acta medica

ORIGINAL ARTICLE

Evaluation of outcomes of replantation, acute repair, and revision amputation for digital amputations: A 5-year retrospective study*

Etkin Boynuyoğun[1]
ORCID: 0000-0002-3861-8450

Hatice Tosun[1]
ORCID: 0009-0001-9638-8374

Yağmur Nahide Bakkaloğlu[1]
ORCID: 0009-0002-4646-2270

Melih Çakaroğlu[1]
ORCID: 0000-0003-2710-9009

Uğur Koçer[1]
ORCID: 0000-0003-4245-0459

[1] Department of Plastic, Reconstructive and Aesthetic Surgery, Ankara Research and Training Hospital, Ankara, Türkiye

* This research was presented as an oral presentation at the 46th National Congress of Turkish Society of Plastic, Reconstructive and Aesthetic Surgery, 2024, Antalya/ Türkiye.

Corresponding Author: Etkin Boynuyoğun
E-mail: etkinbyogun@gmail.com

Received: 17 February 2025, Accepted: 22 March 2025, Published online: 20 June 2025

ABSTRACT

Objective: This study aims to objectively assess postoperative hand function by categorizing patients into three groups: replantation, acute stump repair, and revision amputation after unsuccessful replantation. Additionally, functional evaluation questionnaires were used to assess patient satisfaction among these groups.

Materials and Methods: A total of 150 patients were included in the study, 50 patients in each group. Patients' age, gender, comorbidities, dominant hand, the level of amputation, injured fingers and the mechanism of trauma were recorded. Afterwards, the patients were administered the EQ-5D-5L quality of life scale, the Quick DASH test, the Cold Intolerance and the Semmes–Weinstein monofilament test.

Results: A total of 167 finger amputations in 150 patients, 82% of whom were male and 18% were female. Their ages ranged from 19 to 92, and the mean age was 45.5. The mean score in patients who underwent acute repair was higher than in patients who underwent replantation and revision amputation in the EQ-5D-5L scale, the score of the replantation group was minimally lower than in the other two groups for the Quick DASH scoring, sensory results were minimally decreased in the replantation group compared to the revision amputation and acute repair groups. Cold intolerance was reported in 39% of replantation cases compared to 30.3% in revision amputation and 20% in acute repair ($p<0.05$).

Conclusion: Digital amputations were most frequently seen in male patients, in the 3rd finger and at the level of the distal interphalangeal joint. According to the EQ-5D-5L scale, Semmes-Weinstein monofilament test and cold intolerance assessment, the results were worse in the replantation group compared to the other two groups, and better in the Quick DASH score. The advantages and disadvantages of possible treatment options should be explained to the patient and their expectations should be taken into consideration in choosing the treatment for finger amputations.

Keywords: digit, amputation, replantation, reconstruction

INTRODUCTION

Trauma-related hand injuries involving digital amputations constitute a significant percentage of emergency department visits [1]. Restoration of the hand functions of these patients is crucial for enabling them to perform daily life activities optimally. The success of replantation varies depending on the etiology of trauma, but the primary goal in digital reconstruction is to restore both aesthetic and functional integrity. Since the first successful microsurgical replantation over 50 years ago, advances in microsurgical techniques have established replantation as the preferred

treatment for digit amputations [2]. Factors affecting replantation success including trauma etiology, level of amputation, time elapsed since injury and the preservation conditions of the amputated part [3]. Additional factors such as chronic illnesses, medication use, and smoking habits can also affect postoperative outcomes [4].

Successful replantation rates have been reported up to 90% in the literature. However, during follow up period after replantation, vascular complications may necessitate revision amputation despite all efforts. In cases where replantation is not feasible due to improper preservation or absence of the amputated digit, alternative repair options should be considered to maintain digit integrity and length [3,5]. In such cases, acute stump repair, later-stage graft or flap reconstruction may be chosen based on patient expectations and needs [6].

All surgical interventions aim to prevent workforce loss while restoring functional and aesthetic components of the digit [5,6]. This study aims to objectively evaluate postoperative hand function in patients by categorizing them into three groups: replantation, acute stump repair, and revision amputation following unsuccessful replantation. Additionally, functional evaluation questionnaires were used to assess patient satisfaction among these groups.

MATERIALS AND METHODS

The study was approved by the Ethics Committee of Ankara Training and Research Hospital (Decision No: E-24-33). Patients who presented with traumatic digital amputations to our clinic and completed at least a six- month follow up between January 2019 and January 2024 were retrospectively analyzed. Patients younger than 18 years, those who did not compliant to scheduled clinical examinations, and those with additional injuries were excluded. The remaining patients were categorized into three groups: Replantation (Figure 1), Acute stump repair (Figure 2) and Revision amputation (Figure 3), with 50 patients in each group (150 total). Records regarding demographic data including age and gender, dominant hand involvement, comorbidities, as well as amputation level, affected digits, and trauma mechanisms were collected.

Patients completed the EQ-5D-5L quality of life questionnaire [7] and the Quick DASH test [8] which evaluates upper extremity function after injury.

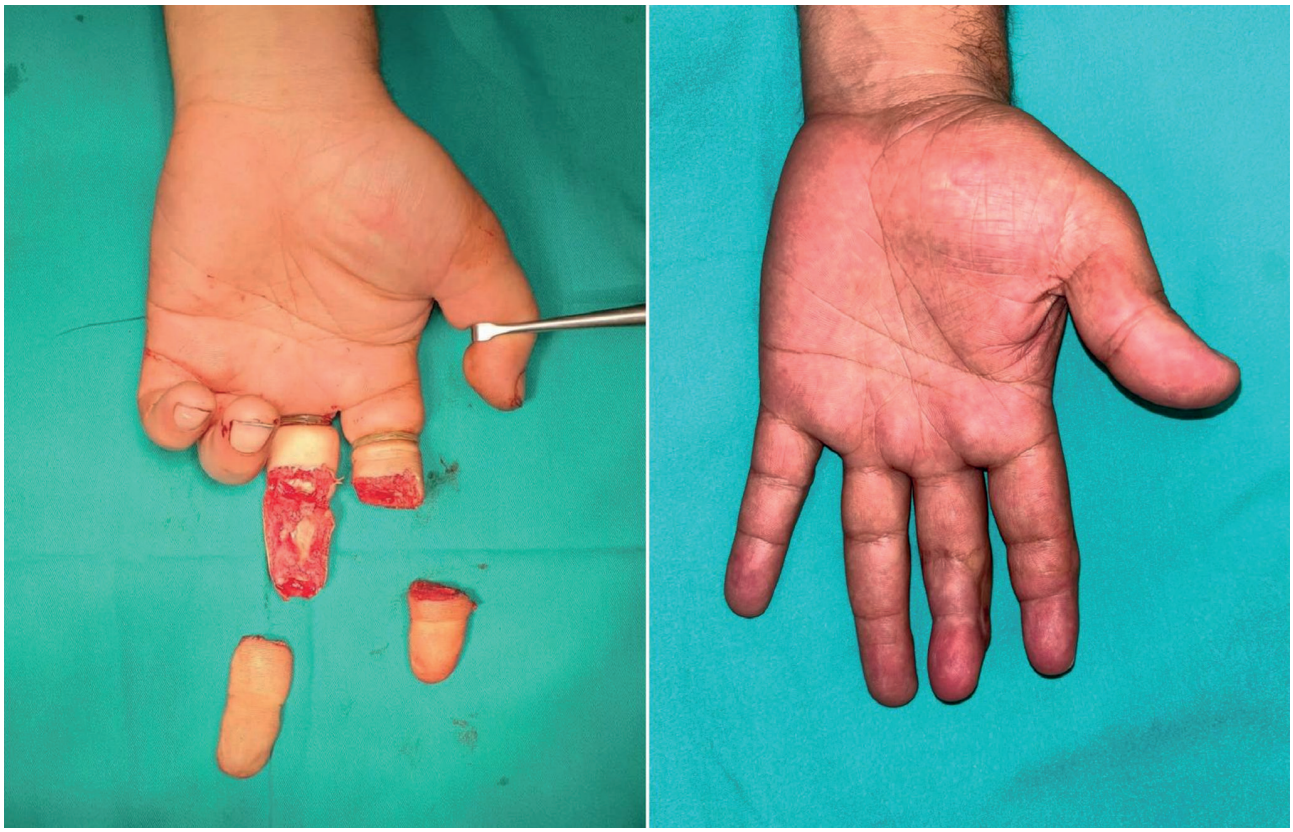

Figure 1. One year post operative result after replantation of two-digit amputation

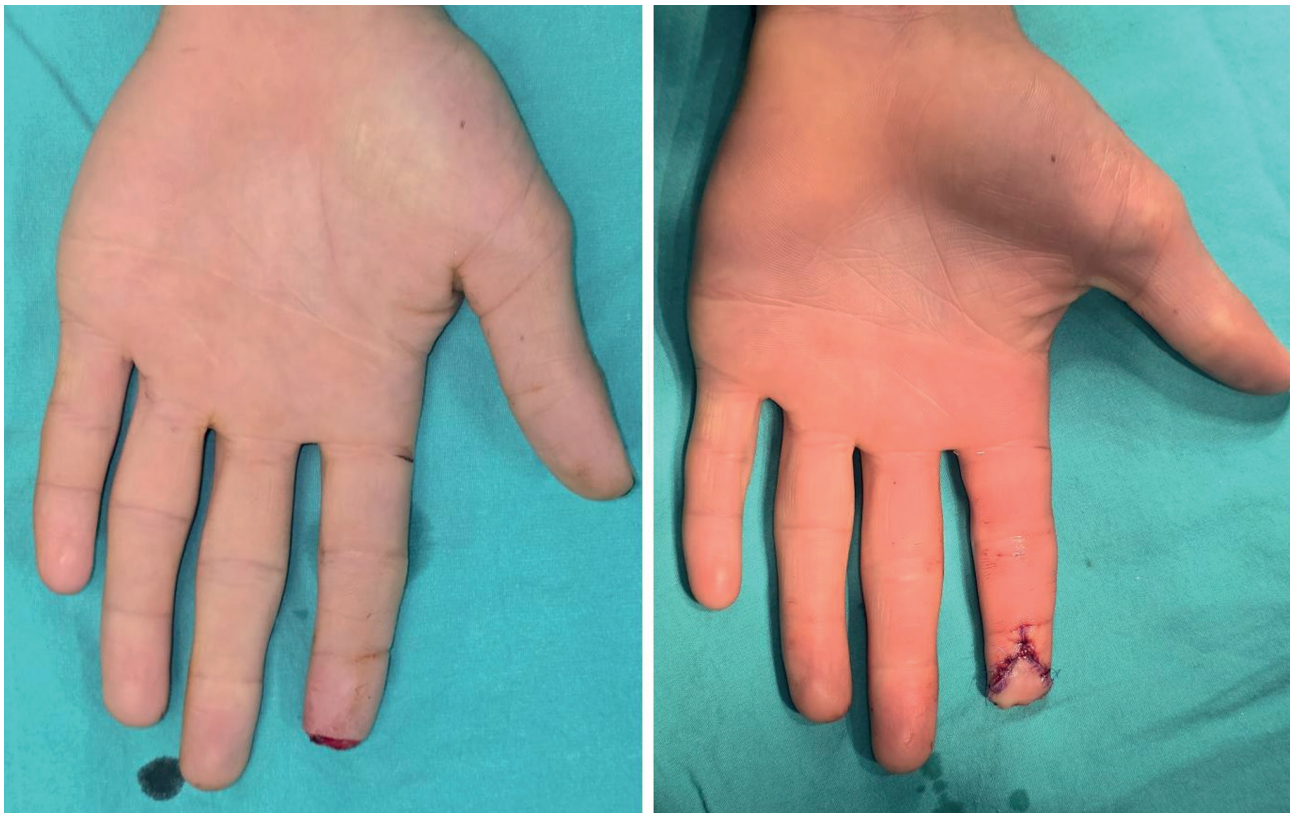

Figure 2. Acute stump repair after amputation injury

Figure 3. Two-digit amputation, 4th digit had revision amputation after circulatory failure following replantation, 5th digit had acute stump repair

The Semmes-Weinstein monofilament test [9] for sensory assessment was conducted during clinical visits and cold intolerance [10] was evaluated subjectively.

Statistical analysis included the Kolmogorov-Smirnov and Shapiro-Wilk tests to assess normal distribution differences in amputation level and digit involvement. The chi-square test was used for categorical variables when parametrical assumptions were not met. The Mann-Whitney U and Kruskal-Wallis tests were applied to compare quantitative data. SPSS 24.0 (IBM, New York, USA) was used for all statistical analyses, with significance set as $p < 0.05$.

RESULTS

This retrospective study was included 150 patients with 167 digital amputations. Among them, 82% were male and 18% were female. Ages ranged from 19 to 92, with a mean of 45.5 years. Right-hand dominance was observed in 90% of cases whereas 10% of patients were left-handed. Right-hand trauma occurred in 52% of patients, while 48% had left-hand injuries (Table 1).

Single-digit amputations were seen in 88% of cases, while 12% had multiple finger amputations, all involving two digits. The most common amputation mechanism was sharp injury (87 patients), followed by crush trauma (35 patients) and blunt trauma (28 patients). The most frequent amputation level was the distal interphalangeal joint (77 cases), followed by the proximal interphalangeal joint (45 cases), proximal phalanx (37 cases), middle phalanx (6 cases), and metacarpophalangeal joint (2 cases).

EQ-5D-5L scores were highest in the acute stump repair group (74.4), followed by the revision amputation group (72.69) and replantation group (72.4), though differences were not statistically significant ($p>0.05$) (Table 2).

Table 1. Patient demographics and characteristics of injury

	n (%)
Gender	
Male	123 (82)
Female	27 (18)
Age (years)	
Mean	45,52
Range	19-92
Injured Hand	
Right	78 (52)
Left	72 (48)
Dominant Hand	
Right	135 (90)
Left	15 (10)
Mechanism of injury	
Sharp injury	87 (58)
Crush trauma	35 (23,3)
Blunt Trauma	28 (18,7)
Type of amputation	
Multiple digits involved	17 (12)
Single digit injured	133 (88)
Amputation level	
Distal Interphalangeal Joint	77 patients
Metacarpophalangeal joint	2 patients
Midphalanx	6 patients
Proximal Interphalangeal Joint	45 patients
Proximal phalanx	37 patients

The Quick DASH score was reported as 10.5 in the replantation group, 11.2 in the revision amputation and 12.6 in acute stump repair groups but the differences were not significant ($p>0.05$) (Table 2).

Sensory function as assessed by Semmes Weinstein monofilament test was 3.82 in the replantation group, 3.75 in the revision amputation group and 3.56 in acute stump repair group with no significant differences ($p>0.05$) (Table 2).

Cold intolerance was reported in 39% of patients in replantation group, 30.3 % in the revision

Table 2. Results of patient reported outcomes

	EQ-5D-5L Score	Quick DASH Score	Semmes-Weinstein Monofilament Test	Cold Intolerance (%)
Replantation	72.4	10.5	3.82	39
Acute stump repair	74.4	12.6	5.56	20
Revision amputation	72.69	11.2	3.75	30.3
p value	**> 0.05**	**> 0.05**	**> 0.05**	**< 0.05**

amputation group and 20% in the acute stump repair group. Cold intolerance was significantly higher in replantation group compared to other two groups ($p<0.05$) (Table 2).

DISCUSSION

Digital amputations constitute a significant portion of emergency department visits due to hand trauma and predominantly affect young and working-age male patients [11]. These injuries may severely impair occupational performance and daily activities [12]. This results in both revenue loss andhave long-term financial implications [13]. Additionally, due to the highly visible nature of the fingers, amputations can lead to social withdrawal and diminished quality of life [14]. The psychological impact varies based on the patient's mental health, social support, and financial stability, but digital amputations have been associated with depression, anxiety, reduced self-esteem, and, particularly in cases of multiple amputations, a negative outlook on the future [15].

Digital amputations are treated either by acute stump repair or replantation [15]. Acute stump repair is a relatively fast procedure requiring less postoperative rehabilitation; however, digit shortening may compromise hand aesthetics, grip strength, and dexterity. Advances in microsurgery have enabled replantation to restore hand aesthetics and most of its functional abilities. However, digital replantation is a technically demanding procedure requiring prolonged rehabilitation and workforce loss. Furthermore, maintaining high success rates in this complex surgery necessitates experienced surgical teams performing high number of procedures and with 24/7 availability [3,15]. Postoperatively, vascular complications may arise, potentially leading to total necrosis of the replanted digit. The survival of a replanted digit is affected by factors such as patient's comorbidities, smoking habits, and the mechanism of trauma. If necrosis occurs despite all efforts, revision amputation becomes necessary [16].

There is significant heterogeneity in the literature regarding outcome measures and classification systems for traumatic digital amputations. Consequently, studies comparing replantation and revision amputation have reported varying results. For instance, Tessler et al. [17] emphasized the superior outcomes of replantation, whereas another study [18] found no significant difference between these treatment modalities. The paradigm for assessing outcomes in hand surgery has shifted towards patient-reported measures, including general health-related quality of life questionnaires and those specifically targeting upper extremity function [19]. Within this framework, our study aimed to evaluate patient-centered outcomes using questionnaires especially targeted evaluating the general quality of life and upper extremity functions for digital amputations managed with replantation, acute stump repair, and revision amputation over a five-year period in our clinic. The assessment also focused on sensory recovery and cold intolerance.

The EQ-5D-5L questionnaire evaluates health in five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression [20]. In our study, patients who underwent acute stump repair had higher mean EQ-5D-5L scores compared to those in the replantation and revision amputation groups, but the differences were not statistically significant. Similarly to our results, Pyörny et al. used the EQ-5D-5L scale in their study and reported comparable outcomes between replantation, revision amputation, and acute stump repair, concluding that successful replantation was not associated with worse patient-reported outcomes. It was also reported that if the amputated tissue was severely damaged or replantation surgery was unsuccessful, the treatment resulted in revision amputation, which was not associated with worse outcomes than successful replantation [21].

The Quick DASH questionnaire was designed to assess overall health, upper extremity injuries and associated symptoms, and focuses mostly on range of motion, grip strength, and skin sensitivity. This tool aids in evaluating the impact of an intervention on the entire upper extremity, providing crucial insights into daily activity limitations with specific questions [8,19]. In our study, Quick DASH scores were slightly lower in the replantation group compared to the other two groups, though the difference was not statistically significant. This could be clinically important in the decision-making process. Prior studies have similarly demonstrated

better Quick DASH scores in replantation patients compared to amputation groups, likely due to the preservation of finger length and improved range of motion [6,15,22].

The Semmes-Weinstein monofilament test is a well-established sensory assessment tool used to detect abnormal sensory function in specific areas and can be performed with a mobile device. Since its first innovation, Semmes-Weinstein monofilament test is proven to gain trust in detecting abnormal functioning in peripheral nerves. This method has been validated for evaluating nerve dysfunction and remains widely utilized [23]. In our study, sensory outcomes in the replantation group were slightly decreased compared to the revision amputation and acute stump repair groups, though no statistically significant differences were observed. Sensory-functional return is one of the main goals of surgical treatment of finger amputations, and the mechanism of trauma and the condition of the amputated finger should be taken into consideration. Literature findings also indicate poorer sensory recovery in replantation cases compared to amputation groups. For instance, Bott et al. reported that 37.8% of patients in the amputation group retained normal tactile sensation, whereas it was decreased to 21% in the replantation group [24]. Another study analyzing 111 patients found superior sensory recovery in amputation cases compared to replantation [25].

Cold intolerance is defined as an "icy cold sensation lasting for hours and potentially progressing to pain," triggered by exposure to low temperatures [26]. Long-term cold intolerance is among the most frequently reported issues following digital replantation [27]. In a study, cold intolerance was found to be twice as prevalent in the replantation group compared to the stump repair group. Peripheral nerve injury, vascular dysfunction and other factors such as central and humoral mechanisms could be the cause of the higher cold intolerance in the replantation group [25]. Similarly, our study revealed a statistically higher significance of cold intolerance in the replantation group compared to the revision amputation and acute stump repair groups. However, some studies suggest that cold intolerance is primarily attributed to the nature of the trauma itself rather than the reconstruction method used. Thus, it has been argued that cold intolerance should not be considered an absolute contraindication for replantation or a decisive factor in treatment selection [10]. The limitations of our study include its retrospective design and it was conducted at a single center.

CONCLUSION

Digital amputations are most frequently observed in male patients, particularly in the third digit at the distal interphalangeal joint. Postoperative evaluations using EQ-5D-5L, the Semmes-Weinstein monofilament test, and cold intolerance assessments indicate decreased outcomes in the replantation group compared to the other two groups, though Quick DASH scores were better. Prospective studies focusing on individualized patient assessments based on injury characteristics and severity are necessary to suggest specific treatment modalities, improve treatment strategies and functional outcomes.

Author contribution

Study conception and design: EB, HT, YNB, MÇ; data collection: EB, HT, YNB; analysis and interpretation of results: EB, HT, YNB, UK; draft manuscript preparation: EB, YNB, MÇ, UK. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

The study was approved by the Ethics Committee of Ankara Training and Research Hospital (Protocol no. E-24-33/22.02.2024).

Funding

The authors declare that the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

[1] Welman T, Popova D, Vamadeva SV, Pahal GS. Management of amputated digits. Br J Hosp Med (Lond) 2020;81(11):1-8. https://doi.org/10.12968/hmed.2020.0087

[2] Feller AM, Graf P, Biemer E. Replantation surgery. World J Surg 1991;15(4):477-485. https://doi.org/10.1007/BF01675644

[3] Cavadas PC, Rubí C, Thione A, Pérez-Espadero A. Immediate versus overnight-delayed digital replantation: Comparative retrospective cohort study of survival outcomes. J Hand Surg Am 2018;43(7):625-630. https://doi.org/10.1016/j.jhsa.2018.03.047

[4] Wang LH, Zhang GQ. Use of digital subtraction angiography for assessment of digital replantation. J Zhejiang Univ Sci B 2012;13(3):209-212. https://doi.org/10.1631/jzus.B1100223

[5] Mohamad Sabri MQ, Judd J, Roslan NFA, Che Daud AZ. Hand characteristics and functional abilities in predicting return to work in adult workers with traumatic hand injury. Work 2022;73(4):1245-1253. https://doi.org/10.3233/WOR-205164

[6] Zhu H, Wang J, Gao T, et al. Contribution of revision amputation vs replantation for certain digits to functional outcomes after traumatic digit amputations: A comparative study based on multicenter prospective cohort. Int J Surg 2021;96:106164. https://doi.org/10.1016/j.ijsu.2021.106164

[7] Herdman M, Gudex C, Lloyd A, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res 2011;20(10):1727-1736. https://doi.org/10.1007/s11136-011-9903-x

[8] Haas F, Hubmer M, Rappl T, Koch H, Parvizi I, Parvizi D. 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(2):460-466. https://doi.org/10.1097/TA.0b013e3181e997fc

[9] Bell-Krotoski J, Weinstein S, Weinstein C. Testing sensibility, including touch-pressure, two-point discrimination, point localization, and vibration. J Hand Ther 1993;6(2):114-123. https://doi.org/10.1016/s0894-1130(12)80292-4

[10] Nyström A, Backman C, Backman C, Bertheim U, Karlsson L, Carlsson A. Digital amputation, replantation, and cold intolerance. J Reconstr Microsurg 1991;7(3):175-178. https://doi.org/10.1055/s-2007-1006776

[11] Chase RA. Costs, risks, and benefits of hand surgery. J Hand Surg Am 1983;8(5 Pt 2):644-648. https://doi.org/10.1016/s0363-5023(83)80233-0

[12] Morrison WA, O'Brien BM, MacLeod AM. Evaluation of digital replantation-a review of 100 cases. Orthop Clin North Am 1977;8(2):295-308.

[13] Sears ED, Shin R, Prosser LA, Chung KC. Economic analysis of revision amputation and replantation treatment of finger amputation injuries. Plast Reconstr Surg 2014;133(4):827-840. https://doi.org/10.1097/PRS.0000000000000019

[14] Hannah SD. Psychosocial issues after a traumatic hand injury: Facilitating adjustment. J Hand Ther 2011;24(2):95-102; quiz 103. https://doi.org/10.1016/j.jht.2010.11.001

[15] Chung KC, Yoon AP, Malay S, et al. Patient-reported and functional outcomes after revision amputation and replantation of digit amputations: The FRANCHISE multicenter international retrospective cohort study. JAMA Surg 2019;154(7):637-646. https://doi.org/10.1001/jamasurg.2019.0418

[16] Gavrilova N, Harijan A, Schiro S, Hultman CS, Lee C. Patterns of finger amputation and replantation in the setting of a rapidly growing immigrant population. Ann Plast Surg 2010;64(5):534-536. https://doi.org/10.1097/SAP.0b013e3181bffcaf

[17] Wang T, Xiong F, Tan JY, Qiu Y, Mi JY. Predictors for necrosis after single-digit replantation: A retrospective analysis of 946 patients. Plast Reconstr Surg 2023;152(1):117-123. https://doi.org/10.1097/PRS.0000000000010266

[18] Tessler O, Bartow MJ, Tremblay-Champagne MP, et al. Long-term health-related quality of life outcomes in digital replantation versus revision amputation. J Reconstr Microsurg 2017;33(6):446-451. https://doi.org/10.1055/s-0037-1601052

[19] Zhu H, Bao B, Zheng X. A comparison of functional outcomes and therapeutic costs: Single-digit replantation versus revision amputation. Plast Reconstr Surg 2018;141(2):244e-249e. https://doi.org/10.1097/PRS.0000000000004024

[20] Giladi AM, McGlinn EP, Shauver MJ, Voice TP, Chung KC. Measuring outcomes and determining long-term disability after revision amputation for treatment of traumatic finger and thumb amputation injuries. Plast Reconstr Surg 2014;134(5):746e-755e. https://doi.org/10.1097/PRS.0000000000000591

[21] Brooks R. EuroQol: The current state of play. Health Policy 1996;37(1):53-72. https://doi.org/10.1016/0168-8510(96)00822-6

[22] Pyörny J, Luukinen P, Sletten IN, Reito A, Leppänen OV, Jokihaara J. Is replantation associated with better hand function after traumatic hand amputation than after revision amputation? Clin Orthop Relat Res 2024;482(5):843-853. https://doi.org/10.1097/CORR.0000000000002906

[23] Hattori Y, Doi K, Ikeda K, Estrella EP. A retrospective study of functional outcomes after successful replantation versus amputation closure for single fingertip amputations. J Hand Surg Am 2006;31(5):811-818. https://doi.org/10.1016/j.jhsa.2006.02.020

[24] Massy-Westropp N. The effects of normal human variability and hand activity on sensory testing with the full Semmes-Weinstein monofilaments kit. J Hand Ther 2002;15(1):48-52. https://doi.org/10.1053/hanthe.2002.v15.01548

[25] Bott SM, Rachunek K, Medved F, Bott TS, Daigeler A, Wahler T. Functional outcome after digit replantation versus amputation. J Orthop Traumatol 2022;23(1):35. https://doi.org/10.1186/s10195-022-00654-7

[26] Goldner RD, Howson MP, Nunley JA, Fitch RD, Belding NR, Urbaniak JR. One hundred eleven thumb amputations: Replantation vs revision. Microsurgery 1990;11(3):243-250. https://doi.org/10.1002/micr.1920110312

[27] Engkvist O, Wahren LK, Wallin G, Torebjrk E, Nystrom B. Effects of regional intravenous guanethidine block in posttraumatic cold intolerance in hand amputees. J Hand Surg Br 1985;10(2):145-150. https://doi.org/10.1016/0266-7681(85)90003-8