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Outcomes of Composite Grafts for Pediatric Fingertip Amputations: A Systematic Review

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Abstract

Introduction The aim of this study was to explore the outcomes of composite grafts in fingertip amputations in children as well as the contributing factors that may affect outcomes.

Methods Literature search was conducted across six databases in March 2022 to select studies on the use of composite grafts on fingertip amputations in the pediatric population.

Results Twelve articles with 735 composite grafts were identified for review. Most fingertip injuries occurred in the less than 5-year age group and were due to crush type injuries. In studies that reported "complete" graft take as a separate outcome measure, 17.3% of fingertips with this result were observed. In the studies that reported "complete" and "partial" graft take together as an outcome measure, 81.6% of fingertips achieved this outcome. A lower proportion of failed graft take was observed in more distal fingertip amputations. Infection (3.8%) and nail abnormalities (3.4%) were the most common complications following composite grafting.

Conclusion Composite grafting can be considered as a useful method of treatment in this population. Clinicians should be aware of the potential complications following this method of treatment such as infection and nail abnormalities. More proximal fingertip amputations may warrant other surgical interventions (beyond Level II on the modified Ishikawa/Ishikawa classification). Significant heterogeneity was observed within the studies, mainly due to lack of standardization in assessment and reporting of outcomes.

Keywords
- amputations
- composite graft
- fingertip
- pediatric

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Introduction

Fingertip amputations account for two-thirds of all hand injuries in the pediatric population with door-related crush injuries being the most common mechanism.[1,2] Several short-term complications can arise following the injury including cold intolerance, hypersensitivity, residual pain, and infection. Poor sensory recovery, scar retraction, and hook nail deformity form part of the long-term sequelae observed in fingertip amputations, resulting in functional disability and becoming a psychological burden to carers and patients.[3]

Various surgical techniques such as replantation have been described to maintain normal function and architecture of the fingertip. While replantation has advantages in re-establishing immediate blood flow, the distal nature of amputations within the distal phalanx makes this technique technically challenging in children.[2] Other limitations of replantation include cost, time efficiency, and increased operating times.[4] Nonmicrosurgical techniques such as healing by secondary intention using various dressings, reconstruction with local or regional flaps as well as repositioning of the amputated part as a composite graft have become an alternative and popular method in recent times.

Paucity in guidelines on the use of composite grafts for fingertip amputation has left the decision for choosing this technique to remain clinician based.[5–12] For example, composite graft technique has been a favored method in most children's hand trauma units when the amputated part is well preserved and in a condition that can be used for reconstruction.[5] However, evidence regarding what is defined as "condition for reconstruction" as well as predictive factors affecting long-term outcomes is sparse.[13] Furthermore, the assessment of outcomes has remained heterogenous in the literature,[13] making it difficult for both clinicians and patients to understand outcomes of composite grafts as well as difficulty in managing expectations from patients and their families.

This article aims to explore the outcomes of composite grafts in fingertip amputations in children as well as the contributing factors such as age and level of amputation that may affect the overall result.

Methods

The study protocol was registered with PROSPERO (CRD42022316590) and was reported via the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines. The following databases were used for the literature search from database inception to May 20, 2023: MEDLINE (PubMed), Embase, Google Scholar and Cochrane Database of Systematic Reviews. ►**Table 1** shows the combinations of MeSH search terms used in each database. Keywords such as "fingertip," "digital tip" "digit," "finger," "thumb," "amputation," "injury," "replantation," and "composite grafts" were used. Forward and backward citation searching was performed for all included and excluded studies as well as relevant systematic reviews by reviewing the reference lists of each study and identifying articles that cited said study in Web of Science.

All titles and abstracts retrieved from the databases were downloaded and duplicates were removed. Full-text articles were retrieved and reviewed independently in the case of discrepancy concerning inclusion/exclusion of articles into the study. The exclusion criteria consisted of adult population (over the age of 18), secondary reconstructions after initial healing, replantations of fingertip, flap reconstruction of fingertip, pocket flap-grafts, and conference abstracts. The inclusion criteria consisted of human studies, fingertip (distal phalanx), composite grafts, and English written studies.

Data was extracted using a modified and custom form by four authors. Each author extracted data from an equal number of included studies. Data was analyzed according to the Patient, Intervention, Comparison and Outcome (PICO) format. The included studies were analyzed for patient demographics and outcomes. The patient demographics analyzed included age, sex, which finger was injured, level of injury (depending on classification used), type of injury, and number of fingertips. The outcome data extracted was divided into primary outcomes, secondary outcomes, and complications. Primary outcomes consisted of graft take, and secondary outcomes consisted of length of follow-up, functional outcomes, patient satisfaction, and effect on quality of life.

The Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool was used to evaluate the risk of bias which is represented visually using robvis tool in ►**Fig. 1**.[14]

Results

The initial search yielded 776 articles for review after eliminating duplicates. After full-text screening, 12 articles (six retrospective reviews, two prospective case reviews, two cohort studies, two case series) published between 1997 and 2020 were included for full-text analysis. The result of this search and yield of articles is represented as a PRISMA flowchart in ►**Fig. 2**.

Demographical Data

A total of 735 composite grafts were performed with the middle finger ($n = 73$, 9.9%) followed by ring finger ($n = 63$, 8.6%) being the most common site of fingertip amputation requiring repair with this technique. Eight studies specified the age of their pediatric population, and the mean age of the patients was 4.1 years with the range of 0 to 17 years. From the seven articles that specified sex of the patients who had composite grafts, 225 males and 170 females were found. The most common mechanism of injury was crush type injury ($n = 333$, 85.2%) followed by laceration ($n = 18$, 4.6%), from the eight articles that specified this data.

Among the 11 articles that classified the level of injury using a classification, the following were used: Ishikawa ($n = 158$), modified Ishikawa ($n = 293$), Das and Brown ($n = 6$), Hirase ($n = 3$), with Imaizumi et al, Son et al, and Heistein and Cook, using their own classification ($n = 17$, $n = 15$, $n = 19$, respectively).[9,15] The various classifications of fingertip injury are shown in ►**Fig. 3** for comparison.[16–19] ►**Table 2** shows the descriptions for all classifications of fingertip injury found in this study.

Table 1 MeSH terms used for literature search

Concept	MeSH term
Finger	‘’anastomosis, surgical,” “graft survival,” “microsurgery,” “surgical flaps,” “surgery, plastic,” “reconstructive surgical procedures,” “surgical procedures, operative,” “surgery,” “debridement,” “conservative treatment,” “wound healing,” “therapeutic irrigation”
Phalanges of fingers	‘’anastomosis, surgical,” “graft survival,” “microsurgery,” “surgical flaps,” “surgery, plastic,” “reconstructive surgical procedures,” “surgical procedures, operative,” “surgery,” “debridement,” “conservative treatment,” “wound healing,” “therapeutic irrigation”
Thumb	“anastomosis, surgical,” “graft survival,” “microsurgery,” “surgical flaps,” “surgery, plastic,” “reconstructive surgical procedures,” “surgical procedures, operative,” “surgery,” “therapeutic irrigation,” “wound healing,” “conservative treatment,” “debridement”
Finger injuries	“anastomosis, surgical,” “graft survival,” “microsurgery,” “surgical flaps,” “surgery, plastic,” “reconstructive surgical procedures,” “surgical procedures, operative,” “surgery,” “debridement,” “conservative treatment,” “wound healing,” “therapeutic irrigation”

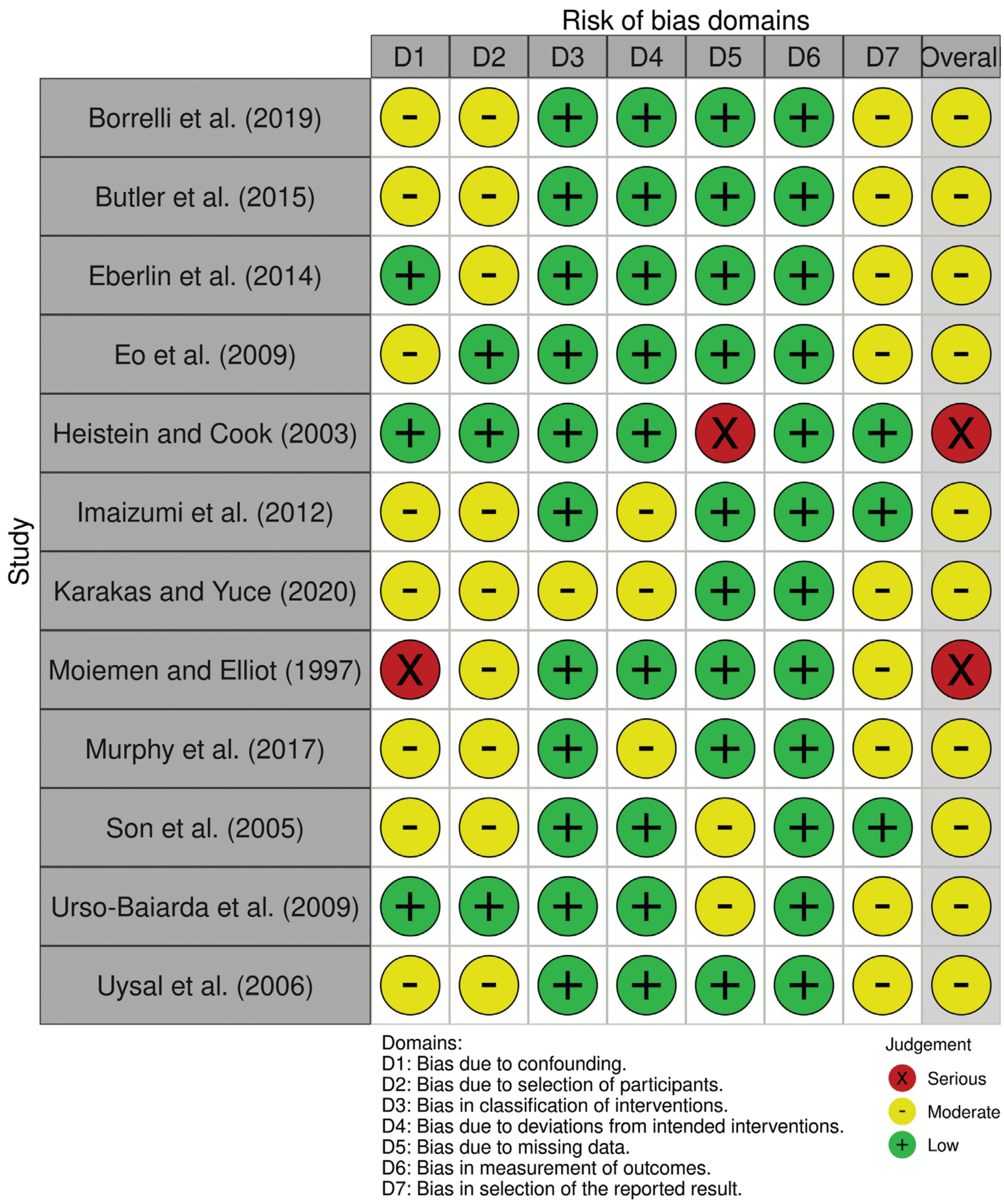

Fig. 1 Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I Tool) assessment for included studies.

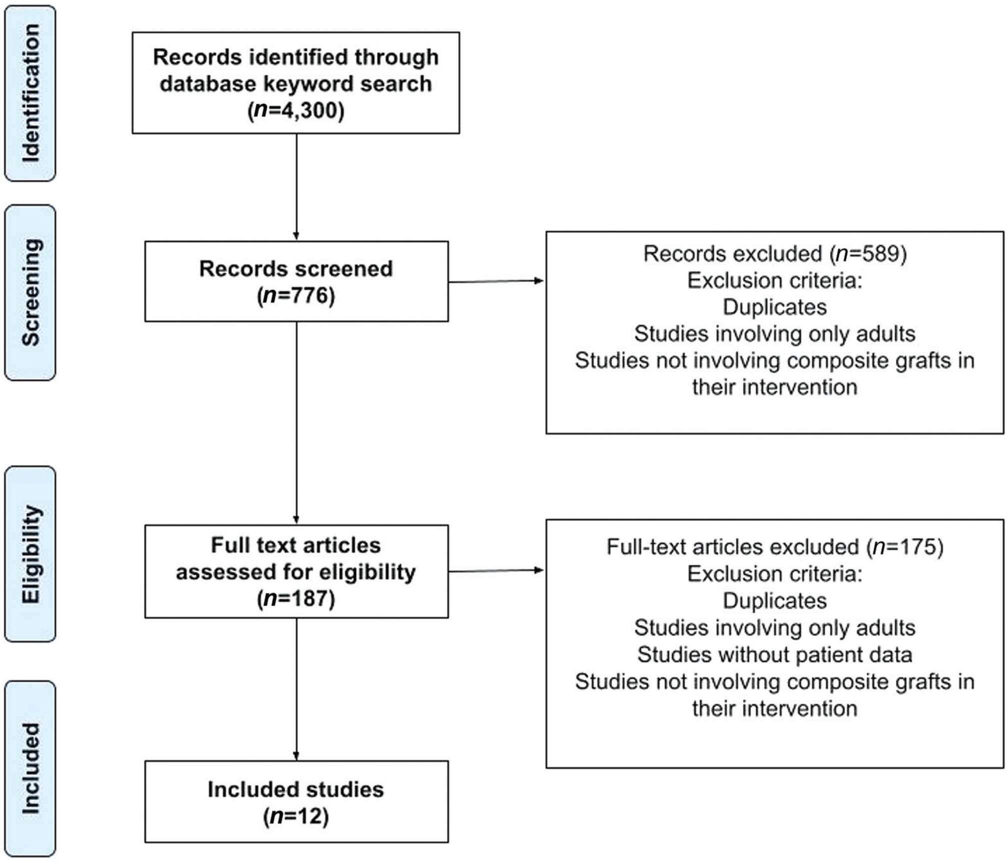

Fig. 2 Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) flowchart of articles.

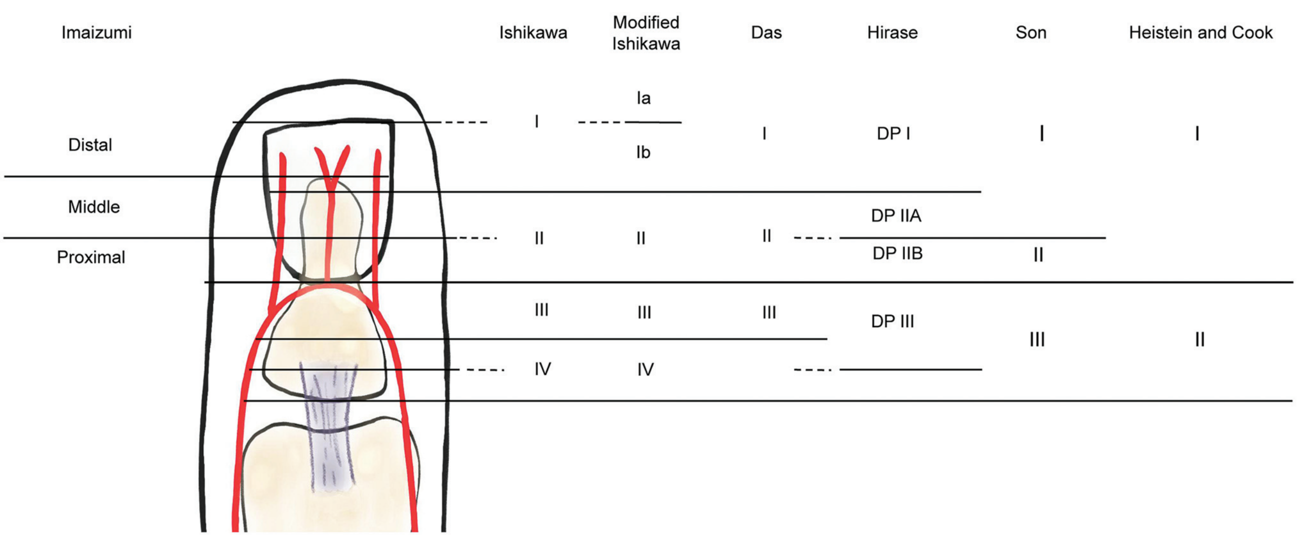

Fig. 3 Anatomical comparison of the various classifications used for fingertip amputations. DP, distal phalanx.

Primary Outcomes

Graft Take

Eleven studies reported graft take or survival as an outcome. For the studies where "complete" graft take was reported as a separate outcome, 17.3% of fingertips overall achieved this result. For studies that combined "partial" and "complete" graft take as an outcome, 81.6% of fingertips achieved this result. Eo et al reported graft "success" in all six of their pediatric patients. This article, however, did not mention graft take but measured "scab" survival in their pediatric population.[20] This was only described as "good"; therefore, it could not be included in overall conclusions.

Table 2 Descriptions for fingertip amputation classifications in this study

Classification	Description
Ishikawa/Modified Ishikawa (MI)	Subzone I—from tip of fingertip to midpoint of nail IA (MI)—from tip of the fingertip to the distal end of the nail IB (MI)—from the distal end to the midpoint of nail Subzone II—from midpoint of the nail to base of the nail Subzone III—from nail base to the midpoint between nail base and the DIPJ Subzone IV—from the midpoint between the nail base and the DIPJ to the DIPJ
Das	Type I—distal pulp (with or without part of nail) Type II—pulp + terminal phalanx up to distal 1/3 Type III—pulp + terminal phalanx up to distal 3/4
Hirase	Zone DP I—distal to the most distal dividing point of the central digital artery Zone DP IIA—c*entral digital artery* arising from the distal palmar arch of digital artery Zone DP IIB—d*istal palmar arch* of digital artery Zone DP III—proximal to the distal palmar arch of digital artery
Imaizumi	Distal type—distal to distal phalangeal tip Middle type—between Distal and Proximal type Proximal type—proximal to the lunula
Son	Zone I—distal to lunula Zone II—at the lunula Zone III—proximal to the lunula
Heistein and Cook	Zone DP I—area distal to the eponychial fold Zone DP II—area distal to the DIPJ yet proximal to the eponychial fold

Abbreviations: DIPJ, distal interphalangeal joint; DP, distal phalanx; MI, modified Ishikawa.

Secondary Outcomes

Patient Satisfaction and Effect of Quality of Life

Three studies reported patient satisfaction. Borrelli et al noted that on average, patients ($n = 100$) rated the appearance as "normal" and were satisfied with the cosmetic appearance, scoring the appearance of the composite graft an average of 3.5/5 with 5 being the best possible outcome.[5] The authors also reported that most of their patients took 2 to 6 months to return to normal daily activities following the repair of their fingertips. Urso-Baiarda et al reported patient satisfaction at 5 years post-surgery, where the patients reported normal use of the digit and satisfaction with the results of surgery.[21] Uysal et al reported full satisfaction from all three of their pediatric patients despite shortening of fingers.[22]

Length of Follow-Up

Length of follow-up was reported by eight articles. The mean length of follow-up was 10.1 months across all studies and the range was 0.5 to 96 months. Borrelli et al (mean follow-up 4.5 months) measured complications and graft survival at follow-up. Heistein and Cook, (1 week and 12 weeks follow-up) measured clinical progress and graft survival at follow-up.[9] Eo et al measured color change, presence of infection or hematoma, scab formation due to insufficient blood supply, and composite graft sensory recovery at follow-up. Seven of the articles measured only graft take at follow-up.[6,11,21–25]

Functional Outcomes

Two of the included studies mentioned functional outcomes as part of their report. Borrelli et al reported sensory problems in 16 to 30% of patients, of which most were due to a tender fingertip or scarring.[5] Butler et al mentioned that their study demonstrated "excellent" long-term functional outcomes; however, they did not discuss any specific criteria for this conclusion.[6]

Complications

The overall infection rate post-composite graft was 3.8% ($n = 28$). Interestingly, Butler et al also reported that patients were significantly more likely to have a postoperative infection if they had an amputation at modified-Ishikawa Level II than if the amputation was in Level Ia or Ib (22 vs. 6%, $p = 0.03$).[6]

Nail Abnormalities

Overall, 3.4% ($n = 25$) of composite grafts presented with a complication of hook nail deformity found across four studies. The highest rate of hook nail deformity was found in the study by Butler et al, who reported nail growth abnormalities in 48% of cases, accounting for 20 patients.[6] This study hypothesized that finger shortening and nail curving cases may be related to bone nibbling when the bone was exposed.[5]

Fingertip Shortening

Two studies reported fingertip shortening. Borrelli et al reported an average fingertip shortening between 3.93 ± 2.84 mm in 57% of cases, accounting for 29 patients. The patient reported outcome of fingertip shortening in this study ranged from 1 to 10mm.[5] Uysal et al reported a mean finger shortening of 6.8 mm.[22]

Factors Affecting Outcomes of Composite Grafts

Level of Amputation

No significant correlation could be identified between graft take and level of amputation; however, in all studies that

Table 3 Study designs with demographical data and associated outcomes

Author, year (country)	Study design	No. of patients (sex)	No. of composite grafts	Age	Classification used	Level of njury (*n*)	Mechanism of injury	Digit (*n*)	Length of follow-up	Graft take	Complications
Borrelli et al 2019 (UK)[5]	Retrospective review	Male, $n=57$ (57.0%) Female, $n=43$ (43.0%)	100	Range 0.08–15.8 years; mean 4.41 ± 3.98 years	Modified Ishikawa	Ia, $n=3$(3.0%); Ib, $n=26$ (26.0%); II, $n=42$ (42.0%); III, $n=16$ (16.0%)	Crush, $n=75$ (75.0%); avulsion, $n=13$ (14.0%); laceration, $n=12$ (12.0%)	Little finger, $n=31$ (31.0%); ring finger, $n=24$ (24.0%); middle finger, $n=21$ (21.0%); index finger, $n=18$ (18.0%); thumb, $n=6$ (6.0%)	Range 0.5–96 months; mean 4.65 ± 10.85 months	Complete, $n=13$ (13.0%); partial, $n=46$ (46.0%); failed, $n=41$ (41.0%)	Infection, $n=17$ (17.0%); hook nail deformity, $n=1$ (1.0%); PTSD, $n=1$ (1.0%); anxiety, $n=1$ (1.0%)
Butler et al 2015 (UK)[6]	Retrospective review	Male, $n=55$ (56.7%) Female, $n=42$ (43.3%)	97	Range 1–15 years; mean 4.3 years	Modified Ishikawa	Ia, $n=12$ (12.4%); Ib, $n=51$ (52.6%); II, $n=32$ (33.0%); III, $n=2$ (2.1%)	Crush, $n=88$ (90.7%); other forms of crush type, $n=6$ (6.2%); sharp amputations, $n=3$ (3.1%)	Did not specify	Mean 1.8 months	Complete, $n=10$ (13.4%); partial, $n=33$ (34%); failed, $n=54$ (56%)	Hook nail deformity, $n=20$ (48.0%); infection, $n=11$ (11.0%), 1 with complete graft survival
Eberlin et al 2014 (USA)[23]	Retrospective review	Male, $n=24$ (61.5%) Female, $n=15$ (38.2%)	39	Range 1–18 years; mean 5.9 years	Did not specify	Did not specify	Crush: closure of a door, $n=24$ (51.5%), mechanical device, n = 6 (15.4%), other crush injury, $n=5$ (12.8%); sharp laceration, $n=2$ (5.1%), sports, $n=1$ (2.6%), strangulation injuries, $n=1$ (2.6%)	Middle finger, $n=15$ (38.5%); ring finger, $n=9$, (23.1%); little finger, n = 8 (20.5%); index finger $n=6$ (15.4%); thumb, $n=1$ (2.6%)	Mean 4.5 months	Complete, $n=3$ (7.7%); partial, $n=23$ (59.0%); failed, $n=13$ (33.3%)	Revision procedures, $n=4$ (10.0%), all no initial graft uptake
Eo et al 2009 (Korea)[20]	Cohort study	Male, $n=1$ (16.7%%) Female, $n=5$ (83.3%)	6	Range 1–5 years; mean 2.5 years	Das	I, $n=5$ (83.3%); II, $n=1$ (16.7%)	Crush type, $n=5$ (83.3%); clean-cut amputation, $n=1$ (16.7%%)	Middle finger, $n=2$ (33.3%); ring finger, $n=1$ (16.7%); small finger, $n=2$ (33.3%); index finger, $n=1$ (16.7%)	Did not specify	Good with no scab formation, $n=3$ (50%); good with scab formation, $n=3$ (50%), fail, $n=0$ (0%)	Did not specify
Heistein and Cook 2003 (USA)[9]	Prospective case review	Did not specify	19	Range 1–17 years	Own classification			Did not specify	Follow-up at week 1 and week 12 post-injury	Graft survival 77.3%	None
Imaizumi et al 2013 (Japan)[24]	Case review	N/A	17	Range 20–81 months; mean 3 years and 8 months	Own classification	Distal, $n=3$ (17.6%); middle, $n=13$ (76.5%); proximal, $n=1$ (5.9%)	Crush (did not specify), avulsion (did not specify)	Middle finger, $n=8$ (47.1%); ring finger, $n=3$ (17.6%); little finger, $n=2$ (11.8%); index finger, $n=2$ (11.8%); thumb, $n=2$ (11.8%)	Range 11–375 days; mean 80 days	11/17 attempted: complete, $n=5$ (47.1%), failed, $n=6$ (52.9%)	Postoperative arterial occlusion, $n=1$ (5.88%)

(*Continued*)

Table 3 (*Continued*)

Author, year (country)	Study design	No. of patients (sex)	No. of composite grafts	Age	Classification used	Level of njury (n)	Mechanism of injury	Digit (n)	Length of follow-up	Graft take	Complications
Karakas and Yuce 2020 (Turkey)[27]	Case series	N/A	185	N/A	Ishikawa	Did not specify	Did not specify	Did not specify	Did not specify	Complete and Partial, $n = 151$ (81.1%); failed $n = 35$ (18.9%)	Did not specify
Moiemen and Elliot 1997 (UK)[11]	Prospective cohort study	Male, $n = 38$ (76.0%) Female, $n = 12$ (24.0%)	50	Range 1–14 years; mean 5.7 years	Modified Ishikawa	Ia, $n = 4$ (8.0%); Ib, $n = 17$ (34.0%); II, $n = 21$ (42.0%); III, $n = 8$ (16.0%)	Crush, $n = 38$ (76.0%); other crush injury, $n = 9$ (18.0%); sharp amputation, $n = 3$ (6.0%)	Did not specify	Mean 14.8 months	Complete, $n = 11$ (22.0%); partial, $n = 26$ (52.0%); failed, $n = 13$ (26.0%)	None
Murphy et al 2017 (Australia)[25]	Retrospective review	Male, $n = 48$ (48.0%) Female, $n = 52$ (52.0%)	96	Range 0–16 years; median age 2.4 years	Modified Ishikawa	Ia, $n = 16$ (16.7%); Ib, $n = 36$ (37.5%); II, $n = 13$ (13.5%); III, $n = 3$ (3.1%)	Crush, $n = 89$ (92.7%); sharp laceration, $n = 4$ (4.2%); mecha-nism not recorded, $n = 3$ (3.1%)	Middle finger, n = 26 (27.1%); ring finger, n = 25 (26.0%); little finger, $n = 18$ (18.8%); index finger, $n = 25$ (26.0%); thumb, $n = 2$ (2.1%)	Median 4 follow- up appoint-ments; mean 68 days	Complete, $n = 15$ (16.0%); partial, $n = 50$ (52.0%); failed, $n = 31$ (32.0%)	Hook nail deformity, $n = 3$ (3%) (all partial graft uptake)
Son et al 2005 (South Korea)[15]	Retrospective study	Did not specify	15	Range 1–15 years	Own classification	Did not specify	Did not specify	Did not specify	Did not specify	Complete, $n = 12$ (80%); failed, $n = 3$ (20%)	Did not specify
Urso-Baiard et al 2009 (UK)[21]	Retrospective case studies	Did not specify	108	Median 5.9 years; IQR 2.8–13.1 years	Ishikawa	I (Did not specify) II (Did not specify) III (Did not specify)	Crush (Did not specify) Avulsion (Did not specify) Laceration (Did not specify)	Did not specify	Mean 5 years	Complete or partial in children 88.5%	Did not specify
Uysal et al 2006 (Turkey)[22]	Prospective case review	Male, $n = 2$ (66.7%) Female, $n = 1$ (33.3%)	3	Range 1.5–6 years; mean 3.83 years	Hirase	IIa, $n = 2$ (66.7%); III, $n = 1$ (33.3%)	Crush $n = 3$	Middle finger, $n = 1$ (33.3%); ring finger, $n = 1$ (33.3%); index finger, $n = 1$ (33.3%)	Mean 14 months	Complete, $n = 3$ (100%)	Nail deformity in one patient Finger shortening of 4mm on average

Abbreviations: IQR, interquartile range; PTSD, posttraumatic stress disorder.

used the modified Ishikawa classification and included data for graft take, a difference between graft take for Levels Ia and III was observed with amputations at Level Ia showing higher levels of graft success. Overall, "complete" graft take was observed in 52.6% of fingertips in Level Ia, 50% for Level Ib, 50.9% for Level II, and 44.4% for Level III. Similar findings were seen in studies using Ishikawa classification. ►**Table 3** shows the results of the studies.

Age

Age was identified as a factor impacting the results of composite graft in two papers. Borrelli et al and Butler et al found that children under 4 years old had higher rates of composite graft survival compared with older children.[5,6] Son et al also found higher rates of graft survival in patients who were 6 years of age and younger compared with patients who were 16 years of age and older, but this difference was not statistically significant.[15] Butler et al specifically noted that those under the age of four had a significantly greater likelihood of composite graft survival compared with patients above the age of four (14 vs. 3%, $p = 0.02$).[6] On the other hand, Heistein and Cook, Murphy et al, Urso-Baiarda et al, and Eberlin et al reported no significant correlation between age and composite graft uptake.[9,21,23,25] Moiemen and Elliot reported that there is no evidence behind recommending composite graft solely for children.[11] Karakas and Yuce offered age-based treatment methods based on the pre-existing literature findings: composite graft for younger patients and V-Y advancement flap for older children and adolescents.[26] One possible explanation for this was that younger children were more likely to experience crush injury.[21]

Mechanism of Injury

Only four studies reported the mechanism of injuries.[6,11,23,25] For crush injuries, a majority were due to fingertips amputated by being caught in a door ($n = 239$, 72%) with only six patients with crush injuries due to mechanical devices. No clear mechanism was provided for sharp lacerations and no mention of mechanism was provided for avulsion injuries. While Eberlin et al found the mechanism of injury insignificant, Borelli et al found that crush injuries were significantly more likely to survive than avulsion injuries in multivariable analysis (odds ratio: 5.430 $p = 0.018$).

Time since Injury to Composite Grafting

Six studies reported the time from injury to composite grafting. However, only three studies involving 152 fingertips provided comparable data on survival of composite grafts in relation with time since injury to intervention,[6,11,20] where there was a trend for higher survival of grafts when composite grafting was performed earlier. A mean time of 4.3 hours was associated with complete graft take, 7.1 hours with partial graft take, and more than 9 hours for failed graft take. Of note however, in four studies,[5,6,23,25] the authors reported no significant difference between time from injury to composite grafting with graft survival. Moiemen and Elliot's study was the only study to report statistical significance between grafts surviving when performed less than 5 hours and when performed more than 5 hours.[11]

Other Potential Factors

In four studies involving 278 fingertips (38%), the fingertips were cooled before composite grafting was performed. Only two studies mentioned the exact method whereby the amputated part was placed in saline soaked swabs that was then placed in a sealed bag in ice and water.[6,11] From the comparable data of 146 fingertips from two studies,[6,11] 14% of fingertips that were cooled beforehand achieved complete graft take, 40% achieved partial, and 46% were failed graft take. Of note, Borelli et al's study was the only study to report a statistically significant result of a higher rate of composite graft survival when cooled compared with fingertips that were not cooled.[5] No association could be found between presence of fractures (whether clean cut, splintered or comminuted) and graft take outcomes due to lack of sufficient data and no bones were shortened for all the composite grafts performed.

Discussion

Composite grafts have become a more common method of fingertip amputation management in children in recent times.[2] Despite its common use, data with regard to effectiveness of composite grafts as a treatment option is sparse. There is also paucity in the literature on the determining factors that may influence outcomes of composite grafts in this population that prevents evidence-based decisions to be made when patients present with fingertip amputations.

Based on the only consistent outcome that was used across the studies (graft take), composite grafting was found to be a relatively effective method of managing fingertip amputations in the pediatric population with a high percentage of grafts presenting with "partial" and/or "complete" take. Composite grafts were observed to be more commonly performed in male children less than 5 years old with middle fingertip amputations due to crush type injury. The authors observed a long mean follow-up time of 10.1 months, but this was due to one of the studies reporting a follow-up time of 96 months. The authors also observed a relatively low rate of infection post-composite graft and high patient satisfaction.

From the data available, the authors observed that more distal amputations lead to better outcomes and reduced complications overall in studies that selected both Ishikawa and modified Ishikawa as their classification of fingertip amputation, particularly in the region of Ib/II where the central digital artery in the distal phalanx divides. This result may be due to the increased vascularity in this area with the terminal segmental branch and fibrous hiatus branch in close vicinity. Only two articles were able to find statistically significant correlations where a lower age of patients (<4 years) leads to better outcomes.[5,6] Borrelli et al also found a correlation between injury mechanism and graft take, where composite grafts performed after crush injuries were more likely to survive.[5] This is concordant with the results observed in our study. We observed an association of higher composite graft survival with a lower time to operation, but this was based on small number of studies and fingertips.

A significant limitation observed in this study was the variability in assessing and reporting graft take due to the lack of standardized assessment for graft success, particularly in the assessment of "partial" graft take. Some authors described graft take in three categories: "complete" take, "partial" take, and graft failure, whereas other authors described it in only two categories: "complete" take and graft failure. Where reporting was done in three categories, percentage results were sometimes calculated by combining "complete" and "partial" take. Due to the difficulty in separating the data consistently, analysis of the results therefore remained difficult. This variability can be attributed to the differences between the authors' understanding and definitions of what constituted as "complete" and "partial" graft take. Of note, Butler et al provided the clearest definition with "complete" graft take as having no areas of necrotic tissue and "partial" graft take constituting of any graft where there were patches of necrotic tissue.[6] The choice of classification system also introduced heterogeneity in how the injury was diagnosed and subsequently treated, leading to a lack of standardized outcomes as the proportion of successful outcomes could depend on the classification chosen and the level of fingertip amputation the chosen classification selects. The length of follow-up was also not constant. For example, assessment of "partial" graft take could have varied with the length of follow-up with some complications such as scar maturation and bone development presenting at later periods of time. Imaizumi et al also reported that the reason for various follow-up periods in their own study was that some children did not come back to clinic after seeing their fingertips survive, while others came back for their subsequent fingertip deformity, making the results difficult to compare and analyze.[24] Finally, the outcomes between young and very young patients may have been different due to the different tissue demand of oxygen and nutrients. However, the outcomes of composite grafts could not be differentiated based on age due to the heterogeneity in how age was reported in the individual studies.

In the study conducted by Jerome and Malshikare, the authors developed a fingertip injuries outcome assessment score that consisted of measuring nail aesthetics, finger length, pulp pad, bone consolidation, cosmesis, sensation with two-point description, pain, range of motion, grip strength, and return to work based on their experience in managing fingertip amputations.[27] Although the study population was mainly adults who did not undergo composite graft procedures, this study can serve as a benchmark for the development of a composite graft outcome assessment tool especially as this scoring system achieved an acceptable level of reliability and internal consistency on statistical analysis. Forming a standardized assessment tool for pediatric composite graft outcomes may help the clinician make a more informed decision, for example, at follow-up with regard to deciding on whether further intervention is required.

Conclusion

Composite grafts for fingertip injury in pediatric patients can be considered as a relatively effective method of treatment with low rates of complications such as infection and hook nail deformity and high patient satisfaction based on evidence found in this study. Clinicians should be aware of the increased risk of complications as well as poorer outcomes associated with more proximal fingertip amputations (notably beyond Level II on the modified Ishikawa classification) and thus amputations at this level may warrant other surgical interventions such as microsurgery. Furthermore, based on the literature, crush type injuries (mostly due to fingertips trapped in doors) as well as the use of composite grafts in children less than 5 years old were associated with better outcomes. However, this result is based on heterogeneous existing data on the use of composite grafting in the pediatric population and thus, well-designed prospective studies with standardized methods of assessment are required.

Statement of Informed Consent

The authors declare that no identifiable patient data was used; therefore, informed consent was not applicable.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Authors' Contributions

All authors made significant contributions to the work and can claim authorship according to the conditions posed.

Conflict of Interest

None declared.

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