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Original article

Long-term functional results of digital replantation: A survey of 28 patients☆

Résultats fonctionnels des replantations digitales à long terme : étude sur 28 patients

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ABSTRACT

We sought to evaluate the long-term quality of life and functional outcome of patients who underwent digital replantation after amputation. A retrospective single-center study was conducted of patients treated between January 2010 to May 2016. Twenty-eight patients who underwent successful replantation after single or multiple digital amputation were reviewed in person after at least 2 years' follow-up (mean 4.6 years). Total active range of motion, grip and pinch strength were assessed. Functional outcomes were evaluated using the SF-36 and DASH questionnaires. The patients' occupational status and daily activities were reported. Mean total active range of motion was 42% of the contralateral healthy side. Better active mobility and higher grip strength were found when the amputation was distal to the insertion of the common flexor tendon. Mean grip and pinch strength were 80% and 65%, respectively. Fusion did not significantly influence active mobility. The mean DASH score was 22.3. In our study, 77% of the patients returned to the same job and 75% experienced cold intolerance. The majority of patients who underwent digital replantation maintain a quality of life that allows them to return to work. Fusion, especially in the thumb, can be performed with few functional consequences. Even many years after the replantation procedure, sensory recovery remains poor.
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Mots clés :
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RÉSUMÉ

Nous souhaitions évaluer à long terme de la qualité de vie et du résultat fonctionnel des patients ayant bénéficié d'une replantation digitale après amputation. Il s'agissait d'une étude rétrospective monocentrique de janvier 2010 à mai 2016. Vingt-huit patients ayant bénéficié avec succès d'une replantation après amputation d'un ou plusieurs doigts ont été revus en consultation à au moins 2 ans de recul (moyenne 4,6 ans). La mobilité active ainsi que la force de préhension (force de poigne et de prise) étaient évaluées. L'évaluation fonctionnelle a été réalisée à l'aide des questionnaires SF-36 et DASH. Le statut professionnel et les activités quotidiennes des patients étaient rapportés. La mobilité active totale moyenne du doigt était de 42,2 % par rapport au côté sain controlatéral. Une meilleure mobilité active ainsi qu'un score plus élevé pour la force de poigne étaient observés lorsque la lésion était située en aval de l'insertion du tendon fléchisseur superficiel des doigts. Les scores moyens de force de prise et de pince étaient respectivement de 79,9 % et 65,4 % des valeurs du côté opposé. La présence d'une arthrodèse n'influençait pas significativement la mobilité active. Le DASH score moyen était de 22,3. Dans notre étude, 77,3 % des patients avaient repris leur activité professionnelle au même poste, 75 % présentaient

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une intolérance au froid. La majorité des patients ayant bénéficié d'une replantation digitale conservent une qualité de vie leur permettant de reprendre le travail. L'arthrodèse, surtout au niveau du pouce, peut être réalisée avec peu de conséquences fonctionnelles. Malgré le recul, la récupération sensitive reste médiocre.

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1. Introduction

In the fifty years since Komatsu and Tamai [1] reported the first successful thumb replantation, microsurgical techniques have improved considerably. Many surgeons have reported success with this procedure. While finger replantation is a challenging procedure, high vascular success rates have been reported by many surgical teams [2–5].

Despite the compulsory safety measures for new industrial, agricultural and household machines, finger amputations are common in France [6]. Along with the physical trauma experienced by the patient, amputation has wide-ranging emotional, social and professional repercussions. There are few studies on the quality of life of patients who have undergone single or multifinger replantation. And there is little data how well the finger has been integrated into the hand's overall function, whether in their personal or professional lives.

For this reason, we sought to reevaluate patients who underwent single or multifinger replantation a few years after the amputation occurred in order to quantify the functional outcomes and the impact on their quality of life.

2. Patients and methods

This was a retrospective, single-center study of patients treated between January 2010 and May 2016. Included were patients who suffered single or multifinger amputation distal to the metacarpophalangeal (MCP) joint and who underwent emergency digital replantation. Ring avulsion injuries were excluded as they have a poor prognosis and require a complex repair procedure. Patients less than 18 years of age were excluded. The patients signed a consent form to participate in this study.

A total of 65 consecutive patients (66 digits) were identified. Of these, 32 patients (33 digits) had a successful outcome, thus the success rate was 50%. Twenty-eight patients (29 digits) were reviewed in person at our clinic. Four patients were lost to follow-up.

The cohort consisted of 27 men and 1 woman. The mean patient age was 45.4 years (18–78). In 10 cases (36%), the amputation occurred in the dominant hand. Four patients (14%) were active smokers. The most common injury mechanisms were a circular saw ($n = 12$), wood splitter ($n = 7$) and avulsion ($n = 3$). The mean length of hospital stay was 8 days (3–16). The digit amputated and the amputation levels are shown in Fig. 1. Arthrodesis was performed on 17 digits, 9 times (53%) at the thumb (Fig. 2). Six patients had early complications: K-wire exposure ($n = 4$), postoperative fixation failure ($n = 1$) and complex regional pain syndrome ($n = 1$). The late complications documented were stiffness ($n = 5$), nonunion ($n = 2$), skin bridle scars ($n = 2$), swan-neck deformity ($n = 1$) and chronic wound ($n = 1$). Four patients underwent secondary surgery for revision of fixation ($n = 1$), arthrodesis ($n = 1$) and grafting of the web commissure ($n = 2$).

Patients were reviewed with a mean follow-up of 4.6 years (2–8). At the review visit, AP and lateral radiographs were made of the replanted digit. The mobility of the injured digit was evaluated by measuring the active and passive joint amplitude with a goniometer according as defined by the American Academy of Orthopaedic Surgeons (AAOS) [7]. For the fingers, the MCP, proximal (PIP) and distal interphalangeal (DIP) joints were evaluated and for the thumb, the MCP and interphalangeal (IP) joint were evaluated. The total active motion (TAM) was expressed as a percentage of the healthy contralateral finger. The patients' grip strength was evaluated using a dynamometer (Jamar™ hydraulic hand dynamometer, Irvington, New York, USA) in the injured hand and the contralateral hand during two trials. The key pinch grip was evaluated the same way (Hydraulic pinch gauge, Irvington, New York, USA).

The Weber static two-point discrimination test (2PD) was used to test tactile spatial acuity. A value of 6 mm or less was considered excellent, 7 to 15 mm was considered good and 16 mm or more was considered poor [8]. Tactile point pressure sensitivity was evaluated using the Semmes-Weinstein monofilament test and pain sensitivity was evaluated by needle stimulation (binary event). Any paresthesia or dysesthesia was documented along with dysautonomia (cold intolerance). The patients' lifestyles were evaluated (i.e., their ability to return to work and impact on recreational activities). We also recorded the patients' satisfaction level along with their inclination to undergo replantation again if another amputation were to occur.

Lastly, two questionnaires were used to evaluate their quality of life: the SF-36 (Short Form 36-items) and the French version of the DASH (Disabilities of the Arm, Shoulder and Hand) [9]. In the SF-36, the patients evaluated their own health on an increasing scale (minimum of 0 and maximum of 100). The review visit was standardized, and all the assessments were done by a single independent examiner.

The statistical analysis was carried out with R software (version 3.5.1) using Fischer's exact test and the Wilcoxon test. The analysis also considered the presence of injuries to adjacent fingers that were not necessarily amputated (tendon lacerations, fractures, thus called "multifinger involvement").

3. Results

3.1. Objective outcomes

The mean TAM was 42 ± 22% of the healthy contralateral digit. It was 44 ± 25% when the digit had been fused and 40 ± 18% when unfused (non-significant difference). The TAM was significantly lower when the thumb had been replanted than when a finger had been replanted (30 ± 15%) (Table 1); however, fusion was more common in the thumb. The outcomes were significantly better when the amputation occurred distal to the insertion of the flexor digitorum superficialis (FDS) tendon in the fingers.

The mean grip strength was 80 ± 21% of the contralateral side and the mean pinch strength was 65 ± 38%. Patients who had their thumb amputated and successfully replanted had significantly better results than those with fingers replantation: grip strength 94% versus 71% ($P = 0.005$) and pinch strength 88% versus 50% ($P = 0.02$). Grip strength was significantly better in patients who suffered an amputation distal to the FDS insertion. Patients with only one

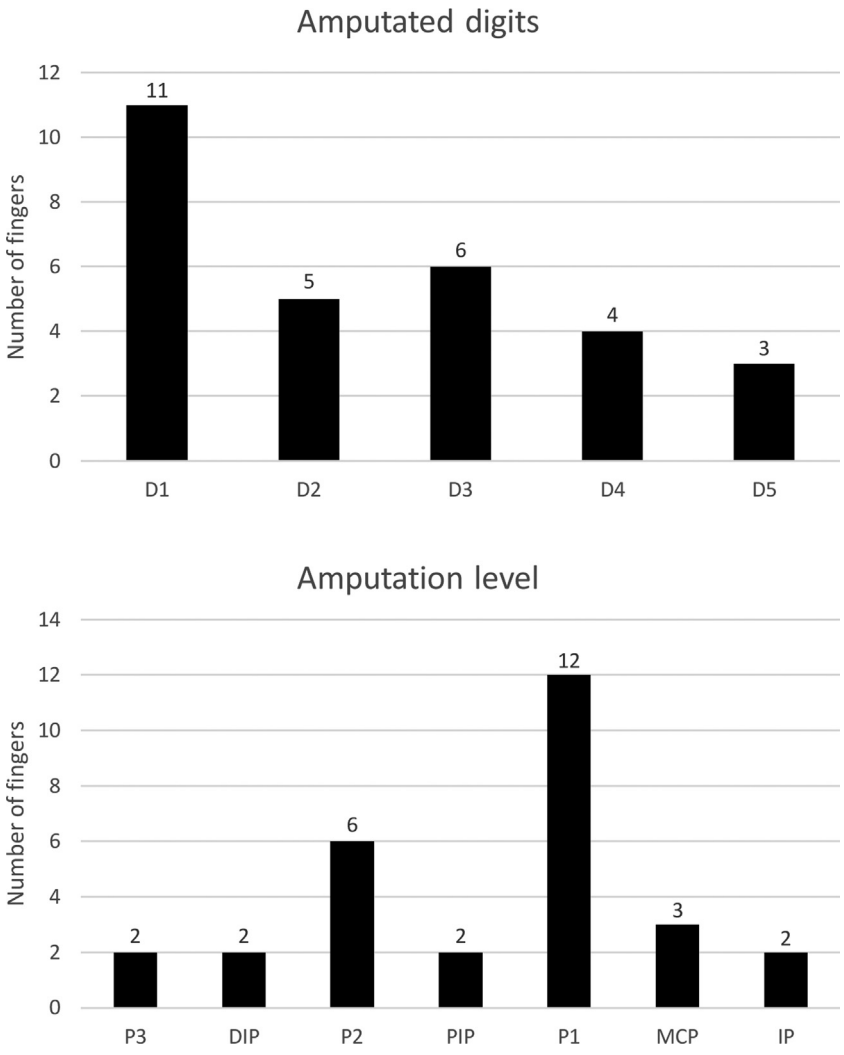

Fig. 1. Distribution of injured digits and amputation level. P1: proximal phalanx; P2: middle phalanx; P3: distal phalanx; DIP: distal interphalangeal joint; PIP: proximal interphalangeal joint; MCP: metacarpophalangeal joint; IP: thumb interphalangeal joint.

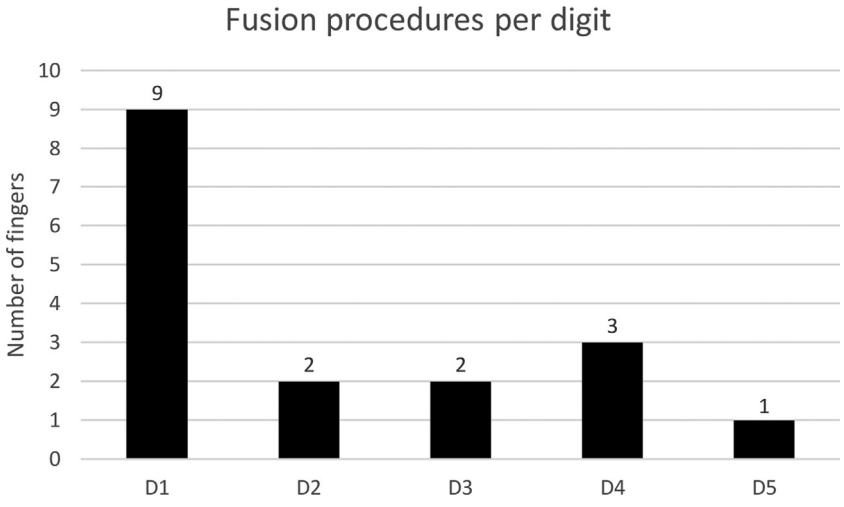

Fig. 2. Distribution of arthrodesis procedures per digit.

Table 1
Functional outcomes.

	TAM (%)	Grip strength (%)	Pinch strength (%)	DASH score	SF-36 PCS	SF-36 MCS
Thumb involvement						
Thumb	30	94	88	10.7	66.8	61.3
Fingers	50	71	50	29.8	64.9	59.8
P-value	0.02	0.005	0.02	0.04	0.72	0.40
Amputation level						
Proximal to FDS	34	55	54	35.7	61.1	53.6
Distal to FDS	62	82	48	25.6	67.6	64
P-value	0.01	0.03	1	0.33	0.49	0.54
Number of digits						
Single	44	94	78	9.2	73.1	64.9
Multiple	40	58	46	42	54.2	53.3
P-value	0.66	1.8 e^{-}05	0.03	5.1 e^{-05}	0.03	0.06

FDS: flexor digitorum superficialis; %: percentage of healthy contralateral side; PCS: physical component score; MCS: mental component score; TAM: total active motion.

affected digit had significantly better outcomes than patients with multidigit involvement (Table 1).

The mean spatial acuity on the 2PD test was 10.4 mm (5–18). Two fingers had a poor spatial acuity (16 mm or higher). On the Semmes-Weinstein monofilament test, 3 fingers had normal sensation (10%), 11 fingers had diminished light touch sensation (39%), 12 fingers had diminished protective sensation (41%) and 3 fingers had loss of protective sensation (10%). Cold intolerance was found in 21 patients (75%).

3.2. Quality of life

All the questionnaires were filled out correctly. The mean SF-36 physical and mental component scores were 65.7 ± 23.7 and 60.4 ± 20.7, respectively. The physical component score was higher when only one digit had been amputated during the accident (71.3 versus 54.4, $P = 0.03$) (Table 1).

The mean DASH score was 22.3 ± 20.5. Multifinger involvement significantly increased the DASH score, as did having finger amputation instead of thumb amputation. The amputation level did not significantly impact the DASH, although the outcome was worse when the amputation occurred proximal to the FDS (Table 1).

3.3. Daily activities

In 13 patients (46%), the amputation occurred at their workplace. The time away from work averaged 4.8 months (2–24). Of the 22 patients who were employed at the time of the amputation, 17 (77.3%) had returned to work at the same job. For the other five patients, two were on disability, two were laid off and one was retrained for another job. Seventeen patients (61%) indicated they were able to resume their recreational activities. When the amputated digit was in the dominant hand, return to work was negatively impacted (50% versus 93%, $P = 0.03$) as were recreational activities (30% versus 78%, $P = 0.02$). Similarly, patients with multifinger involvement were less likely to return to work than patients with single-finger involvement (45% versus 100%, $P = 0.004$).

In terms of satisfaction, 54% of patients were very satisfied with the outcome, including all the patients who had their thumb replanted. Two patients said they would not undergo the same procedure again.

4. Discussion

Our study found that most patients feel they have good quality of life after digital replantation. The long follow-up (mean 4.6 years) provides an assessment of stabilized functional outcomes. Table 2 compares our finding with those of key published studies on this topic.

The MOS 36-Item Short-Form Health Survey [10] is a general questionnaire intended to measure how patients feel about their health. In our study, the mean physical and mental component scores were 65.7 (23.1–100) and 60.4 (10–86.6). The physical score was better than the mental score, suggesting that this type of injury had a greater psychological impact. There are no other digital replantation studies that use this outcome measure. While it is not specific to this type of injury, it is a reliable instrument to measure quality of life related to health.

The DASH is a subjective self-administered questionnaire of the overall capacity of the upper limb. The French version of this questionnaire, validated by the AAOS [9], was completed by our patients. The mean DASH score in the 28 reviewed patients was 22.3 ± 20.5. Among those with single-finger trauma, the DASH was 10.7 ± 12.4 for the thumb and 7.7 ± 7.2 for the fingers. Our findings for the thumb are consistent with those of Unglaub et al. [11], Haas et al. [12], Ciclamini et al. [13] and Dabernig et al. [14] who reported DASH or QuickDASH scores of 16.7 ± 15.0, 11.3 ± 10.8, 11.1 ± 14.6, and 10.0 ± 8.3, respectively. Chen et al. [15] reported a mean DASH score of 5.5 in 14 cases of thumb replantation at a mean follow-up of 3 years. Some authors have shown a correlation between a low DASH score and better grip strength, pinch strength and 2PD results [11,15]. This is consistent with our findings for patients with single-finger or thumb involvement (Table 1).

Amputation can have lasting consequences on day-to-day activities and work-related activities. A DASH score below 15 means there is no clinical deficit in the upper limb, while a DASH score over 50 means the person cannot work. A DASH score above 20 means the patient is negatively affected during activities of daily living [13]. In our study, the high return to work rate in the same job (77%) and for recreational activities (61%) is consistent with the DASH being near 20. The fact that the amputated digit was most often in the non-dominant hand and that most patients were younger (mean age 45.4 years) contributed to a better outcome.

Factors that affect the finger's functional prognosis are the amputation mechanism, extent of tissue damage, quality of surgery, postoperative rehabilitation and patient buy-in. In 1985, Urbaniak et al. [16] found a mean TAM of 13% when the amputation occurred proximal to the FDS insertion and 30% when it occurred distal to it in a cases series of 59 finger replantations evaluated at 53 months' follow-up. In our study of 29 complete amputation cases, the mean TAM was 42% relative to the contralateral hand, which is near the mean value of published results (Table 2). In another study of 59 replantations (of which 64% were complete amputations), Walaszek et al. [17] reported mean TAM for the thumb of 45% and mean TAM for the fingers of 49%. Similarly, Chen et al. [15] reported mean TAM of 53% for the

Table 2
Key published studies reporting quality of life and functional outcome after digital replantation.

Authors (number of patients)	Unglaub et al. [11] (*n* = 24)	Ciclamini et al. [13] (*n* = 20)	Haas et al. [12] (*n* = 34)	Janezic et al. [18] (*n* = 46)	Chen et al. [15] (*n* = 30)	Dabernig et al. [14] (*n* = 45)	Walaszek et al. [17] (*n* = 59)	Holmberg et al. [19] (*n* = 39)	Current study (*n* = 28)
SF-36	–	–	–	–	–	–	–	–	65.7 (PCS) 60.4 (MCS)
DASH score Overall/thumb	6.7	11.06	11.3 (Quick DASH)	–	6.6	12.5/10.0	–	–	22.3/10.7
TAM (% contralateral)	–	–	54.6	77 (distal to IP) 46 (proximal to IP)	53 (thumb) 58.2 (finger)	–	45 (thumb) 49 (finger)	84	30 (thumb) 50 (finger)
Grip strength/pinch strength (% contralateral)	70/68	89.9/84.4	81.7/65.7	92/81	90.5/81.5	87/71	67/54	72/69	94/88 (thumb) 71/51 (finger)
Weber static two-point discrimination (mm)	–	–	–	–	10.4	4.7	–	–	10.4
Cold intolerance (%)	100	86	–	82.6	53	86.7	–	–	75
Return to work[a]/previous occupation (%)	84/66	…/80	…/59	67/…	…/60.7	–	77.5/55	90/…	77/61

n: number of fingers replanted; PCS: physical component score; MCS: mental component score; –: data not available.
[a] Patient employed at time of amputation.

thumb and 58% for the fingers. In our study, the TAM for the thumb was worse (30%) than for the fingers (50%). This can be explained by the larger number of fusion procedures done on the thumb, which did not negatively impact the grip strength and return to work.

Janezic et al. [18] — in their study of 46 thumb replantations — found mean grip strength and pinch strength of 92% and 81%, respectively, relative to the contralateral hand. Unglaub et al. [11] reported 70% and 68%, while Ciclamini et al. [13] reported 90 and 84% relative to the contralateral hand. Our findings for thumb replantation cases were similar to those studies, with mean grip strength and pinch strength of 94% and 88%, respectively. In the literature, factors that impact grip and pinch strength are multifinger amputation or injuries, and whether or not the amputation occurred proximal to the FDS tendon. Our study found that the level of the amputation had no significant impact on pinch strength. Holmberg et al. [19] reported 72 and 69% grip and pinch strength, while Walaszek et al. [17] reported 67 and 54% relative to the uninjured hand. In our study, the average values were 80 and 65%.

Cold intolerance, which manifests itself during the fall and winter seasons, is often found after digital replantation. Campbell et al. [20] described four types of symptoms when exposed to cold: pain, dysesthesia, stiffness and color change. Pain was the most common symptom. According to Nylander et al. [21], cold intolerance is the result of a vasoregulation problem, and not poor circulation in the finger. In our study, 75% of patients ($n = 21$) complained of cold intolerance. Dabernig et al. [14] reported an 87% rate. While cold intolerance did not limit the patients' day-to-day function, it does cast doubt on the extent of sensory recovery (mean 2PD of 10.4 mm).

Despite these encouraging findings in individual patients, the cost of amputation and its sequelae are not insignificant for society. In a US health economics study of digit replantation, Sears et al. [22] showed that single-digit replantation had the highest cost per quality-adjusted life year relative to multifinger or distal amputations. Other authors suggest that patients need to be better informed about the expected functional outcomes and also the time away from work, length of hospital stay, and direct and indirect costs incurred when deciding whether to replant the amputated finger [23].

5. Conclusion

Most patients in our study had good long-term quality of life after digital replantation. This finding is supported by the fact that 77% of patients returned to their preinjury occupation. Multifinger involvement negatively affects the functional prognosis, as does amputation proximal to the FDS insertion. Fusion at the thumb can be carried out as soon as necessary; while it theoretically reduces the mobility, it has minimal effects on gripping and does not negatively affect work-related and daily activities. Despite these good functional outcomes, sensory recovery is incomplete even after a mean follow-up of 4½ years.

Disclosure of interest

The authors declare that they have no competing interest.

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