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Original Article

Effectiveness of the active physical therapy in restoring wrist and hand functional ability in patients with immobility-induced contracture of the wrist joint complicated by median nerve entrapment owing to distal forearm fracture

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Abstract:
The high prevalence of complex upper extremity injuries, intricate anatomy, and high demand on fine motor skills require a novel approach to restore their function. **Objective:**To determine the effectiveness of the developed physical therapy program by evaluating the forearm and wrist functional outcomes in patients with immobility-induced contractures of the wrist joint complicated by median nerve entrapment. **Method:**We examined 56 patients with immobility-induced contracture of the wrist joint complicated by median nerve entrapment owing to distal forearm fracture. The patients were divided into two groups, i.e., the control group (received outpatient rehabilitation program with theprevailing use of passive methods such as manual techniques and, preformed physical factors) and the treatment group (received developed ICF-based physical therapy program with the prevailing use of active methods such as functional training, massage, moist warm compress combined with postisometric muscle relaxation, positional release therapy, and kinesiotaping). The effectiveness of the developed program was assessed in terms ofthe presence and degree of pain (VAS and DN4), goniometry results, signs of median nerve irritation (Hoffman–Tinnel sign, Phalen's test, and Durkan's test), Frenchay Arm Test, ABILIHAND, DASH, Boston Carpal Tunnel Questionnaire, and HADS. **Results:** After receiving rehabilitation, all of the patients showed a decrease in the intensity of pain at rest and duringmovement(VAS). There was an improvement in wrist joint motion (goniometry results) and a decrease in median nerve entrapment (pain intensity in DN4, prevalence of specific symptoms, and Boston Carpal Tunnel Questionnaire). There was also an improvement in the upper extremity function inABILIHAND, DASH, and Frenchay Arm Test. The psycho-emotional stress (HADS) was reduced to subclinical level and normal level in the control and treatment groups, respectively. Based on the studied outcome indicators, the patients fromboth groups showed a statistically significant improvement compared to the baseline values ($p< 0.05$); however, the treatment group demonstrated better outcomes compared tothe control group ($p< 0.05$). **Conclusions:**The developed physical therapy program with the prevailing use of active rehabilitation methods showed a statistically significant improvement in thefunctional ability of distal upper extremity, a reduced severity of median nerve irritation signs, and an improved psycho-emotional state compared tothe outpatient rehabilitation program.
KeyWords: trauma, upper limb, wrist, contracture, median nerve, physical therapy exercises

Introduction

According to the literature, 76–86% of working age population suffer injuries of the distal parts of upper extremity of various severity (Crowe, Massenburg, Morrison, & al., 2020; Kılıç, Adıyaman, Sezer, & Cantürk, 2017). Among them, approximately 50% account for forearm and wrist injuries; almost one third of all bone fractures involve the damage of the wrist joint structures (Albanese, Marini, Taglione, & al., 2019). The social disability of this patient group largely depends on restricted professional activity, i.e., a decrease in qualification, limited training and re-training opportunities, and inability to work in the speciality field. (Akimova, Savchenko, & Gladkova, 2009; Naumenko, 2008).

The treatment of distal forearm fractures is performed conservatively or surgically by closed or open reposition and fragment fixation with an immobilizing bandage from the distal palmar crease to the middle or upper third of the shoulder (Rushai, & Klimovitsky, 2002; Sabapaty, 2016). Prolonged immobilization disrupts muscle neurotrophic control, which (combined with joint dysfunction and anatomical consequences of structural lesion) leads to the most common complication of the musculoskeletal trauma, i.e., immobility-induced contracture. Contractures arising from the multistructural injury of upper extremity with bone, tendon, nerve, and blood vessel damage, which account for 31–57% of all extremity injuries,are a key challenge to the rehabilitation process (Bismak, & Shestopal, 2020; Rolik, Ganich, & Kolisnik, 2004)

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Disability owing to wrist joint injury is usually caused by false joints – 1.5%, nonunions – 5.1%, contractures – 87.6%, and ankylosis – 5.1% (Crowe , Massenburg, Morrison, & al., 2020; Giummarra, Cameron, Ponsford, & al., 2017). The functional ability of the wrist joint mostly determines hand manipulation skills becauseit contains finger flexors, extensor tendons, and neurovascular bundle, which ensure fine motor skills (Lazareva, Aravitska, Andrieieva, Galan, Dotsyuk, 2017)

The most common complications,which greatlyreduce the functional ability of distal parts and entire upper extremity after injury and immobilization, are the tunnel syndromes, complex regional pain syndrome (Sudeck atrophy), Dupuytren's contracture, and improper healing of bone fragments (Rushai,&Klimovitsky, 2002; Wollstein, Harel, Lavi, & al., 2019). Peripheral nerves, which are located in narrow anatomical canals, are more susceptible to trauma. Excessive flexion or extension, traction owing to fractures, soft tissue compression, hematoma, and later on – scar tissue, friction, and trauma owing to callus during active movements lead to post-traumatic tunnel syndromes (Bismak, 2019; Wollstein, Harel, Larevi & al., 2019).

Along with the treatment of injury and its consequences through restoring damaged structures and anatomical integrity, the functional restoration of the impaired extremity is essential because the residual effects can cause permanent reduction of work ability, work disability, and even further disability. According to some researchers, 20–40% of patients (who suffered fractures of the radial bone metaepiphysis and epiphysis) reported negative treatment outcomes (Byrchak, Duma, & Aravitska, 2020; Crowe, Massenburg, Morrison, & al., 2020), which, in at least half of the cases, was directly linked to insufficient rehabilitation. These data justifies further research endeavors in this field. Therefore, the best possible structural and functional recovery using physical therapy should be the goal of the long-term rehabilitation ofthe abovementioned fractures because it directlyaffects the patient quality of life and further socialization prospects (Bogolyubov, 2006; Lazareva, Aravitska, Andrieieva, & al., 2017; Turner, & Hilton-Jones, 2014).

Previous studies have shownthat restoring patient's self-care and professional skills after distal upper extremity injuries, in particular complex ones, has a considerable social and economic impact on the society. These resultssupport the relevance of this research as well as its theoretical and practical value. **Objective:** To determine the effectiveness of using activephysical therapy methods torestore the functional ability of the wrist and hand by assessing motor, sensory, and functional indicator dynamics in patients with immobility-induced contracture of the wrist joint complicated by the median nerve entrapment owing to distal forearm fractures.

Materialsand methods

Participants

We examined 56 people with immobility-induced contracture of the wrist joint owing to the conservative treatment of distal forearm fractures complicated by median nerve entrapment.

Inclusion criteria:

• Early post-immobilization period for the conservative treatment of distal forearm fractures (according to the classifications AO/ASAIF 23-A2.1-3, 23-A3.1-3, 23-B1.1-3, 23-B2.1-3, 23-B3.1-3, 23-C1.1-3, 23-C2.1-3, and 23-C3.1-3) (Kellam, 2018);

• Criteria for applying an immobilizing circular plaster cast bandage from the base of the fingers to the middle or upper third of the forearm.

Exclusion criteria:

• rheumatic/traumatic/neurological lesion of healthy or injured hand in medical history or at the time of examination;

• immobilization with a circular plaster cast bandage with fixation of the elbow joint or with a brace.

Subjects were divided into two groups [i.e., the control group (CG) and the treatment group (TG)]by simple randomization.

Procedure

The CG patients (16 males, 13 females, 41.6 ± 4.7 years old) underwent rehabilitation according to the principles recommended for use duringthe post-mobilization period of forearm injuries in the area of the wrist joint in outpatient hospital settings (Bogolyubov, 2006; Popov, Valeev,. & Garaseeva, 2008). One of the characteristic features of restoration measures practiced in Ukraine is the prevailing use of passive methods (approximately75% of the total rehabilitation time) such asmassage, physical factors (e.g., thermal procedures and electrical stimulation) applied to the wrist joint and forearm muscles compared with the active methods (e.g., kinesiotherapy) (only 25% of the total rehabilitation time).

The TG patients (15 males, 12 females, 38.1±3.4 years old) underwent rehabilitation according to the developed physical therapy program with the prevailing use of active methods and ICF (The International Classification of Functioning, Disability, and Health) based on a complex functional approach to physical therapy. The recovery time in the developed program for passive and active methodswas 25% and 75%, respectively. This approach allowed us to assess the effect of active methods (i.e., therapeutic exercise) and other methods of motor training on the structure and function indicators of distal upper extremity.

The initial examination of all patients was performed duringthe early post-mobilization period. Restoring interventions for both groups were implemented during the outpatient rehabilitation phase (the course

lasted 1.5 months; interventions were performed 3times a week; each session lasted for 1 h). The effectiveness of methodsused was assessed in dynamics before (pre-test) and after (post-test) implementation.

During the rehabilitation, individual short- and long-term goals were set for each patient in the "SMART" format (i.e., S – specific, M – measurable, A – achievable/attainable, R – relevant, T – time-bound) by accounting for the obtained data on patient's health condition and contextual factors (The International Classificationof Functioning, Disability and Health, 2001; Escorpizo, Stucki, Cieza, & al., 2010).

The developed physical therapy program was divided into three periods:

1. Gentle period (2 weeks):

- lymphatic drainage massage of the hand, wrist joint, forearm, and shoulder;
- mild functional training of the forearm and hand;
- combination of moist warm compress application based on thermopackage, combined with postisometric relaxation of the forearm and hand muscles;
- position release therapy in the achieved correction positions using individual dynamic wrist joint orthoses made of low-temperature plastic;
- kinesiotaping of the forearm, wrist joint, and hand.

2. Gentle training period (3 weeks):

- gentle hand, wrist joint, forearm, and shoulder massage with elements of movement in the wrist joint;
- trademark application of moist warm compress based on thermopackage combined with postisometric muscle relaxation;
- functional training of the forearm and hand using "Thera-Band" hand trainers;
- kinesiotaping of the forearm and hand.

3. Training period (3 weeks):

- toning and vibration massage of the hand, wrist joint, forearm, and shoulder with elements of movement in the wrist joint;
- functional training of the forearm, hand and shoulder muscles; resistance and weight exercises (using tape and "Thera-band" hand trainers, "Powerball" gyroscope).

The advantages of the developed program include the functional approach based on changes detected by tests; individual approach through setting short- and long-term rehabilitation goals; combination of classic and modern rehabilitation methods; financial affordability; ease of reproduction in any rehabilitation institution environment.

The study used tests, which allowed to assess all ICF domains – the state of "Body Function and Structures", as well closely related to hand injury "Activity" and "Participation" domains (The International Classification of Functioning, Disability and Health, 2001).

Pain was assessed by the Visual Analogue Scale (VAS) intensity parameters (at rest and duringa movement)(Masur, Papke, Althoff, & al., 2004); its neuropathic component was assessed by Douler Neuropatique 4 questions (DN4) (Bouhassira, & al., 2005).

The severity of immobility-induced contracture during wrist joint movements (flexion, extension, abduction, and reduction) was assessed by goniometry (Buckup, 2020).

Median nerve entrapment was defined as a sum of specific signs in positive provocative tests: Phalen's (wrist flexion), Durkan's (finger compression of the wrist), Hoffmann–Tinnel (percussion of the carpal tunnel), and presence of neuropathic pain (DN4 questionnaire)(Belova, 2014; Buckup, 2020).

Functional capabilities of the forearm and wrist ("Activity" and "Participation" domains) were evaluated by comprehensive tests usingstandard scales, i.e., "Ability of hand" – ABILIHAND (performing basic household and professional manipulations); Frenchay Arm Test (performing standard test tasks with injured hand); Disability of the Arm, Shoulder and Hand Outcome Measure – DASH (unified assessment of whole arm function) (Belova, & Schepetova, 2002; Belova, 2014; Wade, 1992).

The severity of median nerve entrapment signs and its impact on the patient's quality of life were determined by the Boston Carpal Tunnel Questionnaire (Levine, Simmons, Koris, & al., 1993), which was divided into subscales, i.e., Symptom Severity Scale (SSS) and Function Status Scale (FSS).

The Hospital Anxiety and Depression Scale (HADS) was used to assess symptoms of anxiety and depression (which arise from negative emotions, stress, pain, somatic discomfort) and complicate the rehabilitation process, which directly affects patient's activity and participation (Belova, & Schepetova, 2002).

The ICF-based assessment of the nature and degree of the upper extremity dysfunction at the start and during rehabilitation is convenient becausesuch results provideus numeric values of the disorder and also reveal individual weaknesses of hand motor function, which helps tosetindividual short-term rehabilitation goals and develop a kinesiotherapy program that is based on functional training, objectivisation of recovery dynamics, outcome prediction, and correction of physical therapy programs.

This research study was conducted in accordance with "Good Clinical Practice" principles. Informed patient consent was obtained from each participant of the study.

Statistical analysis

Generalization of the studied characteristics was assessed using arithmetic value and standard deviation. Confidence of differences between mean values was assessed by Student's t-criterion.

Assessment of statistical hypotheses was based on a 5% significance level. For statistical data processing, a licensed Microsoft Excel Program (2010) was used. Statistical analysis of the obtained results was performed by considering the Microsoft Excel table usage recommendations for computer data analysis.

Results

The post immobilization period in patients with distal forearm fractures was complicated by the tunnel syndrome and was characterized by disorders in all ICF domains – "Body Function and Structures", "Activity", and "Participation".

Functional tests selected as indicators of impaired structure and function demonstrated the following results.

After the removal of immobilization, patients were presented with pain in the wrist joint; the intensity on VAS was weak at rest and moderately strong duringmovements (Table 1). Pain is one of the key subjective signs of tissue structure disruption; fear of pain interferes with movements and worsens the rehabilitation prognosis.

Another characteristic of pain was its neuropathic nature, which indicated the damage of nervous tissue – more than 4 points on the DN4 scale in both groups.

Table 1. Dynamics of pain intensity in the wrist joint in patients undergoing physical therapy

Pain intensity, scores	Pre-test					Post-test					
	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the control and treatment groups	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the pre-test and post-test	p between indicators of the control and treatment groups
	M	m	M	m		M	m	M	m		
VAS											
At rest	2.11	0.23	2.14	0.19	>0.05	0.67	0.15	0.21	0.08	<0.05	<0.05
Duringmovement	5.30	0.16	5.17	0.14	>0.05	3.04	0.16	1.03	0.14	<0.05	<0.05
DN4	5.52	0.24	5.34	0.22	>0.05	2.26	0.26	0.97	0.19	<0.05	<0.05

According to goniometry results, the motor pattern of the wrist joint in the examined patients significantly differed compared to that in the unaffected side. This observation was supported by the near twofold reduction of movement amplitude in both patient groups (flexion, extension, abduction, and adduction) compared to a healthy limb (Figure 1). Evidently, this may be due to multistructural disorders in injured tissues and immobility-induced hypodynamic and ischemic changes.

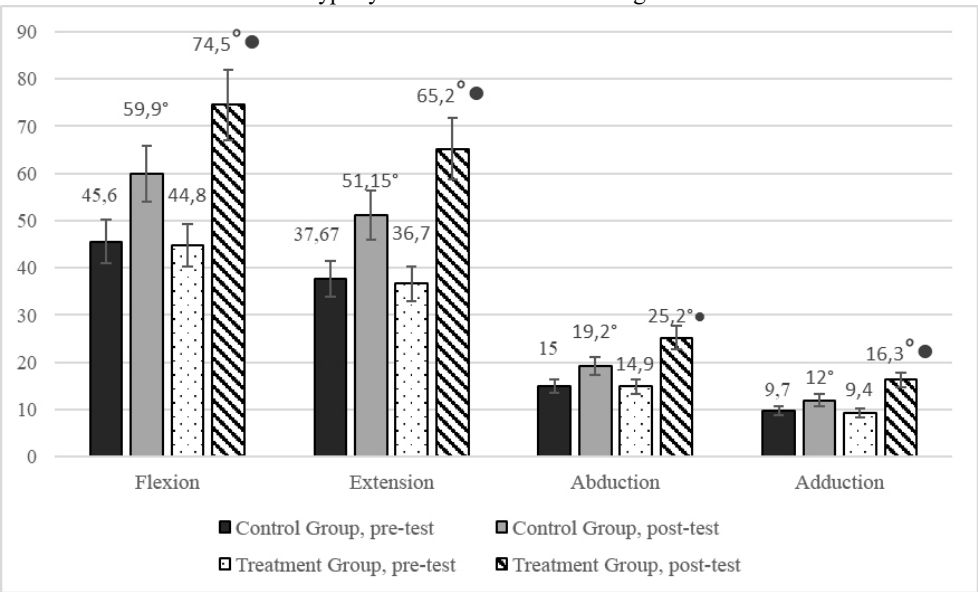

Figure 1. Dynamics of the wrist joint goniometry results of the injured hand in patients undergoing the physical therapy program (degrees). Notes: °– $p < 0.05$ – level of reliability of changes between indicators of pre-test and post-test; ● – $p < 0.05$ – level of reliability ofchanges between indicators of CG and TG

Median nerve entrapment owing to immobilization was characterized by positive median nerve irritation tests: Hoffman–Tinnel (77.78% of CG and 75.86% of CO), Durkan's (92.59% and 89.66%, respectively), Phalen's (74.07% and 72.41%, respectively).

Structural and anatomical damage to bone elements and surrounding soft tissues arising from trauma and subsequent immobilization has led to significant impairment of activity and participation in patients owing

to the complexity of numerous everyday household and professional manipulations and dysfunction of the forearm and wrist. The Frenchay Arm Test revealed low functional ability of the distal parts of injured upper extremities, which resulted in acomplication or inability to perform all test tasks (Table 2). Posttraumatic loss of structure and function also resulted in low ABILIHAND and DASHscores (Table2).

Table 2. Dynamics of activity and participation results in patients undergoing the physical therapy program

Tests, scores	Pre-test					Post-test					
	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the control and treatment groups	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the pre-test and post-test	p between indicators ofthe control and treatment groups
	M	m	M	m		M	m	M	m		
ABILIHAND	68.86	1.92	71.48	2.01	>0.05	96.89	1.54	118.41	1.45	<0.05	<0.05
DASH	73.11	1.63	70.34	1.80	>0.05	38.74	1.43	23.41	1.34	<0.05	<0.05
FrenchayArmTest	2.74	0.22	2.69	0.20	>0.05	3.15	0.30	4.14	0.19	<0.05	<0.05

The Boston Carpal Tunnel Questionnaire showed signs of median nerve entrapment in the examined patients on the subscale Symptom Severity Scale as well as their significant effect on the quality of life and functioning on the subscale Function Severity Scale (Figure 2).

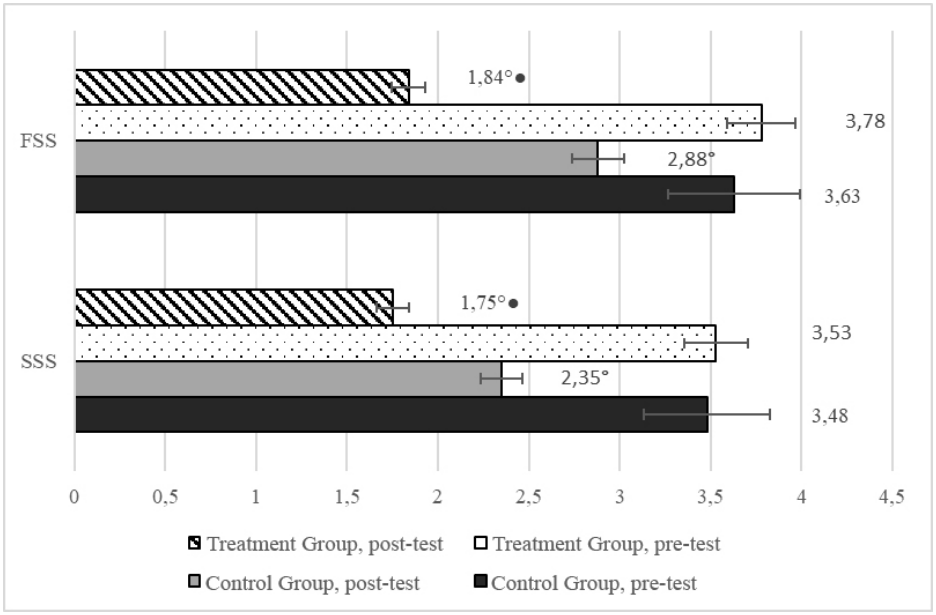

Figure 2. Dynamics of Boston Carpal Tunnel Questionnaire results in patients undergoing the physical therapy program (scores). Notes: ° – $p < 0.05$ – level of reliability ofchanges between indicators of the pre-test and post-test; ● – $p < 0.05$ – level of reliability ofchanges between indicators of CG and TG

Impaired social functioning owing to impaired wrist function, presence of pain, prolonged work disability, and fear of possible loss of skills and earnings owing to inability to perform routine manipulations has contributed to emotional disorderssuch assigns of anxiety and depression. HADS demonstrated changes in the examined patients duringthe initial clinical level (Table 3).

Table 3. Dynamics of anxiety and depression (HADS) in patients undergoing the physical therapy program

Subscale scores	Pre-test					Post-test					
	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the controland treatment groups	Control group, (n = 27)		Treatment group, (n = 29)		p between indicators of the pre-testand post-test	p between indicators of the controland treatment groups
	M	m	M	m		M	m	M	m		
Anxiety	11.89	0.44	11.07	0.35	>0.05	8.37	0.33	2.83	0.40	<0.05	<0.05
Depression	12.11	0.43	11.76	0.47	>0.05	9.04	0.32	3.28	0.35	<0.05	<0.05

According to the results of initial examination, the patients fromthe treatment and control groups did not differ from each other (p> 0.05), i.e., they were comparable, which allowed us to conduct thenext study aimed at correction of identified pathological signs.

According to the program implementation results aimed at restoring the functional ability of upper extremity, the re-examination after corrective intervention was performed, and the following results were obtained.

Pain in the wrist joint under the influence of rehabilitation decreased in both study groups (Table 1). At rest, it was almost undetectable, present only in isolated cases, and its intensity was negligible. However, in CG, it was still more common; the overall dynamics of pain reduction at rest was 68.42% in CG and 90.32% in TG. Movement provocation showed that structural and functional restoration was more consistent in TG patients who showed an 80% reduction in pain inVAS compared to42.66% in CG.

TheVAS pain level dynamics ofboth groups showed a statistically significant improvement compared to baseline values (p< 0.05); however, in TG patients, the level of pain at rest and duringmovement was better than in CG patients (p< 0.05).

Duringthe process of identifying pain intensity, which is indicative of nerve trunk lesions, it was established that re-examination ofCG patients identified its individual features but did not reach the level of neuropathic pain (a decrease in intensity of56.95%). At the same time, in TG patients, it was not actually identified and was statistically significantly better compared to baseline values and also toCG (a decrease in intensity of81.84%) (Table 1).

The dynamics of goniometric examination results also showed the advantages of developed physical therapy program, which resulted in a significant improvement of the pattern of movements of the wrist joint compared toa healthy limb. There was a statistically significant improvement in flexion and extension movements in Cos, i.e.,by 66.22% and −77.67%,respectively, (in CG patients, byonly −31.37% and 35.78%); abduction and adduction, by 68.14 % and 73.56% (in CG, by27.33% and 23.20%) (Figure 1).

Upon re-examination, the frequency of median nerve irritation signs decreased in both groups, which indicated a decrease in inflammatory and edematous changes in the injured area. These signs also indicated the advantages of the developed physical therapyprogram. Specifically, the frequency of detection of the Hoffman–Tinnel sign in CG decreased by 48.15%, in TG – by 65.52%, Durkan's – by 66.66% and 75.87%, respectively, Phalen's – by 37.03% and 58.62%, respectively.

The effect of using functional approach and active kinesiotherapy in the developed physical therapy program is observed in the forearm and hand function test results. TG patients showed a statistically significant improvement in hand function compared to the baseline values and CG patients in all tests performed (p< 0.05), which indicated the recovery of wrist structure and function in everyday and professional activity. The Frenchay Arm Test showed an improvement infunctional ability of only 14.96% in CG, ABILIHAND – of 40.71%, DASH – of 47.01%, while the corresponding parameters in TG were 53.90%, 65.65%, and 66.72% (Table 2).

There-survey of Boston Carpal Tunnel Questionnaire showed better outcomes in TG. Specifically, the SSS score improved by 50.31%, and the FSS score improved by 49.11% (in CG,the scores improved by 32.59% and 23.90%, respectively) (Figure 2).

The improved functioning of the forearm and hand as the main organ of fine manipulations resulted in decreased psycho-emotional stress, which wasobserved in improved HADS results (Table 3) compared to baseline values (p< 0.05) in all examined patients. However, the number values of anxiety and depression in CG decreased only to the level of subclinical signs (decreased by 29.60% and 25.35%, respectively), while TG reached normal values (decreased by 74.44% and 72.11, respectively).

Based on the studied outcome indicators, patients fromboth groups showed a statistically significant improvement compared to the baseline values (p< 0.05); however, the treatment group demonstrated better outcomes compared tothe control group (p< 0.05).This result indicates the higher effectiveness of using active physical therapy forthe studied pathology.

Discussion

Rehabilitation of trauma patients in the context of complete functional recovery is as important as their treatment, especially ofpatients with wrist injuries, who are the most numerous target group of rehabilitation facilities (Crowe, Massenburg, Morrison, et al., 2020). This is preconditioned by the essential role of the distal upper extremity in everyday life, self-care, routine and professional activities becausethe most important function of the wrist is the motor one (i.e., its ability to grasp and manipulate), which is frequentlyaffected (Giummarra, Cameron, Ponsford,&al., 2017).

It has been confirmed and recommended to include various methods for patient rehabilitation duringthe post-immobilization period such as kinesiotherapy, manual techniques (massage, manual therapy), preformed physical factors, and mechanical therapy. Their effect on the course of traumatic disease is well-illustrated in numerous scientific journals (Albanese, Marini, Taglione, & al., 2019; Crowe, Massenburg, Morrison, & al., 2020; Popov, Valeev, & Garaseeva, 2008). Rehabilitation interventions contribute to the consistent regression of clinical manifestation, increase the motion range of immobilized joints, increase daily activity, and improve the quality of patients life and ability to perform movements independently (everyday and professional

manipulations), and positivelyaffect patient's psychological well-being (Kılıç, Adıyaman, Sezer,&Cantürk, 2017; Mayland, Hay-Smith,&Treharne, 2015). However, a common disadvantage of recovery programs is the misuse of passive techniques with unproven or low clinical efficacy (Bogolyubov, 2006; Goldblat, 2015).

The occurrence of post-immobilization complications owing to injuries is associated with several factors that accompany acute and subacute phases such as pain, immobilization, and formation of anatomical structural defects. Persistent pathological changes in the distal parts of upper extremities can be manifested in the long term by serious functional limitations such as the inability to clench the fist. Lack of normalization of motion range may be associated with a complex clinical course of injury, severe damage to the ligaments, incomplete anatomical coincidence (congruence of joints), muscle atrophy, chronic vascular and neurological changes (Rushai,&Klimovitsky, 2002; Wollstein, Harel, Lavi,&al., 2019). In such cases, the purpose of physical therapy is to compensate at the expense of preserved tissues, to improve the quality of patient life, and to restore routine household functions (The International Classification of Functioning, Disability and Health, 2001).

One of the features of immobility-induced median nerve entrapment is its close etiological and pathogenetic connection with the clinical course of general post-immobilization impact. Ischemic, neurotrophic, and other changes in tissues cause mechanical and inflammatory disorders which decrease tissue mobility and increase intra-tissue pressure (Bobowik, 2019;). Decreased nerve mobility during limb movements leads to its microtrauma followed by the formation of adhesions, which further restrict nerve movement, disrupt blood flow, and contribute to the swelling of the nerve sheath and compression of nerve fibers (Goldblat, 2015). At the same time, these changes are reversible and not very pronouncedbecause they occurin the intact nerve relatively shortly before the time of diagnosis and corrective interventions.

Therefore, during the process of physical therapy program development, we addressed several key issues at the ICF "Structure" and "Function" domain level such as the elimination of pain, prevention of edema in the area of injury, improvement of blood and lymph circulation, stimulation of nerve conduction, improvement of tissue regeneration and mobility, prevention of nerve adhesion. In addition, we followed the principles of active functional training focused on exercise performance similar to everyday household activities that maypossibly improve test results in the "Activity" and "Participation" domains. By incorporating the ICF principles into the physical therapy program development allowed us to set individual short- and long-term rehabilitation goals at the stage of patient examination and to plan and perform interventions based on the patient-centered approach, which is the optimal way to achieve the full restorative effect (The International Classification of Functioning, Disability and Health, 2001).

Conclusions

The challenge of functional restoration of the forearm and hand arising from the distal upper extremity fractures remains a pertinent issue of rehabilitation practice. Immobility-induced complications of soft tissues (in particular, contractures and compression neuropathies) present a challenge of theirown.

Patients with immobility-induced contracture of the wrist joint complicated by median nerve entrapment showed disorders in all ICF domains: structure and function [owing to pain (including neuropathic), signs of median nerve irritation, limited motion range of the radial joint, presence of anxiety and depression], activity and participation (according to the Frenchay Arm Test, ABILIHAND, DASH, Boston Carpal Tunnel Questionnaire).

The developed comprehensive physical therapy program with the prevailing use of active methods (functional training using Powerball, Thera-band, combination of moist warm compresses and postisometric relaxation, massage, kinesiotaping, and positional release therapy) is based on ICF and patient-centered model of rehabilitation and demonstrated a statistically significant improvement ($p< 0.05$) inthe studied forearm and wrist functional outcome indicators compared to the outpatient rehabilitation program with the prevailing use of passive methods (e.g., manual technique and preformed physical factors).

Conflicts of interest – The authors have no conflicts of interest to declare.

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