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Original article

REHABILITATIVE PHYSICAL THERAPY INTERVENTION FOR THE ULNAR NERVE PARALYSIS

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Abstract

Objective. The objective of this paper is to highlight the importance and effectiveness of the proprioceptive neuromuscular facilitation techniques in the rehabilitation of the ulnar nerve paralysis, caused by a trauma in the lower third portion of the forearm. The most serious effect of this trauma was the complete disruption of the ulnar nerve (neurotmesis), the patient losing both his motor and sensory function in the area covered by the nerve. The study started by identifying the degree of motor, sensory and trophic injury in the injured area immediately after surgery, then creating a strategy for a physical therapy intervention that would aim for an effective rehabilitation in the shortest amount of time possible.

Research methods. The subject in this case study went through a cycle of five physical therapy sessions per week, of 90 minutes each, over the course of 17 months. The main research methods used were the observation, the exploration and assessment, the experimental method and the graphical representation method. The results were centralized in tables and represented as charts, in order to make it easier to highlight and interpret them.

Results. The interpretation of the results recorded during the initial and final assessments of the patient has emphasized the fact that the use of proprioceptive neuromuscular facilitation techniques has led to effective results, such as: the correction of muscular imbalances, the stimulation of the motor response, the increase of joint mobility, of muscle strength, the improvement of trophicity.

Conclusions. It has been proven that the methods and techniques used in this physical therapy program were effective, leading to results that were maintained over a long period of time after the intervention, giving the patient a chance to return to his previous professional activities.

Key words: neurotmesis, ulnar nerve, facilitation.

Introduction

Peripheral nerve injuries are a very important public health problem because of the consequences that this kind of disorders cause.

Some of the most important clinical aspects are losing the sensitivity or the motor function in the area of the injured nerve. These functional deficits can have a strong impact on the personal or professional lives of the patients with peripheral nerve injuries.

Due to the functional importance of peripheral nerves, modern medicine is still looking for methods and techniques that are as effective as possible in regards to their reconstruction after an injury.

The time interval between the injury and the patient getting to the physician for a clinical diagnosis is essential, because it influences the degree and chances of rehabilitation (Gorgan, 2012).

Certain studies highlight that worldwide 10% of the cases of ulnar nerve injuries are the result of explosions (especially in the countries that are exposed to armed conflicts), 22% are the result of work accidents, 7% - electrocution, 12% - working with fragile materials (glass, ceramic), 18% - sharp objects (knives, blades, etc.), and 31% - maintaining a poor position for a long period of time (Lundborg, 2018).

Studies confirm the fact that prolonged exposure to vibrations, compressions, or activities that involve handling sharp objects leads to a high incidence of low ulnar nerve injuries, thus the idea that a certain profession can be one of the main causes that contributes to the occurrence of this type of injury (Mateescu, 2013).

Current research found in the international literature highlights that most patients with low ulnar nerve injuries return to their pre-surgery professional and social activities within approximately 12 months, if they went through a proper rehabilitation program (Caplan, 2018).

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Methods

The research was conducted on one subject, a male patient with the clinical diagnosis of incised wound on the right forearm, 1/3 distal with neurotmesis of the ulnar nerve. The study was performed at the TransExpert Medical Center in Iasi, Physical Therapy section of the Department of Medical Rehabilitation and Physiotherapy, in collaboration with a neurologist.

The patient went through a cycle of five physical therapy sessions per week, of 90 minutes each, over the course of 17 months. The treatment sessions comprised proprioceptive neuromuscular facilitation (PNF) techniques, posturing, passive and active physical therapy, such as various types of contraction, such as isometric and isotonic, massage.

The somatoscopic evaluation was performed in the following stages:

1) Pain assessment: was performed using the Visual Analogue Scale (VAS), to determine the intensity of muscle pain in the lower limbs. During the initial testing, the subject classified his pain intensity as an 8 on the VAS.

2) Sensitivity examination: consisted in the evaluation of the exteroceptive, proprioceptive and epicritic sensitivity. For the exteroceptive sensitivity, the therapists used tests for the pain, tactile, and thermal senses. For the proprioceptive sensitivity, the therapists used tests for the kinesthetic sense in the injured segment. For the epicritic sensitivity, the therapists used tests for the tactile and pain sense, tests for topognosis, graphesthesia and stereognosis. During these sensitivity examinations, the subject was found to have these functions diminished.

3) Joint testing envisaged primarily the testing of the fist joint range of motion, the metacarpophalangeal and the interphalangeal joints in the injured segment. The initial testing revealed the following mobility deficits in the subject: fist flexion 25°; fist extension 40°; radial inclination 15°; cubital inclination 10°.

4) Muscle testing allowed the analytical evaluation of muscle strength, based on the six-step scale (0-5), in accordance with the methods of the National Foundation for Infantile Paralysis (1946). Muscle testing was performed in positions of gravity elimination and against gravity.

Summary

Following are the treatment objectives, methods and techniques that were implemented:

1) Diminishing the pain and swelling: nonsteroidal anti-inflammatory drugs and pain killers recommended by the neurologist; ice packs applied for 5 minutes, with a 10-minute break.

2) Correcting the muscle imbalances: the rhythmic initiation (RI) technique, applied to relax the hypertonic antagonist muscles; the muscle energy techniques – used to relax the shortened hypertonic muscles, in both flexion and extension.

3) Preventing the development of an ulnar claw: for this, the rehabilitation team recommended the patient to wear a dynamic orthosis. The patient wore the orthosis intermittently, up to the recurrence of innervation.

4) Stimulating the motor response: electrotherapy using low frequency current; repeated contractions (RC) in the case where the muscles have a value of F0-1, 4 series x 8 stretches; stimulation of hypotonic muscles using techniques from the Margaret Rood method, imaginative exercises.

5) Rehabilitating joint mobility: the rhythmic initiation (RI) technique for the fist, fingers, and thumb joints. The hold-relax technique for the fist joint, the antagonist and agonist versions; the slow reversal and slow reversal hold techniques, for the fist joint, in the directions allowed by the joint.

6) Improving the trophicity in the injured muscles: therapeutic massage performed analytically, using the main massage procedures: effleurage, frictions, axis compressions.

7) Strengthening the hypotonic muscles: electrotherapy; repeated contractions in the case where the muscles have the value F2-3, F4-5, 4 series x 8 stretches; timing for emphasis - strengthen the weak muscles through the strong muscles; agonist reversal to favor the concentric and eccentric contraction in the same muscles (the flexors), to recruit more motor units; freestyle exercises and exercises using objects.

8) Improving the stability and mobility in the injured segment: Isometric contraction in the shortened area - to increase stability in the fist, fingers, thumb joints of the injured limb; alternating isometrics for the fist, fingers, thumb joints, to increase stability; rhythmic stabilization; resisted isometric contractions.

9) Rebuilding the exteroceptive sensitivity: using a needle, the physical therapist stimulates (pricks) the skin in certain points in the interested area while the patient watches this action; then the patient is asked to close his eyes and identify again the stimulated area.

In regard to the stereognosis: the patient has to recognize various objects that are put into his injured hand.

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Results

In regards to the progress of pain, three tests were performed: first, intermediate and final, the values from which are presented in table 1.

After analyzing the recorded values, it can be seen that the intensity of pain has progressively diminished, and the patient has had a positive physiological response, with no adverse effects.

Table 1. Pain assessment values

Patient name	First test	Intermediate test	Final test
Date	15.X.2018	18.X.2018	21.X.2018
O. M.	**8**	**5**	**1**

Table 2 centralizes the results recorded for the fist joint mobility test - right fist (the injured one) and left fist, and figure 1 represents these values graphically.

The assessment of the mobility in the 2nd-5th finger and thumb was performed visually and palpatory, comparing them with the fingers of the healthy limb; the results were satisfactory.

Table 2. Fist joint assessment values

Tests / Data	Flexion		Extension		Radial deviation		Ulnar deviation	
	Right fist	Left fist	Right fist	Left fist	Right fist	Left fist	Right fist	Left fist
First test 15.X.2018	**25°**	87°	**40°**	168°	**15°**	30°	**10°**	45°
Intermediate test 15.I.2019	**50°**	87°	**90°**	168°	**20°**	30°	**20°**	45°
Final test 20.IV.2019	**87°**	87°	**168°**	168°	**28°**	30°	**45°**	45°

Figure 1 shows that the fist joint mobility in the injured limb progressively improves, the recorded values being around the normal or standard ones.

Table 3 centralizes the results from the initial, intermediary and final tests for the fist muscle assessment. One can see that the strength in the right fist flexor muscles has increased progressively from F3 to F4+.

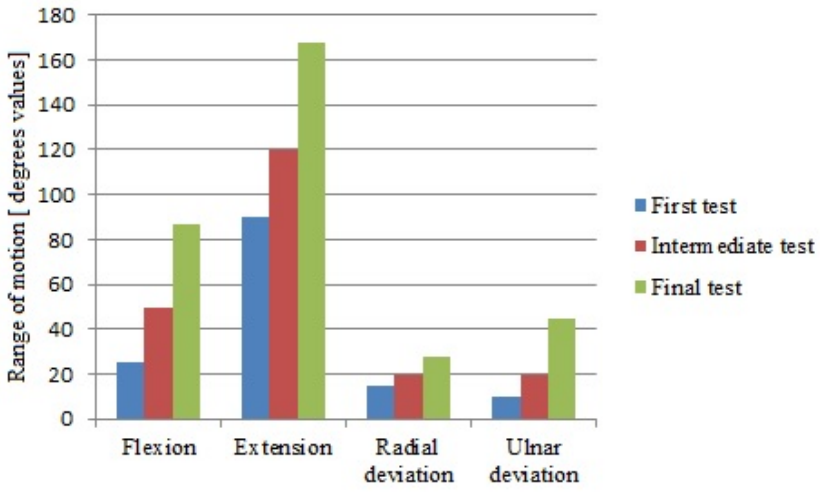

Figure 1. Results for the fist joint mobility assessment

The strength in the extensor muscles increased from F3 to F5, and in the adductor and abductor muscles, also from F3 to F5. Toward the end of the study, muscle strength increased progressively, the patient succeeding in performing movements against gravity. Table 4 presents the values recorded for the muscle assessment in fingers 2-5 of the injured hand. Figure 2 shows the progress of muscle strength in these segments, with values that increase progressively from F1 to F5.

Table 3. Fist muscle assessment values

Tests / Data	Flexor muscles		Extensor muscles		Adductor muscles		Abductor muscles	
	Right fist	Left fist	Right fist	Left fist	Right fist	Left fist	Right fist	Left fist
First test 15.X.2018	**F3**	F5	**F3**	F3	**F3**	F3	**F3**	F5
Intermediate test 5.III.2019	**F3++**	F5	**F4**	F4	**F4+**	F4	**F4++**	F5
Final test 28.IX.2019	**F4+**	F5	**F5**	F5	**F5**	F5	**F5**	F5

Toward the end of the research, muscle strength in fingers 2-5 increased progressively, so that during the final evaluation the patient's values were close to the normal values.

The patient, once his hand muscle strength increased, was able to make some progress in performing various actions of grabbing and prehension.

Table 4. 2nd-5th finger muscle assessment values

Tests / Data	Flexor muscles		Extensor muscles		Adductor muscles		Abductor muscles	
	Right side	**Left side**	**Right side**	**Left side**	**Right side**	**Left side**	**Right side**	**Left side**
First test 15.X.2018	**F1**	F5	**F4**	F5	**F1**	F5	**F1**	F5
Intermediate test 5.III.2019	**F3+**	F5	**F4++**	F5	**F3++**	F5	**F3**	F5
Final test 28.IX.2019	**F4+**	F5	**F5**	F5	**F4**	F5	**F4+**	F5

Table 6 presents the poly-digital-palmar prehension recorded during the first, intermediate and final tests. This type of prehension is related to strength, and was tested with a manual dynamometer. The strength for this type of prehension increases gradually, from an initial value of 30 kgf to 60 kgf.

Table 6. Strength values for poly-digital-palmar prehension

Patient name	First test	Intermediate test	Final test
Data	1.X.2019	7.X.2019	14.X.2019
O. M.	**30 kgf**	**45 kgf**	**60 kgf**

Table 7 presents the results for the exteroceptive sensitivity assessment. The analysis of the results shows an absence of sensitivity during the initial testing, being marked in the table with the "-" sign.

After two months, there was an intermediary testing, where a pain sensitivity was recorded (marked with "+" in the table) and an absence of tactile and thermal sensitivity.

After four months, a tactile sensitivity was recorded and then, during the final testing, the patient showed signs of thermal sensitivity in regards to warm and cold.

Table 7. Results for the exteroceptive sensitivity assessment

Tests / Data	Pain sensitivity	Tactile sensitivity	Thermal sensitivity	
			warm	cold
First test 15.X.2018	-	-	-	-
Intermediate test 5.XII.2018	+	-	-	-
Final test 01-Jul-19	+	+	+	+

Discussions

The effectiveness of a physical therapy rehabilitation in the case of an ulnar nerve paralysis caused by a neurotmesis depends largely on three factors: the time between when the injury happened and the surgery, the surgical method applied, and the adopted physical rehabilitation program. In the case of this subject, the surgical method was a primary neurorrhaphy performed 48 hours after the injury. Currently, primary neurorrhaphy is one of the most used methods in nerve microsurgery, with the most positive results (Noble, 2015).

The surgery and the proprioceptive neuromuscular facilitation techniques that were used and ordered in a logical succession have helped the patient recover 80% of his lost functions within an acceptable period of time.

In 2018, Gould and Billos conducted a similar study on a subject with neurotmesis of the ulnar nerve, which caused its paralysis. In the nerve reconstruction they used the same surgical method, primary neurorrhaphy. In their strategy of creating the physical therapy program, Gould and Billos did not introduce proprioceptive neuromuscular facilitation techniques, adopting only classic means and techniques. Their results show that the recovery of lost functions was 70%.

In 2015, Berger and Callister conducted a comparative study on two subjects with neurotmesis of the ulnar nerve, but different surgical techniques were applied for each one: primary neurorrhaphy and nerve graft. The results concerning the functional rehabilitation, without using proprioceptive neuromuscular facilitation techniques, were superior in the case of the primary neurorrhaphy patient (70%) compared to the nerve graft patient (60%).

A comparative analysis shows that the final results are much more satisfactory when the proprioceptive neuromuscular facilitation techniques are included in the rehabilitation program and implemented in a certain order at a certain stage of the rehabilitation, and are combined with other physical therapy methods and means.

Conclusions

The use of proprioceptive neuromuscular facilitation techniques determined a relaxation of the shortened muscles and a stimulation of the elongated and hypotonic muscles, which contributed to the effective correction of muscle imbalances caused by an injury to the nerve.

The stimulation of a motor response through the myotatic reflex as a result of rapid and repeated stretches, during certain facilitation techniques has led to the stimulation of innervation in the injured muscle in a shorter amount of time.

The application of techniques involving isometrics led to joint mobility and a quick increase in muscle strength in the injured area, with positive long-term effects.

The use of facilitation techniques to develop stability and mobility in the injured segment has led to effective results within a short amount of time, giving the patient the chance to return to his previous professional activities.

At the end, it can be said that the methods and techniques used in this study are obviously very effective, with positive results that can be maintained for a long time after the intervention, in the neurological rehabilitation of patients with peripheral nerve injuries.

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