Composite grafting for pediatric fingertip injuries

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Published online: 24 July 2014
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Abstract

Background Fingertip injuries are common in the pediatric population. Composite grafting is a frequently used technique for distal amputations in children given the reported success rate. We sought to study the early clinical results of composite grafting for fingertip injuries in the pediatric population.

Methods A retrospective review was performed over a 5-year period at a tertiary care pediatric hospital to identify those patients who underwent composite grafting of fingertip injuries. Patients were included if they were 18 years old or younger and sustained an injury distal to the distal interphalangeal joint (or thumb interphalangeal joint). Demographic information was recorded. Graft viability was characterized as no take, partial take, or complete take. The number of secondary procedures and number and duration of follow-up appointments were recorded. Hypothesis testing was done using ordinal logistic regression analysis.

Results Thirty-nine patients underwent fingertip composite grafting. The mean age was 5.9 years (1–18 years); there were 24 males (61.5 %) and 15 females (38.5 %). Thirteen patients had no graft take (33.3 %), 23 patients had partial take (59.0 %), and three patients had complete take (7.7 %). Only

four patients underwent secondary revision (10 %). The median number of follow-up appointments was 3 and the average follow-up time was 4.5 months. Age did not appear to have a statistically significant influence on graft take.

Conclusions Fingertip composite grafts rarely take completely even in young children. Despite poor viability, however, most patients will have at least partial graft take and do not undergo additional reconstructive procedures.

Keywords Composite graft · Fingertip injury · Pediatrics

Introduction

Fingertip injuries are common in children as a result of their curiosity and lack of awareness of their surroundings [6, 8]. Anatomically, the fingertip is defined as the segment distal to the insertion of the flexor and extensor tendons on the distal phalanx [5] and is a specialized structure that participates in the sensibility and dexterity of the hand. The volar pulp of the fingertip provides more than half of the fingertip volume [20]. In the pediatric population, fingertip injuries are most common between 0–2 years of age and often occur following crush injury [6].

Treatment of fingertip injuries in the pediatric population depends on the etiology of the injury and the affected anatomic structures. When the injury involves amputation of the distal fingertip, replantation may confer the best results if technically possible [11], but composite grafting is another established treatment option for injuries not suitable to replantation. The term “composite graft” describes the non-microvascular reattachment of the amputated part of soft tissue, usually skin and fat. Excellent results were first demonstrated by Douglas in 1959 [3]. Overall, this technique has met disparate results in the literature, and there has been mixed enthusiasm for this procedure, particularly when performed in

This work was presented as a poster at the 2014 American Association for Hand Surgery; Kauai, Hawaii, January 2014.

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adults where microvascular replantation or revision amputations are more common [7, 16].

Greater success has been reported in children, however, as in the 1997 study by Moiemien and Elliot [19]. In this pediatric study, 61 % of composite grafts replaced within 5 hours of injury survived completely. Composite grafting has therefore become an acceptable treatment option for fingertip injuries not amenable to replantation in the pediatric population, with subsequent authors stating that “children below the age of five do well” with reconstruction using this technique [24] and that composite grafting “should only be attempted in children and young adults” [16].

The aim of this study was to review our experience with composite grafting of fingertip injuries in the pediatric population. We hypothesized that the viability rate for these grafts was lower than that quoted in the literature.

Materials and Methods

A retrospective review was performed from January 2007 to December 2012 at a tertiary care children’s hospital. This study was reviewed and approved by the hospital’s Institutional Review Board. All patients who presented to the emergency department (ED) with a primary hand injury were included in this study. Patients with fingertip injuries were identified by cross-referencing all emergency department visits with International Classification of Diseases, Ninth Revision (ICD-9) codes indicative of fingertip injuries (816.1X, 883.X, 886.X); the electronic medical record was examined to determine whether or not composite grafting was performed.

Patients 18 years of age or younger were included if they presented to the ED with a fingertip injury distal to the distal interphalangeal (DIP) joint—or interphalangeal (IP) joint of the thumb—and underwent composite grafting of the amputated part. As this was a retrospective chart review, utilization of the term “composite graft” or a detailed procedural note describing the technique was required for inclusion. Patients were excluded if they sustained an injury proximal to the DIP joint (or IP joint of the thumb) on the same digit, or if they had a fingertip or hand injury that did not undergo composite grafting for treatment. Procedures were performed in the emergency department or in the operating room; younger patients (typically 6 or younger) received conscious sedation if the procedure was performed in the emergency department. The procedure of composite grafting included the instillation of local anesthesia for a digital block (typically 0.5 % lidocaine without epinephrine) and thorough irrigation with sterile saline. Replacement of the fingertip was then performed meticulously under loupe magnification with interrupted sutures, with nail bed repair if necessary. Small bony fragments in the amputated parts, debris, and clearly devitalized tissue were removed prior to application of the graft; primary “defatting”

Fig. 1 Composite graft take: **a** no take, **b** partial take, **c** complete take

of the part was not performed. Patients were placed in a cast or splint and discharged home with a 3–5-day course of antibiotics.

Demographic information was recorded, including patient age, gender, laterality of injured hand, specific digit(s) involved, presence of associated fracture, nail bed involvement, and mechanism of injury. Mechanism of injury was stratified by type and included: caught in a door, crush injury, mechanical device, injury while playing sports, sharp laceration, or strangulation injury (caused by rope or cord-like structure). We also recorded whether patients presented directly to our ED or whether they were transferred from another institution.

Composite graft viability was evaluated by retrospectively reviewing the electronic medical record and post-operative notes. Graft take was characterized as no take, partial take, or complete take via documented clinical assessment at the post-procedural clinic visit around 7–14 days after graft placement (Fig. 1). Although some patient notes outlined the degree of partial take in percentage terms, this was not consistent for all patients. This finding was likely because quantifying graft take in percentage terms for a small fragment of skin in a small child is difficult. Accordingly, the degree of take was kept as no take, partial take, and complete take for the analysis in this study. Other measured outcomes included number of secondary procedures required and number and duration of follow-up appointments.

Table 1 Demographic information of study patients

		Number	Percentage
Gender	Male	24	61.5
	Female	15	38.5
Age (range 1–22 years)	0–2 years	13	33.3
	2–6 years	15	38.5
	6–12 years	4	10
	12–18 years	7	18

Table 2 Injury specifics

		Number	Percentage
Hand involved	Right	22	56.4
	Left	17	43.6
Digit involved	Middle finger	15	38.5
	Ring finger	9	23.1
	Small finger	8	20.5
	Index finger	6	15.4
	Thumb	1	2.6
Fracture of distal phalanx	Yes	15	38.5
	No	24	61.5
Nail bed involvement	Yes	24	61.5
	No	15	38.5
Location of treatment	Emergency room	27	69.2
	Operating room	12	30.8

We tested the hypothesis that children who are younger have better composite graft take, either partial or complete. This was done with ordinal logistic regression using the SAS software, version 9.2. We performed two analyses: one using age as a continuous variable and the other using age as a dichotomous variable (age 6 or younger versus older than 6). In both analyses, we controlled for mechanism of injury, the presence of fracture, and location of initial presentation (our hospital ED or outside institution).

Results

Thirty-nine patients were identified by retrospective chart review as having undergone composite graft fingertip

reconstruction using the aforementioned inclusion criteria. The Current Procedural Terminology (CPT) code 15760 indicates placement of a composite graft and was often utilized during these procedures. The mean patient age was 5.9 years (range 1–18 years), and there were 24 males (61.5 %) and 15 females (38.5 %) (Table 1). Twenty-nine patients (74 %) were 6 years of age or younger, while ten patients were older than 6 years of age (26 %). The right hand was injured in 22 patients (56.4 %) and the left hand in 17 patients (43.6 %). The most commonly involved digit was the middle finger ($n=15$, 38.5 %), followed by the ring finger ($n=9$, 23.1 %), the small finger ($n=8$, 20.5 %), the index finger ($n=6$, 15.4 %), and the thumb ($n=1$, 2.6 %) (Table 2).

Fractures were present in 15 patients (38.5 %), and 24 patients (61.5 %) had associated nail bed involvement. The most common mechanism of injury involved closure of a door ($n=24$, 61.5 %), followed by injury with a mechanical device ($n=6$, 15.3 %), other crush injury ($n=5$, 12.8 %), sharp laceration ($n=2$, 5 %), and sports ($n=1$, 2.5 %) or strangulation injuries ($n=1$, 2.5 %) (Fig. 2).

Thirteen patients had no graft take (33.5 %), 23 patients had partial graft take (59 %), and three patients had complete graft take (7.7 %). Four patients underwent secondary revision (10 %), each of whom had no initial graft take. Indications for revision were patient/family dissatisfaction, persistent pain, or aesthetic deformity. Of these, two patients underwent operative debridement of non-viable tissue, one patient underwent debridement with revision amputation, and one patient underwent debridement with V-Y advancement flap closure. The median number of follow-up appointments was 3 and the mean length of follow-up was 137 days (4.5 months) (Table 3). Figure 3 demonstrates a patient with no initial

Fig. 2 Mechanism of fingertip injury resulting in composite graft placement

Table 3 Outcomes

		Age ≤6	Age >7	Total	Percentage
Graft take	No graft take (0–5 %)	10	3	13	33.3
	Partial graft take (5–95 %)	17	6	23	59.0
	Complete graft take (95–100 %)	2	1	3	7.7
Need for secondary revision	4 patients (10 %)				
Median number of follow-up appointments	3				
Mean follow-up	137 days (4.5 months)				

graft take with an acceptable result at 2 months post-injury, without the need for additional intervention.

The mean ages of patients with no take, partial take, and complete take were compared, and these were found to be 6.5, 5.6, and 5.3 years, respectively. Although the trend suggested improvement of graft take in younger patients, this was not statistically significant. Furthermore, ordinal regression analyses failed to show any statistical significance of age as a predictor of graft take when controlling for mechanism of injury, presence of fracture, and location of initial presentation (our ED versus outside institution).

Mechanism of injury, presence of fracture, and location of initial presentation had no statistically significant influence on graft take.

Discussion

Fingertip injuries are common in the pediatric population. The goals of treatment include the provision of durable, sensate soft tissue coverage, and preservation of length [16, 18]. The decision to proceed with composite grafting is based on many factors, including the level and type of injury as well as the quality of the amputated part. In this study, we observed

modest viability of composite grafts in the pediatric population; only 7.7 % of patients had complete graft take and over 1/3 of composite grafts placed died.

Composite grafting has found limited success in adults [22], with reports demonstrating approximately 50 % graft survival or less [4, 12, 15] and smoking status negatively correlated with graft take. In children, however, the improved capacity to heal and absence of smoking and other medical comorbidities may lead to better outcomes. Moiemien and Elliott's study demonstrated 22 % complete graft take and 52 % partial graft take [19]. Their study investigated the time from injury to composite grafting and showed that grafts had greater viability when replaced within 5 hours. The study did not mention whether younger patients had better graft take. When determining time as an influencing factor, Moiemien and Elliott's study did not control for other factors such as age or mechanism of injury. Accordingly, their statistical results would need additional corroboration.

We did not have exact data for time of injury to graft placement. However, 22 of the 39 patients treated with composite grafting (56 %) were initially seen at an outside facility and then transferred to our facility for further care. Accordingly, the care that these patients received was inevitably delayed by at least a few hours as compared to patients who presented directly to our hospital ED (44 %). Using ordinal logistic regression, we found no significant difference in survival rates of grafts between these two groups of patients in our study, suggesting that time to composite grafting did not inversely correlate with graft take. Although muscles suffer irreversible damage after 6 hours of ischemia time, skin and fat (as in a composite fingertip graft) can survive much longer; thus, the 5 hour time limit suggested by Moiemien and Elliott seems arbitrary, especially since other factors were not controlled in their analysis. Perhaps mechanism of injury combined with quality of the composite graft and wound bed (upon clinical inspection) would be better predictive of graft survival.

The survival of composite grafts in this study was not influenced by age. Indeed, those patients who were 6 years of age or younger did not appear to have any improved survival in grafts—even when controlled for potential confounding factors that could possibly influence the outcome.

Fig. 3 Example of poor graft take (a) with acceptable fingertip contour at 2 months (b)

This finding challenges the widely held notion that composite grafts survive better in younger children. Although the number of patients may have been too low to detect a difference in this study, we could not find another study that compared composite graft survival in different age groups. This suggests that the patient's age should not be the only factor in determining whether to use this approach.

Despite limited numbers of complete composite graft take, only 10 % of patients have undergone revision procedures at the time of this review. Although not directly measured in this study, it is also our experience that most patients have satisfactory function and appearance even if the graft has no take. The reasons for this are unclear; one hypothesis is that the graft itself may function as a biologic dressing and promote healing of the native, proximal tissue. Children tend to heal quickly even by secondary intention in this well-vascularized area. Additionally, the nail bed tissue itself may contain regenerative components and may contribute to the developing soft tissue bulk over time [21].

There have been many described strategies to optimize take of composite grafts in various parts of the body, including post-operative cooling [13], hyperbaric oxygen therapy [17], pharmacologic agents [1, 10], and burying the part in a subcutaneous pocket [2, 9], among others. Other authors have proposed using a composite graft from the hypotenar region for reconstruction of fingertip injuries [14], and others have advocated a moist-exposed dressing to maximize composite graft take [23]. These specific techniques were not utilized during this study. Generally good outcomes and expeditious recovery would also argue against the need for additional cost and donor site morbidity with these adjunctive procedures.

There are limitations to this study: it is retrospective and was specifically designed to assess composite graft viability without investigating functional or aesthetic outcomes. Assessing these latter parameters in small children is quite difficult because currently available measures of functional status are limited and are likely to suffer from ceiling effect. The assessment of graft viability was determined at post-operative visits and recorded in the medical record and thus may be subject to observer bias. Additional potential predictive factors of graft take, such as exact time from injury to grafting and quality of the graft (e.g., crushed, bruised, lacerated), were also not available and could not be analyzed. More severe injuries may have undergone revision amputation or replantation; therefore, attempts at composite grafting may have resulted in more revision surgery in these patients; this was not specifically addressed in this study. Lastly, no power analysis was done a priori to determine if the sample size is appropriate to minimize likelihood of a β error. Despite these shortcomings, however, this is the second largest study on composite grafts in children and the first to perform a thorough intersubject statistical analysis.

Given our experience in this study, we continue to perform composite grafting for appropriate fingertip injuries and will do so in a child or adolescent presenting with extensive soft tissue loss from an injury distal to the distal interphalangeal joint. At worst, the composite graft forms a biologic dressing and avoids painful dressing changes and additional donor site morbidity in the young child; other reconstructive options remain possible regardless of the degree of graft take. Our results demonstrate that objective viability rates are modest but that most patients heal quickly and few patients undergo revision surgery. Further prospective studies, ideally ones with involvement of multiple centers, are needed to determine the optimal indications and techniques for composite grafting in the pediatric and adult populations; this represents a practical challenge. Other parameters such as time from injury to treatment, quantity of injured tissue, and exact surgical technique should also be studied.

Conflict of Interest Kyle R. Eberlin declares that he has no conflict of interest.

Kathleen Busa declares that she has no conflict of interest.

Donald S. Bae declares that he has no conflict of interest.

Peter M. Waters declares that he has no conflict of interest.

Brian I. Labow declares that he has no conflict of interest.

Amir H. Taghnia declares that he has no conflict of interest.

Statement of Human and Animal Rights The authors certify that all institutional and national guidelines for the care and use of laboratory animals were followed in this study.

Statement of Informed Consent Informed consent was obtained for the procedures performed in this study, although patient identifying information has been omitted from the manuscript.

Disclosures None of the authors has any financial interest in any of the products, devices, or drugs mentioned in this manuscript, or any other conflict of interest to disclose.

Level of Evidence Clinical Question: Therapeutic
Level of Evidence: IV

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