Effectiveness of physiotherapy in carpal tunnel syndrome (CTS)

A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

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Abstract:

Introduction: Carpal Tunnel Syndrome (CTS) is one of the most common peripheral upper limb's neuropathy. It can affect up to 4% of the human population. There is not one specific CTS's reason. Predisposing factors include: injuries and overloading of the wrists, frequently repetitions of the same activities, pregnancy and acromegaly. The ENG and USG are gold standards in the diagnosis of CTS. CTS treatment includes surgical and physiotherapeutic conservative treatment. Physiotherapists uses manual therapy techniques, neuromobilization, fascial manipulation, osteopathy and other kinds of physical therapy.

Material and methods: A systematic review of the literature was based on publications from the last 5 years. Articles concerned the physiotherapy of people with carpal tunnel syndrome (CTS). Publications from the PubMed and ScienceDirect scientific databases have been analyzed. The inclusion and exclusion criteria were introduced and based on an analysis of the titles and abstracts related to carpal tunnel syndrome (CTS).

Results: Out of over 28,000 CTS articles, 8 were selected to meet all inclusion and exclusion criteria. The publications concerned physiotherapeutic treatment in the conservative treatment of CTS. The analyzed publications examined the effectiveness of wrist manual therapy, median nerve mobilization, kinesiotaping, soft tissue therapy and fascial manipulations as well as other physiotherapy treatments.

Conclusions: The reviewed publications show that physiotherapeutic procedures bring significant benefits and improve CTS symptoms within the hand. The development of physiotherapy and research on rehabilitation in the carpal tunnel syndrome (CTS) allow for more effective conservative treatment. This increases the chance of avoiding or delaying surgical intervention.

Key words: **treatment, carpal tunnel syndrome, physical therapy, manual therapy, neuromobilization**

Introduction

Carpal Tunnel Syndrome (CTS) is the most common peripheral neuropathy in the upper limb, occurring in 3-4% of the human population [1]. CTS most often occurs between 40-60 years of age and affects ten times more often women than men [2].

The median nerve extends in the wrist canal along the tendons of the front forearm muscle group. The wrist canal is limited by: bumps of the trapezium and

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scaphoid bones on the radial side and the pisiform and hamate bones on the ulnar side. Between them on the ventral side, the transverse wrist ligament is spread, commonly referred to as the flexor retinaculum [3]. CTS affects the median nerve by adjacent tissues, which in turn reduces its mobility in the canal [4-6]. Compression and reduction of lateral and longitudinal sliding of the mdian nerve is a direct cause of hand discomfort [7-9].

The etiology of carpal tunnel syndrome is not entirely clear. Usually, CTS arises due to the aggregation of several predisposing factors [1, 10]. These include: prolonged wrist overload, injuries, age, obesity, childbirth, acromegaly, kidney and thyroid diseases, diabetes and osteoarthritis [11,12]. The origins of CTS are mainly related to dysfunction of the median nerve sensory fibers. Most patients also have hand manipulation problems with properly preserved muscle strength. Impaired reception of sensory information of deep sensation causes a reduction in the precision of hand movements and pincer grip. As a result, patients involuntarily generate greater pinch force than is necessary to perform particular activity [13].

Symptoms of carpal tunnel appear in both or in one, dominant hand. These include: parasthesia, stinging, feeling of pain, numbness and weakening of the muscular strength of the hand, especially on the side of the first three fingers [2]. There is also a deterioration of the median nerve conduction [1]. CTS-related symptoms can also coexist within the arm and shoulder [14, 15]. Their significant intensity occurs at night.

Diagnosis of carpal tunnel syndrome includes the history of the disease, clinical symptoms, changes in the anthropometric dimensions of the hand and physical examination of the patient [8,16]. The final CTS verification is possible thanks to electrodiagnostic and imaging methods [1,11,12]. In differential diagnosis of CTS, should be excluded: damage to the spinal cord or brachial plexus, thoracic outlet syndrome(TOS), median nerve compression in the proximal part of the upper limb or in the reentrant muscle, degenerative changes [17,18,19]. For CTS diagnostics, the Boston Questionnaire (BCTQ - Boston Carpal Tunnel Questionarie) is also used. It consists of two parts. The first concerns the severity of the patient's symptoms (SSS). The second one, examines the functional state of the hand and the level of its dysfunction (FSS) [20-22]

Research in the field of electrodiagnosis enables the elimination of polyneuropathy, radiculopathy and other disorders related to the median nerve [23]. Electroneurography (ENG) is a routine procedure performed in the diagnosis of carpal tunnel syndrome [24]. It is a study of nerve conduction, where the most important are: potential peak amplitude and sensory transmission speed of nerve fibers [25,26]. In the majority of cases, the ENG examination of the median nerve shows the extension of the final sensory and motor latency, the release of the conduction velocity in the sensory and motor fibers as well as the reduction of the sensory and motor potential amplitude. On the other hand, EMG allows to evaluate muscle stimulation [27]. Electromyography is helpful because it allows to localize pathological changes in the muscles, shows their size, character and determines the dynamics of the disease process [23,28]. This assessment is carried out on muscle groups innervated by the median nerve. Typically, CTS accompanies a significant reduction in muscle performance and strength, which leads to strength disbalance within the hand [25,29].

Ultrasonography (USG) and magnetic resonance imaging (MRI) are characterized by a lower degree of sensitivity compared to ENG. However, ultrasound is the cheapest and the fastest diagnostic method of CTS. It is worth noting that, the above studies allow to find additional factors and changes within the wrist [6,26,30]. They enable the diagnosis of tendon sheathitis, ganglia, degenerative changes of the bones and necrosis of blood vessels. It is also worth mentioning that, the result of USG or MRI examination may change the concept of the course of surgery, consequently reducing its postoperative effects. Due to economic reasons and the availability of cheaper methods, magnetic resonance is rarely used in the diagnosis of CTS [24].

Neurodynamic tests are used in patients with suspected neuropathy of incarceration. These include the Phalen and Tinnel test [31]. They are used to stretch nerves in patients with radiation to the upper extremity. Using stretch tests, we check whether the symptoms are similar to those described by the patient. Stretching mobilization involves the internal and external movement of the nerve with the casing and soft tissues. Sliding mobilization consists in the movement of the axon itself relative to the casing. The authors demonstrate the effectiveness of neurodynamic tests only in 46% of patients with CTS [32].

Physiotherapeutic interventions in the carpal tunnel syndrome focus on decompression of

the median nerve within the wrist canal [33]. Conventional medical procedures are: relieving and immobilizing the upper limb, oral pharmacology and steroid injections. CTS rehabilitation includes treatments in the field of physical therapy, for example laser therapy or manual therapy in combination with neurodynamic techniques, functional massage [7, 34]. Alternative treatments for carpal tunnel syndrome include: acupuncture, yoga, massages, including the Chinese cupping massage. [7,35]. The effectiveness of conventional physiotherapeutic methods, for example laser therapy in relieving ailments, is temporary [14]. In a slightly newer approach, bioptron, shock wave, diathermy, insulin injection and progesterone are used, but their effectiveness is still the subject of debate. In the treatment of CTS, medicine turns to non-invasive activities in the field of manual therapy, neuromobilization and soft tissue techniques. These effects are very effective in the treatment of signs and symptoms of CTS [36-38].

The aim of this study was to review the literature and analyze the results of the latest research presenting modern methods and physiotherapeutic interventions and their effectiveness in inoperable treatment of patients with carpal tunnel syndrome (CTS).

Material and methods

Review of the literature

The review of the literature concerned physiotherapy in the carpal tunnel syndrome (CTS). It was carried out by one person in December 2018. Among the many medical articles, the works from the PubMed and ScienceDirect databases was analyzed. The review was limited to research articles only. The inclusion and exclusion criteria are set to narrow the number of articles reviewed. These criteria were introduced on the basis of an analysis of the titles and introductions of publications related to carpal tunnel syndrome (CTS). All articles have been published in the last 5 years.

The article has been reviewed if it has met the following inclusion criteria:

- The subject of the work concerned physiotherapy in the carpal tunnel syndrome (CTS)
- The articles was of a research nature, not a review one
- One or more methods of physiotherapeutic interventions in the treatment of carpal tunnel syndrome (CTS) were investigated
- The study did not compare conservative with operative treatment of CTS
- The work contained the results of the latest research on physiotherapy in the CTS from the last 5 years

The review rejected works containing the following exclusion criteria:

- The study included a comparison of physiotherapeutic treatment with surgical treatment of carpal tunnel syndrome (CTS)
- Examination of the effectiveness of physiotherapeutic intervention in people after operative treatment of CTS
- Review work, not research
- A study using drugs as a therapy to support physical therapy in CTS
- Articles too generally describing physiotherapeutic procedures in the treatment of neurological dysfunctions including CTS.

After entering the phrase “carpal tunnel syndrome”, over 10,000 articles from the PubMed search engine and over 17,000 from ScienceDirect were obtained. After adding more keywords: “carpal tunnel syndrome”, “treatment”, “physical therapy”, “manual therapy”, “adults”, “rehabilitation”, the number of publications has narrowed to over 200 works. After adding the appropriate inclusion and exclusion criteria and after analyzing the abstracts, 20 articles remained. All review papers related to the operational and pharmacological procedures in the treatment of CTS were rejected. Pilot studies and those with heterogeneous research groups were excluded from the review, for example only one person get non-steroidal oral medication in addition to the tested rehabilitation. Only 8 articles met all the requirements needed to create the above review and clearly presented only CTS physiotherapy, not the entire hand and other accompanying dysfunctions. The analyzed works were of research nature and concerned various methods of physiotherapeutic interventions in the conservative treatment of carpal tunnel syndrome (CTS).

Results

The main criterion for the selection of articles for the review work was the purpose of the research carried out in them and the method of carpal tunnel syndrome diagnosis. The characteristics and size of the research and control groups of the analyzed works are presented in table 1 (Tab. 1).

Tab. 1. Summary of articles research material

Authors	The aim of the study	Subject of the research group	Subject of the control group	Gender of participants	Age of participants
1. **Pratelli et al. 2015**	Comparison between fascial manipulation (FM) and low level laser therapy (LLLT) in the treatment of CTS.	➢ FM- 35 hands ➢ LLLT- 35 hands	-	➢ 29 females ➢ 13 males	54,2 (38-74 years of age)
2. **Bueno-Gracia et al. 2018**	Evaluation of changes in the size of the carpal tunnel and median nerve after mobilization of the carpal bones.	➢ 33 hands (18 participants) ➢ 3 ultrasound imaging during wrist mobilization without CTS	➢ 33 hands (18 participants) ➢ 3 ultrasound imaging without mobilization of the wrist bones without CTS	➢ 9 females ➢ 9 males	26 (20-37 years of age)
3. **Wolny et al. 2018**	Comparison of the effectiveness of neuromobilization and placebo therapy „Sham therapy" in the treatment of CTS	➢ 78 participants	➢ 72 participants	➢ 135 females ➢ 15 males	NT-54.2 (28-69 years of age) ST- 52.2 (27-70 years of age
4. **Wolny et al. 2017**	Comparison of the effectiveness of manual therapy, neuromobilization and other manual techniques (functional massage of trapezius muscle) with low level laser therapy and ultrasounds in the treatment of CTS	➢ 70 participants with CTS MT ➢ 70 participants with CTS EM	-	➢ MT: 62 famale, 8 male ➢ EM: 60 famale, 10 male	MT: 53.1 (26-72 years of age) EM: 51.5 (28-71 years of age)
5. **Maddali Bongi et al. 2013**	Evaluation of the effectiveness of manual therapy in the treatment of CTS symptoms.	➢ 22 participants CTS (41 hands)	-	➢ 20 females ➢ 2 male	65,5± 8, 12 years of age
6. **Dinarvand iet al. 2017**	Evaluation of the effectiveness of scaphoid and hamate bones mobilization in the treatment of moderate CTS.	➢ 18 hands	➢ 19 hands	➢ 37 females	(35-60 years of age) Research group: 46.36 Control group: 49.22
7. **Oskouei et al. 2014**	Comparison of the effectiveness of neuromobilization with routine physiotherapeutic treatment (immobilization, TENS currents and ultrasounds) in CTS therapy.	➢ 16 hands	➢ 16 hands	➢ 20 participants; no specified gender	46.7± 11 (18- 65 years of age)
8. **Yıldırım et al. 2018**	The influence of kinesiotaping on the treatment of light and moderate CTS	➢ 19 hands	➢ 19 hands	➢ 20 females ➢ 1 males	(18-60 years of age) Research group: 48.81 ± 6.40 Control group: 48.70 ± 7.61

The most important aspect of the analysis of the above articles was the type of physiotherapy intervention applied, its frequency and duration, as well as the conclusions formulated by the authors. Physiotherapeutic interventions consisted mainly of neuromobilization, manual therapy, fascial manipulation and other physical therapy. The results of the above analysis are presented in table 2 (Tab. 2).

Tab. 2. Analysis of applied physiotherapeutic procedures in articles

Authors	Type of physiotherapy intervention	Frequency and duration of the intervention	Intervention effectiveness tools	Effectiveness	Effectiveness some time after the end of therapy	Conclusion
1. Pratelli et al. 2015	Fascial manipulation (FM) Low-level laser therapy (LLLT)	FM: 45 min / 1 time a week / Three weeks LLLT: 780-830 nm 1000-3000 mW 10 min / 5 days	VAS scale BCTQ scale (SSS, FSS)	After 10 days BCTQ, VAS: FM (T0-T1) (p <0.001) improvement LLLT (T0-T1) (P <0.001) improvement	After 3 months BCTQ, VAS: FM (T0-T2) (p <0.001) improvement LLLT (T0-T2) (P <0.001) No changes	FM is an effective method of treating not only musculoskeletal dysfunctions, but also nervous disorders, including CTS.
2. Bueno-Gracia et al.2018	Manual mobilization of the wrist bones	One-time mobilization under ultrasound guidance	Ultrasound of the wrist CSA - cross-sectional area of the wrist ADP- anterolateral diameter TD- larger and smaller nerve axis, Circulation of the wrist canal Coefficient of flattening of the carpal tunnel and median canal	CSA (p=0,003) APD (p=0,001)	-	Manual mobilization of the wrist bones causes significant changes in the dimensions of the wrist canal, enabling CTS treatment.
3. Wolny et al. 2018	Neuromobilization (NT) Placebo techniques (ST)	20 min/ 2 times a week / 10 weeks	BCTQ scale (SSS, FSS) Numeric pain scale (0-10pkt) Study of two-point sensory discrimination (2PD) ENG Dynamometric examination of the hand	NT: NCS (P <0.001) improvement 2PD, BCTQ (FSS, SSS) (p <0.01) improvement reduction of pain (p <0.01) improvement NT and ST: strength of grip and hand clamp (P> 0.05) no changes	-	The use of neuromobilization has an effective therapeutic effect in the treatment of mild and moderate forms of CTS.
4. Wolny et al. 2017	Manual therapy with neuromobilization and functional massage trapezius muscle) Low level laser therapy and ultrasounds (EM)	MT and EM: 2 times a week/ 10 weeks 20 MT sessions 20 treatments Laser: * 5J, 50mW, 658nm, 1 min, 40 sec * 24J, 400mW, 808nm, 1 min Ultrasounds: 1MHz. 1.0 w / cm, 75%, 15 min	VAS scale BCTQ scale (SSS, FSS) ENG	ENG MT and partly EM improvement (p <0.01) VAS MT and EM improvement (P <0.01) BCTQ (SSS, FSS) MT and EM improvement (P <0.01) Statistically significant difference between ENG, BCTQ and VAS between MT and EM groups.	-	Both low level laser therapy and ultrasound therapy as well as manual therapy combined with other techniques is effective in the treatment of CTS . The techniques used in the MT group showed a slightly higher therapeutic efficacy of CTS. The combination of MT and EM methods may brings increased efficacy in the treatment of CTS.

5. Maddali Bongi et al. 2013	Interventions in the field of manual therapy (MT)	10- 15 min / 6 sessions / 2 times a week/ Three weeks	BCTQ scale (SSS, FSS) ENG VAS scale Patient's discomfort associated with CTS (paraesthesia, night pain, pain, hypersensitivity, hand sensitivity)	BCTQ scale (SSS, FSS) (p <0.05) improvement ENG (P <0.05) no changes Patient's discomfort: (p <0.05) improvement	After 24 weeks BCTQ scale (SSS, FSS) improvement (p <0.05) ENG no changes (P <0.05) Patient's discomfort: improvement (P <0.05)	Manual therapy is an effective inoperable way of treating symptoms in patients with CTS
6. Dinarvand et al. 2017	Research group: Manual therapy of scaphoid and hamate bones in the treatment of CTS with immobilization Control group: CTS treatment with immobilization	10 min/ 3 times a week/ 8 weeks	BCTQ scale (SSS, FSS) ENG VAS	BCTQ scale (SSS, FSS) (p <0.05) improvement VAS (p <0.05) improvement ENG (P> 0.05) no changes	-	The mobilization of scaphoid and hamate bones is an effective treatment of middle and moderate carpal tunnel syndrome
7. Oskouei et al.2014	Research group (RG): median nerve neuromobilization + routine therapy Control group (CG): Routine therapy (immobilization 0 degrees, TENS ultrasounds)	RG: 3 times a week / 4 weeks CG: Immobilization - 4 weeks at night, TENS- 80 Hz, 60µs, 3 x per week, 20 minutes Ultrasounds - 5 min, 1MHz, 1W / cm2, 20%, 3 x per week	Clinical (Phalen) ENG BCTQ (SSS, FSS) VAS scale MNTT (median nerve tension test)	RG and CG BCTQ (SSS) (P <0.05) improvement MNTT, Phalen test, VAS (P <0.05) improvement Only RG: BCTQ (FSS) (P <0.05) improvement ENG- DML- (P <0.05) improvement	-	Neuromuscular neuromobilization as well as standard therapeutic procedures (immobilization, TENS, UD) are effective in the treatment of CTS. The techniques used in GB showed a slightly higher therapeutic efficacy of CTS. The combination of RG and CG methods may bring increased efficacy in the treatment of CTS.
8. Yıldırım et al.2017	Research group (RG) exercise, kinesiotaping Control group (CG) exercises	exercises 3 times a day for 15 repetitions / for 6 weeks kinesiotaping: 3 applications every 5 days	BCTQ (SSS, FSS ultrasound Dynamometric measurement of hand and finger strength Moberg test	No significant differences between RG and CG in USG, BCTQ, Moberg test, fist and finger pressure at 6 weeks. (p> 0.005) The difference statistically significant between RG and CG in BCTQ (FSS), Moberg test, ultrasound in week 3 (P <0.05)	-	Exercises in combination with kinesiotaping can be an effective method of CTS therapy, which should be confirmed with subsequent tests .

Legenda 1
BCTQ- Boston Carpal Tunnel Syndrome Questionnaire
FSS- Functional Status Scale
SSS- Symptom Severity Scale
VAS- Visual Analogue Scale
ENG- Electroneurography

The authors assessed the effectiveness of manual therapy in four works. An example of the applied physiotherapeutic intervention in the field of manual therapy according to Cyriax in the carpal tunnel syndrome is shown in Figure 1 (Fig. 1).

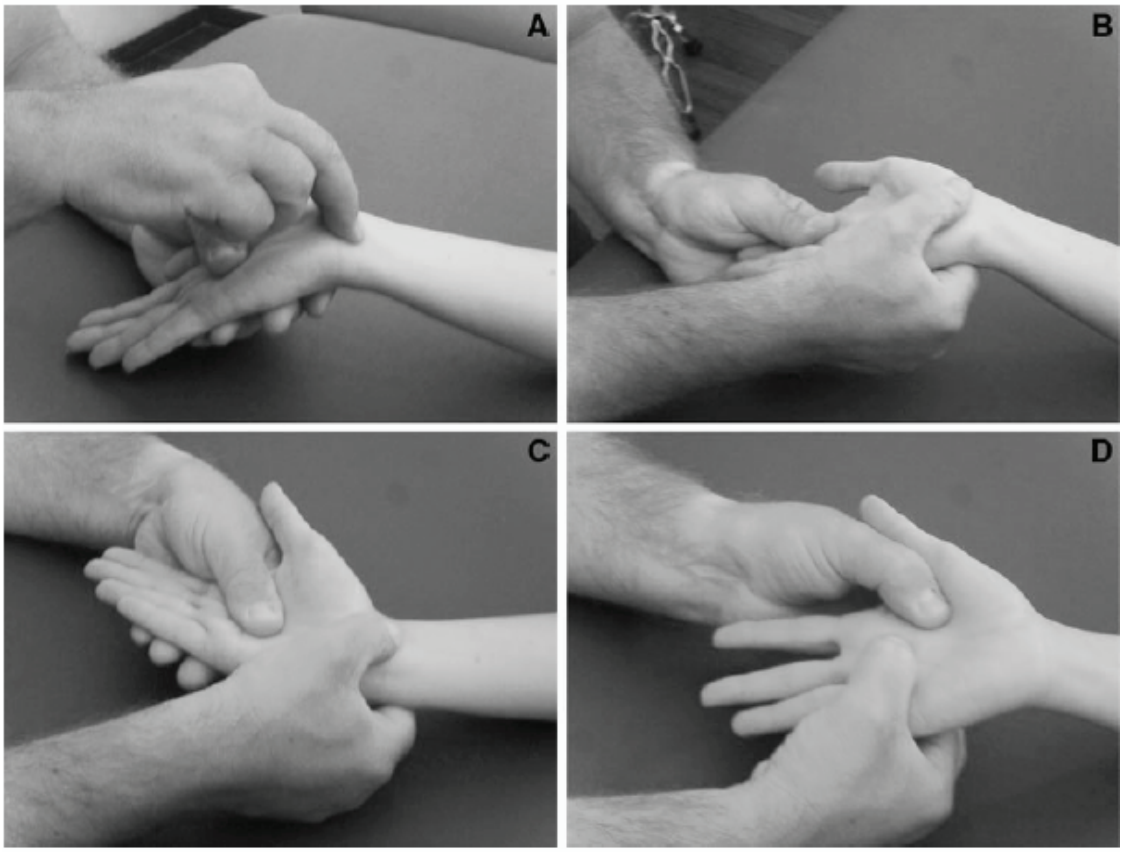

Fig. 1. Cyriax manual therapy techniques used in CTS therapy [37].

Neuromobilization was used to treat carpal tunnel syndrome in three publications. The most reliable was its effectiveness in the study, in which it was compared with placebo techniques. An example of the applied physiotherapeutic intervention in the field of neuromobilization in the carpal tunnel syndrome is shown in Figure 2 (Fig. 2).

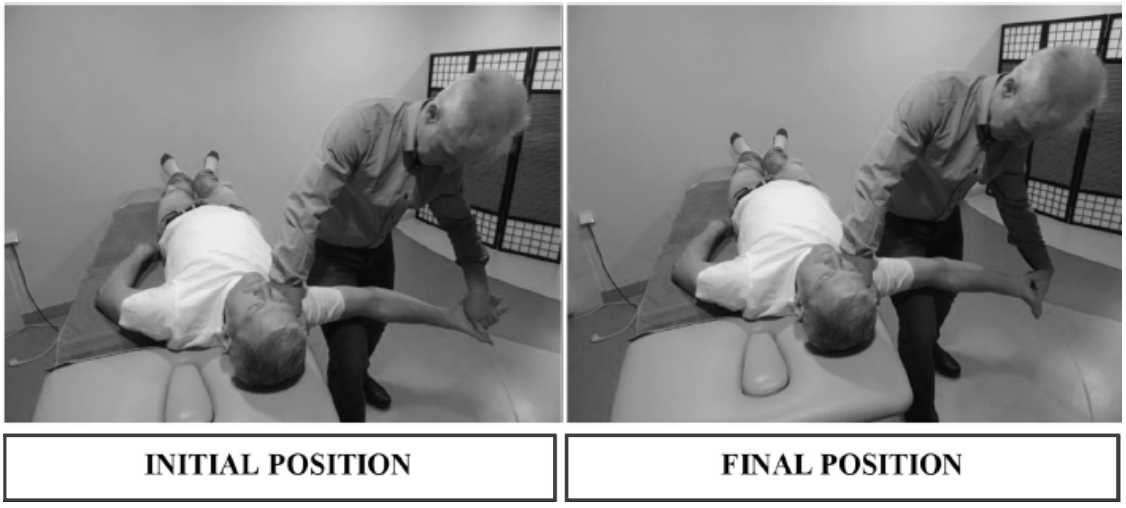

Fig. 2. Neuromobilization used in the treatment of CTS [5].

The effectiveness of fascial manipulation and soft tissue therapy in the treatment of carpal tunnel syndrome was assessed in two works. One publication also tested kinesiotaping. The application according to the kinesiotaping method in the treatment of CTS is shown in Figure 3 (Fig. 3).

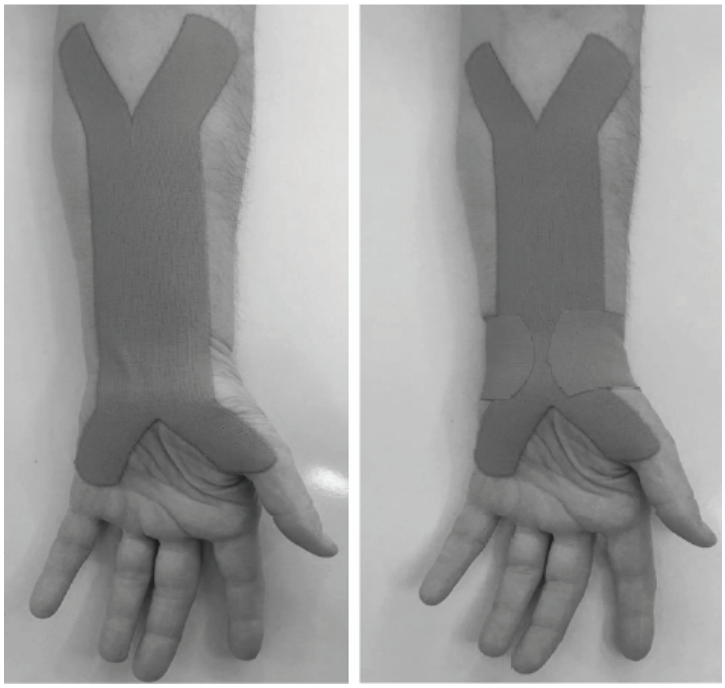

Fig. 3. Application according to the kinesiotaping method used in the treatment of CTS [39].

In addition, the authors compared the effectiveness of the above procedure with standard physiotherapeutic treatment and immobilization in four articles.

Only three publications had a proper control groups. They introduced only one tested factor that allowed to distinguish the research group from the control group. This made it possible to form unambiguous conclusions regarding the effectiveness of the physiotherapy intervention examined. The authors of two publications created two groups in which they compared the effectiveness of completely different therapies, neuromobilization and other physical therapy intervention.

Not all publications accurately describe and clearly present the tested physiotherapeutic interventions. It is worth noting that, in the articles testing the effectiveness of physical therapy, the authors in a very accurate and precise manner showed all the parameters of the treatments examined.

The duration and frequency of physiotherapy interventions in the above publications varied. Their length ranged from 3 to 10 weeks. The time of the treatments was also varied, as in various authors it lasted from 10 to 45 minutes. The frequency of therapy was also different. In some studies, the therapy was carried out once a week, in others up to three times.

In one study, changes in the size of the wrist canal were evaluated during manual therapy of the wrist bone under ultrasound guidance. The process of the study is shown in figure 4 (Fig. 4).

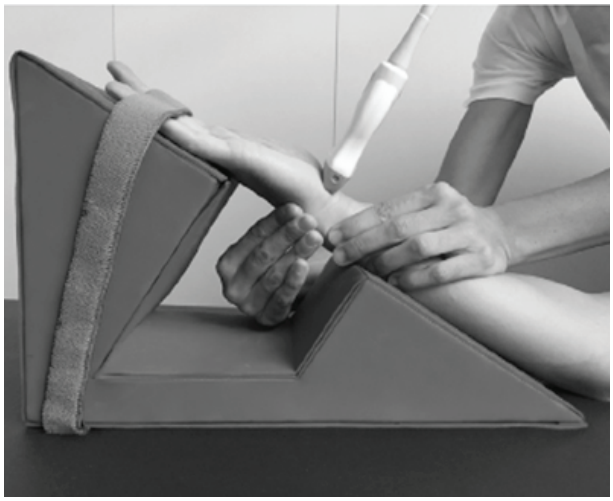

Fig. 4. Examination's position testing changes in the dimensions of the wrist canal during the use of manual therapy techniques [3].

The authors decided to assess the effectiveness of physiotherapeutic interventions in the long-term dimension only in two publications. They made a reassessment of the effectiveness of the therapy few weeks after its completion.

Discussion

Ellis et al. analyzed retrospectively 10 publications of the carpal tunnel syndrome. Their goal was to verify if there is a relationship between decreased nerve mobility in the wrist canal and the onset of CTS. The authors of all the studies reviewed above suggested that the study participants had a reduction in the longitudinal and transverse range of the median nerve (mobility). The mechanism of limiting his mobility begins under the flexor's retinaculum, where is not only pressure on the median nerve, but also on venous and arterial vessels. This compression contributes to the formation of edema and consequently scar tissue, which reduces the mutual mobility of neighboring tissues. A similar situation occurs in the inflamed tendons of the flexor muscles of the fingers. As a consequence, the median nerve sticks to the surrounding tissues and even to the transverse ligament of the wrist. Statistically higher nerve mobility was observed in patients after treatment compared to those in the control group (oblong $p < 0.001$, transverse $p < 0.05$). On this basis, the authors concluded that the consequence of reducing the mobility of the median nerve within the wrist canal is CTS [1]. This study justifies the need for median neuromobilization in the treatment of carpal tunnel syndrome.

Bueno- Gracia et al. decided to assess whether the techniques in the field of manual therapy affect the change in the values of hand and wrist channel parameters. With the applied ultrasound probe at the level of the wrist, they assessed the impact of wrist bones mobilization on particular parameters. Their work shows that during the manual therapy there is a statistically significant increase in the wrist cross-sectional area (CSA) and an increase in the anterior-posterior diameter (ADP) ofs] the wrist canal [3]. The above study proves the need for manual wrist bones therapy in the treatment of carpal tunnel syndrome as it causes decompression of the median nerve.

In the majority of studies, the patients' qualification was based on the most effective diagnostic methods of carpal tunnel syndrome (CTS): USG and ENG [37]. Studies have reported that some people have other conditions that give similar symptoms to CTS, such as cervical reticulopathy, thoracic outlet syndrome (TOS) or proximal median nerve incarceration. [11,12,15,17]. It follows that reliable and unambiguous diagnosis of CTS minimizes the risk of unnecessary physiotherapeutic and surgical interventions [24,26].

Almost in all studies, the BCTQ questionnaire was used to verify the effectiveness of individual therapies. It allowed to evaluate the effectiveness of the therapy in terms of functional (FSS) and symptomatic (SSS). The Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) is an important and reliable clinical tool in the diagnosis of CTS. It consists of two parts: Symptom Severity Scale (SSS) and Functional Status Scale (FSS). The first one (SSS) is built of 11 questions and creates a 5-point scale to assess the severity of symptoms from the CTS. The FSS consists of eight elements estimating the degree of hand functionality. Assessment of the patient according to SSS and FSS gives a final score showing the severity of the carpal tunnel syndrome. [20,39].

Leit et al. decided to assess the effectiveness and credibility of the BCTQ questionnaire. The authors systematically reviewed studies on the psychometric properties of BCTQ to determine its level of diagnostic reliability. An important aspect of the above studies was the inclusion of the patient's condition with CTS from his perspective. The authors analyzed 10 studies to verify the structure of the content, relevance and reliability of the questionnaire. Statistical analysis was performed comparing SSS and FSS with other CTS diagnostic tools, including DASH questionnaire (Disabilities of the Arm, Shoulder and Hand Questionnaire). Based on the data analysis, the authors concluded that BCTQ is a valuable and reliable tool that should be used as a basic measurement instrument in future studies of carpal tunnel syndrome [20]. Virtually all tested interventions in the field of manual therapy, neuromobilization, osteopathy, fascial manipulation and other kinds od physiotherapy have resulted in improved results in BCTQ [20]. In many cases, despite the absence of changes before and after the therapy cycle, the improvement was recorded in the BCTQ parameters. This indicates that patients improved despite the lack of changes in ENG or USG [5,37,38].

Wolny et al. showed how he created a placebo group and what techniques used in this group differ

from the true neuromobilization's techniques of the median nerve [5]. It is also important to provide the exact parameters of the treatments being tested in the field of physical therapy [7,14,38]. Just like the detailed description and insertion of images of the tape application in the kinesiotaping, it concretizes which application was tested [39]. This allowed for a thorough interpretation and understanding of the research published by the authors.

In several of the above publications, the authors compared the effectiveness of two, absolutely different treatments [7,14]. They have proven that routine physiotherapy is often less effective than newer interventions. Others, in turn, created two groups, the research and the control group, which were differed in one parameter tested by the authors [36,38,39]. It should be noted that these tests actually show whether there is a significant difference between the groups and whether the tested therapeutic agent allows to achieve a higher therapeutic effect in patients with CTS.

It is worth mentioning that only in the articles of Pratelli et al. and Mordalii Bongi et al. evaluated the condition of patients several weeks after completion of therapeutic procedures. They were able to confirm that treatments in the field of manual therapy and fascial manipulation demonstrate long-term effectiveness, and the health effects achieved last long [14,37]. Pratelli et al. in his work also showed that in the case of laser therapy (LLLT), after 3 months from the end of the intervention, the obtained therapeutic effect was withdrawn [14]. The above long-term efficacy parameter should be included in all physiotherapeutic studies because it allows for additional conclusions regarding the effectiveness of rehabilitation.

Conclusions

The above review presents a summary of the effectiveness of various types of physiotherapeutic interventions in the conservative treatment of carpal tunnel syndrome (CTS). On their basis, significant benefits and improvement of CTS symptoms are visible. Some authors compared the effectiveness of two different physiotherapeutic interventions in the treatment of carpal tunnel syndrome. Not all studies contained control groups that enable accurate and reliable comparison of the effects of the tested therapies. Some of the studies had very small research and control groups, which indirectly affects the reliability of these tests. Only in two articles was the effectiveness of therapeutic intervention checked a few weeks after its completion, which allowed to formulate broader conclusions on the effectiveness of the physiotherapy methods studied.

The development of physiotherapy and research on therapies in the carpal tunnel syndrome (CTS) allows physiotherapists to do more effective CTS treatment, they give physicians a wider range of methods to help patients with CTS. This increases the chances of avoiding or delaying surgical intervention.

References

1. Ellis R, Blyth R, Arnold N, Miner-Williams W. Is there a relationship between impaired median nerve excursion and carpal tunnel syndrome? A systematic review. J Hand Ther. 2017;30:3-12.
2. Çirakli A, Ulusoy EK, Ekinci Y. The Role of Electrophysiological Examination in the Diagnosis of Carpal Tunnel Syndrome: Analysis of 2516 Patients. Niger J Clin Pract. 2018;21(6):731-4.
3. Bueno-Gracia E, Ruiz-de-Escudero-Zapico A, Malo-Urriés M, Shacklock M, Estébanez-de-Miguel E, Fanlo-Mazas P, et al. Dimensional changes of the carpal tunnel and the median nerve during manual mobilization of the carpal bones. Musculoskelet Sci Pract. 2018 Aug;36:12-6.
4. Baselgia LT, Bennett DL, Silbiger RM, Schmid AB. Negative Neurodynamic Tests Do Not Exclude Neural Dysfunction in Patients With Entrapment Neuropathies. Arch Phys Med Rehabil. 2017 Mar;98(3):480–6.
5. Wolny T, Linek P. Neurodynamic Techniques Versus "Sham" Therapy in the Treatment of Carpal Tunnel Syndrome: A Randomized Placebo-Controlled Trial. Arch Phys Med Rehabil. 2018 May;99(5):843-54.
6. Petrover D, Richette P. Treatment of carpal tunnel syndrome: from ultrasonography to ultrasound guided carpal tunnel release. Joint Bone Spine. 2018 Oct;85(5):545-52.
7. Wolny T, Saulicz E, Linek P, Shacklock M, Myśliwiec A. Efficacy of Manual Therapy Including Neurodynamic Techniques for the Treatment of Carpal Tunnel Syndrome: a Ranomized Controlled Trial. J Manipulative Physiol Ther. 2017 May;40(4):263-72.
8. Trybus M, Stepańczak B, Koziej M, Gniadek M, Kołodziej M, Hołda M. Hand anthropometry in patients with carpal tunnel syndrome: a case-control study with a matched control group of healthy volunteers. Folia Morphol (Warsz). 2018 May.

9. Bartolomé-Villar A, Pastor-Valeroa T, Fuentes-Sanzb A, Varillas-Delgadoc D, García-de Lucasd F. Influence of the thickness of the transverse carpal ligament in carpal tunnel syndrome. Rev Esp Cir Ortop Traumatol. 2018 Apr;62(2):100-4.
10. Turner MR, Hilton- Jones D. Oxford Textbook of Neuromuscular Disorders. Oxford Universisty Press; 2014.
11. Chammas M, Boretto J, Burmann LM, Ramos RM, Dos Santos Neto FC, Silva JB. Carpal tunnel syndrome - Part I (anatomy, physiology, etiology and diagnosis. Rev Bras Ortop. 2014 Aug;49(5):429-36.
12. Chammas M, Boretto J, Burmann LM, Ramos RM, Neto FS, Silva JB. Carpal tunnel syndrome - Part II (treatment). Rev Bras Ortop. 2014 Aug;49(5):437-45.
13. Yen WJ, Kuo YL, Kuo LC, Chen SM, Kuan TS, Hsu HY. Precision pinch performance in patients with sensory deficits of the median nerve at the carpal tunnel. Motor Control. 2014 Jan;18(1):29-43.
14. Pratelli E, Pintucci M, Cultrera P, Baldini E, Stecco A, Petrocelli A, Pasquetti P. Conservative treatment of carpal tunnel syndrome: comparison between laser therapy and Fascial Manipulation. J Bodyw Mov Ther. 2015 Jan;19(1):113-8.
15. Kuliński W, Mróz J, Leśniewski P, Koczorowski R. Cervical discopathy and carpal tunnel syndrome, problems in diagnostics and therapy Adv Rehab. 2004;4:41-4.
16. You D, Smith AH, Rempel D. Meta-analysis: association between wrist posture and carpal tunnel syndrome among workers. Saf Health Work. 2014 Mar;5(1):27-31.
17. Godek P, Ruciński W, Brzuszkiewicz- Kuźmicka G. Functional Thoracic Outlet Syndrome. Adv Rehab. 2017;3:71-86.
18. Jamwal NR, Kumar SP. Therapeutic Efficacy of Peripheral Nerve Sliders in Cervicobrachial Pain Syndrome: Sliding towards Evidence versus Evidence towards Sliding. Indian J Med Res. 2018;2(2):61-64.
19. Gupta R, Sharma S. Effectiveness of Median Nerve Slider's Neurodynamics for Managing Pain and Disability in Cervicobrachial Pain Syndrome. Indian J Physiother Occup Ther. 2012;6(1):127-32.
20. Leite JC, Jerosch-Herold C, Song F. A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. BMC Musculoskelet Disord. 2006;20(7):78.
21. Carpal Tunnel Questionnaire. J Physiother. 2017;63:119.
22. Sezgi˙n M, **İncel** NA, Sevi˙m S, **Çamdevi˙ren** H, As I, ErdoĞan C. Assessment of symptom severity and functional status in patients with carpal tunnel syndrome: Reliability and validity of the Turkish version of the Boston questionnaire. Disabil Rehabil. 2006;28(20):1281-6.
23. de Jesus Filho AG, do Nascimento BF, Amorim MdeC, Naus RA, Loures Ede A, Moratelli L. Comparative study between physical examination, electroneuromyography and ultrasonography in diagnosing carpal tunnel syndrome. Rev Bras Ortop. 2014 Sep 16;49(5):446-51.
24. Onen MR, Kayalar AE, Ilbas EN, Gokcan R, Gulec I, Naderi S. The Role of Wrist Magnetic Resonance Imaging in the Differential Diagnosis of the Carpal Tunnel Syndrome. Turk Neurosurg. 2015;25(5):701-6.
25. Sonoo M, Menkes DL, Bland JDP, Burke D. Nerve conduction studies and EMG in carpal tunnel syndrome: Do they add value? Clin Neurophysiol Pract. 2018 Apr;3:78-88.
26. Billakota S, Hobson-Webb LD. Standard median nerve ultrasound in carpal tunnel syndrome: A retrospective review of 1,021 cases. Clin Neurophysiol Pract. 2017 Sep 15;2:188-91
27. Hermens HJ, Merletti R, Rix H, Freriks B. The State of the Art on Signal Processing Methods for Surface ElectroMyoGraphy. Deliverable of the SENIAM Project, Roessingh Research and Development, Enschede. The Netherlands; 1999.
28. Konrad P. ABC EMG A practical introduction to kinesiological electromyography. Technomex Spółka z o.o. Gliwice; 2007.
29. Alcan V, Zinnuroğlu M, Karataş GK, Bodofsky E. Comparison of Interpolation Methods in the Diagnosis of Carpal Tunnel Syndrome. Balkan Med J. 2018;35:223-7.
30. Rabay Pimentel BF, Faloppaa F, Sugawara Tamaoki MJ, Belloti JC. Effectiveness of ultrasonography and nerve conduction studies in the diagnosing of carpal tunnel syndrome: clinical trial on accuracy. BMC Musculoskelet Disord. 2018;19:115.
31. Buckup K. Clinical tests in the examination of bones, joints and muscles. 2nd edition, Wyd. Lek. PZWL; 2000.
32. Baselgia LT, Bennett DL, Silbiger RM, Schmid AB. Negative Neurodynamic Tests Do Not Exclude Neural Dysfunction in Patients With Entrapment Neuropathies, Arch Phys Med Rehabil. 2017;98:480-6.
33. Schreiber AL, Sucher BM, Nazarian LN. Two Novel Nonsurgical Treatments of Carpal Tunnel Syndrome. Phys Med Rehabil Clin N Am. 2014;25(2):249-64.
34. De-la-Llave-Rincon AI, Ortega-Santiago R, Ambite-Quesada S, Gil-Crujera A, Puentedura EJ, Valenza MC, Fernández-de-las-Peñas C. Response of pain intensity to soft tissue mobilization and neurodynamic technique: a series of 18 patients with chronic carpal tunnel syndrome. J Manipulative Physiol Ther. 2012 Jul;35(6):420-7.
35. Wolny T, Saulicz E, Linek P, Myśliwiec A, Saulicz M. Effect of manual therapy and neurodynamic techniques vs ultrasound and laser on 2PD in patients with CTS: A randomized controlled trial. J Hand Ther. 2016 Jul-Sep;29(3):235-45.
36. Dinarvand V, Abdollahi I, Raeissadat SA, Bandpei AM, Babaee M, Talimkhani A. The Effect of Scaphoid and Hamate Mobilization on Treatment of Patients with Carpal Tunnel Syndrome. Anesth Pain Med. 2017;7(5):e14621.
37. Maddali Bongi S, Signorini M, Bassetti M, Del Rosso A, Orlandi M, De Scisciolo G. A manual therapy intervention improves symptoms in patients with carpal tunnel syndrome: a pilot study. Rheumatol Int. 2013 May;33(5):1233-41.

38. Oskouei AE, Talebi GA, Shakouri SK, Ghabili K. Effects of Neuromobilization Maneuver on Clinical and Electrophysiological Measures of Patients with Carpal Tunnel Syndrome. J Phys Ther Sci. 2014;26:1017–22.
39. Yilddirim P, Dilek B, Sahin E, Gulbahar S, Kizil R. Ultrasonographic and clinical evaluation of additional contribution of kinesiotaping to tendon and nerve gliding exercises in the treatment of carpal tunnel syndrome. Turk J Med Sci. 2018;48:925-32.
40. Burnham T, Higgins DC, Burnham RS, Heath DM. Effectiveness of Osteopathic Manipulative Treatment for Carpal Tunnel Syndrome: A Pilot Project. J Am Osteopath Assoc. 2015;115(3):138-48.
41. Żmijewski M. How to write a review paper? Idea, research, publication: Scientific guide for students of medical majors. Medical University of Gdansk; 2015.
42. Burton CL, Chesterton LS, Chen Y, van der Windt DA. Clinical Course and Prognostic Factors in Conservatively Managed Carpal Tunnel Syndrome: A Systematic Review. Arch Phys Med Rehabil. 2016 May;97(5):836-52.