

# CLINICAL OBSERVATION OF HAND FUNCTION RECOVERY USING VARIOUS METHODS OF AUTOTENDON RECONSTRUCTION AND REHABILITATION

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The authors declare no potential conflict of interest requiring disclosure in this article.

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## Annotation

**Background.** The purpose of the study was to compare objective (range of motion, hand strength) and subjective (Arm, Shoulder, and Hand Disability Questionnaire, Visual Analogue Pain Rating Scale) indicators of the effectiveness of one-stage and two-stage autograft reconstruction combined with Kleinert and SMART rehabilitation methods in hand injuries of different ages.

**Methods.** The study included 200 patients (2021–2024) who underwent surgical treatment of flexor tendon injuries of the fingers at the Syzganov National Scientific Center of Surgery. Patients were divided into the main group (n = 80), which received two-stage reconstruction and rehabilitation according to the SMART method, and the control group (n = 120), which received one-stage reconstruction and rehabilitation according to the Kleinert method. Efficacy was assessed by range of motion, hand grip strength, Rozov's scale, Disabilities of the Arm, Shoulder, and Hand questionnaire, and visual analog scale pain scores.

**Results.** By the 6th month of rehabilitation, the SMART method demonstrated better results in functional movement assessment (65% vs. 60%, p = 0.05), pain reduction (4.0 vs. 3.2, p < 0.05), and shorter return-to-work time (10 vs. 12 weeks, p < 0.05). However, the Kleinert method proved effective in patients with subacute injuries.

**Conclusion.** The Stimulated Motion And Recovery Therapy hand rehabilitation method combined with two-stage reconstruction is effective in the long-term consequences of trauma, while the Kleinert method is preferable in subacute injuries. Restoration of hand function requires a multidisciplinary approach.

## Introduction

Finger flexor tendon injuries are a serious medical problem that significantly reduces the functional potential of the hand, impairs the quality of life of patients, and limits their ability to work. According to various studies, such injuries account for up to 15% of all hand injuries, particularly in the working age population, with significant socio-economic consequences.<sup>1,2,3</sup>

Surgical treatment of flexor tendon injuries may include:

- One-stage autogenous tendon

grafting, which is optimal for injuries between 3 to 6 months old, because the tissue retains elasticity with minimal scarring.<sup>1,4,5</sup>

- Two-stage grafting, used for long-term injuries (more than 6 months) where significant fibrotic changes require tissue preparation for grafting.<sup>6,7,8</sup>

Rehabilitation after surgery plays a crucial role in restoring hand function:

- The Kleinert method offers a conservative approach with gradual activation of movement, reducing the risk of complications but extending rehabilitation time.<sup>4</sup>

- The SMART (Stimulated Motion And Recovery Therapy) Hand Rehabilitation Method focuses on early mobilization, autologous plasma therapy, and high-intensity physiotherapy, promoting faster recovery but requiring careful pain management.<sup>9</sup>

Objective: Comparative analysis of objective (range of motion, hand strength) and subjective (Arm, Shoulder, and Hand Disability Questionnaire, Visual Analogue Pain Rating Scale) indicators of the effectiveness of one-stage and two-stage autograft reconstruction combined with Kleinert and SMART rehabilitation methods in hand injuries of different ages.

### Materials and Methods

The study was conducted as a prospective clinical observation involving 200 patients from 2021 to 2024 at the Syzganov National Scientific Center of Surgery, who underwent surgical treatment for the consequences of flexor tendon injuries of the fingers.

Patients were divided into two groups:

- Main Group (MG, n = 80): Patients with long-term injury consequences (more than 6 months) who underwent two-stage grafting followed by rehabilitation using the SMART Hand Rehabilitation Method.

- Control Group (CG, n = 120): Patients with injuries from 3 to 6 months old, treated with one-stage grafting and rehabilitation according to the Kleinert method.

#### Inclusion and exclusion criteria:

- Included: Patients with flexor tendon injuries of the hand from 3 months to 1 year, without severe somatic diseases.

- Excluded: Patients with infections, systemic connective tissue diseases, or severe contractures.

Methods of effectiveness assessment:

Objective indicators:

- Range of motion: Measured by goniometer (in degrees).

- Hand grip strength: Measured by dynamometer (in kilograms).

- V.I. Rozov scale: Functional evaluation of movements on a 5-point scale.

Subjective indicators:

- DASH questionnaire: Assessment of functional limitations of the upper extremity.

- Pain scale VAS: Intensity of pain syndrome (0–10 points).

**Ethical approval.** The study protocol was approved by the Ethics Committee of the A.O. Syzganov National Scientific Center of Surgery (Protocol No. 15/2021), and all patients provided informed consent prior to participation.

**Statistics.** Statistical analysis was performed using SPSS software (version 25.0). Quantitative data were expressed as mean ± standard deviation (SD). Student's t-test was used for comparison of continuous variables, t-statistic and Chi-square test was applied for categorical variables. A p-value <0.05 was considered statistically significant.

### Results

Up to the 6th month of rehabilitation, the SMART method (main group) shows slightly better results than the Kleinert method (control group) in the evaluation of functional movement, although the statistical significance is at the threshold (p = 0.05), as can be seen from the data in Table 1.

Observation Period	Main Group n=80	Control Group n=120	95%CI	Chi-squared	P value
3 months	50% - 4-5 points	45% - 4-5 points	[8.9;18.7]	0.479	0.489
6 months	65% - 4-5 points	60% - 4-5 points	[8.7; 18.1]	0.507	0.476

**Table 1.** Characteristics according Rozov's Scale

Patients in the main group had more pronounced functional limitations on the DASH scale at all observation periods,

which may be due to the chronic nature of their injuries (Table 2).

**Table 2.**  
DASH questionnaire survey data

Observation Period	Main Group n=80	Control Group n=120	P value
3 months	40.2	35.1	<0.05*
6 months	34.8	28.5	<0.05*

The SMART method allows for contributing to an earlier return to work as greater range of motion and hand grip strength with less pain syndrome, con-

**Table 3.**  
Additional Rehabilitation Indicators

Indicator	Main Group n=80	Control Group n=120	95%CI	t-statistic	P value
Pain scale (VAS)	4.0 ± 1.0	3.2 ± 0.8	[0.5; 1.1]	6.26	<0.0001*
Range of motion (°)	130 ± 8	120 ± 10	[7.4; 12.6]	7.49	<0.0001*
Hand grip strength (kg)	20.0 ± 1.5	18.0 ± 2.0	[1.4; 2.5]	7.63	<0.0001*
Time to return to work (weeks)	10.0 ± 1.0	12.0 ± 1.5	[1.6; 2.4]	10.47	<0.0001*

\*Statistically significant difference P≤0.05

### Discussion

The study results showed that the use of the SMART Hand Rehabilitation Method in combination with two-stage transplantation resulted in higher rates of hand function recovery in patients with long-term injury sequelae. The main group demonstrated significant improvements in range of motion, hand grip strength and reduced time to return to work compared to the control group. This is consistent with other studies confirming the effectiveness of early mobilization and high-intensity physical therapy in hand rehabilitation.<sup>10-12</sup>

The Kleinert method, while showing good results in patients with subacute injuries, was less effective in conditions with pronounced fibrotic changes, confirming the need for an individualized approach to selecting a rehabilitation method depending on the duration of the injury.<sup>13-15</sup>

These findings underscore the importance of adapting rehabilitation strategies based on the duration and severity of the injury. The early mobilization protocols of the SMART Hand Rehabilitation Method may reduce adhesion formation and allow for faster and more complete functional recovery. However, the potential risks associated with intensive rehabilitation, such as pain or re-injury, require careful management and individualized planning.<sup>11,12,16</sup>

In addition, the study highlights the need to combine surgical and rehabilitation strategies for optimal outcomes.

The integration of autologous plasma therapy as part of the SMART Hand rehabilitation method may contribute to improved tissue healing, which may explain the faster recovery times observed in the main group. The reduced time to return to work not only benefits patients, but also has positive socioeconomic implications by reducing the overall burden on healthcare systems and improving patients' quality of life.<sup>7,11,16</sup>

Comparing our results with the existing literature, it is clear that the SMART Hand rehabilitation method, although more intensive, provides significant benefits in cases of chronic injury. However, future studies should address the long-term sustainability of these improvements and investigate potential complications associated with intensive rehabilitation techniques. In addition, examining the psychological aspects of recovery, including patient motivation and adherence to rehabilitation protocols, may provide a more holistic view of treatment effectiveness.<sup>7,8</sup>

**Limitations.** Limitations of the study include the relatively small sample size and short follow-up period. In addition, the study was conducted at a single medical center, which may limit the generalizability of the results.

**What's known?** Previous studies have shown the effectiveness of the Kleinert method for flexor tendon injuries, especially in the subacute setting. However, there was limited evidence

comparing it to more intensive rehabilitation protocols such as the SMART Hand Rehabilitation Method, especially for long-term injuries.

**What's new?** This study provides new insight into the benefits of the SMART Hand Rehabilitation Method in conjunction with two-stage grafting, demonstrating superior outcomes in range of motion, pain reduction, and return to work speed for patients with chronic injuries.

#### Conclusion

The SMART Hand Rehabilitation Method combined with two-stage grafting demonstrates significant improvement in functional outcomes in long-term injury cases. The Kleinert method is effective in patients with injuries up to 6 months, especially in younger patients. Restoration of hand function requires a multidisciplinary approach involving surgeons, rehabilitation specialists, and

psychologists. Further research with a larger sample size and long-term follow-up is needed.

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