessels (Van Beek et al, 1978). These vessels will likely have severe intimal damage. Finally, look for evidence of significant contamination. It is useful to take photographs at this stage to aid referral and to prevent the need for recurrent dressing changes that may cause distress (Figure 1).

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Initial investigations should include baseline blood tests and a preoperative group and screen. Radiographs should be taken of both the stump and the amputated part. Obtain intravenous access and give the patient analgesia, intravenous antibiotics and tetanus prophylaxis (if indicated). The amputated part should be wrapped in saline-soaked gauze and placed in a sealed plastic bag that is in turn submerged in an ice-water solution at approximately 4 °C (Maricevich et al, 2011).

If the decision is made to replant the amputated digit, the patient should be prepared for theatre, and the anaesthetic team and theatre informed. The authors advocate the combination of general anaesthesia and regional anaesthesia (brachial block). In addition to the analgesic benefits, a regional anaesthetic will cause a degree of sympathetic blockade, optimising vasodilatation and the ease of subsequent anastomosis (Maricevich et al, 2011). The general anaesthetic will provide adequate anaesthesia for the duration of the replantation procedure, which may take 2–4 hours.

The decision to replant

Not all amputated digits should be replanted. The decision should be made based upon the entire patient picture, in addition to the level and condition of the amputated part. Concomitant life-threatening injury or multiple severe comorbidities are an absolute contraindication. The thumb is the most important digit to attempt replantation as it provides 40–50% of hand function (Prucz and Friedrich, 2014). Multiple digit replants are also usually indicated, in order to minimise the resultant devastating loss of hand function. Studies have demonstrated that a good functional outcome can be achieved following single digit replantation distal to the insertion of the flexor digitorum superficialis tendon, because of the retained flexion at the proximal interphalangeal joint. Unfortunately, single digit amputations proximal to the flexor digitorum superficialis insertion rarely achieve good post-replant function. A non-functioning, replanted finger may adversely affect the overall hand function more than the original amputation (Prucz and Friedrich, 2014). The ability to achieve a good functional result is particularly important to musicians and patients with occupations that require fine motor skills, and this must be considered in the decision-making process. Patients must be well motivated and able to partake in a prolonged and arduous period of rehabilitation (detailed below). Failure rate is higher in patients with diabetes, vasculopaths and smokers. Severely crushed or mangled amputated parts, or those with gross contamination, should not be replanted.

Table 2 displays the indications and contraindications for replantation while Figure 2 provides an illustrated algorithm to assist decision making. It should be noted that these decisions are rarely clear-cut, and must take into account all patient factors in addition to

Table 2. Indications and contraindications to digital replantation

Indications	Thumb amputation
	Multiple digit amputations
	Single finger amputations distal to the flexor digitorum superficialis insertion
	Any amputation in a child
Contraindications	Severe crush injuries
	Multilevel amputations
	Concomitant life-threatening injuries
	Single finger amputations proximal to the flexor digitorum superficialis insertion
	Patients unable to comply with rehabilitation protocol
	Prolonged warm ischaemia time

Adapted from Prucz and Friedrich (2014)

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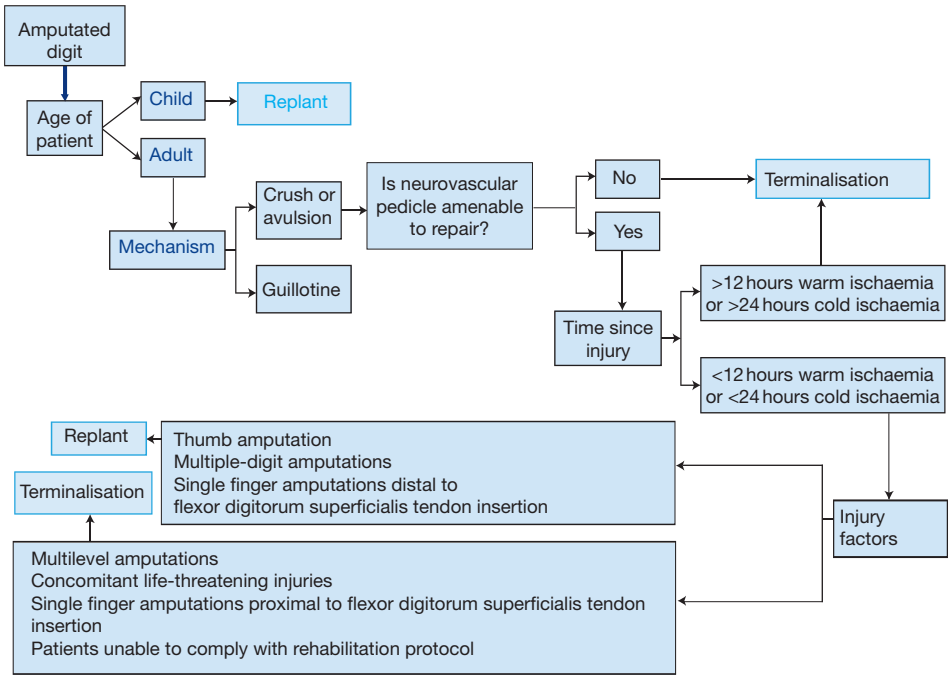

Figure 2. Algorithm to assist decision making in digital replantation. Adapted from Prucz and Friedrich (2014).

the condition and level of the amputated part. Data from across the USA have previously reported replantation rates of 11.2–18% so it is important that expectations are managed appropriately from the initial emergency department consultation (Cho et al, 2018).

Paediatric fingertip amputation

Fingertip injuries in children are common, making up two-thirds of paediatric hand injuries (Murphy et al, 2017). Most often, these are crush injuries causing a nailbed or pulp laceration, distal phalanx fracture or, more rarely, complete amputation of the fingertip. When amputation occurs beyond the level of digital artery trifurcation (at the proximal nail fold), repair of the vessels is rarely possible in children (Murphy et al, 2017). Although not recommended in adults, composite grafting can be a useful technique in this cohort. This describes the re-attachment of the amputated part without revascularisation, a relatively simple procedure that is often successful in children because they have better healing potential and fewer comorbidities (Murphy et al, 2017). Studies have demonstrated at least partial success rates of 50–68% (Moiemen and Elliot, 1997; Murphy et al, 2017). More distal injuries may have a better chance of success (Moiemen and Elliot, 1997), as with those operated on in the first few hours after injury (although previous work has suggested composite grafting can still be considered after 12 hours or more) (Murphy et al, 2017). Composite grafts are significantly more likely to survive in children aged 4 years or younger (Butler et al, 2016). In those that fail, the graft acts as a 'biological dressing' that allows healing beneath by secondary intention (followed by shedding of non-viable tissue after re-epithelialisation) and avoids recurrent, painful dressing changes (Murphy et al, 2017).

Operative management

Digital replantations are complex and often protracted procedures. Having two surgical teams, one for the amputated part and one for the stump, can expedite the operation. Both stump and amputated part need to be debrided under tourniquet control, with subsequent identification and tagging of the vessels, nerves and tendons. This process can start on the amputated part while the patient is in the anaesthetic room (Figure 3).

There are varying opinions as to the order of structural repair but, in general, bone fixation is performed first to provide stability before the microsurgical anastomoses are performed (Maricevich et al, 2011). This can involve Kirschner or intraosseous wires, screw

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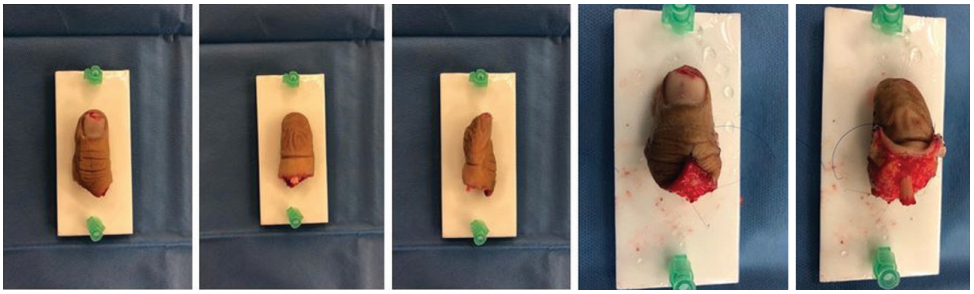

Figure 3. Preparation of the amputated part including tagging of structures.

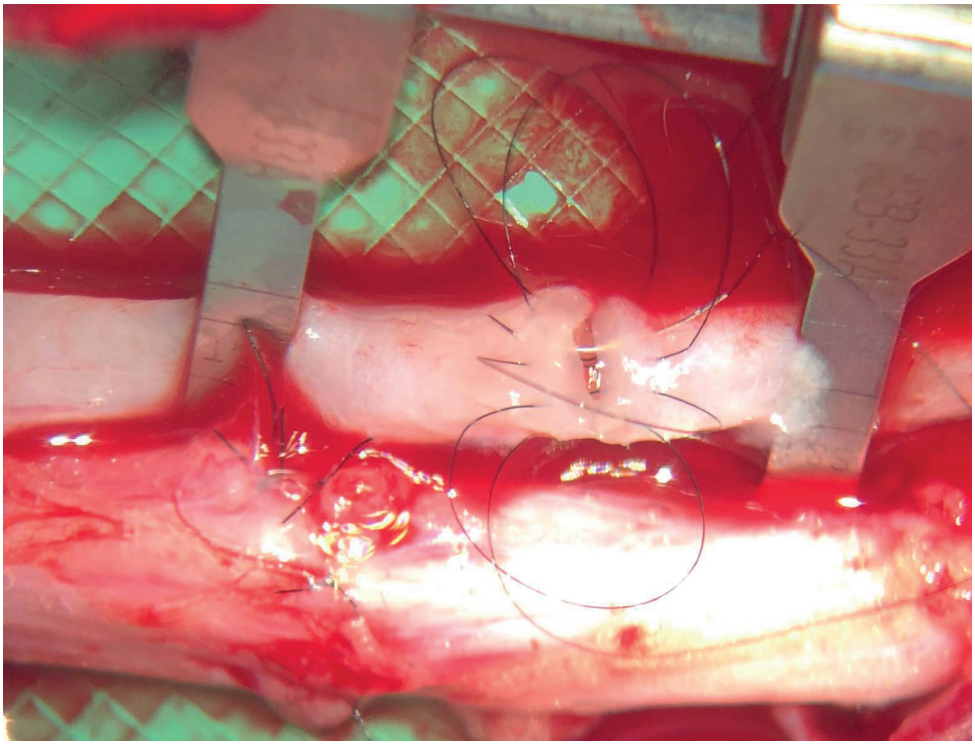

Figure 4. Microsurgical anastomosis of the digital artery (superior) and nerve (inferior). A green 'background' has been positioned to aid the anastomosis. The Acland microvascular clamps are used to stop blood flow and position the vessel ends for anastomosis. In this example, the surgeon has used a loose running arterial suture for the final stitches, where each loop has then subsequently been tightened in turn to ensure the back wall is not incorporated into the stitch and to prevent purse stringing of the anastomosis.

or plate fixation, depending on fracture pattern and surgeon preference. Bone shortening may be required to facilitate tension-free anastomoses. Following bony fixation, the authors prefer to progress with repair of volar structures before dorsal: starting with the flexor tendon, then finishing with the arterial anastomosis (Figure 4) and nerve repair. Dorsally, the extensor tendon is repaired before vein anastomosis (which may require a vein graft) (methods of tendon repair are discussed in another article in this symposium; https://doi.org/10.12968/hmed.2020.0141). Leaving sufficient time between arterial reperfusion and vein repair allows for venous filling and facilitates their identification (Maricevich et al, 2011). Two veins are repaired in order to reduce the risk of failure from venous congestion (Prucz and Friedrich, 2014). The skin is closed, and the hand placed in a plaster splint. Figure 5 demonstrates the appearance of a replanted digit with Kirschner wires used for bony fixation, just before skin closure and Figure 6 at 6 months postoperation.

Postoperative monitoring

Replanted digits should be closely monitored in the immediate postoperative period. Arterial or venous insufficiency is the primary cause of replant loss in the days following

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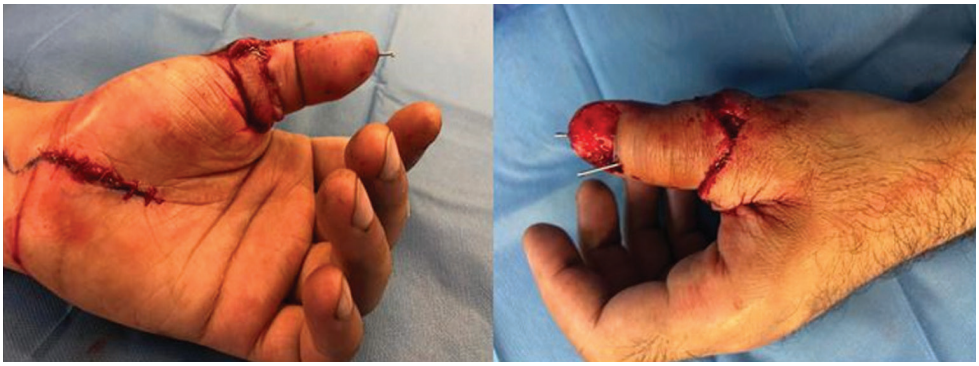

Figure 5. Immediate postoperative appearances of a thumb replantation. (Figure 1 shows preoperative images.) The nail-plate has been removed to permit the potential use of heparin soaked gauze in the event of venous insufficiency. K-wires were used for bone fixation and can later be removed in the outpatient setting. A carpal tunnel incision was used for retrieval of the proximal end of the flexor pollicis longus tendon before repair.

Figure 6. Postoperative appearances of a thumb replantation at 6 months.

repair. To minimise this risk, the digit should be kept warm beneath a forced warm air Bair Hugger blanket, elevated and the patient well hydrated. Adequate pain control helps to minimise the sympathetic response and thus vasoconstriction (Maricevich et al, 2011). Frequent monitoring of the digit's skin colour, turgor and capillary refill is essential for early identification of vascular compromise (Figure 7). Arterial insufficiency will result in a pale or dusky finger, reduced temperature, prolonged capillary refill and an absence of bleeding on needle scratch of the fingertip. In the first instance, blood pressure should be optimised but these patients will likely require urgent exploration and repeat anastomosis (Win and Henderson, 2014). A blue or purple and swollen finger with a brisk capillary refill indicates venous obstruction. Nail plate removal and application of heparin-soaked gauze or leech therapy can be useful ward-based salvage options (Prucz and Friedrich, 2014).

Rehabilitation and long-term outcome

The rehabilitation process following replantation of a digit is long and can be tortuous for a poorly motivated patient. Early involvement of hand therapists is essential and ideally starts

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Digit Replant Monitoring Chart

Patient name:	Ward:	Consultant:
Hospital Number:	Digit replanted:	

This chart is designed for the monitoring of replanted digits. Frequency of flap observations is ½ hourly for 2 hours then hourly until first ward round, then as per ward round instructions. Please removed Bair hugger for 5 mins prior to doing observations.

If the patient scores 1 in any category escalate to the nurse in charge and see overleaf for full escalation procedure.

Date:												
Time:												
Initials of nurse:												

COLOUR OF DIGIT (put corresponding number in box and if abnormal document abnormality)

Similar to surrounding skin / donor site = 0												
Paler = 1												
Darker = 1												

TEMPERATURE OF DIGIT (put corresponding number in box and if abnormal document abnormality)

Warm = 0												
Cool / cold = 1												

CAPILLARY REFILL OF DIGIT (put corresponding number in box and if abnormal document abnormality)

2-3 seconds = 0												
<2 seconds = 1												
>3 seconds = 1												
No refill of non-blanching = 1												

TEXTURE OF DIGIT (put corresponding number in box and if abnormal document abnormality)

Soft = 0												
Firm/Hard = 1												

DOPPLER SIGNAL OF DIGIT (if required)

Present = 0												
Absent = 1												

Escalation procedure for ward nursing staff:

If there is a score of 1 in any of the above categories the following action must be taken:

- **Inform the nurse in charge and then inform the plastics on call team**

Figure 7. Example of a postoperative replant monitoring protocol.

within 5–7 days of the operation. Appropriate splinting with mobilisation, education and support forms the mainstay of rehabilitation and this should be tailored to each patient (Win and Henderson, 2014). Generally, a protocol with early protective motion exercises should start at day five: if delayed for 14 days or more, results are significantly worse (Wolfe and Wang, 2015). Active and passive exercises of non-involved joints should start early and, depending upon the quality of the tendon repair, place and hold exercises in the intrinsic plus and minus positions can start at 2 weeks (Wolfe and Wang, 2015). It can take many months or years to regain adequate function in the replanted digit, and secondary operations are often required.

There is ongoing debate as to whether the resultant functional outcome with replantation is significantly better than revision amputation to negate the therapeutic, emotional and physical cost required to achieve it. Studies have demonstrated a mean return to 50% of finger range of motion and grip strength post-replant (Win and Henderson, 2014). A study of over 1000 patients identified a higher cost, longer duration of hospitalisation and sick leave with replantation compared with revision amputation alone (Zhu et al, 2018). FRANCHISE was an international, multicentre, retrospective cohort study that compared long-term patient-reported outcomes between revision amputation and replantation in digit amputations (Chung et al, 2019). The study identified significantly better outcomes in the replantation cohort for each injury pattern but was most pronounced in patients with three or more amputated digits, thumb or single-finger amputation distal to the proximal interphalangeal joint (Chung et al, 2019).

Conclusions

Amputated digits are an important cause of significant morbidity in young, working people. Prompt referral to a specialist centre is essential for consideration of replantation of the amputated part. Decision to replant should be made at a senior specialist level and should include discussions with the patient where possible.

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Key points

- Traumatic digit amputations account for 1% of all trauma admissions and are an important cause of morbidity in young, working people.
- Physicians should know how to assess a patient presenting with a digit amputation.
- Understand the key steps in the initial management of a patient presenting to the emergency department with a digit amputation, and the factors that affect the decision to replant an amputated digit.

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Conflicts of interest

The authors declare no conflicts of interest.

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