

Factors Affecting Composite Graft Survival in Digital Tip Amputations

Jonathan B. Heistein, MD

Paul A. Cook, MD

Distal fingertip amputations present the hand surgeon with a myriad of treatment options. Composite tissue replantation offers the patient the possibility of maintaining digital length and function. The purpose of this study was to determine the efficacy of this treatment modality and to support its use. During a 2.5-year period, 53 patients with 57 digital tip amputations distal to the distal interphalangeal (DIP) joint underwent composite tissue grafting of the tip with minimal defatting. All patients were evaluated in a prospective manner. Specific information regarding the patient and the injury were recorded. The survival rates for amputations distal to the eponychium and between the DIP joint and eponychium were 58% and 43%, respectively. Smoking was the only significant factor that had a strong, independent association with graft loss. Age older than 18 years and alcohol use appeared only initially to have an effect on graft survival because they were so closely linked with smoking. Diabetes mellitus and crush-type injuries may potentially predispose a graft to fail, but a larger sample size is needed to prove this with significance. There were no infections or serious complications, even in those grafts that failed. After reviewing the data, the authors recommend using composite tissue replantation for fingertip amputations distal to the DIP joint in nonsmokers.

Heistein JB, Cook PA. Factors affecting composite graft survival in digital tip amputations. *Ann Plast Surg* 2003;50:299–303

From the Ohio State University Hospital, Division of Plastic Surgery, Columbus, OH.

Received May 9, 2002, and in revised form Jul 24, 2002. Accepted for publication Jul 24, 2002.

Address correspondence and reprint requests to Dr Heistein, 800 8th Avenue, Suite 240, Fort Worth, TX 76104.

When a fingertip is amputated too far distal for microvascular replantation, a wide spectrum of treatment modalities is available to the surgeon. Unfortunately, none of these has been met with overwhelming success in adults. The therapeutic options range from the noninvasive approach of letting the wound heal by secondary intention with frequent dressing changes to the aggressive microvascular procedures. The goal of treatment is to restore a painless, minimally shortened digit with durable and sensate skin on the tip.^{1–4} Composite tissue replantation offers the patient the possibility of maintaining digital length and function with the patient's own durable fingertip skin.

There have been a few authors who have re-

ported cases of graft survival using a nonrevascularized composite graft of the amputated piece. For example, in 1959, Douglas⁵ described 17 cases with excellent results. Several subsequent practitioners have published their findings, which have also been encouraging.^{6–10}

In line with this progression, there have been articles describing different ways for improving the success rate. For example, Gillies and Reid¹¹ buried the tip in a subcutaneous pocket. This technique was modified and reattempted by Brent¹² but with only limited success. He first denuded (debrided and defatted) the amputated tip, reattached it to the stump, and then put it into a subcutaneous pocket on the abdomen. Lee and colleagues,¹³ Foucher and Citron,⁹ and Hirase¹⁰ also used modified replacement regimens.

Despite this literature, most surgeons are skeptical about composite graft replacement in distal fingertip amputation/avulsion injuries. Most of the articles that report success are fraught with flaws and have small sample sizes. Of course, whenever possible, microscopic revascularization has proved to be a more reliable means of reattaching an amputated finger; however, in the population of injuries that are too far distal for microsurgery (distal to the distal interphalangeal [DIP] joint), the options that avoid shortening of the digit include composite grafting and dressing changes on the stump for healing by secondary intention. The latter involves healing of a finger that will have less than normal function and may not be aesthetically pleasing. Therefore, the desire exists to develop better methods for improving and predicting the outcome of the former.

Most of the current literature is concerned with the different techniques of composite grafting rather than the pertinent issues, which may correlate with the success or failure of these grafts. This study is important because it assesses prospectively patient-specific factors that may affect composite graft survival to determine the efficacy of this treatment modality and to support

its use. It may help practitioners decide which patients would benefit from and which patients would not be good candidates for this type of treatment. Success rates may be improved if certain criteria must be met to qualify for this treatment modality.

Materials and Methods

All patients brought to the Riverside Methodist Hospital and Columbus Children's Hospital emergency rooms in Columbus, Ohio with complete fingertip amputations/avulsions distal to the DIP joint from December 1997 to June 2000 were eligible for inclusion. Amputation/avulsion was assessed as distal to the DIP joint, and thus in zone DP I or DP II, by plain radiographs and physical examinations of the stumps and tips. Zone DP I refers to the area distal to the eponychial fold, whereas zone DP II signifies a location distal to the DIP joint yet proximal to the eponychial fold.¹⁴ Patients of all ages were considered for the study. Initial exclusion from the study occurred if the patient or patient's guardian refused to be included.

The study design was prospective and observational. On acceptance into the study, extensive data were collected. In addition to the demographic information, specific questions about tobacco and alcohol use were recorded. Also, the presence of diabetes mellitus and other medical issues were noted. Important data regarding the time and mechanism of injury and mode of transport of the amputated part were included. Specific details about the injured digit were described explicitly with words and pictures. A section at the bottom of the data sheet was left for clinical data collection regarding the follow-up visits.

The surgical technique was consistent for all the patients, and the first author performed all the procedures. Every effort was made to perform the composite tissue grafting as soon as possible after the injury. The amputated part and digital stump were cleaned meticulously with a solution of povidone iodine and normal saline. All dirt and debris were lavaged thoroughly, but debridement of the skin edges was kept to a minimum. No defatting or de-epithe-

lialization was performed. Hemostasis was achieved with direct pressure to avoid the use of cautery devices. The tip was replaced onto the digit and was sutured carefully under loupe magnification. Meticulous approximation of the tip and nail bed, if involved, were performed. The nail was removed for the repair and was then sutured back to the nail bed to act as a splint after completion of the repair. Kirschner wires were used to create stable bone fixation if a fractured distal phalanx was included with the amputated digital tissue. A small amount of triple antibiotic ointment was then applied, followed by a bulky, but loose, protective dressing. Patients were instructed to keep the affected hand elevated when possible. Cephalexin was administered to all nonallergic patients for 3 to 7 days after the repair, depending on the degree of contamination. No other pharmacological intervention was initiated. The bandage was left intact until the first follow-up appointment, which occurred within 5 to 8 days after the repair.

All patients had a minimum of two follow-up appointments at 1 (5–8 days) and 12 weeks after the injury. Most had more than two appointments, but only the examinations at weeks 1 and 12 were used in the study. At the time of follow-up, information was recorded on the data sheet regarding the clinical progress. Complete survival was documented if less than 10% tip necrosis was present, and incomplete or partial survival was defined as more than 10% but less than 50% tip necrosis. The graft was considered to have no survival if more than half of it was necrotic.

After all the data were collected, an analysis was performed to determine which factors had a potential relationship with graft survival or death. Factors testing significant at the 0.05 level (two-sided test) were entered into a multivariate logistic regression to eliminate factors with a relationship in which the outcome was of a confounding nature.

Results

Sixty-two patients with 66 digital tip amputations met the inclusion criteria. Nine people were

Table 1. Demographic Information of Study Patients (N = 53) and Association With Complete Survival^a

Characteristic	N	Survival, %	<i>p</i> -Value
Gender			
Male	34	55.6	
Female	19	47.6	0.563
Age (range, 1–71; average, 28), yr			
≥18	34	37.1	
<18	19	77.3	0.003
Smoking			
Yes	12	15.4	
No	41	63.6	0.002
Alcohol use			
Yes	23	37.5	
No	30	63.6	0.05
Diabetes			
Yes	6	0.0	
No	47	58.8	0.008
Injury type			
Avulsion	18	63.2	
Crush	19	36.4	
Guillotine	16	62.5	0.093
Transport mode			
Cold	22	52.0	
Warm	31	53.1	0.933

^aFor the purpose of statistical analysis, partial and no survival categories are grouped together in a single category of no survival.

later excluded from the study as a result of insufficient follow-up. The demographic summary of the included patients can be seen in Table 1, and the characteristics of the involved digits are summarized in Table 2. The percentage of those that survived completely and the *p*-values are included in these tables. Of the 57 injured digits, 52.6% (N = 30) survived completely (<10% necrosis). Partial survival (10%–50% necrosis) and no survival (>50% necrosis) occurred in 31.6% (N = 18) and 15.8% (N = 9), respectively. There were no infections or serious complications, even in those grafts that failed. Smoking, diabetes, and age older than 18 were found to have *p*-values less than 0.05, and alcohol use and crush-type injury had *p*-values close to 0.05. Thus, these factors were potentially linked to graft failure. None of the other patient-specific factors affected the outcome with significance (*p* < 0.05).

Because the possibility of having more than one factor associated with each other, a multivariate approach was necessary to determine which factors had a direct causal effect on graft survival. A

logistic regression was used for this calculation. Table 3 depicts this analysis, along with the odds ratios and 95% confidence intervals for each regression. This series determined that smoking was the only factor that had a strong, independent association with graft loss (total or partial).

Age older than 18 years and alcohol use appeared only initially to have an effect on graft survival, because they were linked so closely with smoking. This was reflected when graft survival rates were calculated for age and alcohol use groups in patients that neither smoked nor had diabetes, as illustrated in Table 4.

Incidentally, having a crush injury may have an independent effect on the risk for graft survival despite its nonsignificant *p*-value in the logistic regression model from Table 3. Among nonsmoking patients and nondiabetic patients, 58.3% of the crush-injured digits had complete graft take versus 80.8% when the injury was a guillotine or avulsion type. Although not significant in this study, the 22% difference is large and deserves further attention.

Discussion

Fingertip amputations are the most common type of upper extremity amputation injury. The hand surgeon is always faced with the decision of how to treat the affected digits, and multiple treatment options have been described. These are quite varied and range from conservative measures of healing by secondary intention to aggressive microvascular replantation. Other techniques include primary closure with or without bone shortening, skin grafts, composite grafts, and local, regional, or distant flaps. Tremendous controversy exists in regard to which of these offers the “best” result.

By performing a composite graft on the amputated digit, at least the patient is given some hope of maintaining digital length and function. If the graft does not survive, then a secondary procedure that may involve finger shortening and closure can be performed at a later date. But, if the graft takes, then truly this is advantageous. This is why it is important to try to define what issues hinder graft survival in these patients.

In summary, the study demonstrated that

Table 2. Characteristics of Injured Digits of Study Patients (N = 57) and Association With Complete Survival^a

Characteristic	N	Survival %	p-Value
Zone of injury			
DP1	36	58.3	
DP2	21	42.9	0.259
Tissue involved (most proximal level)			
Skin/fat alone	7	42.9	
Sterile matrix bone	20	70.0	
Germinal matrix bone	23	39.2	
Proximal to germinal matrix bone	7	57.1	0.44
Tissue volume (range, 0.01–2.9 ml; average, 0.61 ml), ml			
≥0.4 ml, average,	28	50.0	
<0.4 ml, average,	29	55.2	0.358
Time to repair (range, 35–420, min; average, 136.5 min), min			
≥90	40	47.5	
<90	17	64.7	0.146

^aFor the purpose of statistical analysis, partial and no survival categories are grouped together in a single category of no survival. DP1 = distal interphalangeal zone 1.

Table 3. Results of Logistic Regression Controlling for Various Factors in Their Relationship With Graft Failure

≥Model	Odds Ratio ^a	95% CI ^b for Odds Ratio	p-Value
Age ≥ 18 yr	1.55	0.36–6.61	0.557
Smoking	12.10	1.91–76.22	0.008
Alcohol use	1.15	0.24–5.40	0.863
Smoking	14.09	2.02–98.44	0.008
Age ≥18 yr	2.55	0.42–15.41	0.308
Alcohol use	1.93	0.34–10.77	0.456
Smoking	14.07	2.58–76.77	0.002
Crush Injury	2.51	0.65–9.73	0.183

^aThe odds ratio is the ratio of the odds of graft failure given that the factor is present vs. the odds of graft failure given that the factor is absent. The odds ratios in this table are adjusted for the other factor in the logistic regression model. The higher the odds ratio, the stronger the association between the factor and graft failure.

^bThe 95% confidence interval (CI) for the odds ratio indicates that if the study were repeated multiple times, 95% of the studies would produce odds ratios that would be within the given range.

smoking was the factor most likely to dictate graft failure. Diabetes and crush-type injuries may potentially be additional variables that would predispose to graft loss, but a larger sample size is needed to have significant proof. It is possible that other variables measured in this study, such as elapsed time to repair, could have direct relationships with graft survival, but that they could not be detected because of the small sample sizes.

After review of these data, we recommend using composite tissue replantation for fingertip amputations distal to the DIP joint in nonsmoking patients. Survival rates are also potentially

Table 4. Graft Survival Rates by Age Group and Alcohol Use Among Patients Who Do not Smoke and Those Without Diabetes

Characteristic	Survival, %	p-Value
Age group, (yr)		
<18	77.27	
18–34	71.43	
35–49	80.00	
≥50	50.00	0.7127
Alcohol use		
Yes	70.00	
No	75.00	>0.9999

increased in young patients, in nondiabetic patients, and in noncrush-type injuries. Even when not successful, the grafts act as biological dressings with minimal risk until subsequent treatment is performed. This information should be used as a guideline when determining a preoperative plan. If none of these factors is present or if the patient is willing to stop smoking reliably, then it is reasonable to consider performing a composite graft for the amputated tip. This gives the patient the best chance to retain a cosmetically pleasing, full-length finger that potentially will provide excellent function. When one or more of these factors are present, the risk for graft failure is high and other treatment options should be entertained.

References

- 1 Fassler PR. Fingertip injuries: evaluation and treatment. *J Am Acad Orthop Surg* 1996;4:84–92

- 2 Martin C, del Pino JG. Controversies in the treatment of fingertip amputations. *Clin Orthop* 1998;353:63–73
- 3 Russell RC, Casas LA. Management of fingertip injuries. *Clin Plast Surg* 1989;16:405–425
- 4 Zook EG, Doermann A. Management of fingertip trauma. *Postgrad Med J* 1988;83:163–176
- 5 Douglas B. Successful replacement of completely avulsed portions of fingers as composite grafts. *Plast Reconstr Surg* 1959;23:213–225
- 6 Showalter J. Results of replacement of fingertip tissue. *Int Surg* 1968;50:306–310
- 7 Chunpraph B. Replantation of portions of four fingers in one hand. *N Engl J Med* 1974;291:460–461
- 8 Rose EH, Norris MS, Kowalski TA, et al. The “cap” technique: nonmicrosurgical reattachment of fingertip amputations. *J Hand Surg [Am]* 1989;14A:513–518
- 9 Foucher G, Citron N. Therapeutic approach in fingertip injuries. In: Evans D, ed. *Skin cover in the injured hand*. Edinburgh: Churchill Livingstone, 1992:182
- 10 Hirase Y. Salvage of fingertip amputated at nail level: new surgical principles and treatments. *Ann Plast Surg* 1997;38:151–157
- 11 Gillies H, Reid D. Autograft of the amputated digit. *Br J Plast Surg* 1955;7:338–342
- 12 Brent B. Replantation of amputated distal phalangeal parts of fingers without vascular anastomoses using subcutaneous pockets. *Plast Reconstr Surg* 1979;63:1–8
- 13 Lee PK, Ahn ST, Lim P. Replantation of fingertip amputation by using the pocket principle in adults. *Plast Reconstr Surg* 1999;103:1428–1435
- 14 Yamano Y. Replantation of the amputated distal part of the fingers. *J Hand Surg [Am]* 1985;10A:211–218

Errata

Ünsal M, Gurunluoglu R, Babuccu O, et al. Effect of long-term cyclosporine administration on muscle flap hemodynamics. *Ann Plast Surg*. 2002;48:305–311.

Gurunluoglu R, Lubiatowski P, Goldman CK, et al. Enhancement of muscle flap hemodynamics by angiopoietin-1. *Ann Plast Surg*. 2002;48:401–409.

Meirer R, Babuccu O, Ünsal M, et al. The effect of chronic cyclosporine administration on peripheral nerve regeneration: a dose-response study. *Ann Plast Surg*. 2002;49:96–103.

Raffi Gurunluoglu, MD was erroneously listed as Raffi Gurunluoglu, MD, PhD in the above-mentioned articles. Dr. Gurunluoglu will receive his PhD in 2003. We regret the error.

Satoh K, Suzuki T, Uemura T, Hosaka Y. Maxillo-mandibular distraction osteogenesis for hemifacial microsomia in children. *Ann Plast Surg*. 2002;49:572–579.

The second author of the above-mentioned article was erroneously listed as Takayuki Suzuki, MD. The author’s correct name is Hiroyuki Suzuki, MD. We regret the error.
