Effectiveness of Perioperative Finger Sensory Rehabilitation in Patients Undergoing Fingertip Amputation and Reimplantation: A Retrospective Study

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AIM: Finger reimplantation is an effective method for the treatment of amputated fingertips. However, there are several shortcomings in traditional postoperative rehabilitation programs, which may affect a patient's functional recovery after surgery. Finger sensory rehabilitation is a comprehensive program that helps patients restore sensory and motor function to their fingers through the use of specific training methods and equipment. Thus, this study aimed to analyze the effect of finger sensory rehabilitation on a group of patients who had undergone fingertip amputation and reimplantation.

METHODS: The medical records of 106 patients having undergone fingertip amputation and reimplantation from January 2022 to January 2024 were retrospectively analyzed. The patients were classified into experimental group (n = 52, receiving conventional rehabilitation training + finger sensory rehabilitation training) and the control group (n = 54, receiving only conventional rehabilitation training). Patients in both groups participated in a 20-week rehabilitation training, and the Semmes-Weinstein monofilament test was used to evaluate the finger touch pressure sensation after completing the rehabilitation training in both groups, and the Visual Analogue Scale (VAS) score, Generic Quality of Life Inventory-74 (GQOLI-74) score to evaluate their pain sensation and quality of life on the 2nd postoperative day and at the end of rehabilitation training.

RESULTS: After completing rehabilitation, a specialized method for assessing the patient's tactile sensory deficits was used, showing that the number of cases with light tactile hypoesthesia to single-fiber sensation in the reimplanted fingertips was higher in the experimental group than in the control group ($p < 0.01$), while there was no significant difference in the number of cases of protective hypoesthesia between the two groups ($p > 0.05$), the number of cases of protective sensory loss was significantly lower in the experimental group than in the control group ($p < 0.01$). There was no significant difference in the pain scores and comfort scores between the two groups before management ($p > 0.05$). However, the pain level of the two groups after management was significantly lower than that before management ($p < 0.01$), whereas the post-management comfort scores of both groups were significantly higher than that before management ($p < 0.001$). The experimental group's degree of improvement was significantly higher than that of the control group ($p < 0.001$). The pre-management GQOLI-74 scores were not significantly different between the groups ($p > 0.05$), whereas after management, the experimental group outperformed the control group in all dimensions of the scores, except in thinking ability ($p < 0.01$). Although not statistically significant ($p > 0.05$), the total perioperative complication rate of the experimental group was lower than that of the control group.

CONCLUSIONS: The implementation of finger sensory rehabilitation training is effective for restoring tactile function, reducing pain levels, and improving quality of life among patients who had undergone fingertip amputation and reimplantation. This finding can inform the development and selection of subsequent rehabilitation programs.

Keywords: fingers; surgical procedures, operative; touch perception; effectiveness comparative research; retrospective studies

Introduction

Following the demonstration of thumb reimplantation for a complete detachment case by Komatsu and Tamai [1] in 1965, fingertip amputation and reimplantation has now become a refined treatment method, but the success of this procedure is no longer defined by the survival rate alone, as the final functional outcome and the recovery of sensitivity have become the more important determinants of surgical success [2]. The fingertips of the fingers are rich in peripheral nerves allowing for fine manipulation, which underscores the challenges of postoperative care [3]. Therefore, continuous, standard rehabilitative care measures should be taken after fingertip amputation and reimplantation to better promote hand function recovery in patients [4].

Fingertip amputation often leads to nerve damage and loss of motor and sensory functions, which severely affects the quality of life. Surgery can facilitate the anastomosis and

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repair of the nerve, but the recovery of sensation lies in the growth of nerve fibers, which grow slowly and are intertwined and adhered to the surrounding tissues. Therefore, purely rehabilitative means such as electrical nerve stimulation and the application of neurotrophic drugs are unable to effectively restore sensory functions for the damaged nerve. The restoration of touch perception to fingers and fingertips is critical to achieving dexterous neuroprosthetic control for individuals with sensorimotor dysfunction [5]. Sensory function cannot be effectively restored by purely electrical nerve stimulation and the application of neurotrophic drugs [6]. Some scholars believe that the tools for sensory retraining hold promise for improving hand sensitivity, dexterity, and activities of daily living (ADLs) in individuals with hand injuries or dysfunctions, emphasizing the importance of sensory retraining in postoperative hand rehabilitation [7].

The traditional rehabilitation training adopts a standardized rehabilitation process, which fails to take into full consideration the individual differences of patients, leading to inconsistent rehabilitation outcomes. The conditions for reimplantation vary among patients, including the site of injury, the degree of injury, and the time of reimplantation. The traditional rehabilitation mode may not be able to provide each patient with the most appropriate form of rehabilitation [8]. The new rehabilitation model developed in this study boast several innovative advantages that can address the limitations of the traditional perioperative finger rehabilitation training model, such as the lack of specificity, low patient participation, and limited rehabilitation facilities and equipment, and meets the patient's rehabilitation needs in terms of enhancing the function of the fingers and promoting the restoration of the tactile function, etc. This novel model provides phased training, which is subcategorized into tactile training, temperature sensory training, and comprehensive training, to achieve the rehabilitation goals by executing the procedures in a specific order, thus improving the quality of life of the patients.

Currently, there is no research validating the effectiveness of perioperative finger sensory rehabilitation in enhancing hand function recovery after fingertip amputation and reimplantation. Thus, the present study was conducted to confirm the effectiveness of this protocol.

Methods

Patients

The medical records of 106 patients who underwent fingertip amputation and reimplantation at the Hospital of Mudanjiang Medical University from January 2022 to January 2024 were selected for retrospective analysis. The study was conducted in compliance with the Declaration of Helsinki [9] and was approved by the Ethics Committee of Second Affiliated Hospital of Mudanjiang Medical University (No. 201910017). Informed consent was obtained from the patient or family.

Inclusion and Exclusion Criteria

Inclusion Criteria

The inclusion criteria for this study are as follows: (i) those who were indicated for the fingertip amputation and reimplantation treatment; (ii) those who had normal cognitive function and independent mobility; and (iii) those with complete medical history.

Exclusion Criteria

The inclusion criteria for this study are as follows: (i) those with severe limb injury or mental disorders; (ii) those who developed necrosis after amputation and reimplantation; (iii) those with amputated fingers due to severe rheumatic immune system diseases or malignant tumors; and (iv) those with missing medical record data.

Postoperative Rehabilitation

The treatment measures for subjects in the control group are given as follows. Firstly, the patients' vital signs after the operation were closely monitored, and anticoagulants or vasodilators were used according to the patients' physical condition. The amputated fingers were carefully cleaned. In the event of severe bleeding, the attending doctor should be notified immediately to carry out relevant emergency measures. After surgery, rehabilitation exercises and dietary advice should be given according to the patient's recovery status. The rehabilitation exercise measures prescribed for these subjects are as follows: Under the guidance of doctors or rehabilitation therapists, the patients performed passive flexion and extension of fingers to prevent joint adhesion. The passive exercises should be conducted in a relatively slow pace, through gradual enhancement of strength to avoid physical damage caused by excessive pulling. If necessary, the patients received physical therapies, such as baking electricity, infrared rays, electromagnetic therapy, and so on, to promote blood circulation and accelerate the wound healing. In the process of rehabilitation training, excessive force or excessive activities should be avoided to prevent injury to the reimplanted finger. The frequency of exercise was 10 min, twice daily, for 20 weeks.

The perioperative finger sensory rehabilitation training for subjects in the experimental group was executed on the basis of the treatment measures for those in the control group with some modifications:

(i) Tactile training: On the same day after the amputation and reimplantation surgery was completed, a soft towel or a soft toothbrush was used to wipe the unamputated finger parts of patients. The visual-tactile feedback training was initially set to 15–20 min per session, 2 times per day, lasting for 3 weeks. In the fourth week, the patients began to do static tactile exercises. In these exercises, the patients were instructed to observe touching the rubber fixed at the end of a pencil with appropriate pressure on the reimplanted fingertip and when removing the

rubber from the fingertip. In the subsequent part, they were instructed to feel the rubber touching and removal with their eyes closed. These exercises took 10 min per session, and they were required to perform twice a day for a consecutive 4–8 weeks. While performing the dynamic mobile tactile training, the rubber end of a pencil was gently slid over the reimplanted fingertip. The patients were instructed to record their observations with the same methods applied in the static tactile training (with eyes open, and with eyes closed). These exercises took 10 min per session, and the patients were required to perform twice a day for a consecutive 6–8 weeks.

(ii) Temperature sensory training: The patients were instructed, under the full-time nurses' guidance, to touch a vial filled with cold water and another with warm water (at 45 °C), with their reimplanted fingertips. They were asked to carry out this exercise with their eyes open and closed to feel the temperature difference between the warm and cold water. This training can be carried out alternately with the tactile training, with 10 min per session, 2 times per day, for 4–8 weeks.

(iii) Comprehensive training: When a patient's sense of touch and temperature sensation has recovered, a more comprehensive training was conducted, in which the patient was instructed to hold his/her hand into a pocket filled with rubber, paper clips, coins, keys, buttons and other small objects, and to identify an item before he/she took it out. This training could be done anytime and anywhere, and assessed according to his/her answer. This training was performed 15 min per session, twice per day for a total duration of 16–20 weeks.

Observation Indicators

Clinical Information

Clinical data such as gender, time from injury to clinical visit, and type of injury (cut, stamping injury, crush injury, and avulsion injury) were collected from medical records and compared between the two groups.

Semmes-Weinstein Monofilament Sensory Measurements

The Semmes-Weinstein monofilament test is currently an internationally recognized method for effectively detecting tactile pressure sensory disorders. The full set of test kits is available in 20 sizes and strength levels (Suzhou Kang Yang Automation Co., Suzhou, Jiangsu, China). Different monofilaments can be selected for the test according to the specific clinical or scientific research applications, with the coarsest being No. 6.65 and the thinnest No. 1.65. During the test, the patient was instructed to assume a comfortable position, and remove gloves, jewelry and other objects that would interfere with the test. With the patient's eyes covered with eye pads, he/she was asked to experience the sensation while a selected monofilament was used for testing (the examiner may use the smallest monofilament in the beginning of the test). The test monofilament was kept perpendicularly to the test site surface and in contact with the test site. Then, pressure was applied to bend the monofilament into a C-shape. The force formed when a monofilament is bent is the test force for that size of monofilament. The test results were recorded: the presence of sensation was recorded as "+", and the absence of sensation was recorded as "-". If the patient's responses were correct for 7 out of the 10 tests administered, the general test was considered accurate and graded according to the evaluation criteria of the Semmes-Weinstein monofilament test, which range from 1.65 to 2.83 for normal light touch sensation, 3.22 to 3.61 for light touch sensory loss, 4.31 to 4.56 for protective sensory loss, 4.56 to 6.65 for protective sensory loss, 6.65 to 6.65 for total loss of sensation, and >6.65 for complete loss of sensation.

Comparison of Pain Levels

Visual Analogue Scale (VAS) score [10] was used to assess the pain level of the patients in the two groups on the second postoperative day and after the completion of rehabilitation training. The VAS is a scoring method used to assess the level of pain in the human body, and the specific steps are as follows: The patients were asked to mark the level of pain they were experiencing on a 100-mm ruler with one end labeled "no pain" and the other end labeled "most severe pain". According to the level of pain they marked on the rule, their levels of pain were categorized as mild pain (1–3 points), moderate pain (4–6 points), or severe pain (7–10 points), according to the points they marked on the ruler. A higher score in VAS indicates a more intense level of pain.

Comfort Situation

The Comfort Scale [11] was used to evaluate the comfort level of the two groups of patients at different moments. The scale used in this study had integrated the characteristics of the patients with fingertip amputation and reimplantation, with 30 entries in physiological, socio-cultural, psycho-spiritual, and environmental domains revised. The revised scale was tested, with a reliability value of 0.929 and Cronbach's α coefficient of 0.91. The scale was built based on a 4-point Likert scale. The minimum score for this test was 30 and the maximum score was 120, with 30–59 points categorized as low comfort, 60–90 as moderate comfort, and 91–120 as high comfort.

Quality of Life Evaluation

Generic Quality of Life Inventory-74 (GQOLI-74) score [12] was used to comprehensively evaluate the quality of life of the two groups of patients. The GQOLI-74 scale is divided into several dimensions, namely material life, social functioning, physical health, mental health and thinking ability, with a total of 74 entries, each of which is rated from 1 to 5 points; some of the entries are positively rated from 1 to 5, whereas some are negatively rated entries from 5 to 1. A few entries of the scale are multi-question entries,

Table 1. Comparison of baseline data between the experimental and control groups.

Variables	Experimental group (n = 52)	Control group (n = 54)	$\chi^2/H/t$	p
Gender (male/female)	34/18	35/19	0.004	0.951
Age (years)	45.00 (33.25, 55.75)	45.00 (32.50, 56.50)	–0.117	0.907
BMI (kg/m^2)	22.45 (20.70, 23.98)	22.30 (20.40, 23.83)	–0.142	0.887
Time from injury to clinical consultation (min)	151.96 ± 66.95	150.48 ± 65.94	0.115	0.909
Injured part			1.614	0.806
Thumbs	12 (23.08)	16 (29.63)		
Index finger	16 (30.77)	15 (27.78)		
Middle finger	9 (17.31)	12 (22.22)		
Ring finger	7 (13.46)	5 (9.26)		
Little finger	8 (15.38)	6 (11.11)		
Injury site			0.136	0.712
Left hand	28 (53.85)	31 (57.41)		
Right hand	24 (46.15)	23 (42.59)		
Type of injury			0.698	0.874
Cut	17 (32.69)	15 (27.78)		
Stamping injury	19 (36.54)	21 (38.89)		
Crush injury	13 (25.00)	16 (29.63)		
Avulsion injury	3 (5.77)	2 (3.70)		
Current residence			0.125	0.724
Countryside	31 (59.62)	34 (62.96)		
Municipalities	21 (40.38)	20 (37.04)		

Abbreviation: BMI, Body mass index.

Table 2. Comparison of single-fiber sensation of the reimplanted fingertip at 6 months postoperatively between the experimental and control groups.

Groups	n	Light touch		Light tactile hypoesthesia		Protective hypoesthesia		Loss of protective sensation		Total loss of sensation	
		n	%	n	%	n	%	n	%	n	%
Experimental group	52	0	0.0	27	51.92	19	36.54	6	11.54	0	0.0
Control group	54	0	0.0	12	22.22	22	40.74	18	33.33	2	3.70

Light tactile hypoesthesia: χ^2 = 10.049, p = 0.002; Protective hypoesthesia: χ^2 = 0.197, p = 0.657; Loss of protective sensation: χ^2 = 7.184, p = 0.007

containing several questions. Containing good psychometric elements, this questionnaire is widely used in clinical settings.

Occurrence of Perioperative Complications

The frequency of perioperative complications of both experimental and control groups was counted. These complications include vascular crisis, infection, dysesthesia, limb edema, soreness, and muscle weakness.

Statistical Analyses

The collected data were analyzed and processed using SPSS 26.0 software (64-bit, IBM, Armonk, NY, USA). Data of categorical variables are expressed as count and percentage. Chi-square test was used when the sample size was ≥40 and the theoretical frequency was T ≥5; continuity-corrected chi-square test was used when the sample size was ≥40 but the theoretical frequency was $1 \leq T < 5$. If the sample size was <40 or the theoretical frequency was T <1, Fisher's exact test was employed. For continuous variables, the Shapiro-Wilk test was first used to test whether the data conformed to the normal distribution. Normally distributed data are expressed as mean ± standard deviation. For the same kind of data, t-tests were carried out for analysis. Data not conforming to normal distribution are expressed as median and interquartile range (M [P_{25}, P_{75}]). Kruskal-Wallis test was carried out to analyze non-normally distributed data. Differences with $p < 0.05$ were considered statistically significant.

Results

Comparison of Baseline Data

We found that there was no significant difference between the experimental and control groups in terms of gender, time from injury to clinic consultation, type of injury, age, Body mass index (BMI), injured part, injury site, current residence ($p > 0.05$) (Table 1).

Table 3. Comparison of VAS scores pre- and post-treatment between the two groups.

Groups	Pre-treatment	Post-treatment	*H*	*p*
Experimental group	7.00 (6.00, 8.00)	4.00 (3.00, 5.00)	–7.494	<0.001
Control group	7.00 (5.00, 8.00)	6.00 (5.00, 7.00)	–2.864	0.004
H	–0.585	–6.061		
p	0.558	<0.001		

Note: Data are expressed as M (P_{25}, P_{75}). VAS, Visual Analogue Scale.

Table 4. Comparison of comfort levels pre- and post-treatment between the experimental and control groups.

Groups	Pre-treatment	Post-treatment	*H*	*p*
Experimental group	48.50 (42.25, 52.00)	81.00 (79.00, 83.00)	–8.801	<0.001
Control group	48.00 (44.00, 52.25)	65.50 (61.00, 70.00)	–8.966	<0.001
H	–0.339	–8.884		
p	0.735	<0.001		

Note: Data are expressed as M (P_{25}, P_{75}).

Comparison of Tactile Training Results

Our results showed that at 6 months postoperatively, the number of cases who had undergone reimplantation of fingertip for single-fiber sensation restoration with light tactile hypoesthesia in the experimental group was higher than that in the control group ($p < 0.01$), while there was no significant difference in the number of cases of protective hypoesthesia between the two groups ($p > 0.05$), the number of cases of protective sensory loss was significantly lower in the experimental group than in the control group ($p < 0.01$) (Table 2).

Comparison of Pain Levels

SPSS software was used to analyze the pain levels recorded pre- and post-treatment in the two groups of patients. Our analysis showed that there was no significant difference in the VAS scores of the patients in the two groups before the treatment ($p > 0.05$), whereas the VAS scores of the patients in the two groups after the treatment were significantly lower than those before the treatment ($p < 0.01$) (Table 3).

Comparison of Comfort Levels

The analysis of the comfort levels reported by the two groups of patients before and after treatment showed that there was no significant difference in pre-treatment comfort levels between groups ($p > 0.05$), but the post-treatment comfort levels of the experimental group were significantly higher than those of the control group ($p < 0.001$) (Table 4). Further comparative analysis revealed that the post-treatment comfort levels of both groups were significantly higher than their pre-treatment scores ($p < 0.001$) (Table 4).

Comparison of GQOLI-74 Scores

Comparison of the pre- and post-treatment GQOLI-74 scores of the experimental and control groups showed no significant difference in the pre-treatment dimensional scores between these two groups ($p > 0.05$) but significantly higher scores in all tested dimensions in the experimental group than in the control group, except for thinking skills ($p < 0.01$) in the post-treatment (Table 5).

Comparison of Perioperative Complication Rates

Our results showed that the total incidence of perioperative complications in the experimental group was lower than that in the control group, although the analysis showed no statistical significance ($p > 0.05$) (Table 6).

Discussion

Fingertip amputation and reimplantation is a challenging and technically demanding procedure [13]. Specifically, the highly complex anatomy of the fingertip necessitates excellent technical expertise in the identification of vessels of sub-millimeter scale for reanastomosis [14]. The procedure typically uses a ticked bone-nail complex plus a localized transfer flap to cover the dissociated lateral bone-nail complex in order to maintain the original finger length, nail complex, and sensory function of the fingertips.

Perioperative rehabilitation training can effectively improve the recovery of hand function. Specifically, a systematic rehabilitation training of holomorphic reconstructed fingers during the perioperative period can ensure the survival of reconstructed fingers and achieve an excellent hand function rate of 98.20% within 6 months to 2 years after surgery [15]. Therefore, rehabilitation training after finger reimplantation is indispensable for hand function recovery. Some scholars have found that a sensory training program to enhance finger discrimination helps to improve not only the sensory function but also the hand function of stroke patients [16]. Traditional rehabilitation programs have focused on the application of comprehensive rehabilitation nursing strategies and the adjunctive treatment using herbal infusions [17,18], without placing much emphasis on the tactile sensation of the patient's fingers and the recovery of nerve function. The rehabilitation training program used in

Table 5. Comparison of GQOLI-74 scores pre- and post-treatment between the experimental and control groups.

Groups	*n*	Pre-treatment					Post-treatment				
		Material life	Social function	Physical health	Mental health	Thinking ability	Material life	Social function	Physical health	Mental health	Thinking ability
Experimental group	52	65.00 (62.00, 68.00)	64.50 (59.00, 68.75)	57.00 (53.00, 62.00)	62.00 (59.00, 64.00)	73.50 (67.00, 77.00)	75.00 (72.00, 79.75)	72.00 (68.00, 77.75)	73.00 (68.00, 76.75)	72.00 (69.00, 75.75)	76.00 (69.25, 79.00)
Control group	54	64.50 (61.00, 68.00)	62.50 (56.00, 68.00)	61.00 (55.00, 64.00)	61.00 (56.00, 66.00)	70.50 (67.00, 77.25)	68.50 (64.00, 72.25)	70.00 (66.00, 73.00)	69.00 (67.00, 72.00)	69.50 (65.00, 73.00)	72.00 (67.75, 77.25)
H		–0.063	–1.294	–1.896	–0.950	–0.725	–5.987	–3.076	–3.254	–3.587	–1.763
p		0.949	0.196	0.058	0.342	0.469	<0.001	0.002	0.001	<0.001	0.078

Note: Data are expressed as M (P_{25}, P_{75}). GQOLI-74, Generic Quality of Life Inventory-74.

Table 6. Comparison of perioperative complication rates between the experimental and control groups.

Groups	*n*	Vascular crisis	Infections	Dysesthesia	Limb edema	Soreness	Muscle weakness	Total incidence
Experimental group	52	1 (1.92)	2 (3.85)	0	0	2 (3.85)	2 (3.85)	13.46% (7/52)
Control group	54	3 (5.56)	2 (3.70)	1 (1.85)	2 (3.70)	3 (5.56)	2 (3.70)	24.07% (13/54)
χ^2								1.949
p								0.163

Note: Except for total incidence, data are expressed as *n* (%).

this study emphasizes the plasticity of the patient's nerves, and by improving neuroplasticity, the sensory and motor functions of the hand can be effectively improved [19], which is of great significance to the rehabilitation treatment and daily functional recovery. Compared to traditional rehabilitation training methods, finger sensory rehabilitation training has multiple advantages: (i) focusing on the recovery of finger sensory function, thereby improving the overall rehabilitation effect; (ii) leveraging advanced technology and equipment to improve the accuracy and efficiency of training, so as to motivate patients to participate in the training; and (iii) using innovative training methods to improve the patient's experience of rehabilitation and adherence. These advantages of finger sensory rehabilitation training underscores its application value in promoting the recovery of patients' hand function. Therefore, by reviewing the clinical experience shared by other authors in the published literature, we hope to provide more references regarding the postoperative rehabilitation of hand function patients undergoing fingertip amputation and reimplantation.

Effect of Finger Sensory Training on Patients' Sense of Touch

Fingertip amputation often leads to nerve damage and loss of motor and sensory functions, which seriously affects patients' quality of life. Surgery can be performed to achieve anastomosis and repair injured nerves, but the restoration of sensory functions lies in the growth of nerve fibers, which are slow-growing and often intertwined with and adhered to the surrounding tissues [20]. Therefore, solely utilizing rehabilitation means such as electrical nerve stimulation or applying neuronutrient therapy is not sufficient for effectively restoring sensory functions of the damaged nerves [21]. Clinical practice and literature review suggest that implementing postoperative finger sensory rehabilitation training promotes recovery of finger sensation in patients having undergone fingertip amputation and reimplantation. In this study, the Semmes-Weinstein monofilament test was used to assess the recovery of finger's tactile sensation in the postoperative period. With high sensitivity and specificity, this test is an easy-to-perform, noninvasive test used to assess the sensitivity of the skin's tactile sensation [22]. In this study, we found that the number of cases with light tactile hypoesthesia to single-fiber sensation in the reimplanted fingertips was higher in the experimental group than in the control group ($p < 0.01$), while there was no significant difference in the number of cases of protective hypoesthesia between the two groups ($p > 0.05$), the number of cases of protective sensory loss was significantly lower in the experimental group than in the control group ($p < 0.01$). This training method attaches importance to the training of the patient's sensory function, and the training dedicated to establishing early tactile feedback is added as a combination of dynamic and static tactile training that maintains the patient's sensory function for 4–8 weeks. The specific mechanism underlying the benefit of this form of training is promoting regeneration of nerve cells and axonal sprouting through repeated stimulation of damaged nerve endings. This stimulation activates nerve growth factor, which promotes the proliferation, differentiation and migration of nerve cells, thereby forming new nerve connections in the damaged area.

Effect of Finger Sensory Rehabilitation Training on Pain Levels

The results of this study found that patients who received finger sensory rehabilitation training during the perioperative period had lower VAS scores, mostly because this form of training improves not only sensory function of the hands, but also their functional recovery. Functional recovery is often accompanied by a reduction in pain, allowing patients to perform daily activities with ease [23].

Effect of Finger Sensory Rehabilitation Training on Patients' Comfort

Based on our results, the comfort scores of both the experimental and control groups after treatment were significantly higher than those before treatment ($p < 0.001$), and the comfort scores of the experimental group were significantly higher than those of the control group ($p < 0.001$). These results highlight that professional rehabilitation training can effectively shorten the cycle for hand function recovery and enhance the patients' participation to a certain degree, thus enhancing the overall therapeutic effect and comfort.

Effect of Finger Sensory Rehabilitation Training on Patients' Quality of Life

The present set of findings suggest that the implementation of finger sensory rehabilitation training is also beneficial for improving patients' quality of life. This may be due to the fact that the tactile pressure threshold and hand grip strength of patients can be significantly improved by specific sensory training procedures, underlining the roles of sensory training in not only enhancing finger perception, but also promoting the ability of practical hand manipulation, which is critical for basic self-care in daily life [24]. Perioperative sensory training has been shown to indirectly enhance the quality of life by improving the psychological state of patients [25].

For this study, we clearly defined the purpose, hypotheses, and scientific questions to be verified in this study, and adopted the research method of retrospective analysis to estimate the sample size based on the expected effect size, significance level, and statistical efficacy, to ensure that the study has sufficient power to detect the expected effects. Moreover, we also collected clinical data from patients by using validated questionnaires and scales to ensure data accuracy and consistency. Every aspect of the study was designed and conducted in adherence to the principles of scientific rigor to ensure authenticity and reliability of results. Despite that the application value of finger sensory rehabilitation training was verified in this study, several shortcomings should be acknowledged. For example, as a retrospective study, this research is prone to selection and recall biases, which may lead to result discrepancies when compared to the actual scenario. Besides, the conclusions of this study are subjected to the influence of confounding variables. The current study also lacks long-term follow-up data. In view of these limitations, future studies should consider long-term monitoring of rehabilitation effects through follow-ups and employing randomized research design and blinding to improve the representativeness of the samples. Other considerations also include adopting multi-stage analysis methods, providing appropriate training to the personnel and participants involved in the study, conducting multivariate analysis, to minimize the impact of unfavorable factors on the results of the study. In our future plan, we shall continue to adjust and optimize the perioperative rehabilitation protocol based on the clinical experiences gained and the latest research results to improve its effectiveness and safety.

Conclusions

Despite the broad adoption of fingertip amputation and reimplantation, the number of research reports on perioperative finger rehabilitation training remains relatively scarce. This study shows that the finger sensory rehabilitation training can improve the mobility of finger joints, muscle strength and sensory function of patients having undergone fingertip amputation and reimplantation, as well as achieve good blood circulation. This rehabilitation approach has also proven effective in reducing postoperative swelling, pain and other complications, effectively shortening the rehabilitation cycle, and improving the quality of life of patients. Promoting the finger sensory rehabilitation training can help elevate the overall level of rehabilitation medicine, benefiting the patients requiring this form of rehabilitative treatment and the rational allocation of medical resources.

Availability of Data and Materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Author Contributions

SBG and CY designed the research study. SBG and CY performed the research. CY analyzed the data. SBG was involved in drafting the manuscript. Both authors contributed to editorial important changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in compliance with the Declaration of Helsinki and was approved by the Ethics Committee of Second Affiliated Hospital of Mudanjiang Medical University (No. 201910017). Informed consent was obtained from the patient or family.

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Conflict of Interest

The authors declare no conflict of interest.

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