Complete digital amputations undergoing replantation surgery: a 10-year retrospective study

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Abstract

Background As a result of growing expertise and skill, replantation surgery has evolved to more than the technical reattachment of an amputated part.

Methods A retrospective study of complete digital amputations undergoing replantation surgery was conducted for the purpose of assessing trends in these complex cases. All incomplete and partial amputations were excluded.

Results A total of 171 patients who had replantation surgery between January 1, 1994 and December 31, 2003 for 278 completely amputated digits were reviewed. Of the 171 patients, 91 (53 %) had work-related injuries. The main mechanism of injury was saw injury (95 patients) for both occupational- and non-occupational-related injuries. The proximal phalanx was the most common level of amputation and the thumb was most frequently involved. The injuries happened more commonly in the summer months. Microvascular failure

occurred in 29 % of the replanted digits and was most commonly associated with avulsion-type injuries.

Conclusions Complete amputations represent a more complex injury than incomplete amputations, with a higher failure rate.

Keywords Complete amputations · Outcomes

Introduction

Digital replantation has made significant progress since 1965 when Komatsu and Tamai of Japan first successfully replanted a thumb [1]. Today, digital replantation is practiced in both academic and community centers throughout the world [2]. As a result of growing expertise and skill, replantation surgery has evolved to more than the technical

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reattachment of an amputated part. Today, replantation surgeons need to consider both the functional and esthetic outcomes of replantation, as well as the impact of replantation on each patient's quality of life [3].

Even though replantation surgery is routinely performed, the surgical techniques, selection criteria, and results vary from center to center. In a 2001 review, Soucacos [4] summarized the indications for replantation. He emphasized that the thumb is given priority [5] along with any amputated part in a child. Single digit amputations on flexor zone 1 are candidates for replantation. Multiple digit amputations should always be considered for replantation. With extensive damage, the best amputated parts should be replanted to the best stumps with a functional goal in mind. Mid-palm amputations are considered an excellent indication for replant. Relative contraindications include crush and avulsion injuries, along with other life threatening trauma and medical conditions that influence blood flow. These include diabetes, collagen vascular disorders, autoimmune diseases, and a strong smoking history. The concept of function being an entity that includes societal standing and cosmesis is a consideration for the senior surgeons' indications for replantation surgery. The purpose of this study was to retrospectively review the senior authors' experience with digital replantation following complete amputation and identify any trends or patterns in this subgroup.

Materials and methods

Retrospective data were collected on all patients who underwent replantation following a complete digital amputation at the between January 1, 1994 and December 31, 2003. Using billing codes, a chart audit was conducted to identify potential study patients. A number of different surgeons were involved. There were two orthopedic trained surgeons and the rest were plastic surgeons. All surgeons had completed hand surgery fellowships. Patients were included in this study if they had a complete amputation to a single or multiple digits, or complete amputations through the hand or wrist. Complete amputation was defined as a complete separation of parts with no intervening tissue of any kind. Patients were excluded from this study if they had incomplete or partial amputations. Even a small skin bridge was classified as an incomplete amputation and therefore excluded from this study. Patients with incomplete data were excluded from this study. The final outcome measure in this study was "failure" and was defined as a microvascular failure requiring revision amputation of the replanted digit.

Collected data were entered into a Microsoft Access 2000 (Microsoft Inc. 1 Microsoft Way., Redmond, WA 98052) database. Patient information collected included: demographic data, hand dominance, hand injured, mechanism of injury,

description of the injury, length of hospital stay, if injury was work related, and the level of the amputation. Amputation levels were categorized according to Foucher's classification of mutilating hand injuries [6]. Descriptive statistical analyses were performed using SPSS statistical software (SPSS Inc. 233 S. Wacker Dr., Chicago, IL 60606) and Microsoft Excel (Microsoft Inc. 1 Microsoft Way., Redmond, WA 98052).

Results

Approximately 60 patients are admitted each year to the microsurgical unit of the for postoperative monitoring following microvascular repair. Over the past 10 years, there have been more than 600 admissions including both replantation and elective microvascular cases. A total of 171 patients had replantation surgery for 278 completely amputated digits. Of these patients, 161 were male and 10 were female. The most common level of amputation was through the proximal phalanx. The thumb was the most frequently replanted digit accounting for 77 of all replants (Table 1).

Of the 171 patients, 91 (53 %) had work-related injuries. Of the work-related injuries, over one third (32 patients) worked in the industry/manufacturing sector (Fig. 1).

A seasonal variation in traumatic amputations was identified. These injuries occurred most commonly in the summer months (52 patients) for both occupational- and non-occupational-related injuries. The fewest traumatic amputations treated with replantation surgery occurred in the winter months (Fig. 2). Saw injuries (95 patients) were the most common mechanism of injury for both occupational- and non-occupational-related injuries (Fig. 3).

In this study, 29 % of all replanted digits failed (Table 2) and required revision amputation. Sixty-two percent of patients with avulsion injuries went on to have a microvascular failure. Whereas 12 patients (50 %) with crush injuries and 27 (28 %) patients with saw injuries had failures.

Table 1 Patient demographics

Injury	Occupational	Non-occupational	Total
Patients	91	80	171
Sex	Male 86	Male 75	161
	Female 5	Female 5	10
Amputated digits	D1 40	D1 37	77
	D2 36	D2 26	62
	D3 31	D3 27	58
	D4 29	D4 26	55
	D5 16	D5 10	26

Fig. 1 Injuries by industry

Discussion

The total number of replantation and revascularization cases performed in Toronto over the 10-year study period exceeded 300. Approximately 50 % of the cases represented complete amputations. The motivation for studying replantation of complete amputations is based on several unique features of this subgroup. Complete digital amputations are technically more difficult to replant [7] and are associated with higher reported failure rates [8]. When reporting clinical experience, the grouping of all amputations (i.e., complete and incomplete) with revascularizations may generate higher overall success rates. These reported success rates may not in fact be representative of the success rates associated with complete digital amputations.

In this study, a replant failure was defined as any microvascular failure requiring revision amputation surgery. Arterial thrombosis is the most common cause of all microvascular failures [9]. Successful replantation depends on numerous important factors including patient factors, injury factors, operative technique, and postoperative monitoring [10]. Our reported failure rate of 29 % is higher than other published

Fig. 3 Injuries by mechanism

rates [8, 11]. Firstly, previous studies that have reported high (>90 %) survival rates included incomplete amputations and revascularizations in their data [6]. Our study excluded these injuries from assessment. It is well known that complete amputations have a poorer prognosis for digital replantation survival [12]. Secondly, this study did not exclude patients with comorbid traumas or underlying diseases, like diabetes, that may compromise circulation as was done in a previous study [8]. Finally, it has been shown that cigarette smoking is associated with a higher risk of revascularization failure [13]. At our institution, smoking is not considered an absolute contraindication to replantation surgery and smokers were not excluded from this analysis. In this study, information on comorbidity and smoking status was not reliably documented. Therefore, specific statistical analysis on the influence of comorbidity and smoking on microvascular failure was not performed.

Avulsion injuries are associated with a high rate of failure [6]. Though avulsion injuries are sometimes considered a contraindication for replantation, the senior authors do not considered them to be an absolute contraindication to

Fig. 2 Injuries by season

Table 2 Failures by mechanism

Mechanism of injury	Number patients	Number patients with failure	Patient failures (%)	Number digit failures	Total digit failures (%)
Saw	95	27	28	33	41
Crush	24	12	50	13	16
Avulsion	13	8	62	13	16
Explosion	0	0	0	0	0
Knife	0	0	0	0	0
Other	39	17	44	21	26
Total	171	64		80	

surgery. The high failure rate associated with avulsion-type injuries may require further re-exploration into the role of replantation in this subgroup.

Patient selection for replantation surgery is often guided by specific patient considerations. Gender, cultural, and religious considerations may often play greater roles in the decision to attempt replantation than the mechanism of injury or the likely functional outcome. The fairly aggressive practice of our surgeons is consistent with Merle and Dautel [14] who stress the importance of considering the psychological, cultural, or cosmetic indications for replantation. Clearly, greater consideration of the indications for digital replantation is required such that the surgeon includes both patient-specific and technical considerations.

In conclusion, this study represents an analysis of complete amputations. Complete amputations treated with replantation are more complex than incomplete amputations or revascularizations and should therefore be studied separately. This group suggests that surgeons embarking on replantation surgery should recognize all factors governing a decision to replant with an understanding that failure rates may be higher when using this individualized approach. It may be easier for some patients to accept an amputation once all measures have been undertaken.

Conflict of interest The authors declare no conflicts of interest and no sources of funding.

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