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Outcome of Composite Graft Uptake in Fingertip Amputation in All Age Groups

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ABSTRACT

Objective: To determine the outcome of composite grafting for fingertip amputation in terms of graft survival.
Study Design: Prospective longitudinal study
Place and Duration of Study: Department of Plastic Surgery, Combined Military Hospital, Rawalpindi Pakistan from, Jan 2020 to Sep 2022.
Methodology: We conducted this study on 174 adults with distal upper limb digital amputations. Patients of both genders between the age of 5 and 80 years were included. Patients with previous surgery for same injury, multiple amputations or complex injuries or compartment syndrome were excluded. All patients received repair with a composite graft and were followed-up for one-year post-procedure to assess outcomes and monitor for complications. Data was analyzed using SPSS 26.0.
Results: The study sample had a median age of 32.00 (IQR: 22.00) years, with males accounting for a majority of the cases i.e., 136(78.2%). Graft failure was seen in 27(15.5%) patients. A total of 12(6.9%) patients required revision surgery. Neuromas and surgical site infections were seen in 9(5.2%) and 7(4.0%) patients, respectively, while 13(7.5%) patients complained of significant pain in the re-implanted digit at one-year, post-surgery. Advancing patient age (p=0.010), a longer time elapsed from trauma to surgery (p<0.001) and development of surgical site infections (p<0.001) were all associated with graft failure.
Conclusion: Composite grafting is associated with good outcomes in patients with digital amputations in-terms of graft survival.

Keywords: Composite Grafting, Digital Amputation, Graft Survival.

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INTRODUCTION

The fingertip is defined as the part of the distal phalanx that is located distal to the point of insertion of the flexor and extensor tendons.[1] Fingertip injuries are one of the most common reasons for reporting to the emergency department: an estimated five million cases per annum report for treatment of such injuries to the emergency department in the United states, with roughly a quarter suffering from sub-total or total amputations.[2] The injury can result from a wide variety of causes but the basic mechanisms usually revolve around some form of crush, lacerative or avulsive injury.[3] The main objectives of treatment are to conserve mobility and sensation of the affected digit, minimize shortening and make the re-implant as pain-free and aesthetically pleasing as possible.[4] Microsurgical technique involves the reattachment of the amputated part to the stump with repair of the damaged blood vessels and nerve, which is the standard of care, however, this may not always be possible especially in cases with crush injuries where the anatomy may be significantly distorted.[5,6] For such cases a composite graft may be employed, which has been used successfully in the re-attachment of other appendages such as the ear.[6]

Composite grafting involves harvesting the graft from the amputated portion and suturing this to the digit.[7] This technique carries the advantage of not requiring the highly expert microsurgeon and time-consuming technique of microsurgery to restore the vascular and nerve supply of amputated part. The composite graft initially acquires its nutrition and waste exchange through passive diffusion from the stump but switches to regular exchange through blood circulation once neovascularization occurs.[8] The initial nutritional requirements of the composite graft can be lowered down by immersing the composite grafted finger in 4 degrees Celsius of cold water.[9] This time-saving, cheap and non-expertise intensive procedure can be associated with aesthetically pleasing, length-preserved digits with the return of sensory and motor function and in some cases, avoiding a long rehabilitation program if otherwise a microsurgical technique is applied. However, due to the lack of vessel anastomoses, it carries the theoretically higher risk of graft failure.[8-10]

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We conducted this study with the aim of determining the frequency of graft failure in patients undergoing composite grafting for fingertip amputations. Determining whether this technique is successful or not is essential in deciding whether it can be employed on a regular basis in patients whose injuries may be unfit for microsurgical repair. If graft failure is found to be low, then the technique of composite grafting can be employed on a more frequent basis.

METHODOLOGY

This prospective longitudinal study was conducted from Jan 2020 to Sep 2022 in the Department of Plastic Surgery, Combined Military Hospital, Rawalpindi on 174 patients with distal finger amputations, after obtaining consent for inclusion in the study. Ethical approval was obtained via CMH, Rwp IERB letter no. 299. All patients were selected via consecutive, non-probability sampling. The WHO sample size calculator was used to calculate the sample size keeping a confidence level of (1-α) of 95%, an absolute precision (d) of 0.05 and an anticipated population proportion (P) of 0.13, which was the percentage of patients with complete graft survival post-composite grafting, from Borrelli *et al*.[11]

Inclusion Criteria: All patients who have suffered traumatic distal digital amputations, of both genders between the age of 5 and 80 years were included.

Exclusion Criteria: Patients who have received previous surgery for same injury, those with multiple amputations, or with compartment syndrome or trauma involving the proximal limb were excluded.

Patients either received a local nerve block or general anesthesia depending upon the surgeons' preference. All patients received the same technique for composite grafting, with minor adjustments based on the characteristics of the injury. The level of amputation was classified according to the Tamai classification.[12] Fixation of bone, where required, was done and any bone fragment was nibbled, which was followed by minimal debridement and careful irrigation. Composite grafting was done with trimming of graft fat where required, and the amputated appendage was secured with interrupted, absorbable sutures. Nerve repair was conducted using the centro-central neurorrhaphy (coaptation) on all the patients. All patients were asked to immerse the composite grafted finger or fingers in cold water at 4°C for 5 days from the time of surgery, with aluminum foil wrapping. All patients were followed-up in outpatient services of Plastic Surgery of CMH for one-year post-procedure for graft uptake, development of complications and postoperative pain. The pain was assessed using the Visual Analog Scale (VAS) score, and score of ≥5 was considered indicative of significant pain.[13]

Data was analyzed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows version 26, IBM Corp; Armonk, USA). Mean and standard deviation was calculated for quantitative variables specifically patient age, time from trauma to operating table, total tourniquet time, length of hospital stay, and VAS score at one year. Qualitative variables like gender, whether patient was a smoker, mechanism of trauma, which digit was injured, which hand was involved, partial/complete amputation, amputation level, graft survival at one-year post-surgery, formation of neuroma, development of infection, requirement for revision of surgery and the presence of significant pain was recorded in terms of frequency and percentage. Patients were grouped into two: Group 1 contained patients whose grafts survived completely or partially up to one-year post-surgery, while Group 2 contained patients whose grafts failed. Quantitative variables were compared across groups using the independent samples t-test while the chi square test was used for qualitative variables, and a *p*-value of ≤0.05 was considered significant.

RESULTS

Our study sample was composed of 174 patients with a median age of 32.00 (IQR: 22.00) years, with a male majority: 136(78.2%). A total of 23(13.2%) patients were smokers. Most of the patients suffered crush injuries, which accounted for 96(55.2%) cases, lacerations occurred in 67(37.5%) and avulsions in 11(6.3%) patients. A majority of injuries were sustained on the middle finger 75(43.1%), while the index finger was injured in 51(29.3%) cases. The ring, little finger and thumb were involved in 27(15.5%), 18(10.3%) and 3(1.7%) cases, respectively. The digits on the right hand were more frequently involved: 134(77.0%), partial amputations were seen in 118(67.8%), while the majority of amputations were Zone II: 121(69.5%). The mean time from inciting trauma to operating table was 11.70±5.85 hours. Table-I shows the patient characteristics distributed according to gender.

Table-II displays the characteristics of surgery and its outcomes after one-year of follow-up as per

gender. The mean time on tourniquet was 25.61±5.36 minutes, while the mean length of hospital stay was 19.23±6.53 hours. A total of 12(6.9%) patients required re-surgery. Graft failure was seen in 27(15.5%) patients, while neuromas formed in 9(5.2%) cases. Surgical site infections were seen in 7 (4.0%) patients. The mean pain score at one-year post-surgery was 2.34±1.50, with 13(7.5%) patients complaining of significant pain.

Table-I: Patient Characteristics According to Gender (n=174)

Variable	Male (n=136)	Female (n=38)
Gender	136 (78.2%)	38 (21.8%)
Smoking	20 (14.7%)	3 (7.9%)
Mechanism of Injury		
Crush	80 (58.8%)	16 (42.1%)
Laceration	48 (35.3%)	19 (50.0%)
Avulsion	8 (5.9%)	3 (7.9%)
Digit Involved		
Middle	61 (44.9%)	14 (36.8%)
Index	37 (27.2%)	14 (36.8%)
Ring	21 (15.4%)	6 (15.9%)
Little	15 (11.0%)	3 (7.9%)
Thumb	2 (1.5%)	1 (2.6%)
Upper Limb Involved		
Right	103 (75.7%)	31 (81.6%)
Left	33 (24.3%)	7 (18.4%)
Degree of Amputation		
Partial	91 (66.9%)	27 (71.0%)
Complete	45 (33.1%)	11 (29.0%)
Level of Amputation		
Zone 1	43 (31.6%)	10 (26.3%)
Zone 2	93 (68.4%)	28 (73.7%)
Time from Trauma to Surgery (hours)	11.68 ± 5.87	11.74 ± 5.83

Table-III shows the association of different factors with graft success. Advancing age (p=0.010) and time elapsed from trauma to surgery (p<0.001) were significantly associated with the occurrence of graft failure. Other factors such as gender, digit and limb involved, mechanism of trauma, degree and zone of amputation did not appear to have a bearing on graft success, (p>0.05).

DISCUSSION

Digit amputations of the upper limb present a unique challenge to the plastic surgeon, principally because of the variety of mechanisms in which seemingly minor trauma incurs significant tissue damage, which can lead to substantial vascular injury rendering the amputated part unfit for microsurgical procedures.[14] Composite grafting may be employed in such cases, particularly if the patient desires the restoration of aesthetics and digit length.[15]

Table-II: Surgery Characteristics and Results according to Gender (n=174)

Variable	Male (n=136)	Female (n=38)
Time on Tourniquet (minutes)	25.79±5.35	25.00±5.43
Length of Hospital Stay (hours)	19.15±6.65	19.50±6.16
Requirement for Revision Surgery	10 (7.4%)	2(5.3%)
Graft Survival at One Year	118(86.8%)	29(76.3%)
Neuroma Formation	7(5.1%)	2(5.3%)
Infection Development	2(3.7%)	5(13.2%)
VAS Score at One Year	2.24±1.51	2.71±1.41
Presence of Significant Pain at One Year	10(7.4%)	3 (7.9%)

Table-III: Factors associated with Graft Success (n=174)

Variable	Graft Success (n=147)	Graft Failure (n=27)	p-value
Gender			
Male	118 (80.3%)	18 (66.7%)	0.116
Female	29 (19.7%)	9 (33.3%)	
Age (years)	30.48±15.45	38.81 ± 14.50	0.010
Smoking	21(14.2%)	2 (7.4%)	0.332
Mechanism of Injury			
Crush	78(53.1%)	18 (66.7%)	0.414
Laceration	59(40.1%)	8 (29.6%)	
Avulsion	10(6.8%)	1 (3.7%)	
Digit Involved			
Middle	59(40.1%)	16 (59.3%)	0.383
Index	46(31.3%)	5 (18.5%)	
Ring	24(16.3%)	3 (11.1%)	
Little	15(10.2%)	3 (11.1%)	
Thumb	3(2.0%)	-	
Upper Limb Involved			
Right	113(76.9%)	21 (77.8%)	0.918
Left	34(23.1%)	6 (22.2%)	
Degree of Amputation			
Partial	98(66.7%)	20 (74.1%)	0.449
Complete	49(33.3%)	7 (25.9%)	
Level of Amputation			
Zone 1	46(31.3%)	7 (25.9%)	0.578
Zone 2	101(68.7%)	20 (74.1%)	
Time from Trauma to Surgery (hours)	10.84±5.44	16.33±5.92	<0.001

A total of 86.8% experienced graft survival at one-year post-procedure in our study. Borrelli *et al.*,

noted that 59% of composite grafts succeeded in their study on upper limb digit amputations,[16] however, depending on the study, composite graft survival rates for digits are highly variable, ranging from 0% to 93.5%.[16,17] The reasons for this are myriad; studies have different study populations which vary with regards to mechanism of injury, degree, time to presentation and associated co-morbidities, most of whom lack control arms, which explains the varying results. This lack of standardization between studies decreases the ability to interpret their findings.

The patients in this study sample had a mean age of 31.77±15.55 years. Advancing age was significantly associated with a decrease in graft survival, (p=0.010). This is in keeping with existing studies on the subject such as Larsen et al and Long et al where patients with digital amputations had mean ages within their fourth decade of life. noted a mean age of 39.3±20.4 years, with the higher incidence in this age group being ascribed to work-related trauma, with increasing age being associated with poorer outcomes, likely due to poorer wound healing and vascular supply.[18,19]

Our patients were comprised of a male majority of 78.2%; gender did not appear to have an effect on the occurrence of graft failure, (p=0.116). Larsen *et al.*, studied the epidemiology of upper limb digit amputations and also noted that males reported more frequently with such trauma which is likely due to the preponderance of males operating heavy machinery, power tools and taking part in heavy labour.[18]

Smoking did not appear to have any effect in the development of graft failure in our study, (p=0.332). Landin et al reported, in their review, that smoking was clearly associated with graft failure in digital amputations, which was at odds with our side, with the likely cause being compromised blood supply due to smoking.[20] We believe the difference in results has occurred due to the smaller number of smokers in out study sample; further study of this subject may be required preferably comparing smokers to non-smokers to confirm or negate our observations.

Crush injuries were the most common form of trauma seen accounting for 55.2% of cases; the mechanism of injury did not appear to have an effect on graft survival, (p=0.414). Ono et al, in their review of reimplantation of the hands and digits noted that crush and avulsion injuries had a lower success rate with regards to graft survival while laceration had better rates, due to better integrity of the tissue, which was converse to our results.[21] Most injuries are not neatly classifiable into a single category: trauma is usually composite, which may account for this difference in our results.

Patients with graft failure had a significantly longer mean time period elapsed between inciting trauma to surgery of 16.33±5.92 hours versus 10.84± 5.44 hours in those who did not, (p<0.001). Harbour et al describes the importance of keeping time between inciting trauma and surgery, the so-called ischaemia time, as short as possible, to maintain tissue viability of the amputated part and ensure better graft survival, a conclusion that was in keeping with our study.[22] Another aspect is the Time on Tourniquet during the surgery which also causes ischaemia and may influence graft uptake, however, in our study this variable did not appear to be significantly different between patients with composite graft failure and those without, (p=0.544). Gangadharan et al noted in their study that prolonged use of tourniquets (with a mean time of 191 minutes in their study on foot and ankle procedures) only resulted in transient adverse effects such as paresthesias, anaethesia pain, and had no lasting effect on graft uptake.[23] However, this aspect requires further research before adequate conclusions can be made.

Patients who developed surgical site infections had a significantly higher risk of composite graft failure in our study, (p<0.001). Greenblatt et al studied the effect of surgical site infections (SSIs) in terms of graft loss in patients undergoing lower limb revascularization and grafting procedures and determined that graft loss was increase two-fold in patients with SSIs, compared to those without.[24]

LIMITATIONS OF STUDY

We conducted this study in a single center without a control arm: a better perception of the various factors associated with graft survival may be obtained by conducting a study with a comparison arm. Moreover, injuries were grouped according to the primary inciting trauma for the purposes of the study, however, in reality most injures are composite and are not so easily classifiable. Lastly, some amputated digits were brought while stored at different temperatures which could not be adequately accounted for, which may have resulted in some confounding within the results.

CONCLUSION

Composite grafting for digital amputations is a viable option in patients who are unable to undergo microsurgical repair due to excessive tissue, especially vascular, damage, with good outcomes in terms of survival. Early employment of the procedure to minimize total

ischaemia time and institute measures to limit surgical site infections may result in improved outcomes. Further research is required to determine factors which influence the development of graft failure in digital amputations, which will help to limit their effects and improve surgery outcomes.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

KA & SH: Data acquisition, data analysis, critical review, approval of the final version to be published.

MAN & FM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

KUM & AQ: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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