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Outcomes of Digit Replantation in Children: A Systematic Review

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Background: Children have been suggested to benefit from digit replantation due to a greater neurogenerative capacity. We aimed to conduct a systematic review on digit replantation in children to provide a comprehensive overview of survival rates and functional outcomes.
Methods: A systematic literature search was conducted on Ovid MEDLINE, Embase, and the Cochrane Controlled Register of Trials for studies published between 1980 and 2023. We included peer-reviewed studies reporting on digit survival rates in pediatric patients under the age of 18 years who underwent single or multiple digit replantations distal to the metacarpophalangeal joint. Preoperative, intraoperative, and postoperative outcomes were extracted, and pooled estimates were derived using univariable analysis.
Results: Twenty-two studies reporting on 761 patients and 814 digit replantations were included in our study. Most replantations occurred in the index (n = 74), Tamai zone I (n = 168), and from clean-cut injuries (n = 190). The mean survival rate was 76% (n = 618/814), with a mean range of motion at the distal interphalangeal joint ranging from 64 degrees to 90 degrees and two-point discrimination ranging from 3.8 mm to 6.4 mm. Compared with clean-cut injuries, digit replantations from avulsion [odds ratio (OR), 0.81; 95% confidence interval (CI), 0.74–0.89] or crush (OR, 0.71; 95% CI, 0.59–0.82) injuries were associated with a lower odds of survival. Digit replantations performed with two venous (OR, 1.43, 95% CI; 1.28–1.59) or arterial anastomoses (OR, 1.65; 95% CI, 1.48–1.81) were associated with a higher odds of survival.
Conclusions: Our systematic review suggests that digit replantation may be a viable option in children. Further research is required to explore functionality after digit replantation in diverse pediatric populations. *(Plast Reconstr Surg Glob Open 2023; 11:e5482; doi: 10.1097/GOX.0000000000005482; Published online 14 December 2023.)*

INTRODUCTION

Amputation represents the loss or removal of a body part, typically associated with traumatic injuries.[1] Amputation often leads to irreversible physical and psychological problems, especially at an earlier age.[2] It is estimated that the prevalence of traumatic amputation in the US will reach 1,326,000 civilians by the end of 2050, nearly doubling the estimated 700,000 traumatic amputation patients in the year 2005.[3] Using the National Trauma Databank, Barmparas et al (2010) found that approximately 77% of amputation patients between the years 2000 and 2004 experienced digit amputation in particular, thus representing the majority of amputation cases.[4] The primary objective of digit replantation is to reattach a salvaged amputated digit. However, the goals of such procedures do not entirely revolve around the survival of the replanted digit, but also the extent of restored functionality. Overall, there are many factors that affect the procedure's efficacy, including (but not limited to) the time between injury and surgery, mechanism of injury (ie, clean-cut, crush, or avulsion), and degree of contamination from other sources.[5]

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Previous literature on digit replantation outcomes have been predominantly focused on adult patient populations.[4,6] However, there is a paucity of data synthesizing digit replantation outcomes across individuals aged 18 years or younger. This is problematic, as individuals aged 18 or younger represent a substantial number of digit amputation patients, and age is an essential factor that influences a clinician's decision to recommend digit replantation.[7] Withal, it has been suggested that children in particular may benefit significantly from digit replantation, due to a greater neurogenerative capacity.[2,5] Our systematic review aims to provide a comprehensive overview of digit replantation outcomes in pediatric patient populations.

Takeaways

Question: What are the survival rates and functional outcomes of children receiving digit replantation?

Findings: Twenty-two studies reporting on 761 patients, and 814 digit replantations were included in our study. The mean survival rate was 76% (n = 618/814). Compared with adults, children show better functional outcomes after digit replantation, despite lower rates of digit survival. Reporting of functional outcomes, patient-reported outcomes, and long-term outcomes were notably limited across included studies.

Meaning: Further research is required to explore functionality following digit replantation in diverse pediatric populations.

METHODS

Eligibility Criteria and Search Strategy

Our systematic review was registered with the International Prospective Register of Systematic Reviews under the ID CRD42023441387. We performed a systematic literature search for records published on Cochrane Library, Ovid Medline, and Embase from January 1980 to July 2023. A summary of our Medline search strategy is detailed in Supplemental Digital Content 1. (**See table, Supplemental Digital Content 1,** which shows the search strategy for MEDLINE. **http://links.lww.com/PRSGO/C948**.) We included peer-reviewed studies reporting on digit survival rates and functional outcomes in pediatric patients under the age of 18 years who underwent single or multiple digit replantations distal to the metacarpophalangeal (MCP) joint. We excluded the following: (1) review articles or meta-analyses; (2) in vitro or nonhuman studies; (3) studies reporting on adult patients aged 18 years or older; (4) case reports or case series reporting on fewer than five patients; (5) studies on incomplete amputations or revascularization; (6) studies with an unclear injury diagnosis, where the extent of amputation could not be determined; (7) studies with an unclear procedure, where the distinction between outcomes associated with replantation and revascularization could not be determined; and (8) studies that do not specify the survival of digits included in the study. Furthermore, we excluded conference abstracts, editorials, non-English studies, and letters to the editor. Our systematic review was conducted in accordance with the Declaration of Helsinki, and research ethics approval was not required by virtue of our study design.

Study Selection, Data Collection and Statistical Analysis

Two independent reviewers (R. S. H. and A. H.) performed title and abstract screening and full-text screening using Covidence (Veritas Health Innovation, Melbourne, Australia), as well as data collection using Microsoft Excel (Microsoft Corporation, Redmond, Wash.). A third independent author (K. W. Y.W.) was consulted for conflict resolution throughout all stages of study selection and data collection. Our primary outcome was the digit survival rate of children undergoing digit replantation procedures. Studies that did not provide data on this primary end point were excluded from our analysis. Our secondary outcomes were the preoperative characteristics (ie, digits to be replanted, type of injury, and level of amputation); intraoperative characteristics (ie, mean time from injury to surgery, vein grafting, venous or arterial anastomoses, nerve repair, tendon repair, bone fixation, shortening of bone length, and administration of anticoagulants); and postoperative outcomes (ie, range of motion, two-point discrimination, Semmes Weinstein testing, and complications) associated with digit replantation in patients aged 18 years or younger. The level of amputation was classified per Tamai zone, as displayed in Figure 1.

Data pertaining to preoperative and intraoperative outcomes across included studies were pooled together for analysis using Stata version 17.0 (StataCorp LLC, College Station, Tex.) to identify potential predictive factors associated with digit survival. An odds ratio (OR) and 95% confidence interval (CI) was reported for each univariable logistic regression analysis. Furthermore, continuous end points were summarized as means, and discrete end points were summarized as counts.

Risk of Bias Assessment

The risk of bias of observational studies included in our systematic review were evaluated using the Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) tool from Cochrane. The following domains of bias from the ROBINS-I tool were assessed for each study: confounding, selection of participants into the study, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported results. A complete summary of our risk of bias assessment is found in Figure 2.

RESULTS

Preoperative Characteristics of Study Participants

A total of 361 studies underwent title and abstract screening, 31 studies underwent full-text screening, and 21 studies reporting on 761 patients were included in our systematic review (Fig. 3).[8–28] The timeframe of patient recruitment in included studies ranged from 1973 to 2020, where

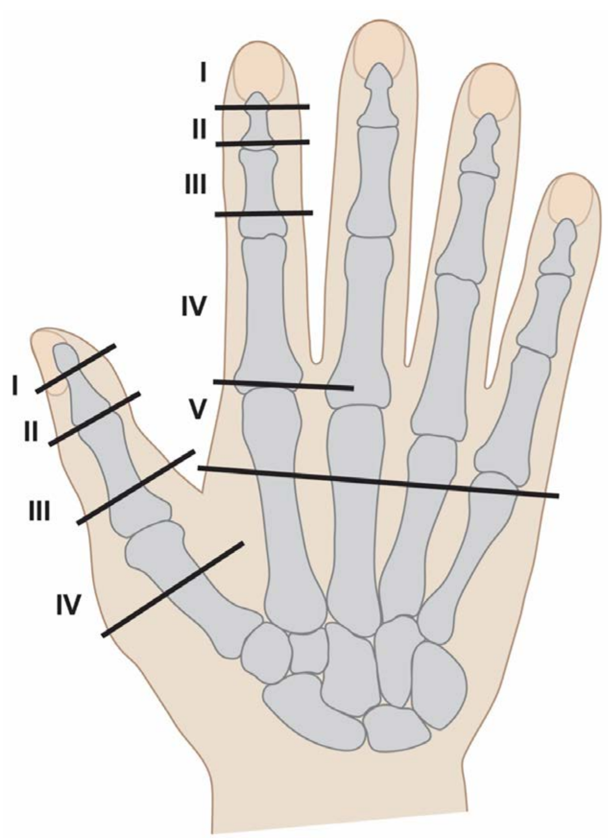

Fig. 1. Classification of Tamai zones used to stratify level of digit amputations.

13 studies included patients who were recruited before the year 2000,[8–12,15,17,20,21,23,25,27,28] and 10 studies recruited patients who were recruited onwards of the year 2000 (Table 1).[10,13,14,16,18,19,22,24,26,27] The mean age of patients across included studies ranged from 1.3 to 11.7 years old. The proportion of male patients across included studies ranged from 46% to 87%; hence, the proportion of female patients ranged from 13% to 54%. A total of 814 digit replantation procedures were performed across our included studies, with 36 replantations reported in the thumb across 10 studies.[9,10,12,16,18–22,28] Seventy-four index finger replantations were performed across 11 studies,[9,10,12,16,18–21,24,27,28] 48 middle finger replantations were performed across 10 studies,[9,10,12,16,18–20,24,27,28] 55 ring finger replantations were performed across 10 studies,[9,10,12,16,18–20,24,27,28] and 29 little finger replantations were performed across nine studies (Table 2).[9,10,12,16,18,20,24,27,28] Nine studies did not report which specific digits were replanted.[8,11,13–15,17,23,25,26] Across 14 studies, 190 digit replantations were secondary to clean-cut injuries,[9,11,12,14–16,18–21,23–26,28] Another 154 digit replantations across 10 studies were secondary to crush injuries,[10–12,15,18,20,22,24,25,28] and 138 digit replantations across 13 studies were secondary to avulsion injuries.[9,10,12,18,19,21,23–28] The type of injury preceding digit replantation was not reported in four studies.[8,13,14,17] When classified by Tamai zones, 168 digit replantations were reported at Tamai zone I across 11 studies,[10,11,13,15,16,18–20,22,24,28] 140 digit replantations were reported at Tamai zone II across 13 studies,[8–13,15,16,18,20–22,24] 121 digit replantations were reported at Tamai zone III across 12 studies,[8–13,15,17,20–22,24,27] and 62 digit replantations were reported at zone IV across eight studies.[8,9,12,20,21,24,27,28] The level of amputation was not reported in six studies.[14,17,19,23,25,26]

Intraoperative Outcomes

The mean time from injury to surgery across included studies ranged from approximately 3 hours to 18 hours, where the bone length of the replanted digit was shortened at least minimally across all studies (Table 3). Thirteen studies reported performing tendon repair in some digit replantation patients,[9,13,15–17,19–21,23,24,26–28] 11 studies reported performing bone fixation using a Kirschner wire,[9–12,14,17–19,21,22,25] eight studies reported performing nerve repair,[9,16,17,19,24,26–28] and four studies reported performing vein grafting.[9,12,21,27] With respect to anticoagulation agents, the use of intravenous heparin intraoperatively was reported in eight studies,[11,12,15,17–19,21,27] the use of heparin gauze was reported in two studies,[24,29] and the use of heparin sponge was reported in one study.[14] No studies reported on postoperative anticoagulation. Thirteen studies reported performing venous anastomosis in some digit replantation patients,[10,12,14,15,17–19,21,22,24,26–28] and six studies reported performing arterial anastomosis in some digit replantation patients.[10,16,18,19,21,27] Only one study reported on artery size, recording a mean diameter of 0.4 mm.[16]

Postoperative Outcomes

The mean follow-up time of pediatric patients undergoing digit replantation ranged from approximately two months to 25 months (Table 4). The digit survival rate of patients across included studies ranged from approximately 46.7% to 100%, where the overall digit survival rate pooled across all studies was 76%. Across six studies reporting on the mean range of motion at the distal interphalangeal joint (DIP) in replanted digits[14–16,18,23,27]; this value ranged from 64 degrees to 90 degrees, with a mean of 83 degrees. No studies reported range of motion at the proximal interphalangeal joint. Across eight studies reporting on the mean two-point discrimination of replanted digits,[8,14,16,18–20,25,27] this value ranged from approximately 3.8 mm to 6.4 mm, with a mean of 4.4 mm. Three studies reported on the use of Semmes Weinstein testing in patients with replanted digits,[19,25,28] where the mean score ranged from 2.7 to 3.5, with a mean of 3.2. The incidence of postoperative complications was further noted in seven studies, with the most common adverse events being pulp atrophy and nail deformity.[9,12,14–16,24,30]

Predictors for Digit Survival

Compared with digit replantations resulting from clean-cut injuries, digit replantations resulting from avulsion (OR, 0.81, 95% CI, 0.74–0.89) or crush (OR, 0.71, 95% CI, 0.59–0.82) injuries were associated with a lower odds of digit survival (Table 5). Compared with digit replantations where an arterial anastomosis was not reported, digit replantations performed with one arterial anastomosis reported (OR, 1.42; 95% CI, 1.25–1.59)

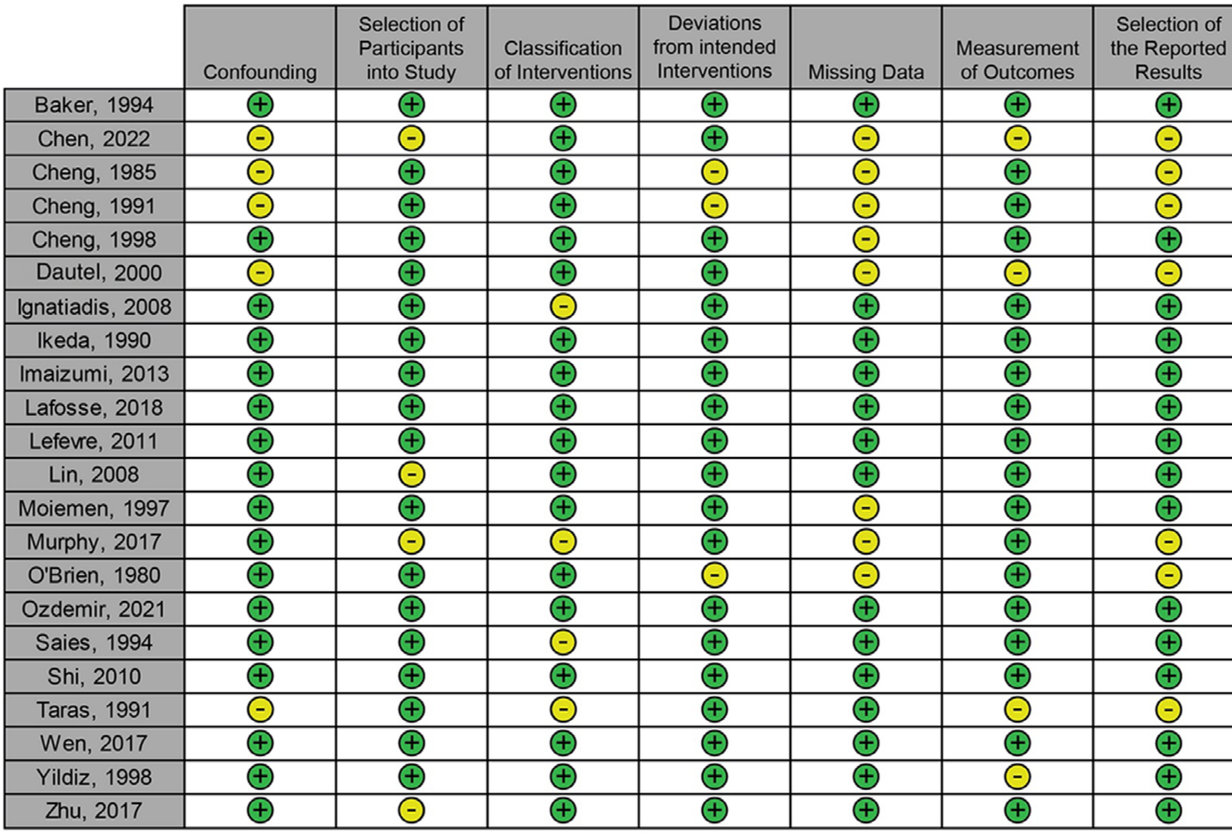

Fig. 2. ROBINS-I risk of bias classification of included studies. ROBINS-I: risk of bias in nonrandomized studies of interventions.

or two arterial anastomoses reported (OR, 1.65; 95% CI, 1.48–1.81) were associated with a higher odds of digit survival. Compared with digit replantations where a venous anastomosis was not reported, digit replantations performed with one venous anastomosis reported (OR, 1.33; 95% CI, 1.20–1.49) or two venous anastomoses reported (OR, 1.43; 95% CI, 1.28–1.59) were associated with a higher odds of digit survival. Patients in whom tendon repair was not reported were associated with a lower odds of digit survival (OR, 0.68; 95% CI, 0.49–0.90) compared with digit replantations with a reported tendon repair procedure. The following preoperative and intraoperative characteristics were not significantly associated with digit survival: sex, digit number, zone of injury, nerve repair, year of publication, and volume of replantations.

DISCUSSION

With respect to digit replantations performed in the United States from 1999 to 2011, approximately 16%–27% of replantations were performed on patients aged 18 years or younger.[31] Hence, there is a relatively lower volume of digit replantation cases among pediatric patients, making it essential to consolidate these data to better understand the outcomes, trends, and specific challenges associated with replantation in this setting. Our systematic review on digit replantation in individuals aged 18 years old or younger found that the overall digit survival rate was 76% across 21 included studies. Furthermore, after successful digit replantation, we found that the average range of motion at the DIP joint was approximately 83 degrees, the average two-point discrimination was approximately 4.4 mm, and the average Semmes-Weinstein Testing score was approximately 3.2. To the best of our knowledge, we present the first systematic review to provide a comprehensive synthesis of data pertaining to digit replantation outcomes in pediatric patients.

The 76% digit survival rate found in our study for digit replantation distal to the MCP and MTP joints was lower compared with a previous analysis in adults.[6] In a previous systematic review by Sebastin et al where the average age of patients was 31 years, the overall digit survival rate was 86%.[6] Although the analysis of Sebastin et al was limited to replantations in Tamai zones I and II, their study found no difference in survival across Tamai zones in adults,[6] supporting our findings in pediatric patients. Nonetheless, our findings pertaining to digit survival may have also been mediated by other significant confounders, such as the number of venous and/or arterial anastomoses, whether patients underwent tendon repair, and the type of injury endured. The latter has previously been shown to substantially influence digit survival rates following replantation.[6,7] Similar to Sebastin et al, we found that digit replantations in children caused by clean-cut injuries were more likely to survive than those secondary to crush or avulsion injuries.[6] Given Sebastin et al reported

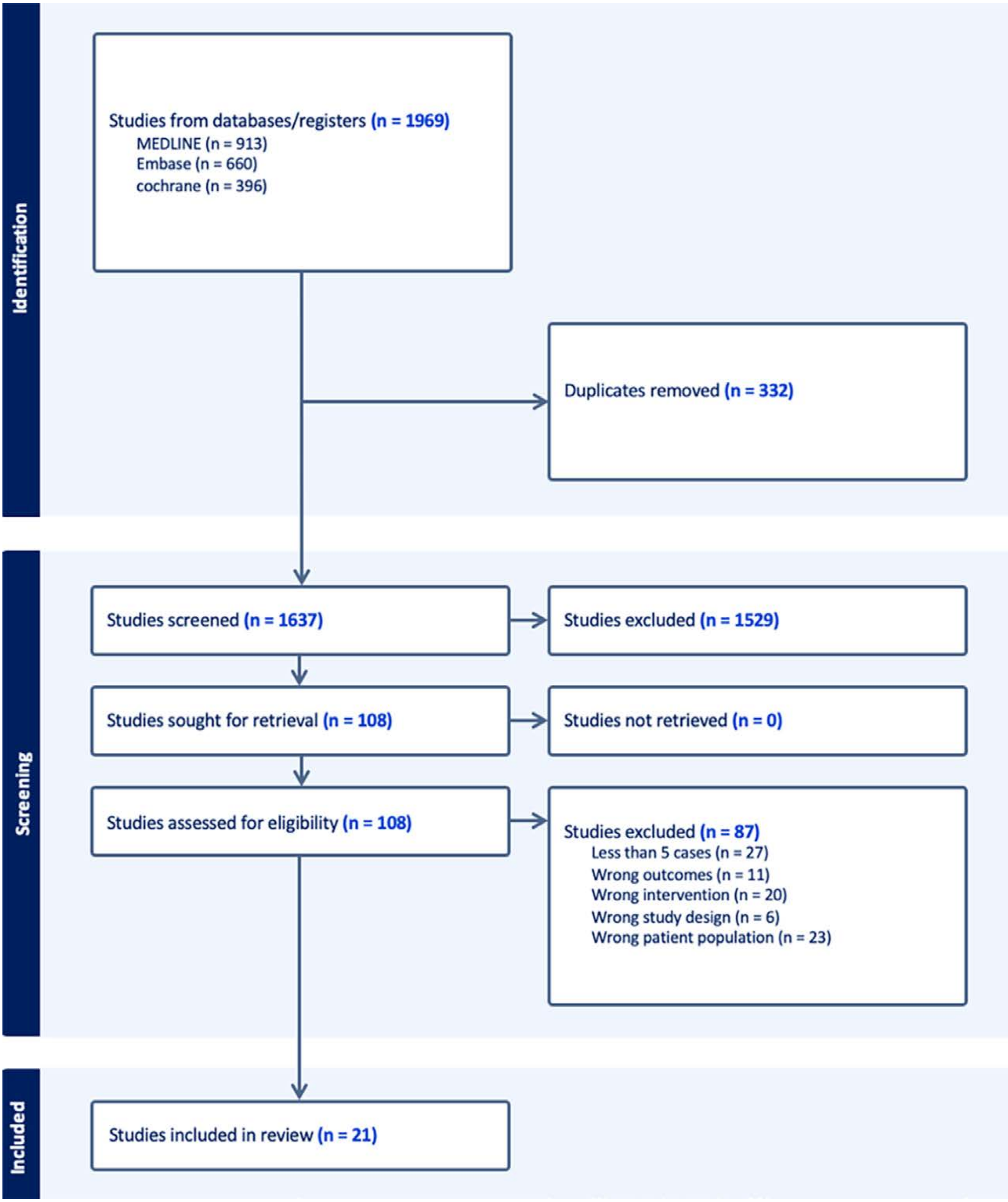

Fig. 3. PRISMA diagram of included studies.

a higher proportion of clean-cut injuries in adults compared with what was observed in our study,[6] it is likely that the increased number of crush and avulsion injuries sustained in children influenced the lower survival rate we found.

Sebastin et al also found that venous anastomoses were associated with improved digit survival, albeit with a weaker effect size compared with our study.[6] We speculate that the increased effect size of this outcome in younger patients may be due to the presence of smaller blood vessels, which may be at an elevated risk of blockage during replantation surgery. It is also plausible that lower digit survival rates in children may be due to more aggressive treatments. However, it is important to note that reporting

Table 1. Characteristics of Study Patients Undergoing Replantation

First Author	Study Time	Country	No. Patients	Men	Women	Mean Age, Y (Range)
Baker[9]	1973–1988	United States	32	18	14	1.9 (0.8–2.8)
Chen[22]	2015–2018	China	30	25	5	1.3
Cheng[8]	1979–1984	China	21	12	9	3.5
Cheng[23]	1981–1991	China	45	–	–	3.9 (1.0–10.0)
Cheng[20]	1979–1985	China	26	15	11	4.7
Dautel[25]	1993–1999	France	33	–	–	11.4
Ignatiadis[26]	2002–2007	Greece	10	–	–	7.8 (1.5–14.0)
Ikeda[28]	1974–1984	Japan	14	8	6	4.0 (1.2–9)
Imaizumi[10]	1993–2008	Japan	17	–	–	3.7
Lafosse[24]	2007–2017	France	15	13	2	2.9 (1.1–5.7)
Lefevre[27]	1997–2007	France	23	–	–	11.7 (1.5–15)
Moiemen[11]	1989–1993	United Kingdom	50	38	12	5.7 (1.0–14.0)
Murphy[13]	2003–2014	Australia	105	48	57	2.4 (0–16.0)
O'Brien[12]	–	Australia	27	17	10	6.8
Ozdemir[14]	2017–2020	Turkey	12	10	2	8.9
Saies[15]	1974–1988	United States	120	90	30	–
Shi[16]	2000–2007	China	12	9	3	6 (4.0–10.0)
Taras[17]	1976–1991	United States	120	–	–	–
Wen[18]	2008–2013	China	16	11	5	6.6 (3.0–12.0)
Yildiz[21]	–	Turkey	25	13	12	6.4
Zhu[16]	2014–2015	China	8	5	3	6.8 (2-18)

"–" denotes not specified in study.

Table 2. Preoperative Characteristics of Patients Undergoing Replantation

		Digit to be Replanted					Type of Injury			Level of Amputation*			
First Author	No. Replantations	Thumb	Index	Middle	Ring	Little	Clean-cut	Crush	Avulsion	Zone I	Zone II	Zone III	Zone IV
Baker[9]	32	4	13	4	6	5	11	–	21	–	2	24	6
Chen[2]	30	7	–	–	–	–	–	30	–	9	12	9	–
Cheng[8]	32	–	–	–	–	–	–	–	–	–	11	18	3
Cheng[23]	78	–	–	–	–	–	55	–	23	–	–	–	–
Cheng[20]	44	2	10	12	14	6	20	6	–	8	3	26	6
Dautel[25]	33	–	–	–	–	–	11	11	11	–	–	–	–
Ignatiadis[26]	10	–	–	–	–	–	6	–	4	–	–	–	–
Ikeda[28]	17	4	6	2	3	2	4	5	6	2	4	7	4
Imaizumi[10]	17	2	2	8	3	2	–	8	9	17	–	–	–
Lafosse[24]	15	–	4	5	5	1	3	7	1	5	1	3	6
Lefevre[27]	23	–	3	5	11	4	–	–	23	–	–	6	17
Moiemen[11]	50	–	–	–	–	–	3	47	–	21	21	3	–
Murphy[13]	96	–	–	–	–	–	–	–	–	52	13	2	–
O'Brien[12]	30	5	11	4	5	5	7	8	15	–	2	13	13
Ozdemir[14]	12	–	–	–	–	–	–	–	–	–	–	–	–
Saies[15]	73	–	–	–	–	–	39	34	–	26	46	1	–
Shi[16]	12	1	6	2	2	1	5	–	7	3	9	–	–
Taras[17]	162	–	–	–	–	–	–	–	–	–	–	–	–
Wen[18]	21	4	5	5	4	3	8	11	2	10	11	–	–
Yildiz[21]	25	5	10	–	–	–	17	–	8	–	5	9	7
Zhu[16]	9	2	4	1	2	–	1	–	8	9	–	–	–

"–" denotes not specified in study.
*Level of amputation specified by Tamai zones.

on intraoperative replantation techniques was often incomplete in our included studies, with seven studies failing to report on any use of either venous or arterial anastomosis in their replantation procedures. In addition, no included studies reported on postoperative anticoagulation. The establishment of consolidated surgical and anticoagulation protocols in replantation procedures would better inform treatment in pediatric populations in future practice.

Our systematic review found that the lack of nerve repair was nonsignificantly associated with digit survival in children. These findings are similar to those of a previous study in adults by Wong et al, who also found no significant difference between postoperative surgery outcomes with and without nerve repair for distal finger amputations.[32] In addition, Faivre et al demonstrated that neurotization occurred after digit replantation in the absence of nerve repair in eight children with a mean age of 9.2 years, showing that

Table 3. Intraoperative Characteristics of Participants Undergoing Replantation

First Author	Mean Time Injury to Surgery (h)	Vein Grafting	Venous Anastomosis (1,2)	Arterial Anastomosis (1,2)	Nerve Repair	Tendon Repair	Bone Fixation (Kirschner Wire)	Bone Length Shortened (mm)	Intraoperative Anticoagulation
Baker[9]	11.9	15	–	–	32	32	+	4.7	–
Chen[22]	3.55	–	30 (2)	–	–	–	+	Minimal	–
Cheng[8]	18	–	–	–	–	–	–	Minimal	–
Cheng[23]	–	–	–	–	–	+	–	Minimal	–
Cheng[20]	–	–	–	–	–	+	–	Minimal	–
Dautel[25]	–	–	–	–	–	–	+	Minimal	–
Ignatiadis[6]	–	–	5 (1)	–	3	7	–	Minimal	–
Ikeda[28]	8	–	15 (1,2)	–	15	11	–	Minimal	–
Imaizumi[10]	–	–	+	+	–	–	+	Minimal	–
Lafosse[24]	–	–	11 (1)	–	+	+	–	Minimal	Heparin gauze
Lefevre[27]	–	6	13 (1,2)	32 (1,2)	23	23	–	Minimal	IV heparin
Moiemen[11]	6.5	–	–	–	–	–	+	Minimal	IV heparin
Murphy[13]	7.5	–	–	–	–	+	–	Minimal	–
O'Brien[12]	–	7	+	–	–	–	+	Minimal	IV heparin
Ozdemir[14]	–	–	10 (1)	–	–	–	+	Minimal	Heparin sponge
Saies[15]	–	–	73 (1,2)	–	–	+	–	Minimal	IV heparin
Shi[16]	3.6	–	–	4 (1)	12	+	–	Minimal	Heparin gauze
Taras[17]	–	–	+	–	+	+	+	Minimal	IV heparin
Wen[18]	9.7	0	16 (1)	16 (1)	–	–	+	Minimal	IV heparin
Yildiz[21]	3.4	1	25 (2)	25 (1)	–	+	+	Minimal	IV heparin
Zhu[16]	–	–	4 (1)	5 (1)	3	+	+	Minimal	IV heparin

"–" denotes not specified in study, and "+" denotes specified, but no number of digits reported.
For venous and arterial anastomosis, the first number represents the number of digits the authors reported performing arterial/venous anastomoses in, whereas the number of brackets represents the number of anastomoses performed in each digit.

Table 4. Survival and Functional Outcomes of Patients Undergoing Replantation

First Author	Mean Follow-up (y)	Overall Survival	Range of Motion in DIP Joint Mean (SD)	Mean Two-point Discrimination (mm)	Mean Semmes Weinstein Testing	No. Complications
Baker[9]	–	22/32	–	–	–	5
Chen[22]	–	27/30	–	–	–	–
Cheng[8]	–	31/32	–	4.5	–	–
Cheng[23]	–	68/78	–	–	–	–
Cheng[20]	11	43/44	90 degrees	4.0	–	–
Dautel[25]	2.1	21/33	–	4.3	3.5	–
Ignatiadis[26]	–	6/10	–	–	–	–
Ikeda[28]	8	15/17	–	–	2.7	–
Imaizumi[10]	0.3	10/17	–	–	–	–
Lafosse[24]	2	7/15	–	–	–	13
Lefevre[27]	–	5/16	64 degrees (26.4)	6.0	–	–
Moiemen[11]	1.2	37/50	–	–	–	–
Murphy[13]	0.2	65/96	–	–	–	–
O'Brien[12]	–	19/30	–	–	–	5
Ozdemir[14]	1.2	10/12	88 degrees (5.4)	4.0	–	2
Saies[15]	2.5	46/73	74 degrees	–	–	2
Shi[16]	–	11/12	89 degrees (1.2)	4.0	–	2
Taras[17]	–	125/162	–	–	–	–
Wen[18]	3.3	20/21	89.3 degrees (2.5)	3.8	–	3
Yildiz[21]	4.2	21/25	–	–	–	–
Zhu[16]	0.8	9/9	–	6.4	3.2	–

"–" denotes not specified in study. DIP, distal interphalangeal.

alternative techniques may achieve adequate nerve function during replantation surgery.[33] Our study also found no significant effect of sex on the odds of digit survival in children. This finding contrasts the meta-analysis of success rates for digit replantation in adults by Dec, who found that men experienced lower survival rates than women.[7] Dec postulated that this may be due to adult male patients experiencing severe mechanisms of injury associated with digit amputation more frequently,[7] whereas this difference between sexes may not occur in children.

Table 5. Association of Patient-related Factors and Digit Survival After Replantation

Characteristic	OR	95% CI
Sex		
Male	*Reference*	
Female	1.03	0.91–1.18
Mechanism of Injury		
Clean-cut	*Reference*	
Avulsion	0.81	0.74–0.89
Crush	0.71	0.59–0.82
Digit Number		
Thumb	*Reference*	
Index	1.06	0.95–1.18
Middle	1.04	0.93–1.15
Ring	0.99	0.91–1.09
Little	0.93	0.71–1.17
Zone of Injury		
Zone I	*Reference*	
Zone II	1.05	0.96–1.14
Zone III	0.94	0.89–1.05
Zone IV	0.91	0.78–1.08
Arterial Anastomosis		
0	*Reference*	
1	1.42	1.25–1.59
2	1.65	1.48–1.81
Venous Anastomosis		
0	*Reference*	
1	1.33	1.20–1.49
2	1.43	1.28–1.59
Nerve Repair		
Yes	*Reference*	
No	0.87	0.71–1.05
Tendon Repair		
Yes	*Reference*	
No	0.68	0.49–0.90
Year of Study		
1980–1999	*Reference*	
2000–2023	1.09	0.91–1.25
No. Replants		
<20	*Reference*	
20–50	0.96	0.88–1.05
>50	0.93	0.81–1.06

Odds ratios estimated through univariable logistic regression models of pooled results.

Across included studies on successful pediatric digit replantations, we found that reporting of patient-reported outcomes after replantation was limited. In particular, no studies reported outcomes using the Disabilities of the Arm, Shoulder, and Hand questionnaire. However, we were able to collect range of motion and sensory discrimination data across six and eight studies, respectively, reporting a mean range of motion of 83 degrees at the DIP joint and a mean two-point discrimination of 4.4 mm. Because normal active range of motion at the DIP joint has been reported to be 80 degrees, our results indicate that children show excellent recovery after digit replantation.[34] Comparatively, studies on adult replantations have shown significantly lower values of range of motion at the DIP joint after replantation.[35–38] None of the included studies reported range of motion outcomes at the proximal interphalangeal joint. For two-point discrimination, Sebastin et al reported a mean two-point discrimination of 7.7 mm after successful digit replantation in their systematic review of adult patients, in contrast to our two-point discrimination of 4.4 mm in pediatric patients. These results suggest that successful pediatric digit replantation presumably leads to a greater restoration of sensory function than adult digit replantation.[6] There are several plausible explanations for better functional outcomes in pediatric replantations, including a greater regenerative capability and a more robust and adaptable vascular system.[39] In addition, these findings support previous reports indicating that children exhibit greater amounts of spontaneous neurotization, thus providing a plausible mechanism of greater sensory recovery.[33] Postoperative reporting of complications was also limited in studies on digit replantation in children. In studies reporting adverse events, nail deformity and pulp atrophy were the most commonly reported, which is similar to complications reported in adult replantations.[6]

We acknowledge there were several limitations in our systematic review. Although our inclusion criteria consisted of individuals aged 18 years old or younger, the mean age of our included patients ranged from 1.3 to 11.7 years. Thus, our data may not adequately represent all individuals in the proposed pediatric cohort. Moreover, our results may be biased toward younger individuals. Additionally, there was substantial variation in reported data by included studies, specifically regarding intraoperative techniques, follow-up, and outcomes that limited our ability to perform additional statistical analyses. In particular, we note that there was a lack of data surrounding patient-reported outcomes. None of the studies included Disabilities of the Arm, Shoulder, and Hand or Michigan Hand Outcomes Questionnaire scores, while we only recovered six studies reporting range of motion and eight studies reporting two-point discrimination. Thus, we were limited in our ability to draw definitive conclusions for various functional outcomes. The variability in results across our included studies points to the need to consolidate reporting on replantation procedures in pediatric patient populations and develop protocols for future practice. Our 21 inclusions also varied greatly in publication date from 1980 to 2022, thus representing substantial temporal variation in data collection. However, we did not observe a significant correlation between time of study and replantation survival, despite microsurgical techniques improving considerably over this time span.

CONCLUSIONS

In conclusion, our systematic review found that although the survival rate is lower in pediatric replantations compared with adults, children have better functional outcomes. We also found several factors that may influence the odds of digit survival and found notable overlap between many of the predictors of digit survival found in our present study and those found in previous works on adult patients. Reporting of functional outcomes, patient-reported outcomes, and long-term outcomes were notably limited across included studies. Future research should include these outcomes to better understand digit replantation success in diverse pediatric populations.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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