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# Comparison of Shoulder Management Strategies after Stage I of Fingertip Skin Defect Repair with a Random-Pattern Abdominal Skin Flap

Authors' Contribution:  
Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
Funds Collection G

ABE 1 **Feng Zhao**  
BCD 2 **Wei He**  
DE 1 **Guoping Zhang**  
CD 1 **Shaojun Liu**  
BC 2 **Kunlun Yu**  
BD 2 **Jiangbo Bai**  
CD 2 **Hongjuan Zhang**  
AEF 2 **Dehu Tian**

1 Department of Orthopedics, The First Hospital of Hebei Medical University, Shijiazhuang, Hebei, P.R. China  
2 Department of Hand Surgery, The Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, P.R. China

**Corresponding Author:** Dehu Tian, e-mail: dhtianhb@126.com  
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**Background:** In the absence of scientific evidence regarding the effectiveness of shoulder management strategies after stage I of fingertip reconstruction, the purpose of this study was to compare the clinical outcomes of various rehabilitation procedures.





**Material/Methods:** Patients who underwent fingertip reconstruction with a random-pattern abdominal skin flap between March 2007 and February 2013 were enrolled in the study (n=95). Thirty performed only active exercise (group A), 29 performed only passive exercise (group B), and 32 received a combination of active exercise and pulsed electromagnetic field (PEMF) (group C). The mean age at the time of treatment was 30.2 years in group A, 29.6 years in group B, and 31.8 years in group C.

**Results:** At the final follow-up, there were significant differences between group A and B in terms of Constant score ( $P=.001$ ), VAS ( $P=.047$ ), forward flexion of the shoulder ( $P=0.049$ ), and muscle strength with forward flexion and external rotation ( $P=0.049$  and  $P=0.042$ , respectively). A higher Constant score was observed in group C compared to group A, and although there were no differences in the other evaluations between groups A and C, a trend toward better function of the shoulder was demonstrated in group C.

**Conclusions:** The most important findings in our study are that a combination of active exercise and PEME produces superior patient-reported outcomes regarding relief of shoulder signs and symptoms. Given the limitations of this study, better-designed studies with large sample sizes and long-term follow-up are required.

**MeSH Keywords:** **Finger Injuries • Rehabilitation • Skin Transplantation**

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## Background

Hand injuries are very common in China. Based on the epidemiological studies of hand injuries, approximately 23–54% of all emergency department visits were for hand injuries from 1994 to 2005 in China [1]. Most of the hand injuries were caused by transient risk factors [2]. Moreover, the increased hand injuries were also due to low-level consciousness and self-protection [3].

The fingertip skin defect, often accompanied by tendon or bone exposure, is one of the most common hand injuries [4]. When the tendon, bone, or nail bed is exposed, flap reconstruction is necessary to preserve finger function after treatment of fingertip skin defects [3]. The goal of fingertip reconstruction is to preserve functional length and sensitivity, restore joint flexibility, prevent the development of joint stiffness or neuroma, minimize aesthetic deformities, and provide a quick return to work [5,6]. Various treatment options include the random-pattern abdominal flap, fascial pedicle dorsal flap of the finger, advanced skin flap, and cross-finger flap [6–8]. Generally, wide flaps from the abdomen are used for treating multiple finger defects [9]. Numerous studies have reported satisfactory results in the reconstruction of fingertip skin defects with abdominal skin flaps [3,10,11].

Previous studies focused on skin flap survival and sensory recovery of the flaps and showed that the abdominal skin flap technique was effective for the treatment of fingertip skin defects. Flap pedicle division is often performed 3 or more weeks after the first stage of fingertip reconstruction surgery [3,12]. However, some shoulder diseases, including joint pain and stiffness, muscular soreness, and even joint inflammation, that occur in many patients are often overlooked [13]. This results in terrible patient suffering. During the immobilization of the hand, we generally perform several shoulder-conservative management procedures, including massage of the muscles around the joint, active and passive mobilization exercises, physical therapy practice, and pulsed electromagnetic field (PEMF) [14].

To date, although the effectiveness of rehabilitation in the treatment of shoulder diseases has been proven in many published studies, the outcomes in patient who receive treatment after the first stage of fingertip reconstruction remain unknown. In addition, there is no standardized rehabilitation protocol for those patients. Therefore, the aim of this study was to investigate the clinical effectiveness of shoulder management strategies for stage I of fingertip skin defect repair with a random-pattern abdominal skin flap.

## Material and Methods

This study is retrospective, and the First Hospital of Hebei Medical University Institutional Review Board and the Third Hospital of Hebei Medical University Institutional Review Board approved this study.

### Patient selection

A total of 95 patients who underwent fingertip skin reconstruction with a random-pattern abdominal skin flap between March 2007 and February 2013 were enrolled in the study. All patients presented with a traumatic fingertip skin defect accompanied by tendon or bone exposure, as well as a completely or partially missing nail. Each participant provided written informed consent prior to the emergency surgery being performed. Patients with finger injuries that were managed with a combination of abdominal flaps and other local flaps and those with clinical diseases were excluded from the study. According to the rehabilitation method employed after the first stage, 32 patients underwent active exercise (group A), 29 patients underwent passive exercise (group B), and 34 patients underwent a combination of active exercise and PEMF. The mean age at the time of operation was 30.2 years in group A (range, 18–46 years), 29.6 years in group B (range, 19–49 years), and 31.8 years in group C (range, 18–50 years). There were no significant differences in the preoperative demographic data among groups (Table 1). Follow-up data were obtained from hospital charts with a minimum of 6 months of follow-up.

### Operative technique

All of the operations were performed by the same surgeon. All patients underwent fingertip skin reconstruction with random-pattern abdominal skin flap, as recommended by Kleinman and Dustman [15]. The random-pattern abdominal flap was constructed based on the shapes and sizes of the wounds. The skin flap area was 15–20% larger than the actual wound area to avoid excessive tension. The flap pedicle division of the second stage was performed 3 weeks later after the first step.

### Postoperative rehabilitation

Before performing the flap pedicle division, all patients underwent rehabilitation according to instructions from the same supervising physiotherapist. After the second-stage surgery was performed, all patients continued with the home exercise program, including the home exercises, and received advice on sleep, posture, and pain relief. Early ambulation was encouraged.

**Table 1.** Demographic characteristics of patients.

	Group A (n=32)	Group B (n=29)	Group C* (n=34)	P value	P value*
Mean follow-up, (mo)	7.9±1.8	8.2±1.8	8.0±2.0	.516	.831
Age (y)	30.2±13.2	29.6±13.9	31.8±14.6	.863	.642
Gender (M/F)	28/4	26/3	30/4	.792	.927
BMI (kg/m <sup>2</sup> )	22.6±2.3	23.2±1.9	22.9±2.1	.271	.581
Side involved	21/11	19/10	22/12	.993	.938
Causes of injury				.736	.675
Incised wound	18	20	20		
Crush injury	10	7	9		
Animal bite	4	2	5		
Type of defect				.547	.739
Finger pulp defects	27	26	29		
Dorsal digital defects	6	5	5		
Finger lateral defects	3	3	5		
Distal transection cut	7	6	8		
Distal degloving injury	4	3	4		

M – male; F – female; BMI – body mass index; \* difference in demographic s between group A and group C.

### Active exercise

The patients began to undergo active exercise 1 day postoperatively and were showed demonstrations of each exercise by a supervising physiotherapist. Patients performed a 30-minute exercise circuit composed of 6 parts. Each 5-minute part was designed to facilitate range of motion exercises of the shoulder. The exercises included shrugs, lowering the shoulder, moving the joint backwards, forward extension, clockwise rotation, and counter-clockwise rotation. This active exercise was conducted 3 times a day.

### Passive exercise

Continuous passive exercise was performed by a physiotherapist twice a day for 30 minutes each session, starting on the first postoperative day. The shoulder joint exercise included forward and side elevation of the upper extremities, and internal and external rotation of the shoulder. The exercises prevented torsion of the skin flap pedicle.

### PEMF

The treatment in group 3 consisted of active exercise and PEMF. The PEMF was completed in 9 sessions provided 3 times per week. The method was described by Quittan et al. [16].

### Outcome assessments

After baseline evaluations, the outcome measures were assessed at 1, 3, and 6 months. All outcome measurements were performed and recorded by an independent physiotherapist. The Constant [17] and University of California/Los Angeles (UCLA) [18] scales were used to measure joint function. A subjective pain score was measured with the visual analogue scale (VAS). Quantitative muscle strength measurements of the rotator cuff were assessed with use of a portable handheld Nottingham Mecmesin myometer (Mecmesin Co., Nottingham, UK) [19]. Elevation strength was tested with the patient in the seated position with the arm flexed to 90° in the scapular plane. External and internal rotation was measured with the shoulder in a neutral position and the elbow in 90° of flexion. Range of motion (ROM) included forward flexion, external rotation, internal rotation, and abduction. Patients were also asked to evaluate the clinical outcome as excellent, good, fair, or poor.

### Statistical analysis

Statistical analysis was performed using SPSS 13.0 software. Descriptive statistics for the demographic data and all outcome measures are expressed as averages and SDs with a normal curve. A paired t test was performed to assess the difference in preoperative demographics. An independent t test was used to compare the outcomes between groups A and B and groups

**Table 2.** Clinical outcomes at the final follow-up.

	Group A	Group B	Group C*	P value	P value*
Constant score	95.6±5.3	91.2±5.4	98.3±4.2	.001	.023
UCLA score	27.7±3.6	26.7±4.9	29.1±3.7	.362	.122
VAS	0.8±1.1	1.3±0.8	0.6±0.9	.047	.443
ROM, deg					
FF	172.5±7.4	168.6±7.9	173.2±6.8	.049	.690
ERs	78.7±9.6	73.9±10.4	80.2±9.8	.063	.531
IRp	T10.1	T11.3	T9.6	.325	.264
Abd	172.2±12.4	168.2±11.9	172.9±12.1	.202	.817
Muscle strength, kg					
FF	8.4±2.5	7.1±2.6	8.5±2.6	.049	.359
ER	6.1±1.9	5.1±1.9	6.1±2.0	.042	.539
IR	6.2±1.8	5.6±2.1	6.1±1.9	.264	.526
Satisfaction				.120	.592
Excellent/good	10/19	8/14	14/18		
Fair/poor	3/0	6/1	2/0		

UCLA – University of California at Los Angeles; VAS – visual Analogue Scale; Abd – abduction; ER – external rotation; ERs – external rotation at the side; FF – forward flexion; IR – internal rotation; IRp – internal rotation to the posterior; \* difference in clinical outcomes between group A and group C.

A and C. Pearson  $\chi^2$  test was also performed to compare the satisfaction levels. Significance was set at  $P < 0.05$ .

## Results

All patients in the 3 groups were followed up at a mean time of 8.0 months. All groups were homogeneous for age, sex, and body mass index (BMI). Table 1 presents the characteristics of the 3 groups. No participants in this study were lost to follow-up.

### Outcomes evaluation

All of the clinical evaluations at the final follow-up are listed in Table 2.

A higher Constant score was observed in group C ( $P=0.023$ ) compared with group A. However, the patients who received passive exercise exhibited the lowest Constant score among the 3 groups, and a significant difference was observed between groups A and B ( $P=0.001$ ). There was no significant difference in the UCLA score between groups A and B or between group A and C. The pain scores on the VAS were lowest in group C. However, no difference was found between

groups A and C. There was a significant difference in VAS between groups A and B ( $P=0.047$ ).

Additionally, although relatively higher ROM was achieved in Group C, there was no statistically significant difference between groups A and C. However, there was a significant difference between groups A and B in ROM in terms of forward flexion ( $P=0.049$ ). Regarding muscle strength, there were significant differences in forward flexion and external rotation between groups A and B ( $P=0.049$  and  $P=0.042$ , respectively).

Most patients were satisfied with the rehabilitation (excellent or good). No difference was observed among the 3 groups. Of the 12 patients who judged the treatment as fair or poor, 5 patients exhibited shoulder stiffness, 5 felt shoulder pain, and 2 experienced muscular atrophy. Most of these 12 patients were discontent with the treatment as a result of the ineffective rehabilitation procedure.

## Discussion

To the best of our knowledge, this is the first study to compare various shoulder management strategies for stage I of fingertip skin defect repair with a random-pattern abdominal

skin flap. In our study, the combination of active exercise and PEME provided better clinical outcomes compared to only active or only passive exercise. The major strengths of our study are that a single fully trained surgeon conducted all of the operations using a well-established technique, and the follow-up evaluations were performed by an independent physiotherapist.

Fingertip injuries are common and are the result of sharp lacerations and crush or avulsed injuries. Although often initially cosmetically unappealing to the patient, a good repair or reconstruction can provide a sensitive, durable fingertip with excellent results [20,21]. Different regions of the body have different skin sensations because of the diverse receptors and the varying density of the nerve fibers in these parts [22]. Numerous previous studies have evaluated fingertip reconstruction with the random-pattern abdominal skin flap and reported good results [3,10,11]. However, patients often complain of shoulder pain during postoperative follow-up. Shoulder immobilization results in those patients' symptoms beyond the first stage of the surgery. In general, 3 weeks are required to stabilize the flaps and skin grafts before performing the flap pedicle division. Although several authors suggested active and passive finger mobilization exercises during stabilization of the flaps, there is no evidence to determine which rehabilitation strategy is more effective. However, the findings of this study support and provide substantial evidence for the use of active exercise, and in particular physiotherapy, in the treatment of patients after stage 1 of fingertip reconstruction.

PEMF is commonly described as "bioelectromagnetic therapy," and is based on the principle of the interaction between non-ionizing electromagnetic fields and biological systems [23]. Previous studies [24–26] have suggested therapeutic effects in various pathologic conditions, including pseudoarthrosis, osteoarthritis, and acute and chronic pain from different musculoskeletal conditions, as well as tendon injuries. The results of the study confirmed that patients receiving a combination of active exercise and PEME, supervised by a physiotherapist, had better patient-reported outcomes than patients in the only-active or only-passive exercise groups. The group that received PEMF and performed active exercises showed better results regarding forward flexion and external rotation muscle strength in contrast to the only-active or passive exercise

groups. A recent trial by Freitas et al. [27] showed that the combination of PEMF and shoulder exercises is effective for improving function and muscle strength and decreasing pain. Therefore, PEMF treatment was effective in increasing shoulder function with good to excellent results.

In this study, lower VAS was observed in patients who performed only active exercise or those in the combination of active exercise and PEME group. However, there was no difference between groups A and C. The findings in the present study suggest that PEME had no role in relieving pain. However, Freitas et al. [27] reported different results. Some previous studies [28,29] showed that that electromagnetic therapy can be a useful tool for relieving pain, but other studies suggested no effects of PEME [30,31]. The effects of PEMF in patients with shoulder pain are still controversial.

In the absence of scientific evidence regarding the effectiveness of the multimodal rehabilitation programs after stage 1 of fingertip reconstruction, our research sought to provide some useful reference for other studies. However, some limitations remained. First, the limitations of retrospective analysis might cause inherent bias. The number of patients included was small, and the period of follow-up was relatively short. Finally, the selection of the rehabilitation procedure was based on the physiotherapist's preference, and some bias may therefore exist in those selections.

## Conclusions

This is the first study to evaluate the effectiveness of multimodal rehabilitation after the first stage of fingertip reconstruction. The most important findings in our study is that compared to passive exercise, active exercise can provide satisfying results and higher functional scores as part of a combination of active exercise and PEME. Further well-designed studies with longer-term follow-up and involving a larger group of patients are needed.

## Competing interests

The authors declare that they have no competing interests.

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