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A systematic review of outcomes after revision amputation for treatment of traumatic finger amputation

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Abstract

Background—Revision amputations are often the treatment for traumatic finger amputation injuries. However, patient outcomes are inadequately reported, and their impact poorly understood. We performed a systematic review to evaluate outcomes of revision amputations and amputation wound coverage techniques.

Methods—We searched all available English literature in PubMed and EMBASE for articles reporting outcomes of non-replantation treatments for traumatic finger amputation injuries, including revision amputation, local digital flaps, skin grafting, and conservative treatment. Data extracted were study characteristics, patient demographic data, sensory and functional outcomes, patient-reported outcomes (PROs), and complications.

Results—1659 articles were screened, yielding 43 studies for review. Mean static 2-point discrimination (2-PD) was 5.0 ± 1.5 mm (n=23 studies) overall. Mean static 2-PD was 6.1 ± 2.4 mm after local flap procedures and 3.8 ± 0.4 mm after revision amputation. Mean total active motion (TAM) was $93 \pm 8\%$ of normal (n=6 studies) overall. Mean TAM was $90 \pm 9\%$ of normal after local flap procedures and 95% of normal after revision amputation. 77% of patients report cold intolerance after revision amputation. 91% of patients (217/238) report “satisfactory” or “good/excellent” ratings regardless of treatment.

Conclusion—Revision amputation and conservative treatments result in better static 2-PD outcomes compared to local flaps. All techniques preserve TAM, although arc of motion is slightly better with revision amputation. Revision amputation procedures are frequently associated

with cold intolerance. Patients report “satisfactory,” “good,” or “excellent” ratings in appearance and quality of life with all non-replantation techniques.

Level of Evidence—III

Keywords

systematic review; patient-reported outcomes; finger amputation; revision amputation

INTRODUCTION

Traumatic finger amputations are common and often debilitating, totaling 45,000 cases annually in the United States.^{1–4} Up to 90% of these injuries are treated with revision amputations and other non-replantation techniques.^{5–9} However, the impact of these treatments on patients is not well understood owing to inadequate reporting of the outcomes in the literature.^{10,11} As healthcare shifts from volume to value, knowledge of patient-reported outcome (PRO) measures is becoming equally as important as familiarity of clinically-measured outcomes. PROs offer patient perspectives on the impact of disease on quality of life and experience with healthcare providers, thus helping to improve the effectiveness of patient care.^{11–13}

PROs have proven to be an invaluable platform and adjunct to assessing hand surgery outcomes.^{11–13} However, current literature on revision amputations and other non-replantation techniques after traumatic finger amputation injuries lacks the breadth of patient-reported and clinically-measured outcomes available for replantation.^{14–16} Consequently, our understanding of this patient population is inadequate. Given the immense burden these injuries have on patients and healthcare systems worldwide,^{9,17–19} we must strive to improve our understanding of patients who undergo these procedures.

To inform sound clinical decision-making and understand the role of revision amputations and non-replantation techniques in treating traumatic finger amputations, all available outcomes must be rigorously evaluated. The purpose of this study is to conduct a systematic review of the existent outcomes literature on revision amputation and other non-replantation treatments to synthesize the best available outcomes and most comprehensive assessment of these treatments to date and, in turn, expose and gaps in the literature. Ultimately, this will help improve our understanding of these procedures, paving the way to develop more effective strategies in resource allocation and improving quality of care and treatment of traumatic finger amputations.

MATERIALS AND METHODS

Literature Search and Study Selection

Utilizing the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines,⁷⁰ a systematic search of the English literature using PubMed and EMBASE databases was conducted to identify original articles related to revision amputation and non-replantation techniques (Figure 1). The keywords “fingers,” “thumb,” “finger injuries,” “amputation,” and “traumatic” were used, yielding 2113 citations. First,

the resulting articles were screened based on title alone; 454 duplicate articles were identified and excluded. The remaining 1659 abstracts were read to determine relevance to our topic before ensuring that they met inclusion and exclusion criteria (Table 1).

Inclusion and Exclusion Criteria

Articles were included if (1) the study presented primary quantitative or both quantitative and qualitative data on outcomes, (2) traumatic finger amputations were distal to the metacarpophalangeal (MCP) joint, and (3) the study utilized non-replantation techniques. Articles were excluded if (1) the study presented entirely qualitative data or did not clearly report any primary data, (2) the study included patients with injuries that occurred along with the amputation, and (3) the study was not in English.

Data Extraction and Analysis

After full-text review, two reviewers independently extracted data for the selected studies. The following study patient demographics and descriptive statistics were extracted: study published year and location, patient and digit number, level of injury, treatment method, mean follow-up time, and mean time-off work. We also extracted the clinically-measured and patient-reported outcomes of revision amputation and non-replantation techniques, including (1) sensation – static (Weber test) and dynamic (Dellon test) 2-point discrimination (2-PD), and sensibility via the Semmes-Weinstein (S-W) monofilament test, (2) function – grip and pinch strength, and arc of motion, and (3) PRO and other quality of life (QOL) outcome measures, and (4) complications.

Statistical Evaluation

The data were categorized based on treatment method. Mean patient age, duration of follow-up, and time-off work were weighted based on the number of patients per study. Similarly, mean functional and sensory outcomes, and complication rates of each treatment group and subgroup were weighted based on the number of digits per study. Standard deviations were not weighted due to the lack of individual data, and thus do not accurately reflect our final data and can only be used as a proxy. Articles that did not report individual sensory and/or functional outcomes were excluded from our final analyses. Studies with similar ways of reporting outcomes were grouped together for analysis, while studies with distinctive ways of reporting outcomes were discussed individually.

RESULTS

Study Retrieval and Characteristics

2113 citations were identified through the PubMed and EMBASE databases (1473 and 640, respectively). Of the 1659 titles that underwent abstract and article review, 43 studies met our inclusion and exclusion criteria.^{17–62} The majority of studies were either prospective or retrospective analyses; two studies were cross-sectional investigations^{26–27} (Table 2). The studies were divided into four groups: local flaps used with revision amputation (n=29), revision amputation alone (n=10), skin grafting (n=3), and conservative treatment (n=10). Six studies presented outcomes in multiple treatment groups.^{17–25} The majority of studies (n=18) were published in Europe and account for 42% of the 43 studies, while less than 20%

of studies (n=8) originated from the United States. Three studies were from Africa, one study was from Israel, and one was from Australia (Table 2).

Patient and Digit Characteristics

Our review included 29 articles (74 thumbs and 258 index, 214 middle, 132 ring, and 66 little fingers) in the local flaps group, 10 articles (76 thumbs and 236 index, 211 middle, 158 ring, and 107 little fingers) in the revision amputation only group, three articles (24 thumbs and 76 index, 63 middle, 41 ring, and 25 little fingers) in the skin grafting group, and 10 articles (37 thumbs and 89 index, 69 middle, 46 ring, and 26 little fingers) in the conservative treatment group. The majority of injuries involved the distal phalanx and either the index or middle fingers. Overall, mean patient age was 36 ± 2 years, ranging from 34–39 years (Table 3), with the highest mean among the revision amputation group (39 ± 9 years). Mean follow-up period was 25 ± 16 months, ranging from 10–52 months, with a median between 8 and 26 months. Four studies had relatively long durations of follow-up when compared to other studies.^{27,30–32} Mean time-off work was 74 ± 28 days, ranging from 47–116 days.

Sensory Outcomes

70% of our studies (n=30) reported sensory outcomes. 54% of our studies (n=23) reported static 2-PD. Overall, mean static 2-PD was 5.0 ± 1.5 mm with a range between 3.7–6.5 mm, where less than 6 mm is considered within normal range⁶³ (Table 4). Mean static 2-PD after conservative treatment was 3.7 ± 0.4 mm. Similarly, mean static 2-PD after revision amputation was 3.8 ± 0.4 mm. Among local flaps, where the mean static 2-PD was 6.1 ± 2.4 mm, homodigital flaps outperformed heterodigital flaps (5.8 ± 2.2 mm versus 7.5 ± 2.5 mm, respectively). Mean static 2-PD after skin grafting was 6.5 mm. 14% of our studies (n=6) reported dynamic 2-PD,^{26,41–43,55,56} with an overall mean of 7.0 mm; normal range is between 2.8–4.6 mm.^{67,68} All six studies were in the local flaps group (e.g. homodigital, heterodigital, or other flaps), with mean values of 7.0 mm in each of the three subgroups (Table 4). 12% of our studies (n=5) utilized the Semmes-Weinstein (S-W) monofilament test (Table 4).^{21,34–36,43} Most patients had recognition up to the 3.61 monofilament in their affected digits. Overall, revision amputation and conservative treatment resulted in better static 2-PD outcomes when compared to local flaps. Additionally, dynamic 2-PD and S-W sensibility outcomes were limited.

Functional Outcomes

40% of our studies (n=17) reported functional outcomes. 35% of our studies (n=15) reported arc of motion (AOM) outcomes (Table 5). Overall, mean total active motion (TAM) was $93 \pm 8\%$ of normal (n=6 studies), ranging from 70–99%.^{17,40} Revision amputation (n=2) outperformed local flaps (n=5) in preservation of TAM (95% versus $90 \pm 9\%$ of normal, respectively). Among local flaps, homodigital flaps resulted in better TAM than heterodigital flaps ($93 \pm 2\%$ versus $86 \pm 11\%$ of normal). Mean proximal interphalangeal (PIP) AOM was 94 ± 8 degrees (n=5) overall, with a range between 86–108 degrees. Local flaps (n=4) outperformed revision amputation (n=1) in this aspect (98 ± 5 degrees versus 85.9 degrees, respectively). Mean distal interphalangeal (DIP) AOM (n=6) was 72 ± 12 degrees, with a range between 54–86 degrees; all six studies utilized local flaps. 12% of our

studies (n=5) reported grip strength with varying methods^{17,23,28,37,38}, studies on revision amputation reported this outcome the most (Table 5). 9% of our studies (n=4) reported pinch strength.^{17,23,28,39} Mean pinch strength was 3 ± 1 kg (n=2), ranging from 2–5 kg (Table 5).^{17,39} Overall, local flaps outperformed revision amputation in preserving PIP AOM, but slightly underperformed in preservation of TAM.

Complications

88% of our studies (n=38) reported complications. Studies reported an average of 2.8 complications, with a range between 0–7 complications. Among these studies, 367 out of 853 patients (43%) reported cold intolerance (Table 7). Patients who underwent homodigital flaps reported cold intolerance more often than patients who underwent heterodigital flaps (35% versus 14%, respectively). More patients reported cold intolerance after revision amputation (77%) than after any other modality. Patients who underwent local flap treatments reported less paresthesia/numbness and scar sensitivity when compared to patients who underwent other treatment types. Similarly, patients who underwent conservative treatments reported less tenderness/pain and hypersensitivity. Infection was reported in five studies, with an incidence of 11% (20/189 patients). Hypertrophic scar formation was the least reported complication (n=2 studies), while neuroma formation had the least incidence (4/393 patients, or 1%) among all reported complications. Overall, complications were reported extensively; patients who underwent revision amputation experienced more cold intolerance than patients who underwent other treatment modalities (Table 8).

Patient-Reported Outcomes

35% of our studies (n=15) utilized PRO measures (Table 6). 16% of our studies (n=7) assessed patient satisfaction.^{26,30,31,35,37,54,56} 16% of our studies (n=7) evaluated cosmetic satisfaction.^{17,21,27,39,43,45,55} 85% of patients (112/131) reported “satisfactory” ratings and 98% of patients (105/107) reported “good” or “excellent” ratings, irrespective of treatment. 9% of our studies (n=4) evaluated other PRO measures, such as the Disabilities of the Arm, Shoulder, and Hand (DASH) score.^{36,37,54,55} Three of these four studies assessed activities of daily living (ADL) and use of the affected fingertip in ADL. The majority of patients reported no limits on ADL,^{54,55} and up to 40% of patients were able to use their affected digits in ADL.³⁷ Patients generally conveyed improved QOL after treatment. Two studies used as many as three PRO measures.^{37,54} Overall, patients were satisfied with their treatment and subsequent QOL.

DISCUSSION

In the United States, close to a third of traumatic finger amputations are work-related, with even greater numbers world-wide.^{1–3} Thus, it is important that we fully understand the resultant post-injury and post-surgical outcomes. PROs have been critical in determining the value of an intervention and guiding clinical decision-making. Although there have been a host of studies exploring and detailing these outcomes after finger replantation,^{14–16} studies relating to revision amputation and other local non-replantation treatments are lacking.^{10,11}

In this systematic review, we screened over 2000 citations and extracted data from 43 articles. Mean patient age was 36 ± 2 years with a mean 74 ± 28 days off work. These extensive days off work may be as much a reflection on a patient's mental willingness as their physical readiness, and independent of treatment modality.^{71–73} A total of 1430 digits were evaluated – 151 thumbs and 462 index, 391 middle, 270 ring, and 156 little fingers. Noticeable gaps and variability in outcome reporting exists (Table 9), especially of PROs, hampering the possibility to generate an inclusive overview of non-replantation treatments. Consequently, understanding of the value and impact these procedures have on patients is limited.

In general, restoration of static 2-PD was excellent among patients treated with either revision amputation or conservative methods, with values well within the normal limits set by the American Society for Surgery of the Hand.⁶³ Conversely, local flaps used with revision amputation not only diminished static 2-PD, though only slightly outside of normal limits, but also substantially worsened dynamic 2-PD, as indicated by a mean value 2.5 mm over the upper limits of normal.^{67,68} However, these treatments generally resulted in normal to slightly diminished S-W sensibility. Unfortunately, variability in reporting methods limited any further comparative analysis of S-W sensibility outcomes. For instance, Van den Berg divided their results into (1) sensory recognition between 1.65–3.61 monofilaments (normal to diminished superficial sensibility) and (2) sensory recognition between 3.84–4.31 monofilaments (diminished vital to absent vital sensibility),²¹ whereas Sano correlated S-W sensibility with distance of flap advancement.³⁴

Revision amputation not only achieved better 2-PD when compared to local flap treatments, they also resulted in better functional results, specifically TAM (95% versus $90 \pm 9\%$ of normal, respectively). Conservative treatment produced the best TAM (99% of normal) among all groups studied. Patients who underwent local flaps did preserve more PIP AOM when compared to patients who underwent revision amputation; homodigital flaps (99 ± 7 degrees) and heterodigital flaps (97 ± 1 degrees) showed comparable results. We could not abundantly comment on grip or pinch strength, as they were reported in only 21% of our studies and in varying methods. Ma's study was one of a select few that offered transferrable results of functional outcomes. They measured pinch and grip strength of all four treatment groups (local flaps, revision amputation alone, skin grafting, and conservative treatments) up to six months after final follow-up and revealed mean grip strengths of 20.3 kg, 21.4 kg, 21.8 kg, and 21.6 kg, respectively, and mean pinch strengths of 2.7 kg, 2.4 kg, 2.9 kg, and 2.4 kg, respectively.¹⁷ They also found that cross-finger flaps resulted in the highest degree of finger stiffness (TAM 93% of normal), while conservative dressings produced the best results (TAM 99% of normal).¹⁷ These results parallel our pooled functional results.

Despite better sensory and function outcomes compared to local flap procedures, revision amputation led to a higher incidence of cold intolerance among patients (77%). Interestingly, patients who underwent conservative treatments reported cold intolerance the least among all treatment groups (30%), further adding credence to this modality (when viable) given its superior TAM and static 2-PD outcomes. However, cold intolerance has been assumed to be the result of vascular insufficiency and peripheral nerve injury suffered during the original trauma and thus may be independent of treatment method.^{63–65} Studies

reported various other post-treatment digital morbidities, such as hypersensitivities or paresthesias, graft necrosis or eventual loss, stiffness and residual pain, or post-operative infections. Many of these complications are not easily or reliably measured and reported.

PROs were the least reported outcome in our systematic review. Among them, assessment of PROs through surveys/questionnaires was largely utilized, focusing on general patient satisfaction, satisfaction on cosmesis, and QOL. Patients generally reported “satisfactory” or “good/excellent” ratings irrespective of treatment type. Studies evaluating ADL and use of the affected digit in ADL found that patients’ QOL were generally not affected by any treatments.^{37,54,55} Validated PRO measures such as the Michigan Hand Outcomes Questionnaire (MHQ) and DASH scores were infrequently applied (n=2 studies).^{37,45} Shao utilized the MHQ to assess the appearance of patient fingertips after dorsal island pedicle flaps. They reported that seven patients were “strongly satisfied” (score of 5/5) and four patients were “satisfied” (score of 4/5).⁴⁵ Hattori reported a statistically better DASH standardized response mean (SRM) score – a measure of the index of change in the DASH score preoperatively to postoperatively – of 1.9 after revision amputation.⁶⁹ Overall, PROs were limited to a few studies examining local flaps and revision amputation, with no noticeable differences observed. Without these important outcome measures, it is difficult to compare the true merit of these treatments, as clinically-measured outcomes only provide us with half the picture.

This study was limited by the quality of available literature. Many studies focused more on surgical techniques rather than presenting outcomes. Thus, data was generally poorly reported, preventing complete statistical analysis. Level of amputation was often not clearly delineated, which limits the value of some comparisons. Moreover, many studies varied in their methods of reporting outcomes, making summarization and comparative analysis difficult. For example, Tsai et al., who treated amputations with neurovascular island flaps, reported static 2-PD as less than 5 mm (nine patients), 6–10 mm (three patients), 11–15 mm (three patients), or greater than 15 mm (one patient).³⁰ Alternatively, Netscher et al., who performed full-thickness perionychial grafting, reported static 2-PD as either 5–7 mm (four patients) or 7–10 mm (three patients).³³ Many studies also did not stratify their results, making it difficult to extract and compare outcomes based on treatment. For instance, Chow et al. summarized their results of 89 digits as a “corrected percentage recovery,” which is defined as the percentage recovery measured against the pre-injury strength in their three treatment groups – revision amputation alone, skin grafting, and conservative treatments. They concluded that multiple finger amputations produced a statistically significant impairment. However, without data stratification, it is impossible to determine the effect of each treatment on these outcomes.

Despite the multitude of dedicated efforts to describe novel and interesting ways to treat traumatic amputations of the finger with non-replantation techniques, few conclusions can be drawn about these procedures. Consequently, little is known regarding the true merit and practicality of these procedures for patients who suffer traumatic finger amputations. In a healthcare environment focused on improving the understanding of outcomes, studies aimed to close these gaps are increasingly important. With the support of organizations such as the Plastic Surgery Foundation (PSF), whose research agenda is focused on bridging such gaps,

future studies can be made possible. A multi-center retrospective cross-sectional finger amputation and replantation outcomes study (the Finger Replantation and AmputationN-CHallenges in assessing Impairment, Satisfaction and Effectiveness – FRANCHISE study) sponsored by the PSF is currently underway (Table 10) and is an indication of the future direction research must take to realize this end. Similar future studies with more emphasis on the concept of PROs should be undertaken, as they are imperative to our understanding of patients who undergo revision amputations and other related techniques. We may then be able to embark on further comparative studies among treatment modalities to better guide our decision-making processes.

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List of References

1. Conn J, Annest J, Ryan G. Non-work-related finger amputations in the United States, 2001–2002. *Ann Emerg Med.* 2005; 45:630–5. [PubMed: 15940097]
2. McCall B, Horwitz I. An assessment and quantification of the rates, costs, and risk factors of occupational amputations: analysis of Kentucky workers' compensation claims, 1994–2003. *Am J Ind Med.* 2006; 49:1031–8. [PubMed: 17099905]
3. Boyle D, Parker D, Larson C, Pessoa-Brandao L. Nature, incidence, and cause of work-related amputations in Minnesota. *Am J Ind Med.* 2000; 37:542–50. [PubMed: 10723048]
4. Centers for Disease Control and Prevention; www.2a.cdc.gov/risqs/ [Accessed August 1, 2014]
5. Komatsu S, Tamai S. Successful replantation of a completely cut-off thumb: case report. *Plast Reconstr Surg.* 1968; 42:374–7.
6. Friedrich J, Poppler L, Mack C. Epidemiology of upper extremity replantation surgery in the United States. *J Hand Surg Am.* 2011; 36:1835–40. [PubMed: 21975098]
7. Liang H, Chen S, Hsu J. Work-related upper limb amputations in Taiwan, 1999–2001. *Am J Ind Med.* 2004; 46:649–55. [PubMed: 15551379]
8. Moini M, Rasouli M, Khaji A. Patterns of extremity traumas leading to amputation in Iran: results of Iranian National Trauma Project. *Chin J Traumatol.* 2009; 12:77–80. [PubMed: 19321050]
9. Omoke N, Chukwu C, Madubueze C. Traumatic extremity amputation in a Nigerian setting: patterns and challenges of care. *Int Orthop.* 2012; 36:613–8. [PubMed: 21779952]
10. Bindra R, Dias J, Heras-Palau C. Assessing outcome after hand surgery: the current state. *J Hand Surg Br.* 2003; 28:289–94. [PubMed: 12849936]
11. Hoang-Kim A, Pegreff F, Moroni A, Ladd A. Measuring wrist and hand function: common scales and checklists. *Injury.* 2011; 42:253–8. [PubMed: 21159335]
12. Alderman A, Chung K. Measuring outcomes in hand surgery. *Clin Plast Surg.* 2008; 35:239–50. [PubMed: 18298996]
13. Giladi A, Chung K. Measuring outcomes in hand surgery. *Clin Plast Surg.* 2013; 40:313–22. [PubMed: 23506772]
14. Sears E, Chung K. Replantation of finger avulsion injuries: a systematic review of survival and functional outcomes. *J Hand Surg Am.* 2011 Apr; 36(4):666–94.
15. Walaszek I, Zyluk A. Long term follow-up after finger replantation. *J Hand Surg Eur.* 2008; 33:59–64.

16. Haas F, Hubmer M, Rappl T. Long-term subjective and functional evaluation after thumb replantation with special attention to the Quick DASH questionnaire and a specially designed trauma score called modified Mayo score. *J Trauma*. 2011; 71:460–6. [PubMed: 21206290]
17. Chase R. Costs, risks, and benefits of hand surgery. *J Hand Surg Am*. 1983; 8:644–8. [PubMed: 6415154]
18. Gaul J Jr. Identifiable costs and tangible benefits resulting from the treatment of acute injuries of the hand. *J Hand Surg Am*. 1987; 12:966–70. [PubMed: 3116070]
19. Holmberg J, Lindgren B, Jutemark R. Replantation-revascularization and primary amputation in major hand injuries. Resources spent on treatment and the indirect costs of sick leave in Sweden. *J Hand Surg Br*. 1996; 21:576–80. [PubMed: 9230937]
20. Ma G, Cheng J, Chan K, Chan K, Leung P. Fingertip injuries – A prospective study on seven methods of treatment on 200 cases. *Ann Acad Med Singapore*. 1982 Apr; 11(2):207–13. [PubMed: 6753711]
21. Van den Berg W, Vergeer R, Van der Sluis C, Ten Duis H, Werker P. Comparison of three types of treatment modalities on the outcomes of fingertip injuries. *J Trauma Acute Care Surg*. 2012 Jun; 72(6):1681–7. [PubMed: 22695441]
22. De Smet L, Kinnen L, Moermans J, Ceuterick P, Van Wetter P. Fingertip amputations: distal or advancement flaps. *Acta Orthop Belg*. 1989; 55(2):177–82. [PubMed: 2801078]
23. Chow S, Ng C. Hand function after digital amputation. *J Hand Surg Br*. 1993 Feb; 18(1):125–8. [PubMed: 8436849]
24. Braun M, Horton R, Snelling C. Fingertip amputation: review of 100 digits. *Can J Surg*. 1985 Jan; 28(1):72–5. [PubMed: 3971228]
25. Söderberg T, Nyström A, Hallmans G, Hultén J. Treatment of fingertip amputations with bone exposure. A comparative study between surgical and conservative treatment methods. *Scand J Plast Reconstr Surg*. 1983; 17(2):147–52. [PubMed: 6361983]
26. Adani R, Busa R, Pancaldi G, Caroli A. Reverse neurovascular homodigital island flap. *Ann Plast Surg*. 1995 Jul; 35(1):77–82. [PubMed: 7574292]
27. Buckley S, Scott S, Das K. Late review of the use of silver sulphadiazine dressings for the treatment of fingertip injuries. *Injury*. 2000 Jun; 31(5):301–4. [PubMed: 10775681]
28. Sagiv P, Shabat S, Mann M, Ashur H, Nyska M. Rehabilitation process and functional results with amputated fingers. *Plast Reconstr Surg*. 2002 Aug; 110(2):497–505. [PubMed: 12142667]
29. Harvey F, Harvey P. A critical review of the results of primary finger and thumb amputations. *Hand*. 1974 Jun; 6(2):157–62. [PubMed: 4858511]
30. Tsai T, Yuen J. A neurovascular island flap for volar-oblique fingertip amputations. Analysis of long-term results. *J Hand Surg Br*. 1996 Feb; 21(1):94–8. [PubMed: 8676038]
31. Tupper J, Miller G. Sensitivity following volar V-Y plasty for fingertip amputations. *J Hand Surg Br*. 1985 Jun; 10(2):183–4. [PubMed: 4031598]
32. Hovgaard C, Angermann P, Hovgaard D. The social and economic consequences of finger amputations. *Acta Orthop Scand*. 1994 Jun; 65(3):347–8. [PubMed: 8042493]
33. Netscher D, Meade R. Reconstruction of fingertip amputations with full-thickness perionychial grafts from the retained part and local flaps. *Plast Reconstr Surg*. 1999 Nov; 104(6):1705–12. [PubMed: 10541172]
34. Sano K, Ozeki S, Kimura K, Hyakusoku H. Relationship between sensory recovery and advancement distance of oblique triangular flap for fingertip reconstruction. *J Hand Surg Am*. 2008 Sep; 33(7):1088–92. [PubMed: 18762102]
35. Yazar M, Aydin A, Kurt Yazar S, Ba aran K, Güven E. Sensory of the reverse homodigital island flap in fingertip reconstruction: A review of 66 cases. *Acta Orthop Traumatol Turc*. 2010; 44(5): 345–51. [PubMed: 21343684]
36. Foucher G, Dallaserra M, Tilquin B, Lenoble E, Sammut D. The Hueston flap in reconstruction of fingertip skin loss; results in a series of 41 patients. *J Hand Surg Am*. 1994 May; 19(3):508–15. [PubMed: 8056984]
37. Hattori Y, Doi K, Ikeda K, Estrella E. A retrospective study of functional outcomes after successful replantation versus amputation closure for single fingertip amputations. *J Hand Surg Am*. 2006 May-Jun; 31(5):811–8. [PubMed: 16713848]

38. Ratliff A. Amputations of the distal part of the thumb. *Hand*. 1972 Jun; 4(2):190–3. [PubMed: 5040341]
39. Varitimidis S, Dailiana Z, Zibis A, Hantes M, Bargiotas K, Malizos K. Restoration of function and sensitivity utilizing a homodigital neurovascular island flap after amputation injuries of the fingertip. *J Hand Surg Br*. 2005 Aug; 30(4):338–42. [PubMed: 15936132]
40. Hashem A. Salvage of degloved digits with heterodigital flaps and full thickness skin graft. *Ann Plast Surg*. 2010 Feb; 64(2):155–8. [PubMed: 20098098]
41. Adani R, Marcoccio I, Tarallo L, Fregni U. The reverse heterodigital neurovascular island flap for digital pulp reconstruction. *Tech Hand Up Extrem Surg*. 2005 Jun; 9(2):91–5. [PubMed: 16201250]
42. Bakhach J, Guimberteau J, Panconi B. The Gigogne flap: An original technique for an optimal pulp reconstruction. *J Hand Surg Eur*. 2009 Apr; 34(2):227–34.
43. Ni F, Appleton S, Chen B, Wang B. Aesthetic and functional reconstruction of fingertip and pulp defects with pivot flaps. *J Hand Surg Am*. 2012 Sep; 37(9):1806–11. [PubMed: 22763057]
44. Hammouda A, El-Khatib H, Al-Hetmi T. Extended step-advancement flap for avulsed amputated fingertip – A new technique to preserve finger length: case series. *J Hand Surg Am*. 2011 Jan; 36(1):129–34. [PubMed: 21193132]
45. Shao X, Chen C, Zhang X, Yu Y, Ren D, Lu L. Coverage of fingertip defect using a dorsal island pedicle flap including both dorsal digital nerves. *J Hand Surg Am*. 2009 Oct; 34(8):1474–81. [PubMed: 19733984]
46. Momeni A, Zajonc H, Kalash Z, Stark G, Bannasch H. Reconstruction of distal phalangeal injuries with the reverse homodigital island flap. *Injury*. 2008 Dec; 39(12):1460–3. [PubMed: 18573493]
47. Tuncali D, Barutcu A, Gokrem S, Terzioglu A, Aslan G. The hatchet flap for reconstruction of fingertip amputations. *Plast Reconstr Surg*. 2006 May; 117(6):1933–9. [PubMed: 16651967]
48. Kim K, Yoo S, Kim D, Lee S, Cho B. Fingertip reconstruction using a volar flap based on the transverse palmar branch of the digital artery. *Ann Plast Surg*. 2001 Sep; 47(3):263–8. [PubMed: 11562030]
49. Shibu M, Tarabe M, Graham K, Dickson M, Mahaffey P. Fingertip reconstruction with a dorsal island homodigital flap. *Br J Plast Surg*. 1997 Feb; 50(2):121–4. [PubMed: 9135429]
50. Foucher G, Smith D, Pempinello C, Braun F, Citron N. Homodigital neurovascular island flaps for digital pulp loss. *J Hand Surg Br*. 1989 May; 14(2):204–8. [PubMed: 2746121]
51. Frandsen P. V-Y plasty as treatment of fingertip amputations. *Acta Orthop Scand*. 1978 Jun; 49(3):255–9. [PubMed: 356514]
52. Freiberg A, Manktelow R. The Kutler repair for fingertip amputations. *Plast Reconstr Surg*. 1972 Oct; 50(4):371–5. [PubMed: 4561577]
53. Woon C, Lee J, Teoh L. Resurfacing hemipulp losses of the thumb: the cross finger flap revisited: indications, technical refinements, outcomes, and long-term neurosensory recovery. *Ann Plast Surg*. 2008 Oct; 61(4):385–91. [PubMed: 18812707]
54. Kappel D, Burech J. The cross-finger flap. An established reconstructive procedure. *Hand Clin*. 1985 Nov; 1(4):677–83. [PubMed: 3831054]
55. Chen S, Wang C, Fu J, Chang S, Chen S. Composite grafting for traumatic fingertip amputation in adults: Technique reinforcement and experience in 31 digits. *J trauma*. 2011 Jan; 70(1):148–53. [PubMed: 20404757]
56. Omokawa S, Fujitani R, Dohi Y, Tanaka Y, Yajima H. Reverse midpalmar island flap transfer for fingertip reconstruction. *J Reconstr Microsurg*. 2009 Mar; 25(3):171–9. [PubMed: 19037846]
57. Scott J. Amputation of the finger. *Br J Surg*. 1974 Jul; 61(7):574–6. [PubMed: 4602146]
58. Mennen U, Wiese A. Fingertip injuries management with semi-occlusive dressing. *J Hand Surg Br*. 1993 Aug; 18(4):416–22. [PubMed: 8409649]
59. Lamont R, Cicero J, Frascione R, Hass W. Open treatment of fingertip amputations. *Ann Emerg Med*. 1983 Jun; 12(6):358–60. [PubMed: 6859631]
60. Louis D, Palmer A, Burney R. Open treatment of digital tip injuries. *JAMA*. 1980 Aug 15; 244(7):697–8. [PubMed: 7392172]

61. Farrell R, Disher W, Nesland R, Palmatier T, Truhler T. Conservative management of fingertip amputations. *JACEP*. 1977 Jun; 6(6):243–6. [PubMed: 864887]
62. Fox J, Golden G, Rodeheaver G, Edgerton M, Edlich R. Non-operative management of fingertip pulp amputation by occlusive dressings. *Am J Surg*. 1977 Feb; 133(2):255–6. [PubMed: 835804]
63. Lundborg G, Rosen B. The two-point discrimination test – time for a re-appraisal? *J Hand Surg Br*. 2004; 29:418–422. [PubMed: 15336741]
64. Gelberman R, Urbaniak J, Bright D, Levin L. Digital sensibility following replantation. *J Hand Surg*. 1978; 3:313–319.
65. Graham B, Schofield M. Self-reported symptoms of cold intolerance in workers with injuries of the hand. *Hand (N Y)*. 2008; 3:203–209. [PubMed: 18780096]
66. Irwin M, Gilbert S, Terenghi G, Smith R, Green C. Cold intolerance following peripheral nerve injury. Natural history and factors predicting severity of symptoms. *J Hand Surg Br*. 1997; 22:308–316. [PubMed: 9222907]
67. Louis D, Greene T, Jacobson K, Rasmussen C, Kolowich P, Goldstein S. Evaluation of normal values for stationary and moving two-point discrimination in the hand. *J Hand Surg*. 1984; 9:552–5.
68. Dellon E, Mourey R, Dellon A. Human pressure perception values for constant and moving one- and two-point discrimination. *Plast Reconstr Surg*. 1992; 90:112–17. [PubMed: 1615069]
69. MacDermid J, Richards R, Donner A, Bellamy N, Roth J. Responsiveness of the Short Form-36, Disability of the Arm, Shoulder, and Hand questionnaire, Patient-Rated Wrist Evaluation, and Physical Impairment Measurements in evaluating recovery after a distal radius fracture. *J Hand Surg*. 2000; 25A:330–340.
70. Moher D, Liberati A, Tetzlaff J, Altman D. Preferred reporting items for systematic reviews and meta-analyses: the PRIMA statement. *J Clin Epidemiol*. 2009 Oct; 62(10):1006–12. [PubMed: 19631508]
71. Cooper A, Hankins M, Rixon L, Eaton E, Grunfeld E. Distinct work-related, clinical and psychological factors predict return to work following treatment in four different cancer types. *Psychooncology*. 2013 Mar; 22(3):659–67. [PubMed: 22434715]
72. Parot-Schinkel E, Roquelaure Y, Ha C, Leclerc A, Chastang J, Raimbeau G, Chaise F, Descatha A. Factors affecting return to work after carpal tunnel syndrome surgery in a large French cohort. *Arch Phys Med Rehabil*. 2011 Nov; 92(11):1863–9. [PubMed: 22032220]
73. Seland K, Cherry N, Beach J. A study of factors influencing return to work after wrist or ankle fractures. *Am J Ind Med*. 2006 Mar; 49(3):197–203. [PubMed: 16421918]
74. Tracey E, Greene A, Doty R. Optimizing reliability and sensitivity of Semmes-Weinstein monofilaments for establishing point tactile thresholds. *Physiol Behav*. 2002 Feb 28; 105(4):982–6. [PubMed: 22100625]

Figure 1.

Flow chart of database search, including number of citations identified at each level of search. * Citations that included patients from multiple groups.

Table 1

Predetermined Inclusion and Exclusion Criteria for Literature Search

Inclusion Criteria	Exclusion Criteria
English	Non-English
Studies that presented primary, qualitative data or both qualitative and quantitative data on patient outcomes	Studies that were review articles or presented entirely qualitative data
Studies that included patients who sustained traumatic finger amputations distal to the metacarpophalangeal (MCP) joint	Studies that included patients with amputations proximal to MCP or other injuries that occurred along with the amputation
Studies that included patients treated with non-replant techniques (i.e. local flap reconstruction used with revision amputation, revision amputation only, skin grafting only, or conservative wound treatments)	Studies that failed to clearly report any primary outcomes (PROs, sensation, and/or function)

Table 2

Study Characteristics

Local Flaps Used With Revision Amputation					Revision Amputation Alone	Skin Grafting	Conservative Treatment	TOTAL
Homodigital				Heterodigital				
Study Design								
Prospective	14*	5*	2	4*	3*	7*	27*	
Retrospective	7*	1	1	6*	0	2*	14*	
Cross-Sectional	1	0	0	0	0	1	2	
Period Study Reported								
2000–2012	11	3	2	3	0	2*	19*	
1990–1999	4	0	1	2*	1*	2*	8*	
1980–1989	5*	3*	0	2*	2*	4*	9*	
1972–1979	2	0	0	3	0	2	7	
Study Location								
North America	4*	1	1	0	1*	4	10*	
Europe	12	2*	0	5*	0	3*	18*	
Asia	5*	2*	2	3*	2*	2*	10*	
Other [‡]	1	1	0	2	0	1	5	

* Indicates those studies involved in 2 or more study subgroups

‡ Includes Africa (specifically Qatar, Egypt, and South Africa), Israel, and Australia

Patient and Digit Characteristics

Table 3

	Local Flaps Used With Revision Amputation			Revision Amputation Alone	Skin Grafting	Conservative Treatment
	Homodigital	Heterodigital	Other Flaps			
Patient Demographics						
Mean age, years	35 ± 6	35 ± 10	35 ± 15	39 ± 9	35	34 ± 9
Mean follow-up period, months	33 ± 20	28 ± 6	18 ± 12	52 ± 52	12 ± 1	10 ± 31
Median follow-up period, months	24	25	20	26	11	8
Mean time off work, days	46 ± 18	58 ± 8	†	63 ± 31	116 ± 60	89 ± 52
Level of Injury						
Distal phalanx	22	6	3	5	2	7
Distal to MCP	0	0	0	6	0	0
MCP to DIP	1	0	0	2	1	1
Distal to PIP	0	0	0	1	0	0
Distal to IPJ	0	0	0	1	0	0
Digit Distribution						
Thumb	60	44	5	76	24	37
Index	230	80	14	236	76	89
Middle	188	87	17	211	63	69
Ring	116	47	13	158	41	46
Little	61	31	3	107	25	26
TOTAL:	655	289	52	788	229	267

† Indicates data unextractable, unclear, or not available

Table 4

Summary of Sensory Outcomes

First author (ref.)	Year	No. of digits	Static 2PD (mm)	Dynamic 2PD (mm)	S-W Sensibility
LOCAL FLAPS USED WITH REVISION AMPUTATION					
Homodigital Flaps					
Van den Berg ²¹	2012	25	$\ddagger$	$\ddagger$	14/25 digits (56.0%) normal - diminished superficial [‡] 11/25 digits (44.0%) diminished vital - absent vital [‡]
Ni ⁴³	2012	22	4.7	3.9	Recognition of 3.92 monofilament [§]
Hammouda ⁴⁴	2011	6	4	$\ddagger$	
Yazar ³⁵	2010	70	5.7	$\ddagger$	64/70 digits normal (2.83) 6/70 digits diminished (3.61)
Shao ⁴⁵	2009	11	4.45	$\ddagger$	
Bakhach ⁴²	2009	15	7	5.5	
Momeni ⁴⁶	2008	11	9	$\ddagger$	
Sano ³⁴	2008	14	$\ddagger$	$\ddagger$	6/11 cases (9 digits) normal (2.83) 5/11 cases (5 digits) diminished (3.61)
Tuncali ⁴⁷	2006	$\ddagger$	6.3	$\ddagger$	
Varitimidis ³⁹	2005	63	4	$\ddagger$	
Kim ⁴⁸	2001	25	4.2	$\ddagger$	
Tsai ³⁰	1996	$\ddagger$	$\ddagger$	$\ddagger$	
Adani ²⁶	1995	11	12	11	
Foucher ³⁶	1994	43	7	$\ddagger$	35/43 digits identical to contralateral digit 8/43 digits inferior to contralateral digit
Foucher ⁵⁰	1989	64	5.6	$\ddagger$	
De Smet ²²	1989	41	8.9	$\ddagger$	
Tupper ³¹	1985	20	5.7	$\ddagger$	
Ma ²⁰	1985	34	4.1	$\ddagger$	
Freiberg ⁵²	1972	22	6	$\ddagger$	
Mean $\pm$ SD:			5.8 $\pm$ 2.2 mm	7.0 $\pm$ 3.7 mm	
Heterodigital Flaps					

First author (ref.)	Year	No. of digits	Static 2PD (mm)	Dynamic 2PD (mm)	S-W Sensibility
Hashem ⁴⁰	2010	6	8.3	†	
Woon ⁵³	2008	30	3.3	†	
Adani ⁴¹	2005	22	9	7	
De Smet ²²	1989	29	10.6	†	
Kappel ⁵⁴	1985	†	8.25	†	
Ma ²⁰	1982	18	7.2	†	
		Mean ± SD:	7.5 ± 2.5 mm	7.0 mm	
Other					
Chen ⁵⁵	2011	31	†	6.3	
Omokawa ⁵⁶	2009	15	†	8.4	
Netscher ³³	1999	11	†	†	
		Mean ± SD:	N/A	7.0 ± 1.5 mm	
		LOCAL FLAPS MEAN ± SD:	6.1 ± 2.4 mm	7.0 mm	
REVISION AMPUTATION ALONE					
Van den Berg ²¹	2012	25	†	†	15/23 digits (65.2%) normal - diminished superficial 8/23 digits (34.8%) diminished vital - absent vital
Hattori ³⁷	2006	23	3.5	†	
Ma ²⁰	1982	18	4.1	†	
		MEAN ± SD:	3.8 ± 0.4 mm	N/A	
SKIN GRAFTING					
		MEAN ± SD:	6.5 mm	N/A	
CONSERVATIVE TREATMENT					
Van den Berg ²¹	2012	25	†	†	9/11 digits (81.8%) normal - diminished superficial 2/11 digits (18.2%) diminished vital - absent vital
Mennen ⁵⁸	1993	†	3	†	
Ma ²⁰	1982	17	3.8	†	
Louis ⁶⁰	1980	38	3.5	†	
Fox ⁶²	1977	22	4	†	

First author (ref.)	Year	No. of digits	Static 2PD (mm)	Dynamic 2PD (mm)	S-W Sensibility
		MEAN ± SD:	3.7 ± 0.4 mm	N/A	
		ALL GROUPS MEAN ± SD:	5.0 ± 1.5 mm	N/A	

[†] Indicates data unextractable, unclear, or not available

[‡] 1.65–2.83 (normal sensibility) to 3.22–3.61 (diminished superficial sensibility)

[§] 3.84–4.31 (diminished vital sensibility) to 4.56–6.65 (absent vital sensibility)

[§] Mean sensibility of the reconstructed fingertip area (range, 2.83–4.56)

Table 5

Summary of Functional Outcomes

First author (ref.)	Year	No. of digits	Grip Strength	Pinch Strength	Range of Motion [‡]
LOCAL FLAPS USED WITH REVISION AMPUTATION					
Homodigital Flaps					
Van den Berg ²¹	2012	25	†	†	Mean reduction in AAOM – 22.0% (0–48.6%) Mean reduction in PAOM – 18.1% (0–45.3%) Mean reduction in TAM – 12.3% (0–26.1%) Mean reduction in TPM – 10.7% (0–25.5%)
Ni ⁴³	2012	22	†	†	Mean PIP AOM – 97° Mean DIP AOM – 81°
Hammouda ⁴⁴	2011	6	†	†	Mean PIP AOM – 107.5° Mean DIP AOM – 68.8°
Shao ⁴⁵	2009	11	†	†	Mean PIP AOM – 98° (contralateral 97°) Mean DIP AOM – 86° (contralateral 87°)
Bakhach ⁴²	2009	15	†	†	Mean TAM – 89.5% of total (270°)
Varitimidis ³⁹	2005	63	†	5.4 kg	Normal PIP/DIP AOM – 48 digits Loss of extension up to 10° - 8 digits Loss of DIP extension up to 20° - 7 digits
Shibu ⁴⁹	1997	7	†	†	Mean DIP AOM – 54.3°
Tsai ³⁰	1996	†	†	†	Mean MCP AOM – 83° (contralateral 82°) Mean PIP AOM – 96° (contralateral 98°) Mean DIP AOM – 54° (contralateral 61°) Mean IP AOM – 54° (contralateral 55°)
Adani ²⁶	1995	11	†	†	Mean TAM – 93.3% of total (270°)
Ma ²⁰	1985	34	21.7 kg	3.3 kg	Mean TAM – 94.0% of total (270°)
Heterodigital Flaps					
Hashemi ⁴⁰	2010	6	†	†	Mean TAM – 70.4% of total (270°)
Adani ⁴¹	2005	22	†	†	Mean TAM – 85.2% of total (270°)
Ma ²⁰	1982	18	17.6 kg	1.7 kg	Mean TAM – 92.6% of total (270°)
Other					
Netscher ³³	1999	15	†	†	Mean DIP AOM – 70°
REVISION AMPUTATION ALONE					
Van den Berg ²¹	2012	25	†	†	Mean reduction in AAOM – 22.0% (0–48.6%) Mean reduction in PAOM – 18.1% (0–45.3%)

First author (ref.)	Year	No. of digits	Grip Strength	Pinch Strength	Range of Motion [‡]
Hattori ¹⁷	2006	23	93% of contralateral hand	†	Mean reduction in TAM – 12.3% (0–26.1%) Mean reduction in TPM – 10.7% (0–25.5%)
Sagiv ²⁸	2002	84	59.9% of contralateral hand	48.9% of contralateral hand	Mean PIP AOM – 85.9°
Chow ²³	1993	89	69.4% corrected percentage	65.4% corrected percentage	†
Ma ²⁰	1982	18	21.4 kg	2.4 kg	Mean TAM – 95.2% of total (270°)
Ratliff ³⁸	1972	11	No loss in 8/11 patients Slight loss in 2/11 patients Severe loss in 1/11 patient	†	†
SKIN GRAFTING					
Chow ²³	1993	89	69.4% corrected percentage	65.4% corrected percentage	†
Ma ²⁰	1982	33	21.8 kg	2.9 kg	Mean TAM – 95.6% of total (270°)
CONSERVATIVE TREATMENT					
Van den Berg ²¹	2012	25	†	†	Mean reduction in AAOM – 22.0% (0–48.6%) Mean reduction in PAOM – 18.1% (0–45.3%) Mean reduction in TAM – 12.3% (0–26.1%) Mean reduction in TPM – 10.7% (0–25.5%)
Chow ²³	1993	89	69.4% corrected percentage	65.4% corrected percentage	†
Ma ²⁰	1982	17	21.6 kg	2.4 kg	Mean TAM – 98.5% of total (270°)

† Indicates data unextractable, unclear, or not available

‡ AAOM = Active arc of motion

PAOM = Passive arc of motion

TAM = Total active motion

TPM = Total passive motion

PIP AOM = Proximal interphalangeal arc of motion

DIP AOM = Distal interphalangeal arc of motion

MCP AOM = Metacarpophalangeal arc of motion

IP AOM = Interphalangeal arc of motion

Table 6

Summary of Patient-Reported Outcomes

First author (ref.)	Year	Patient satisfaction	Cosmetic result	Other results
LOCAL FLAPS USED WITH REVISION AMPUTATION				
Homodigital Flaps				
Van den Berg ²¹	2012		Score – 7.1/10 ^F	
Ni ⁴³	2012		20/21 patients strongly satisfied 1/21 patient satisfied	
Yazar ³⁵	2010	66/66 patients satisfied		
Shao ⁴⁵	2009		MHQ ^E : Score – 5/5 (7 patients) Score – 4/5 (4 patients)	
Varitimidis ³⁹	2005		9/63 Excellent results 54/63 Good results	
Tsai ³⁰	1996	9/16 patients very satisfied 5/16 patients satisfied 2/16 patients dissatisfied		
Adani ²⁶	1995	6/11 patients very satisfied 4/11 patients satisfied 1/11 patient dissatisfied		
Foucher ³⁶	1994			Functional impairment: 1/41 patient very often 3/41 patients at times 4/41 patients infrequent 33/41 patients without impairment
Tupper ³¹	1985	12/16 patients satisfied 2/16 patients dissatisfied 2/16 patients noncommittal		
Ma ²⁰	1982		Score – 2.6/4 ^F	
Heterodigital Flaps				
Kappel ⁵⁴	1985	21/23 excellent/good 2/23 fair/poor		Sensation of affected digit: 9/23 excellent/good 14/23 fair/poor ADL ^S : 18/23 normal 5/23 less than normal
Ma ²⁰	1982		Score – 2.79/4 ^F	
Other				
Chen ⁵⁵	2011		24/29 patients very satisfied 2/29 patients moderately satisfied 1/29 patients slightly satisfied 2/29 patients dissatisfied	ADL ^S : 25/29 normal 4/29 limited
Omokawa ⁵⁶	2009	14/15 patients satisfied 1/15 patients dissatisfied		
REVISION AMPUTATION ALONE				
Van den Berg ²¹	2012		Score – 6.9/10 ^F	
Hattori ³⁷	2006	5/23 patients highly satisfied 9/23 patients fairly satisfied 7/23 patients poorly satisfied 2/23 patients badly satisfied		Use of affected finger in ADLs ^S : 9/23 always used 4/23 sometimes used 4/23 rarely used 6/23 never used DASH SRM ^E score:

First author (ref.)	Year	Patient satisfaction	Cosmetic result	Other results
				1.9
Ma ²⁰	1982		Score – 2.58/4 [¥]	
SKIN GRAFTING				
Ma ²⁰	1982		Score – 2.6/4 [¥]	
CONSERVATIVE TREATMENT				
Van den Berg ²¹	2012		Score – 8.0/10 ^ℱ	
Buckley ²⁷	2000		12/21 excellent results 9/21 good results	
Ma ²⁰	1982		Score – 2.57/4 [¥]	

^ℱ Aesthetic result scored on a visual analog scale from 0 to 10

[¥] Aesthetic result scored on a system in which 'excellent' appearance gained 4 points, 'very good' appearance gained 3, 'good' appearance gained 2, 'fair' appearance gained 1, and 'poor' gained no points.

[§] ADL = Activities of daily living

[€] DASH SRM = Disabilities of the Arm, Shoulder, and Hand (DASH) standardized response mean

[£] MQH = Michigan Hand Outcomes Questionnaire

Table 7

List of Reported Complications

Reported Complication	No. of studies	No. of patients	Homodigital Flaps	Heterodigital Flaps	Other Flaps	Revision Amputation Alone	Skin Grafting	Conservative Treatment	Overall Incidence
Cold intolerance	27	367/853	35%	14%	†	77%	33%	30%	43%
Graft tenderness/residual pain/rest pain	12	180/518	20%	7%	†	43%	81%	4%	37%
Paresthesia/numbness/loss of sensation	13	101/327	34%	†	11%	47%	47%	50%	32%
Hypersensitivity	13	155/582	26%	†	†	30%	18%	14%	27%
Scar sensitivity	4	60/256	11%	22%	†	26%	45%	28%	23%
Joint stiffness	3	13/81	17%	†	†	10%	†	12%	16%
Hypertrophic scar	2	5/33	18%	14%	†	†	†	†	15%
Venous congestion	4	8/65	†	9%	†	†	†	†	12%
Infection	5	20/189	8%	28%	†	21%	†	11%	11%
Graft necrosis	11	21/284	7%	11%	5%	†	†	†	7%
Graft failure/loss	6	11/145	3%	3%	0%	†	18%	†	7%
Wound dehiscence/ulceration	4	8/93	6%	†	†	†	4%	†	6%
Scar contracture	5	8/146	4%	11%	†	†	†	†	5%
Neuroma	7	4/393	1%	0%	†	0%	0%	1%	1%

Percentages are based on number of patients from all studies that reported specific complication.

Indicates data unextractable, unclear, or not available

Table 8

Summary of Complications

First author (ref.)	Year	No. of digits	Incidence of cold intolerance (%)	No. of other complications	Comments
LOCAL FLAPS USED WITH REVISION AMPUTATION					
Homodigital Flaps					
Van den Berg ²¹	2012	25	84	3	0 patients with neuromas 2 patients with scar sensitivity 6 patients with infection overall
Ni ⁴³	2012	22	100	1	3 patients with venous cong.
Hammouda ⁴⁴	2011	6	†	2	1 patient with flap necrosis 1 patient with hypersensitivity
Yazar ³⁵	2010	70	11	4	1 patient with flap necrosis 3 patients scar contracture 2 patients with neuroma 2 patients with hypersensitivity
Shao ⁴⁵	2009	11	100	2	2 patients with venous cong. 1 patient with tenderness
Bakhach ⁴²	2009	15	†	1	1 patient with flap necrosis
Momeni ⁴⁶	2008	11	0	3	1 patient with flap necrosis 1 patient with venous cong. 0 patients with scar contracture
Sano ³⁴	2008	14	9	1	7 patients with tenderness
Tuncali ⁴⁷	2006	†	22	2	1 patient with dehiscence 1 patient with paresthesias
Varitimidis ³⁹	2005	63	8	4	0 patients with dehiscence, infection, neuroma, or scar sensitivity
Shibu ⁴⁹	1997	7	29	1	1 patient with partial graft loss
Tsai ³⁰	1996	†	69	2	9 patients with numbness 7 patients with hypersensitivity
Adani ²⁶	1995	11	27	2	2 patients with hypertrophic scar 1 patient with neuroma
Foucher ³⁶	1994	43	78	3	2 patients with scar contracture 6 patients with hypersensitivity 6 patients with rest pain
Foucher ⁵⁰	1989	64	3	5	5 patients with graft necrosis 11 patients with joint stiffness 0 patients with neuroma 1 patient with scar sensitivity

First author (ref.)	Year	No. of digits	Incidence of cold intolerance (%)	No. of other complications	Comments
					2 patients with graft loss
De Smet ²²	1989	41	†	1	15 patients with residual pain
Tupper ³¹	1985	20	75	2	5 patients with tenderness 8 patients with hypersensitivity
Braun ²⁴	1985	52	42	6	18 patients with hypersensitivity 11 patients with rest pain 4 patients with loss of sensation 18 patients with paresthesia 1 patient with ulceration 1 patient with graft loss
Ma ²⁰	1985	34	†	2	7 patients with dehiscence 10 patients with scar sensitivity
Frandsen ⁵¹	1988	28	43	4	4 patients with graft necrosis 5 patients with infection 14 patients with hypersensitivity 1 patient with paresthesia
Freiberg ⁵²	1972	22	27	6	7 patients with mild numbness 3 patients with paresthesias 2 patients with graft necrosis 2 patients with infection 8 patients with tenderness 7 patients with mild hypersensitivity
Heterodigital Flaps					
		Mean:	35 ± 34%		
Hashemi ⁴⁰	2010	6	50	2	3 patients with graft necrosis 1 patient with scar contracture
Woon ⁵³	2008	30	†	2	1 patient with graft necrosis 1 patient with graft loss
Adani ⁴¹	2005	22	5	4	2 patients with venous congestion 2 patients with scar contracture 3 patients with hypertrophic scar 0 patients with neuroma
De Smet ²²	1989	29	†	1	1 patient with residual pain
Kappel ⁵⁴	1985	†	48	1	8 patients with residual pain
Ma ²⁰	1982	18	†	2	5 patients with infection 4 patients with scar sensitivity
		Mean:	14 ± 26%		
Other					
Chen ⁵⁵	2011	31	†	2	4 patients with numbness

First author (ref.)	Year	No. of digits	Incidence of cold intolerance (%)	No. of other complications	Comments
Netscher ³³	1999	11	0	3	2 patients with graft necrosis 0 patients with numbness, graft necrosis, or graft loss
LOCAL FLAPS MEAN: 33 ± 23%					
MEAN: 0					
REVISION AMPUTATION ALONE					
Van Den Berg ²¹	2012	23	91	3	0 patients with neuromas 2 patients with scar sensitivity 6 patients with infection
Hattori ³⁷	2006	23	44	2	14 patients with tenderness 7 patients with paresthesia
Hovgaard ³²	1994	150	†	2	55 patients with hypersensitivity 45 patients with residual pain
Chow ²³	1993	89	†	4	Overall cold intolerance of 21.3%, 64 patients with numbness, 0 patients with neuroma, 18 patients with hypersensitivity
Soderberg ²⁵	1983	†	†	1	10% patients with joint stiffness
Ma ²⁰	1982	18	†	2	2 patients with infection 8 patients with scar sensitivity
Scott ⁵⁷	1974	151	81	1	53 patients with tenderness
Ratliff ³⁸	1972	11	†	1	4 patients with hypersensitivity
MEAN: 77 ± 25%					
SKIN GRAFTING					
Chow ²³	1993	89	†	4	Overall cold intolerance of 21.3%, 64 patients with numbness, 0 patients with neuroma, 18 patients with hypersensitivity
Braun ²⁴	1985	27	33	6	9 patients with hypersensitivity 22 patients with rest pain 2 patients with loss of sensation 6 patients with paresthesia 1 patients with ulceration 4 patients with graft loss
Ma ²⁰	1982	33	†	2	7 patients with graft loss 15 patients with scar sensitivity
MEAN: 33%					
CONSERVATIVE TREATMENT					
Van den Berg ²¹	2012	11	100	3	1 patients with neuromas 0 patients with scar sensitivity 6 patients with infection overall

First author (ref.)	Year	No. of digits	Incidence of cold intolerance (%)	No. of other complications	Comments
Buckley ²⁷	2000	21	42	1	4 patients with scar sensitivity
Chow ²³	1993	89	21	4	Overall cold intolerance of 21.3%, 64 patients with numbness, 0 patients with neuroma, 18 patients with hypersensitivity
Lamon ⁵⁹	1983	25	†	2	1 patient with tenderness 2 patients with loss of pin prick
Ma ²⁰	1982	17	†	1	9 patients with scar sensitivity
Louis ⁶⁰	1980	38	21	1	2 patients with hypersensitivity
Farrell ⁶¹	1977	21	†	3	2 patients with moderate joint stiffness 4 patients with hypersensitivity 3 patients with loss of sensation
MEAN:			30 ± 37%		
ALL GROUPS MEAN:			43 ± 23%		

† Indicates data unextractable, unclear, or not available

Table 9

Summary of Reported Outcomes

Reported Outcomes	No. of studies	Percentage (%)
Sensory Outcomes	30	70%
Static 2-PD	23	54%
Dynamic 2-PD	6	14%
S-W Sensibility	5	12%
Functional Outcomes	17	40%
AOM	15	35%
Grip Strength	5	12%
Pinch Strength	4	9%
Patient-Reported Outcomes (PRO)	15	35%
Patient Satisfaction	7	16%
Cosmetic Satisfaction	7	16%
Other PRO Measures	4	9%
Complications	38	88%

‡ 2-PD = 2-Point Discrimination

S-W = Semmes-Weinstein

AOM = Arc of Motion

Table 10

List of Finger Replantation and Amputation-Challenges in assessing Impairment, Satisfaction and Effectiveness (FRANCHISE) Study Sites

Institution	Location
1. The Buncke Clinic	San Francisco, CA
2. Curtis National Hand Center	Baltimore, MD
3. Duke University	Durham, NC
4. Johns Hopkins University	Baltimore, MD
5. Lehigh Valley Health Network	Allentown, PA
6. The Medical College of Wisconsin	Milwaukee, WI
7. The Ohio State University	Columbus, OH
8. Scott & White Memorial Hospital	Temple, TX
9. Southern Illinois University	Springfield, IL
10. St. Paul Hospital	Dallas, TX
11. Stanford University	Stanford, CA
12. University of Michigan	Ann Arbor, MI
13. University of Pittsburgh	Pittsburgh, PA
14. The University of Utah	Salt Lake City, UT
15. University of Washington	Seattle, WA
16. University of Wisconsin	Madison, WI
17. Vanderbilt University	Nashville, TN
18. Washington University	St. Louis, MO