fizjoterapia polska
nr 4/2014 (14)

Odbudowa funkcji ręki w następstwie zastosowanego programu fizjoterapii u pacjentów po chirurgicznym uwolnieniu nerwu łokciowego w rowku

Restoration of hand function as a result of physiotherapy program used in patients after surgical decompression of the ulnar nerve in the groove

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Streszczenie
Cel pracy.
Celem pracy była ocena wybranych parametrów funkcji ręki u pacjentów po chirurgicznym uwolnieniu nerwu łokciowego w rowku oraz jej restytucja pod wpływem zastosowanego programu fizjoterapeutycznego.
Materiał i metody.
Do badań zakwalifikowano 19 pacjentów (9 kobiet i 10 mężczyzn) leczonych operacyjnie z powodu ucisku nerwu łokciowego w rowku. Badania zostały przeprowadzone dwukrotnie, przy przyjęciu na rehabilitację (badanie 1) oraz po zakończeniu okresu rehabilitacji (badanie 2). W ich trakcie oceniano siłę mięśniową (ścisk globalny i chwyty precyzyjne), czucie powierzchowne (two-point discrimination test) oraz czynną ruchomość nadgarstka, kciuka i palców II-V ręki, na której podstawie określono ubytek funkcji ręki zgodnie z metodyką Swansona.
Wyniki.
Wykazano istotną statystycznie restytucję funkcji ręki pod wpływem zastosowanego programu fizjoterapeutycznego. Odnotowane wskaźniki poprawy siły mięśniowej były istotne zarówno w zakresie chwytu globalnego jak i chwytów precyzyjnych. Wykazano także istotną poprawę wskaźnika czucia w obszarze unerwienia zarówno przez nerw łokciowy jak i pośrodkowy dla nerwu łokciowego i pośrodkowego.
Wnioski.
Odpowiednio dobrany program fizjoterapeutyczny umożliwia istotną odbudowę funkcji ręki u pacjentów po chirurgicznym uwolnieniu nerwu łokciowego w rowku.

Słowa kluczowe:
nerw łokciowy, fizjoterapia, odbudowa funkcji

Abstract
Aim.
The aim of this study was to evaluates selected parameters of hand function in patients after surgical release of the ulnar nerve in the groove and its restitution under the influence of the applied program of physiotherapy.
Material and methods.
The study included 19 patients (9 women and 10 men) after surgical decompression of the ulnar nerve in the groove. The research was conducted two times, at the beginning of rehabilitation (study examination 1) and after finishing rehabilitation programm (study examination 2). Examinations included measurements of muscle strength (grip hand and precise grips), superficial feeling (two-point discrimination test) and active mobility of the wrist, thumb and fingers II- V of the hand, which was used for calculation of loss of hand function in accordance with the Swanson's methodology.
Results.
A statistically significant restitution of hand function under the influence of the applied program of physiotherapy was noted. Indicators of improvement in muscle strength were important both in the grip hand and in precise ones. It was also showed a significant improvement in sensation to the ulnar and median nerve.
Conclusions.
Adequate selected physiotherapy program allows a significant restoration of hand function in patients after surgical release of the ulnar nerve in the groove.

Key words:
ulnar nerve, physiotherapy, functional restitution

Background

The cubital tunnel syndrome is one of the most common compression neuropathies of the upper limb, the incidence of which is second after the carpal tunnel syndrome [1, 2, 3]. It often results in a significant reduction of the functional capabilities of both the hand and the entire upper limb. The mechanism leading to the formation of cubital tunnel syndrome is disturbed nerve excursion at the level of the groove between the medial humeral epicondyle and the olecranon process of the ulna. The most common sites of nerve compression include 5 points in this area: medial intermuscular septum, Struthers arcade, medial epicondyle of the humerus, Osborn ligament and deep flexor and pronator layer around their attachments [4, 5]. These points are located in the projection of the nerve – 10 cm proximally and 5 cm distally to the medial epicondyle of the humerus [5]. In some cases, nerve compression, impeding its normal slide, is caused by cysts or ganglions, the presence of osteophytes in the course of osteoarthritis of the elbow joint and the appearance of post-traumatic complications [6, 7, 8]. The most common and most characteristic symptoms of cubital tunnel syndrome include paresthesia within the 5th and ½ of the 4th finger, as well as pain, and hand muscle weakness. Detailed characterization of the symptoms is presented in Table. 1.

However, it should be noted that the degree of severity of symptoms is largely dependent on the degree of nerve compression and its duration. The initial symptom of cubital tunnel syndrome is mild paresthesia in the area of the ulnar nerve innervation. Deficit symptoms usually appear with a considerable degree of nerve compression, and

Table 1 Characterization of the symptoms of cubital tunnel syndrome

Clinical manifestations	Subjective symptoms
Muscle weakness	Paresthesia within the 5th and ½ of the 4th finger
Froment's sign	Night pain
Wartenberg's sign	Limitations of precise hand movements
Claw hand	
Reduction of superficial feeling in the 5th and ½ of 4th fingertips	

mainly include muscle weakness and sensory disturbances. The reduction of muscle strength often leads to muscular atrophy. It is most frequently observed in the interosseous muscles (Wartenberg's sign, claw hand) and the thumb adductor (Froment's sign). Superficial sensory disorders usually occur on the fingertips of the 4th and 5th fingers. The possible causes of cubital tunnel syndrome include: inadequate performance of professional activities, metabolic diseases (diabetes, obesity, atherosclerosis), rheumatoid arthritis, alcoholism, and post-traumatic disorders of the upper limb axis [4, 5]. The diagnosis of cubital tunnel syndrome is based on clinical examination and additional tests. The clinical examination usually includes provocation tests for the ulnar nerve, i.e. elbow flexion test, tourniquet test, Tinel's test and Froment's test, enabling to assess the strength of the adductor pollicis muscle, whose weakness is often the first deficit symptom of cubital tunnel syndrome [9]. Among additional tests, the most commonly used examinations are ultrasonography (USG) and electroneurography (ENG) [10, 11, 12].
The aim of the study was to evaluate selected parameters of hand function in patients after surgical decompression of the ulnar nerve in the cubital tunnel and its restitution as a result of the applied physiotherapy program.

Material and Methods

The study involved 19 patients of the Specialist Hand Rehabilitation Centre in Cracow, who were referred to rehabilitation after a previous surgical treatment of cubital tunnel syndrome. The group of subjects consisted of 10 women and 9 men. The average age of respondents was 49.4 years. The basic characteristics of the study group are presented in Table 2 and Table 3.
Tests were carried out twice. The first test was on the day of admission to the Centre, whereas the second test was performed after termination of rehabilitation. Both tests involved goniometric measurements of the active motion of the elbow, rotation of the forearm and the wrist using a universal plastic goniometer 360o, and of the thumb and II-V fingers using a metal finger goniometer. Muscle strength was also evaluated using the Jamar dynamometer, assessing the global grip strength and precision pinch grip; the two-point discrimination test was performed by means of the standardized Dellon di-

Tab. 2. Type of surgery performed

Simple decompression	Anterior intramuscular transposition	Anterior submuscular transposition	Anterior subcutaneous transposition
11	4	1	2

Tab. 3. Basic characteristics of the study group

Number of respondents		19
Number of women		10
Number of men		9
Mean age (years)		49,4 (SD=15,8)
The average time from the onset of symptoms to the initiation of treatment (months)		34,4 (SD=41,1)
The average time from surgery to the initiation of rehabilitation (days)		53,3 (SD=67,8)
Average duration of rehabilitation (number of weeks/number of procedures)		6/18
Number of persons who were previously treated conservatively		10
Side of disease occurrence	Predominant	9
	Nondominant	10
Place of residence	Town	16
	Village	3
Type of work	Mental	14
	Physical	5
Circumstances of the symptom onset	Overstrain	10
	Injury	9

scriminator. Based on the results of goniometric measurements, the percentage of functional deficit of the hand, wrist, thumb and II-V fingers was calculated in accordance with the Swanson's methodology [13]. Based on the results of the two-point discrimination test, the sensory index was calculated for the median and ulnar nerves according to the methodology proposed by Szczechowicz et al. (2008) [14]. The rehabilitation program included the elements of training aimed at strengthening the hand using the peg-board and flextend systems, visual biofeedback, kinesiotaping, manual therapy, neuromobilization and physiotherapy. Moreover, each patient received instructions for the home program, which included elements of prevention and treatment of scars, sensory training and neuromobilization (based on the FLOSS methodology) [15].

Results

The results were statistically analyzed using the descriptive characteristics and the Student's t-test.

There were no significant deficits regarding elbow movements (Fig.1); flexion was 130 degrees on average in test 1 and almost 150 in test 2; extension was around 0 degrees. Nevertheless, the differences between the first and second test were statistically significant at $p < 0.05$.

Results obtained for the rotation of the forearm (Fig.2) showed an improvement of 5.3 degrees for supination and 5.5 degrees for pronation, and both of these differences were statistically significant at $p < 0.05$.

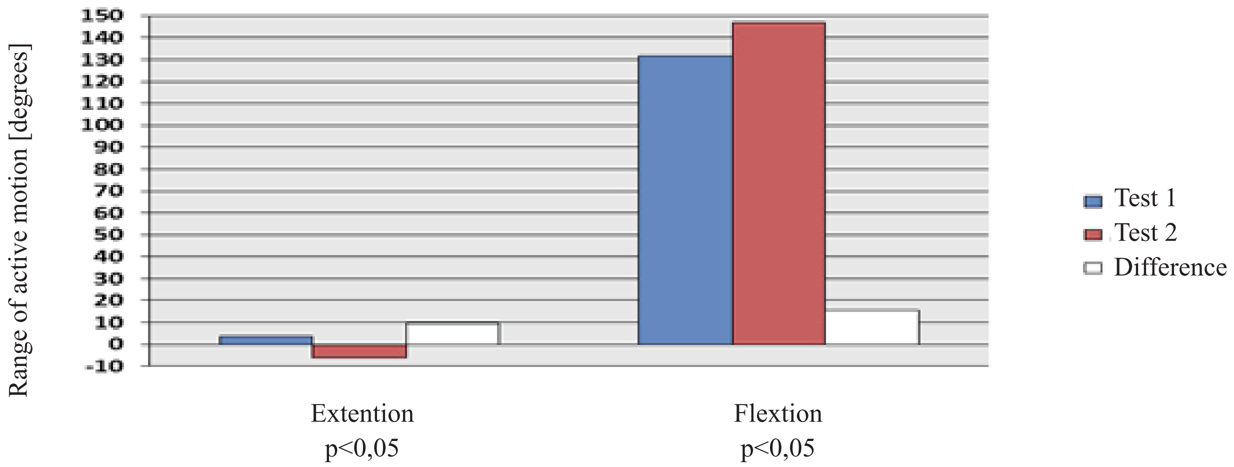

Fig.1. Evaluation of the active elbow joint motion

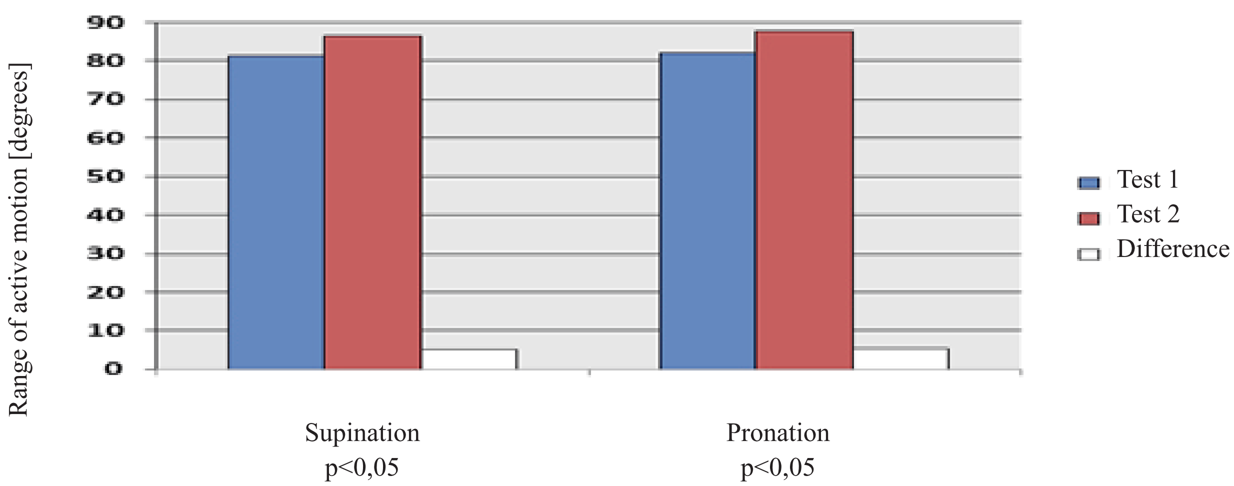

Fig.2. Evaluation of active rotation of the forearm

The results obtained for motion of the wrist joint were calculated according to the methodology proposed by Swanson, and presented as the percentage loss of joint function. In test 1, the greatest deficit was observed for extension (6.6%), followed by ulnar deviation (5%), flexion (2.3%) and radial deviation (2.2%). In test 2, the obtained values did not exceed a 2% deficit. The resulting differences were statistically significant at p <0.05. The functional deficit of the whole wrist was 8.3% in test 1 and 2.2% in test 2, respectively. The difference, which exceeded 6%, was also statistically significant (Fig.3).
Within the thumb, the biggest deficits were observed in the CMCP joint (26.6% in test 1 and 15.1% in test 2), followed by deficits in the MCP joint (7.2% and 3.9%, respectively) and IP (4.7% and 2.7%). All resulting differences were statistically significant at p <0.05 and amounted to 2-11%. In the CMCP joint, the biggest deficit was observed in both tests for the opposition movement (Fig. 4).

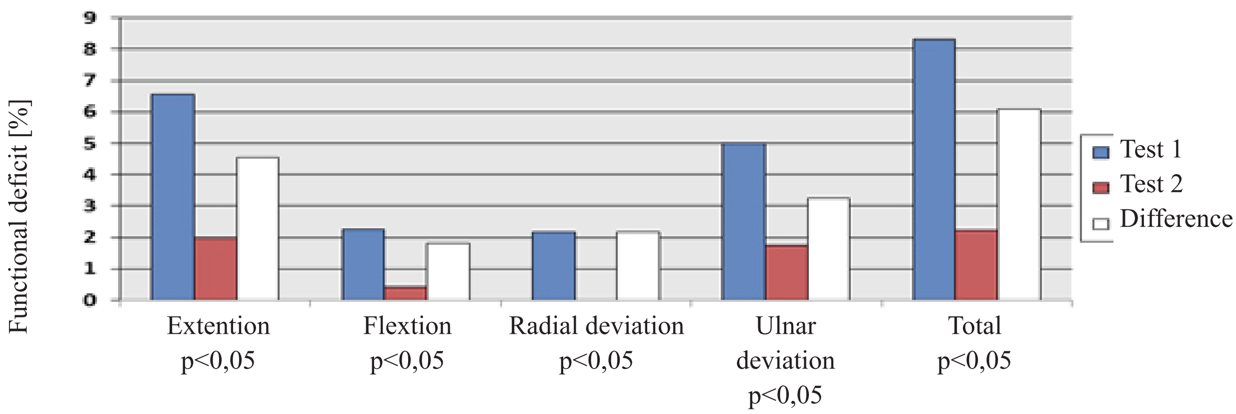

Fig.3. Functional deficit of the wrist by Swanson

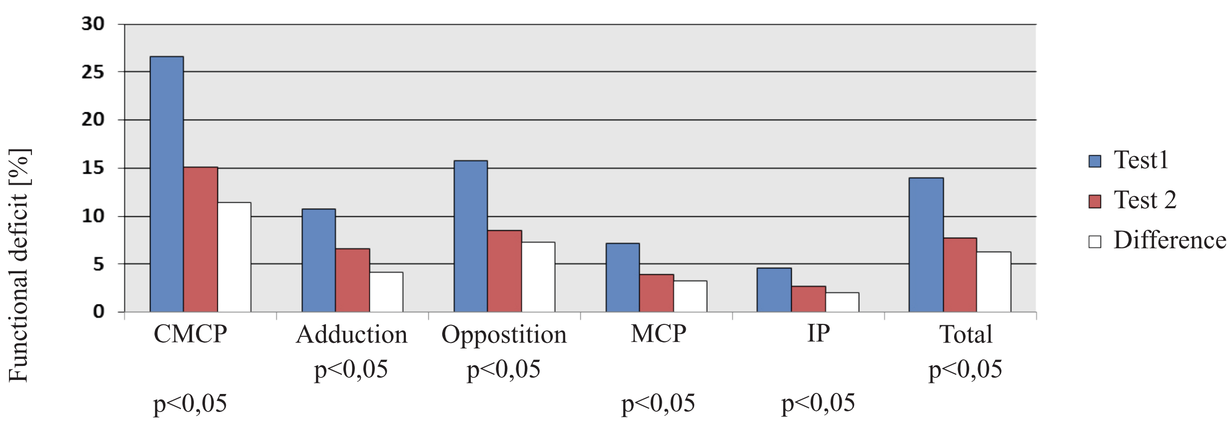

Fig.4. Functional deficit of the thumb by Swanson - carpometacarpal joint – CMCP; metacarpophalangeal joint – MCP; interphalangeal joint – IP

Among fingers II-V, the largest deficit in test 1 was observed for finger V (14.7%), followed by fingers II and IV (in 10.7%) and III (10.3%). In test 2, deficits were in the range of 3.4-5.1% and the highest value was still achieved for finger V. The observed differences were statistically significant ($p < 0.05$) (Fig.5).
Total functional deficit of the hand was 12.6% in test 1 and 5.5% in test 2. The difference, which exceeded 7%, was statistically significant at $p < 0.05$ (Fig.6).

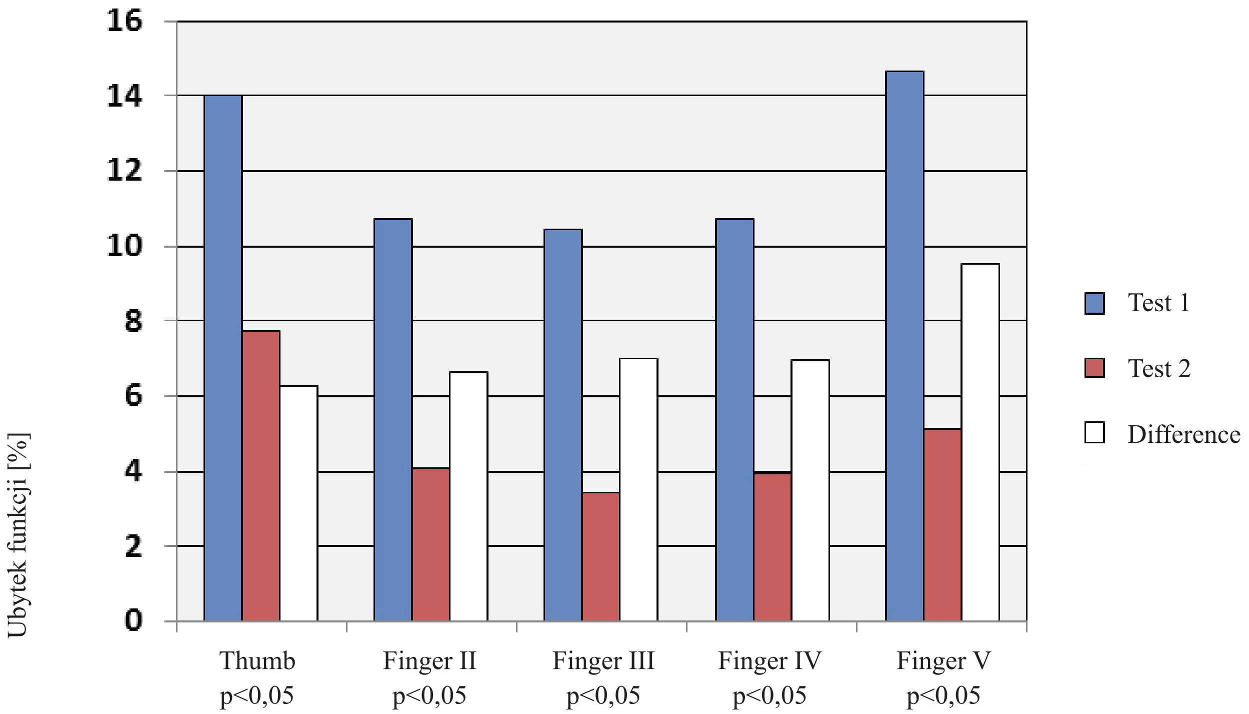

Fig.5. Functional deficit of fingers I-V by Swanson

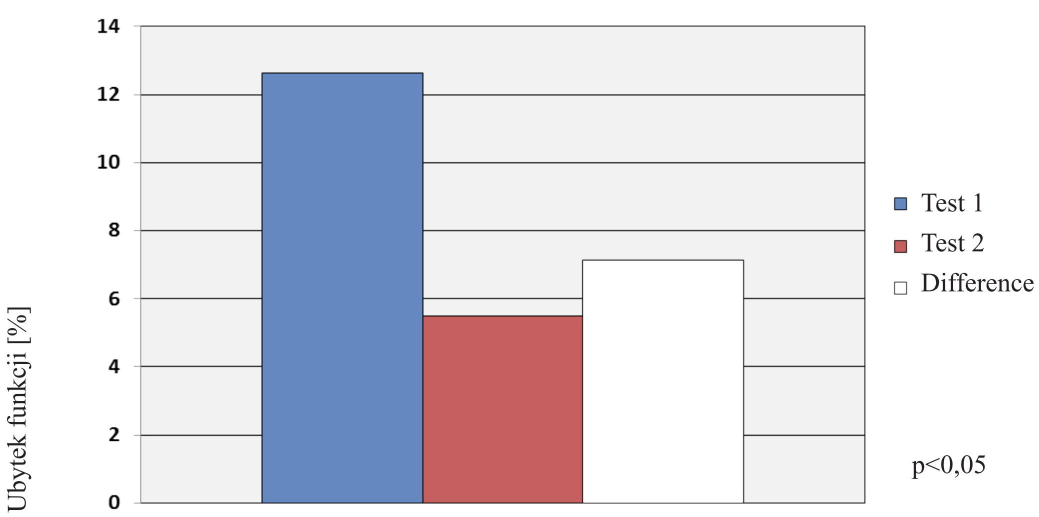

Fig.5. Functional deficit of fingers I-V by Swanson

Based on the results of the "Two-point Discrimination Test", the sensory index was calculated for the median and ulnar nerves (Fig.7). In test 1, this index was 26.8 for the median nerve and 9.3 for the ulnar nerve; in test 2, these values were 27.6 and 10.7, respectively. The resulting differences were statistically significant at $p < 0.05$.
The muscle strength was also evaluated. The standard assessment included the global grip strength and precision pinch grips. Each of the evaluated parameters improved after rehabilitation. The largest change was found for the global grip strength at the second level of the grip width (12 kg), and the difference was statistically significant at the level of $p < 0.05$. Statistically significant differences were also recorded for precision grips - lateral and two-point pinch grips. Within the internal muscles, the largest difference was found for the lateral grip, which mainly involves the adductor pollicis (AP), with motor innervation by *n. ulnaris* (Fig.8).

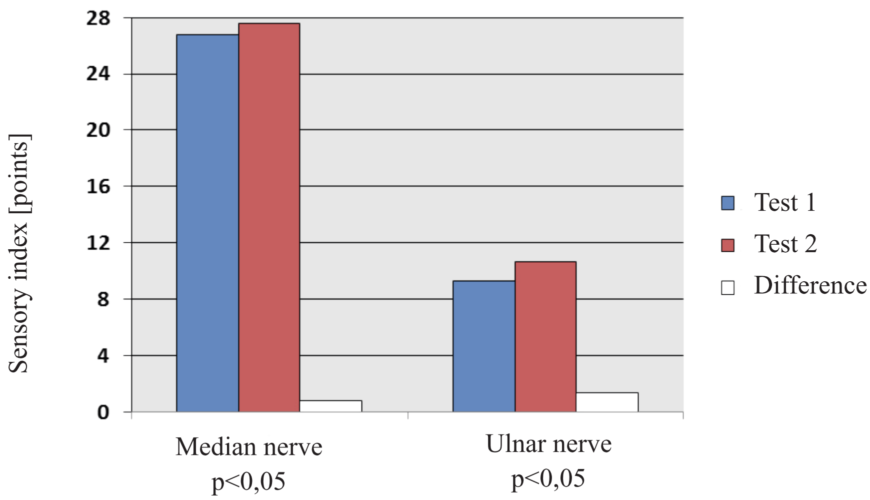

Fig.7. The sensory index

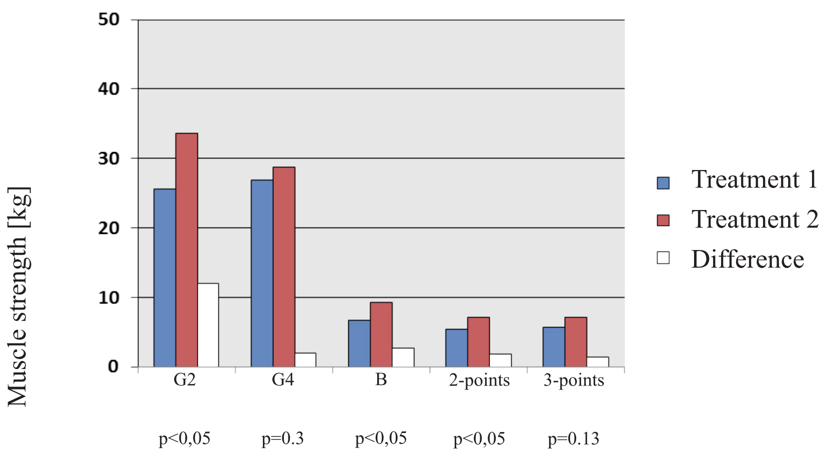

Fig.8. Muscle strength (global grip at the second – G2 and fourth – G4 level of grip width, and precision grips: lateral – B, two-point – 2 pts., and three-point – 3 pts.) – operated hand

Despite a significant increase in muscle strength observed in test 2, there was still a visible difference between the operated and healthy hands (Fig.9). The largest differences were observed for the global grip strength, and the smallest – for the two-point pinch grip.

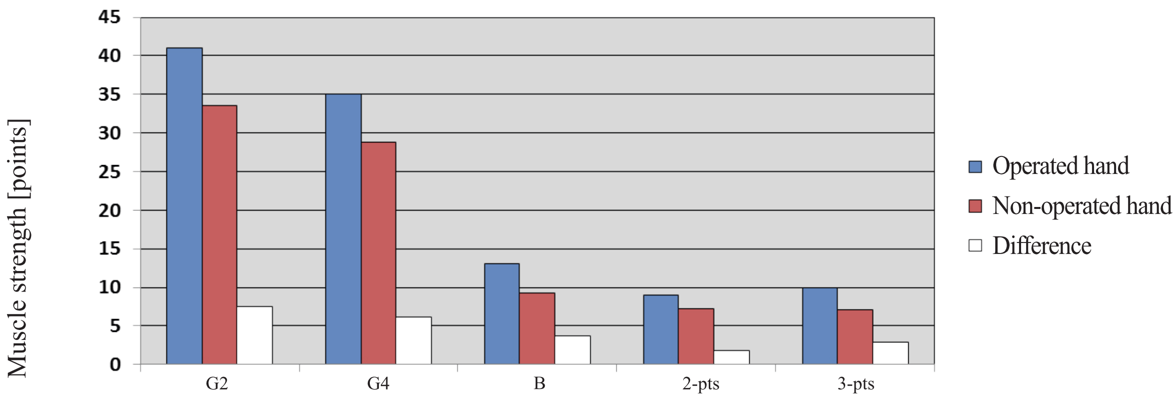

Fig.9. Differences in muscle strength (global grip strength at the second – G2 and at the fourth – G4 level of grip width, and precision grips: lateral – B, two-point – 2 pts. and three-point - 3 pts.) – test 2.

Discussion

Similarly to other neuropathies, cubital tunnel syndrome leads to reduced functional capabilities. The progressive damage to the nerve results in decreased strength, mobility and sensation in the area innervated by this nerve. Patients complain of pain, paresthesia, increasing difficulty in performing activities of daily living and professional activities as well as other activities.

In our study, there was no relationship between the incidence of neuropathy and the study group (men and women) or between the incidence and lateralization. It has been shown, however, that far more respondents lived in urban areas and were white-collar workers.

Our study showed that operated patients started rehabilitation relatively late, up to 53 days after surgery, on average. However, this result was overestimated because of 4 patients, who started rehabilitation much later, dissatisfied with the results of the previous treatment. The average time of rehabilitation initiation was 247 days after surgery (172, 180, 192 and even 443 days; SD = 131.1). After excluding these patients, the average time between surgery and the initiation of rehabilitation was only 20 days (SD = 9.9). This result corresponds to the findings of other authors; Bickhart (2006) recommended to begin rehabilitation in the first week after surgery [16], and Porretto-Loehrke and Soika (2011) suggested initiation of rehabilitation in the second or third week after surgery, depending on the performed surgical procedure [15].

The analysis of our results showed a statistically significant improvement in the strength and sensation in patients rehabilitated after the surgical treatment of cubital tunnel syndrome, and a significant improvement in hand function assessed according to Swanson's methodology. The available literature contains results of studies carried out by Rajan et al. (2005), who observed a relationship between the hand strength and daily functioning of patients with damage to the ulnar and median nerves [17].

Even though the neuropathy is "located" in the elbow joint, our studies have demonstrated that the greatest functional deficits are not in the elbow, but distally to this joint. These findings provide a valuable guidance for physiotherapists that both at the stage of diagnosis and treatment their activities should not be limited to the areas that are directly at or adjacent to the surgery site, but they should also include other, sometimes distant areas of the limb.

Our study showed that the greatest percentage deficit of the thumb function was observed in the CMCP joint, both in test 1 and 2, especially for the opposition movement. While comparing the total functional deficit of the particular fingers, the greatest deficit was observed in the little finger (test 1), then in the thumb, and next in the other fingers. This result is consistent with the findings reported by Rekant (2011), showing that the "usefulness" of the little finger in daily functioning is often impaired in cubital tunnel syndrome [18]. Our study also showed that at the end of rehabilitation, the thumb remained the most functionally impaired finger. The function of each finger and the entire hand, however, significantly improved.

In our study, statistically significant improvement was also observed for sensation in the area innervated by both the operated ulnar nerve and the median nerve. Similar results were also achieved in postoperative patients with carpal tunnel syndrome, in whom sensory disturbances also included the area innervated by the adjacent ulnar nerve [14]. Sensory disturbances existing at the end of rehabilitation and identified in test 2 confirm the progressive restoration of the nerve function. However, they also suggest that this is a long-term process. These findings are consistent with the report by Matsuzaki et al. (2004), who demonstrated that nerve function recovery after the surgical treatment of cubital tunnel syndrome is a long process and may take more than two years [19].

Regarding the muscle strength, Rekant (2011) reported a decrease in the global grip strength and pinch grip in patients with chronic neuropathy [18]. Matsuzaki et al. (2004) pointed out a very important problem, i.e. internal muscle weakness in patients with cubital tunnel syndrome, especially concerning the index finger abductor. Functionally, it causes weakness and clumsiness of the pinch grip, which is particularly evident in activities such as fastening buttons or writing. An important goal of physical therapy is to strengthen the internal muscles, which also improves the performance of daily living activities [19]. Our rehabilitation program included the peg-board system which allows for exercising various muscle groups, including the internal muscles. It also creates the possibility of targeted strengthening of weakened muscles in more or less isolated conditions and depending on the stage of post-operative rehabilitation.

Our study demonstrated a statistically significant improvement of strength in the operated hand – In terms of global grip at the second width level of the dynamometer, and precision grips – lateral and two-point pinch grips. However, the hand that was not subjected to surgery remained stronger, regardless of whether it was the dominant hand or the opposite one. In test 2, the operated hand strength was between 71% and 82% of the normal hand strength. This result indicates the advisability of continuing the strength recovery program at home.

Conclusions

1. Our results indicate the effectiveness of the implemented improvement program.
2. Dysfunction of the operated ulnar nerve leads to functional changes in the region innervated by the non-operated median nerve.
3. Recovery of muscle strength is a long process and requires a targeted therapy including both external and internal muscles.

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