REHABILITATION APPROACH IN PATIENTS WITH MULTIPLE HAND INJURIES

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Abstract. *Hand trauma presents a demanding therapeutic challenge due to the complexity of the cases and the importance of the goal pursued: the recovery of hand functionality and the psychosocial reintegration of the patient. A carefully designed, individualized and efficient functional hand recovery protocol can significantly improve the healing process and lead to the restoration of the affected hand's functions. The objective of the study was to assess the effectiveness of a structured hand rehabilitation program on improving grip strength, range of motion and quality of life in patients after hand trauma. The study included 26 patients who had experienced complex hand injuries and subsequently underwent surgical interventions. Participants underwent a standardized rehabilitation program consisting of targeted exercises and therapies three times per week for 3 months. Outcomes were measured at baseline, 4 weeks and 3 months using the dynamometer Jamar for grip strength, a goniometer for range of motion, and for quality of life we used the arithmetic mean of the percentages for the VAS score, the GAD-7 score and the Quick Dash score. The data analysis highlights improvements in all measured outcomes. Grip strength and range of motion showed significant increases at 1 and 3 months compared to baseline. Quality of life assessments also demonstrated notable enhancements, correlating with physical improvements. In conclusion, the findings suggest that structured hand rehabilitation significantly improves functional outcomes in patients' post-hand trauma. These results underscore the importance of implementing comprehensive rehabilitation protocols to restore function and enhance quality of life.*

Keywords*: hand trauma; rehabilitation; range of motion; quality of life; hand therapy.*

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Introduction

The hand represents the most complex segment of a limb in the body, with its structure and function adapted to the complexity of human activities. According to Silva and Giostri (2021) it is the segment most exposed to trauma, with a large volume of care in urgent and emergency services. A perfectly functional hand is one of the main characteristics of an independent person. Impairment of hand functionality leads to a severe compromise in the ability to feed oneself and perform self-care, and limits participation in normal activities: work, social, and family life.

Multiple hand injury occurs when high-energy forces are transmitted to the hand (Agarwal et al., 2019). These injuries are often seen in industrial accidents, agricultural incidents involving threshing machines, household mishaps with kitchen equipment such as mixer grinders or road traffic accidents where the hand may be run over by a vehicle.

This type of injury involves multiple systems and structures, including the skin, blood vessels, nerves, tendons, muscles, bones, ligaments and articular capsules. Despite having similar wound healing characteristics, each structure has a unique healing timeframe, precautions, and optimal treatment methods. Key factors affecting the healing process and outcome include the patient's age, occupation, psychological status, surgical procedure, and medical history. The physiotherapist must consider all these factors to develop the best treatment plan for each case.

Hand injuries can be devastating both physically and psychologically. Often, they occur right before the patient's eyes, with the injured hand being visible to them immediately after the accident. Therefore, such an injury impacts not only function but also self-image (Grob et al., 2008). After the initial shock of the injury, patients experience additional distress as they start to grapple with and reflect on the implications of their situation. Beyond the physical discomfort, they may become anxious and have troubling thoughts, which can lower their mood. This process is common, especially as one adjusts to an unexpected or traumatic event. Additionally, they might need to visit the hospital and undergo treatment, which introduces new and unfamiliar experiences, adding to the stress of their current circumstances (Clarke, 2015).

Multiple hand injuries present a demanding therapeutic challenge due to the complexity of the cases and the importance of the goal pursued: the recovery of hand functionality and the psychosocial reintegration of the patient. Additionally, the high incidence of hand injuries and the significant impact these types of injuries have on patients' quality of life highlight the importance of the entire postoperative recovery process after such traumas.

Methodology

Aim

The purpose of this research was to design a comprehensive therapeutic program for patients who have suffered complex traumatic injuries to the hand, to be applied after the immobilization period, and to evaluate its effects on improving grip strength, range of motion and quality of life.

Hypothesis

A carefully designed, individualized and modern hand recovery program significantly improves the range of motion, grip strength, and leads to the restoration of the affected hand's functions, thereby enhancing the quality of life for the patient.

Participants and Procedure

A group of 26 patients, 21 males and 5 females, aged between 19 and 64 years (professionally active patients), all of whom had undergone surgical interventions for complex hand injuries, was selected for the study. The inclusion criteria for these study participants were patients who underwent surgical intervention, with rehabilitation treatment initiated after the removal of immobilization, within a maximum of 6 weeks from the accident; location of injuries - distal to the carpal bones. The exclusion criteria were: injuries above the metacarpal bones; decompensated systemic diseases; only one tendon injured; only one bone fractured; infections; arthritis; central motor neuron impairment.

The participants were categorized into two subgroups. The first subgroup consisted of 13 patients, 11 males and 2 females, aged between 31 and 64 years, who had sustained soft tissue injuries and amputations. These injuries included phalanx or finger amputations, along with complex trauma involving the skin, tendons, ligaments, muscles, nerves, and blood vessels. The second subgroup also comprised 13 patients, 10 males and 3 females, aged between 19 and 53 years, who had experienced complex soft tissue trauma and fractures of the hand bones without undergoing any amputations.

The research was conducted at the Bucharest Emergency Clinical Hospital from July 2023 to March 2024. Written consent from the patient was obtained.

Assessment protocol

We developed a comprehensive evaluation form that included both objective and subjective assessments of the patients. We conducted an initial assessment before the start of rehabilitation, an interim assessment at 4 weeks after the commencement of rehabilitation, and a final assessment at 12 weeks after the start of rehabilitation.

The assessment protocol comprised the following components: evaluating range of motion (ROM) with the Total Active Motion (TAM) Score, measuring grip strength using Jamar dynamometry, and assesing patients' quality of life through the arithmetic mean of Visual Analog Scale (VAS), Quick Dash (QD), and GAD-7 scores.

The TAM Score is calculated by adding the values of flexion at the metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints, from which the sum of the extension deficit at these joints is subtracted. For the accuracy of measurements and results, the same goniometer (Figure 1) was used for each measurement. Values are measured on both hands, and the TAM score represents the percentage of the value obtained on the affected hand compared to the value obtained on the healthy hand (Collocott et al., 2021).

Figure 1. ROM measurement using a finger goniometer

Hand grip strength assessment (Figure 2) was conducted utilizing the Jamar dynamometer (Lee et al., 2020). The procedure involved the patient sitting on a comfortable chair without elbow or forearm support, with the elbow flexed at 90 degrees and the arm positioned slightly away from the lateral chest area for enhanced accuracy. Patients were instructed to squeeze the dynamometer handle three times consecutively with each hand, exerting maximum force and sustaining the contraction for at least 5 seconds.

Figure 2. Hand grip strength assessment utilizing the Jamar dynamometer

Pain assessment was conducted using the VAS (Randall et al., 2022). Because pain is subjective, patients' self-assessment provides the most valid measure of their experience. The scale is represented by a 10 cm line, where the left end corresponds to "no pain" and the right end corresponds to the worst possible pain. The subjects were asked to mark a point on the line representing the level of pain experienced.

To evaluate quality of life, we computed the average of the percentages derived from the VAS score, GAD-7 score, and QD score. For VAS, we equated 100% with the maximum pain threshold (10). Similarly, for GAD-7, 100% corresponded to the maximum anxiety threshold (21). The Quick Dash score was expressed as a percentage. Higher scores on VAS, GAD-7, and QD indicated lower quality of life.

The Quick Dash questionnaire (Dogu et al., 2019) employs 11 items to assess the functionality and symptoms of individuals affected by musculoskeletal issues in the upper limb. Participants were requested to rate, on a scale from 0 to 5, their ability to perform specific activities using the injured hand. These activities include tasks like opening tightly closed jars, washing their back, engaging in household cleaning, or working without experiencing pain.

The GAD-7 questionnaire comprises 7 inquiries directed to the patient, designed to screen for anxiety disorders (Löwe et al., 2008). These symptoms are frequently observed in patients who have sustained hand injuries, substantially impacting their quality of life. Administering the test is brief, typically taking a few minutes, with the 7 questions centering on symptoms experienced over the preceding 2 weeks. These symptoms include pronounced anxiety, psychological tension, excessive worry, difficulty relaxing and physical restlessness, fear of impending doom, and irritability. The scoring is done by assigning 0, 1, 2, and 3 to the response categories of "not at all," "several days," "more than half the days," and "nearly every day," respectively. The GAD-7 total score for the seven items can range from 0 to 21: 0–4: minimal anxiety, 5–9: mild anxiety, 10–14: moderate anxiety, 15–21: severe anxiety.

Anxiety (related to perceived stress) is the body's natural response to perceived danger, serving as an alarm and survival mechanism. Patients experiencing anxiety may describe symptoms like nausea, dizziness, tingling sensations, alterations in breathing patterns, or a rapid heartbeat. They might also encounter sleep disturbances or persistent worrying thoughts about various aspects of life. These manifestations are indicative of anxiety and stress (Clarke, 2015).

Rehabilitation protocol

We developed a comprehensive rehabilitation protocol incorporating diverse assessments and interventions tailored to meet the requirements of patients grappling with intricate hand injuries. The objectives of the rehabilitation program encompassed pain management, reduction of soft tissue swelling, scar management, facilitation of fracture healing, enhancement of mobility, and restoration of functionality. The overarching goal was to furnish patients with a sensitive, pain-free, resilient, and flexible hand, empowering them to resume their daily activities and work (Karunadasa, 2015).

Swelling is a natural part of tissue healing and commonly affects the entire hand following injury or surgical procedures. Prolonged swelling can impede healing, increase the risk of infection, and restrict the range of motion. If swelling persists beyond 2 to 3 weeks, it can progress into chronic fibrotic swelling, prolonging the inflammatory phase. Therefore, managing edema was a primary focus of the rehabilitation process. Patients were advised that elevating the hand from day 1 post-injury or surgery is crucial, as it reduces arterial pressure and enhances venous return when the hand is positioned above heart level. Gravity assists in lymphatic drainage. Additionally, Coban compressive bandages were employed to improve capillary and venous function, thus reducing swelling (Kapan et al., 2022). Compression was initiated distally, and circulation was monitored by leaving tips free (Figure 3). Temperature manipulation, such as applying ice packs or alternating hot and cold water, aided in reducing swelling. Alternating between heat (vasodilation) and cold (vasoconstriction) while performing fist exercises stimulated lymphatic drainage. Massage techniques, including retrograde massage from distal to proximal and manual edema mobilization, promoted the flow of exudate and stimulated lymphatic activity. Active exercises were utilized to enhance blood flow, venous return, and tendon movement while managing swelling and preserving joint flexibility. Kinesio taping was employed to create negative pressure, facilitating the drainage of excess fluid through lymphatic vessels.

Figure 3. Coban compressive bandage

Scar management was another important goal in our rehabilitation protocol approach. During wound healing fibroblasts infiltrate the wound, synthesize, and secrete collagen. Myofibroblasts are what make up scar tissue, they have contractile properties and are not as elastic as normal tissue. Scars can form within healed skin, wound, tendon or soft tissue. Collagen responds to stress and change in orientation, bulk, and form. Complications of scars include adhesions, contractures, hypersensitivity, pain, and inflammation.

Massage was employed as a frequent intervention, utilizing a firm circular motion over healed scars to promote the reorientation of collagen into elongated and parallel patterns. Splinting was also utilized for contracted scars and restricted range of motion. Applying a gentle stretch with low load over an extended period was advocated to encourage the realignment of collagen fibers. The protocol encompassed Active and Passive Range of Motion exercises, recognized for their significant role in facilitating scar remodeling by applying controlled internal stress, allowing tendon excursion, and preserving joint mobility to mitigate the risk of contractures.

Splinting served various purposes, including pain relief, offering support, and maintaining specific positions during functional activities, particularly in instances of nerve palsy (Figure 4). It was also employed for protection or immobilization post-procedures such as open reduction internal fixation, as well as to prevent or correct maladaptive positions. Additionally, splinting aided in edema control and contributed to the maintenance or restoration of range of motion, especially in cases of tendon repair. Moreover, it played a role in scar remodeling (Richards et al., 2017).

Figure 4. Splinting

A range of exercises were implemented to enhance range of motion, bolster weak muscles, elongate shortened muscles, boost endurance, enhance coordination, promote nerve and tendon gliding, and reinstate function. These exercises were gradually advanced through passive, active assisted, active, and resisted stages. Additionally, the protocol encompassed proprioception training (Cantero-Téllez & Medina Porqueres, 2021), mirror therapy exercises, mechanotherapy, ergotherapy, and desensitization techniques. The frequency and repetition of exercises were tailored based on the specific goals and rationale for each exercise selection. Additional modalities employed included laser therapy, ultrasound therapy (Figure 5), galvanic iontophoresis, transcutaneous electrical nerve stimulation (TENS), electrical muscle stimulation (EMS), and neuromuscular electrical stimulation (NMES).

Figure 5. Ultrasound therapy

Patients attended the rehabilitation unit three times per week for a duration of 12 weeks. The rehabilitation program adhered to the principles of pain management and gradual progression. The participants were instructed on the lifestyle regimen and exercises they should perform at home.

Results

All the data from the study was analyzed using IBM SPSS Statistics 25 and illustrated using Microsoft Office Excel/Word 2013. Quantitative variables were tested for normal distribution using the Shapiro-Wilk Test and were written as averages with standard deviations or medians with interquartile ranges.

Quantitative variables with non-parametric distribution and repeated measures were tested between measurements using Friedman tests (with post-hoc Dunn-Bonferroni tests).

Table 1. *Comparison of grip strength (GS) scores evolution in the entire study group*

Parameter	Average ± SD	Medium (IQR)	Average Rank	P*
GS – I (p<0.001**)	2.52 ± 5.43	0 (0-2.5)	1.25	
GS – II (p<0.001**)	6.57 ± 7.94	4 (0-9.25)	1.94	<0.001
GS – III (p=0.005**)	14.69 ±13.28	11 (2.375-28.75)	2.81	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 2. *Post-hoc comparison of grip strength (GS) score evolution in the entire study group*

Parameter*	GS – I	GS – II	GS – III
GS – I	-	0.038	<0.001
GS – II	0.038	-	0.005
GS – III	<0.001	0.005	-

*Dunn-Bonferroni Post-Hoc Test; I (initial test), II (intermediate test), III (final test)

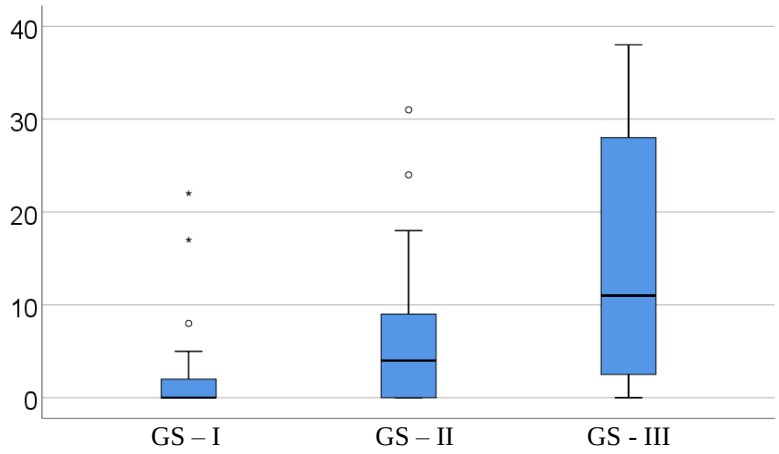


Figure 6. Comparison of grip strength scores (GS) evolution in the entire study group

The data from Tables 1, 2, and Figure 6 represent the evolution of grip power scores in the overall study group. The distribution of GS score measurements was non-parametric in most intervals, according to the Shapiro-Wilk test ($p<0.05$). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and the post-hoc Dunn-Bonferroni tests showed that the GP score value increased significantly from one measurement to the next. The differences between GP - I (median = 0, IQR = 0-2.5) and GP - II (median = 4, IQR = 0-9.25) ($p=0.038$) or GP - III (median = 11, IQR = 2.375-28.75) ($p<0.001$) were also significant, as were the differences between GP - II and GP - III ($p=0.005$). The mean difference between GP - I and GP - II was -4.05 ± 4.29 (median = -3.5, IQR = -7 - 0), and the mean difference between GP - I and GP - III was -12.17 ± 10.96 (median = -11, IQR = -18.75 - -2).

Table 3. *Comparison of Total Active Motion (TAM) scores evolution in the entire study group*

Parameter	Average ± SD	Medium (IQR)	Average Rank	P*
TAM – I (p<0.001**)	21.7 ± 24.58	7.4 (0.45-45.3)	1.25	
TAM – II (p=0.083**)	39.22 ± 28.8	32.6 (11.5-62.1)	1.94	<0.001
TAM – III (p=0.004**)	58.13 ±29.18	70.8 (2.375-28.75)	2.81	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 4. *Post-hoc comparison of Total Active Motion (TAM) score evolution in the entire study group*

Parameter*	TAM – I	TAM – II	TAM – III
TAM – I	-	0.002	<0.001
TAM – II	0.002	-	0.001
TAM – III	<0.001	0.001	-

*Dunn-Bonferroni Post-Hoc Test

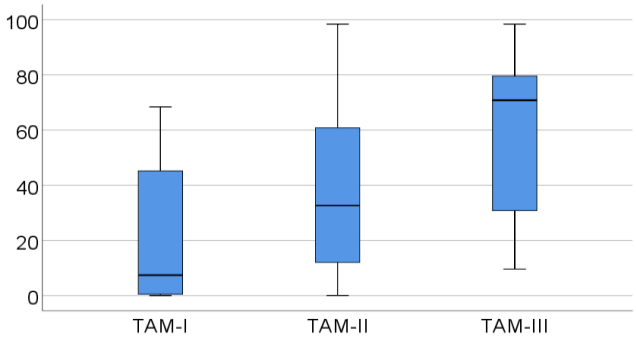


Figure 7. Comparison of Total Active Motion (TAM) scores evolution in the entire study group

The data from Tables 3, 4 and Figure 7 represent the evolution of TAM scores in the overall study group. The distribution of TAM score measurements was non-parametric in most intervals, according to the Shapiro-Wilk test ($p<0.05$). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and the post-hoc Dunn-Bonferroni tests showed that the TAM score value increased significantly from one measurement to the next. The differences between TAM - I (median = 7.4, IQR = 0.45-45.3) and TAM - II (median = 32.6, IQR = 11.5-62.1) ($p=0.002$) or TAM - III (median = 70.8, IQR = 28.9-79.8) ($p<0.001$) were also significant, as were the differences between TAM - II and TAM - III ($p=0.001$). The mean difference between TAM - I and TAM - II was -17.52 ± 11.98 (median = -15.4, IQR = -23.06 - -9.28), and the mean difference between TAM - I and TAM - III was -36.43 ± 22.19 (median = -33.72, IQR = -52.22 - -16.84).

Table 5. *Comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)*

Parameter	Average ± SD	Medium (IQR)	Average Rank	P*
GS – I (p<0.001**)	4.3 ± 7.23	0 (0-6)	1.15	
GS – II (p=0.075**)	10 ± 9.38	8 (2-14.5)	1.92	<0.001
GS – III (p=0.327**)	20.92 ±12.5	18 (10-32)	2.92	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 6. *Post-hoc comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)*

Parameter*	GS – I	GS – II	GS – III
GS – I	-	0.150	<0.001
GS – II	0.150	-	0.032
GS – III	<0.001	0.032	-

*Dunn-Bonferroni Post-Hoc Test

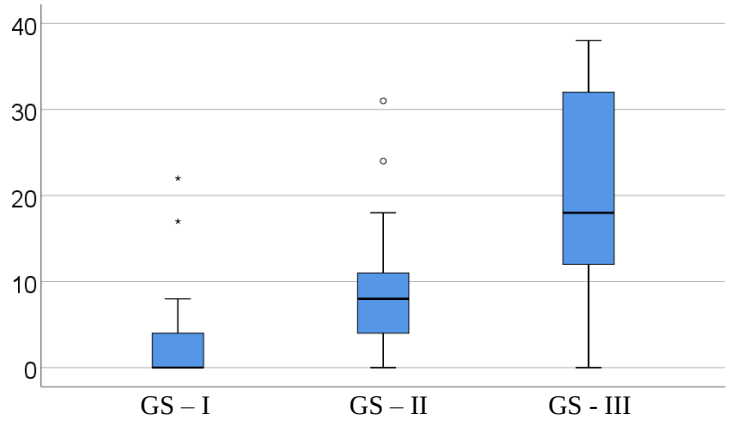


Figure 8. Comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)

The data from Tables 5, 6 and Figure 8 represent the evolution of grip strength score comparison in the subgroup of patients with soft tissue injuries and fractures (TMF). The distribution of GS score measurements was non-parametric for GS- I according to the Shapiro-Wilk test ($p<0.001$). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and the post-hoc Dunn-Bonferroni tests showed that the GS score value increased significantly. The differences between GS - III (median = 18, IQR = 10-32) and GS - I (median = 0, IQR = 0-6) ($p<0.001$) or GS - II (median = 8, IQR = 2-14.5) ($p=0.032$) were significant, but the differences between GS- I and GS- II were not statistically significant ($p=0.150$). The mean difference between GS - I and GS - II was -5.69 ± 4.9 (median = -7, IQR = -7.5 - -1) and the mean difference between GS - I and GS - III was -16.61 ± 10.3 (median = -14, IQR = -24 - -10).

Table 7. *Comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)*

Parameter*	Average ± SD	Medium (IQR)	Average Rank	P*
TAM – I	30.91 ± 25.85	21.6 (6.2-60)	1.08	
TAM – II	48.8 ± 26.62	59.2 (21.6-69)	1.92	<0.001
TAM – III	68.95 ±20.61	78.4 (50.6-80.6)	3.00	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 8. *Post-hoc comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)*

Parameter*	TAM – I	TAM – II	TAM – III
TAM – I	-	0.093	<0.001
TAM – II	0.093	-	0.018
TAM – III	<0.001	0.018	-

*Dunn-Bonferroni Post-Hoc Test

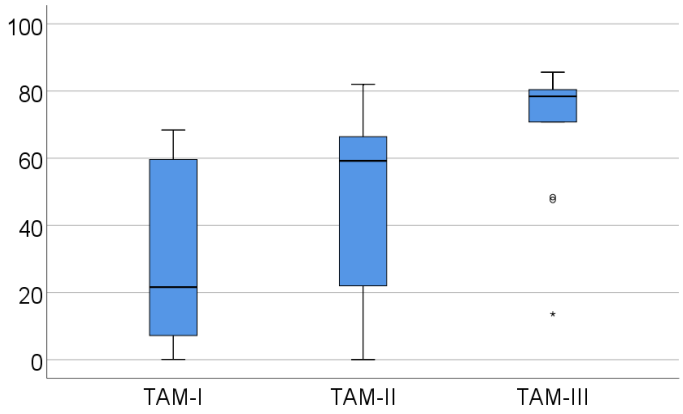


Figure 9. Comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and fractures (TMF)

The data from Tables 7, 8 and Figure 9 represent the evolution of TAM score comparison in the subgroup of patients with soft tissue injuries and fractures (TMF). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and the post-hoc Dunn-Bonferroni tests showed that the TAM score value increased significantly. The differences between TAM - III (median = 78.4, IQR = 59.6-80.6) and TAM - II (median = 59.2, IQR = 21.6-69) ($p=0.018$) or TAM - I (median = 21.6, IQR = 6.2-60) ($p<0.001$) were significant. The mean difference between TAM - I and TAM - II was -17.88 ± 11.85 (median = -16, IQR = -21.4 - -12.8), and the mean difference between TAM - I and TAM - III was -38.03 ± 22.16 (median = -39.6, IQR = -53.8 - -18.6).

Table 9. *Comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)*

Parameter	Average ± SD	Medium (IQR)	Average Rank	P*
GS – I (p<0.001**)	0.73 ± 1.48	0 (0-1.25)	1.35	
GS – II (p=0.004**)	3.15± 4.26	1.5 (0-5)	1.96	<0.001
GS – III (p=0.004**)	8.46 ±11.28	2.5 (0-13)	2.69	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 10. *Post-hoc comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)*

Parameter*	GS – I	GS – II	GS – III
GS – I	-	0.350	0.002
GS – II	0.350	-	0.187
GS – III	0.002	0.187	-

*Dunn-Bonferroni Post-Hoc Test

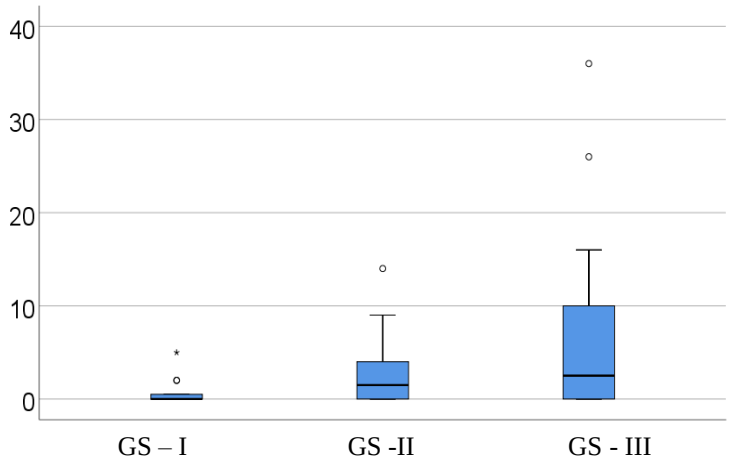


Figure 10. Comparison of grip strength score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)

The data from Tables 9, 10 and Figure 10 represent the evolutionary comparison of the grip strength score in the subgroup of patients with soft tissue injuries and amputations (AMP). The distribution of GS score measurements was non-parametric according to the Shapiro-Wilk test ($p<0.05$). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and Dunn-Bonferroni post-hoc tests showed that the GS score value increased significantly, with the differences between GS - I (median = 0, IQR = 0-1.25) and GS - III (median = 2.5, IQR = 0-13) ($p=0.002$) being significant, but the differences observed between GS-I and GS-II ($p=0.350$) or GS-II and GS -III ($p=0.187$) were not statistically significant. The mean difference between GS - I and GS - II was -2.42 ± 2.93 (median = -1.5, IQR = -4 - 0), and the mean difference between GS - I and GS - III was -7.73 ± 10.06 (median = -2.5, IQR = -13 - 0).

Table 11. *Comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)*

Parameter	Average ± SD	Medium (IQR)	Average Rank	P*
TAM – I (p<0.001**)	12.49 ± 20.17	0.64 (0.24-27.9)	1.00	
TAM – II (p=0.031**)	29.65 ± 28.64	17.6 (7.72-53)	2.04	<0.001
TAM – III (p=0.090**)	47.31 ±33.1	34.4 (15.8-78.8)	2.96	

*Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, **Shapiro-Wilk Test

Table 12. *Post-hoc comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)*

Parameter*	TAM – I	TAM – II	TAM – III
TAM – I	-	0.024	<0.001
TAM – II	0.024	-	0.056
TAM – III	<0.001	0.056	-

*Dunn-Bonferroni Post-Hoc Test

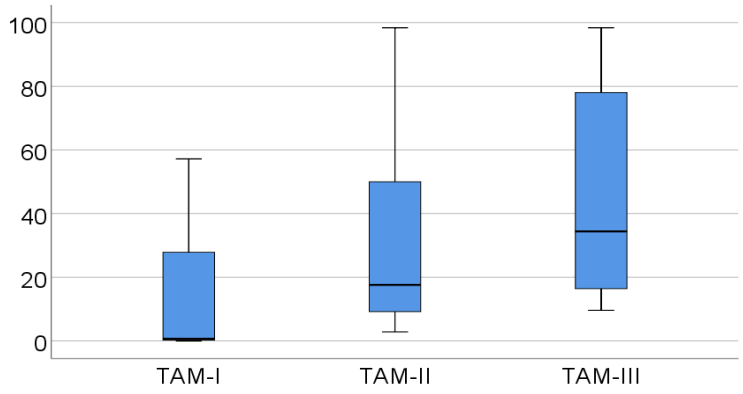


Figure 11. Comparison of TAM score evolution in the subgroup of patients with soft tissue injuries and amputations (AMP)

The data from Tables 11, 12 and Figure 11 represent the evolutionary comparison of the TAM score in the subgroup of patients with soft tissue injuries and amputations (AMP). The distribution of TAM score measurements was non-parametric in most intervals, according to the Shapiro-Wilk test ($p<0.05$). The differences between intervals were statistically significant according to the Friedman test ($p<0.001$), and Dunn-Bonferroni post-hoc tests showed that the TAM score value increased significantly, with the differences between TAM - I (median = 0.64, IQR = 0.24-27.9) and TAM - II (median = 17.6, IQR = 7.72-53) ($p=0.024$) or TAM - III (median = 34.4, IQR = 15.8-78.8) ($p<0.001$) being significant, but the evolution from TAM - II to TAM - III was not statistically significant ($p=0.056$). The mean difference between TAM - I and TAM - II was -17.16 ± 12.6 (median = -11.04, IQR = -27.8 - -7.205), and the mean difference between TAM - I and TAM - III was -34.82 ± 23 (median = -29.84, IQR = -54.96 - -15.28).

To assess the quality of life, we used the arithmetic mean of the percentages for the VAS score, the GAD-7 score, and the QD score. For VAS, we considered 100% for the maximum pain threshold (10). For GAD-7, we considered 100% for the maximum anxiety threshold (21). For Quick Dash, the value was expressed in percentage. The higher the VAS, GAD-7, and QD scores, the lower the quality of life

Table 13. *Analysis of distribution between the two groups, AMP and TMF at the initial assessment - we used the Independent Samples T-test.*

Parameter*	AMP	TMF
Mean	80.2772	79.3705
Variance	464.15	314.452
Observations	13	13
Pooled Variance	389.301	
Hypothesized Mean Difference	0	
df	24	
t Stat	0.11716	
P(T<=t) one-tail	0.45385	
t Critical one tail	1.71088	
P(T<=t) two-tail	0.90771	
t Critical one tail	2.0639	

Interpretation: P(T<=t) two-tail > 0.05 => there is no significant difference between the means of the two groups (Table 13).

Table 14. *The analysis of the distribution between the two groups AMP and TMF at the interim assessment*

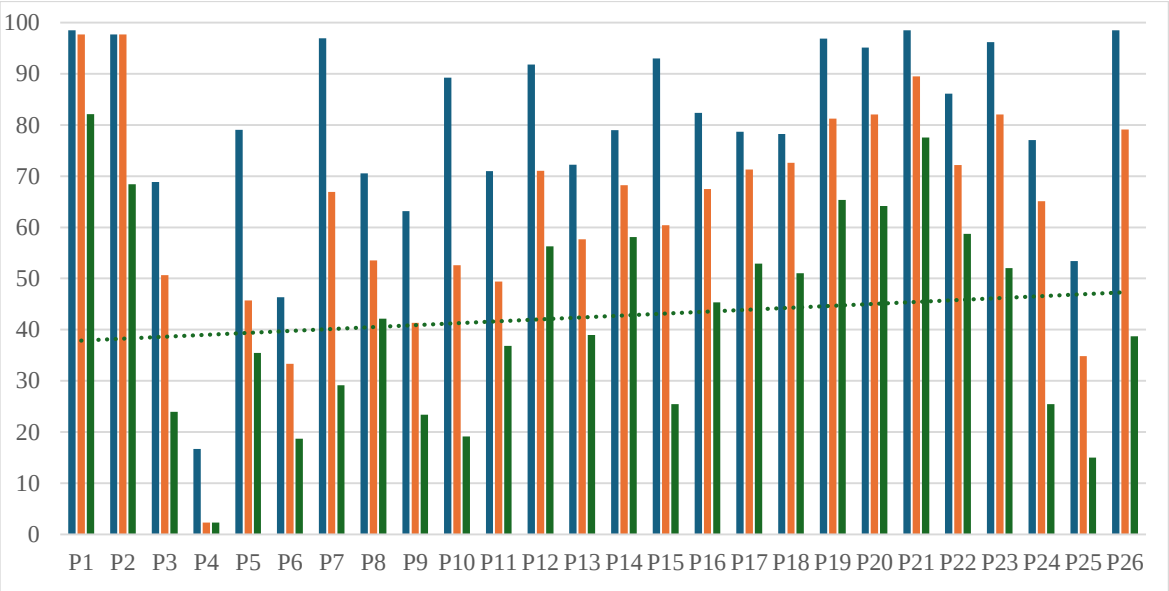
Parameter*	AMP	TMF
Mean	67.59	59.0379
Variance	554.454	365.266
Observations	13	13
Pooled Variance	459.89	
Hypothesized Mean Difference	0	
df	24	
t Stat	1.01676	
P(T<=t) one-tail	0.1597	
t Critical one tail	1.71088	
P(T<=t) two-tail	0.31941	
t Critical one tail	2.0639	

Interpretation: P(T<=t) two-tail > 0.05 => there is no significant difference between the means of the two groups (Table 14).

Table 15. *The analysis of the distribution between the two groups AMP and TMF at the final assessment*

Parameter*	AMP	TMF
Mean	53.2974	31.8271
Variance	401.243	224,911
Observations	13	13
Pooled Variance	313.077	
Hypothesized Mean Difference	0	
df	24	
t Stat	3.09364	
P(T<=t) one-tail	0.00248	
t Critical one tail	1.71088	
P(T<=t) two-tail	0.00496	
t Critical one tail	2.0639	

Interpretation: P(T<=t) two-tail < 0.05 => there is a significant difference between the means of the two groups; we observe that for those with TMF, the quality of life has significantly improved compared to those in the AMP group (Table 15).



Note. P1-P26 represent the study participants, and 0-100 represents the percentage value indicating the quality of life of the pacients. Blue = Initial evaluation; Orange = Intermediate evaluation; Green = Final evaluation.

Figure 12. The evolution of the quality of life of all participants

Figure 12 illustrates the progression of each patient's quality of life across the initial, intermediate, and final evaluations. While the data demonstrate an overall upward trend, statistically significant improvement was observed only between the intermediate and final assessments. No significant differences were found between the initial and intermediate evaluations, as supported by the results presented in Tables 13 and 14.

Discussions

Based on statistical analysis, after implementing the therapeutic protocol, a notable enhancement in the condition of patients across the entire group was noted. Specifically, there were increases in grip strength and finger joint mobility of the injured hand, along with significant reductions in psycho-emotional distress levels between initial and final evaluations, as well as between interim and final evaluations. Additionally, there was a substantial improvement in patients' overall quality of life.

The therapeutic process was primarily constrained by the compromised anatomical integrity of the hand, with the most affected individuals being those who had undergone amputations. The physical therapy protocol following surgery for hand flexor tendon injuries often includes a combination of a set of phasic exercises and wearing an orthosis, plus other means of therapeutic intervention, usually done together. Peters et al. (2021) considered that the effectiveness of these interventions remains unclear. Therefore, it is necessary to evaluate the effects (benefits and damages) of these rehabilitation interventions.

The study by Kovacs et al. (2011) explores the quality of life in 118 patients who suffered severe hand injuries. Each patient responded to five different validated rating scales: DASH, FLZM, HADS, BDDE-SR and FBeK, which were incorporated into a single questionnaire. Each of these questionnaires covered one or more of the established domains of quality of life.

The study reveals that overall life satisfaction in this study group with hand injuries is highly dependent on patients' satisfaction with their health and appearance, as well as self-confidence.

Therapy involves a mutual effort, where therapists must motivate, reassure, and educate patients about their healing process, limitations, and prognosis. Simultaneously, patients must actively engage in prescribed tasks and adhere to treatment plans. Functional activities and job-oriented rehabilitation enable patients to concentrate on tasks rather than specific movements. It's essential to discuss with patients their roles, interests, and any activities that inspire them, setting goals related to these activities. By making therapy and rehabilitation purposeful and meaningful to the patient, compliance can be enhanced. There are endless possibilities to engage and enhance a patient's recovery, such as adjusting tasks by increasing weight, object size, grip strength, and repetitions.

Conclusion

The hypothesis is confirmed by the assessments and that statistical data, the individualized rehabilitation protocol has significantly improved the range of motion, grip strength and patients‘ quality of life.

The recovery of the hand after severe trauma can vary significantly based on the nature and severity of the injury and the patient’s particularities. Individulization of the rehabilitation protocol is the key for the best result.

The multidisplinary team plays a central role in the therapeutical process. The patient-physiotherapist colaboration is extremely important for the patient’s motivation and determination in order to reach the rehabilitation goals.

Based on the statistical analysis of the outcomes, we recommend early integration of the patients into the therapeutic recovery process post-surgery, thus mitigating the adverse effects of prolonged immobilization.

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Institutional Review Board Statement: The research was conducted according to the principles stated in the Declaration of Helsinki and approved by the Research Ethics Committee of UNEFS Bucharest (number assigned 34/20.01).

Informed Consent Statement: The written informed consent was obtained from all participants involved in this study.

Data Availability Statement: Data are available upon request to the contact author.

Conflicts of Interest: The authors declare no conflict of interest.

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