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doi: 10.14735/amcsnn2019345

Effect of vacuum-compression therapy for carpal tunnel syndrome as a part of physiotherapy – pilot study

Využití vakuově-kompresní terapie v léčbě syndromu karpálního tunelu jako součást fyzioterapie – pilotní studie

Abstract

Aim: The aim of this pilot study was to assess the effect of combined kinesiotherapy and vacuum-compression therapy (VCT) in patients with carpal tunnel syndrome (CTS). A secondary aim was to evaluate the correlation between subjective symptoms and the results of objective measurements. *Methods:* Ten patients (six women; average age 55.0 ± 12.7 years) with a total of 18 hands, indicated for the surgical treatment of CTS underwent six individual kinesiotherapy sessions and ten applications of VCT. The effect of the intervention was evaluated by EMG and a visual analogue scale (VAS) of pain. *Results:* After the therapy, EMG did not show a statistically significant difference in distal motor latency, sensory nerve action potential and sensory conduction velocity of the median nerve. However, the VAS decreased significantly (P = 0.001). We found immense inter-individual differences in measurable parameters of the manifestations of CTS. Additionally, nine of the patients opted for surgical treatment even one year after finishing the therapy. *Conclusion:* After therapy consisting of kinesiotherapy and VCT, the typical symptoms of CTS decreased.

Souhrn

Cíl: Cílem této pilotní studie bylo vyhodnotit efekt kombinace kinezioterapie a vakuově-kompresní terapie u pacientů se syndromem karpálního tunelu (carpal tunnel syndrome; CTS). Sekundárním cílem bylo sledovat korelaci mezi subjektivními příznaky a výsledky objektivního měření. *Metodika:* Deset pacientů (šest žen; věkový průměr 55,0 ± 12,7 roku) s osmnácti hodnocenými horními končetinami, indikovaných k chirurgické léčbě CTS, absolvovalo šest individuálních kinezioterapií a deset aplikací vakuově-kompresní terapie. Efekt intervence byl hodnocen pomocí EMG a vizuální analogové škály bolesti. *Výsledky:* Výsledky EMG neprokázaly po terapii statisticky významné rozdíly v měření distální motorické latence, velikosti senzitivní amplitudy a senzitivní rychlosti vedení vzruchu. Velikosti hodnot na vizuální analogové škále bolesti se však signifikantně snížila (p = 0,001). V měřených parametrech CTS jsme nalezli velké inter-individuální rozdíly. Devět pacientů nepodstoupilo chirurgickou léčbu ještě rok po ukončení intervence. *Závěr:* Po terapii sestávající z kinezioterapie a vakuově-kompresní terapie došlo ke snížení výskytu typických příznaků CTS.

Key words

carpal tunnel syndrome – kinesiotherapy – vacuum-compression therapy

Klíčová slova

syndrom karpálního tunelu – kinezioterapie – vakuově-kompresní terapie

The authors declare they have no potential conflicts of interest concerning drugs, products, or services used in the study.
Autoři deklarují, že v souvislosti s předmětem studie nemají žádné komerční zájmy.
The Editorial Board declares that the manuscript met the ICMJE "uniform requirements" for biomedical papers.
Redakční rada potvrzuje, že rukopis práce splnil ICMJE kritéria pro publikace zasílané do biomedicínských časopisů.

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Accepted for review: 18. 1. 2019
Accepted for print: 5. 4. 2019

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Introduction

Carpal tunnel syndrome (CTS) is a set of symptoms caused by compression of the median nerve as it travels through the wrist in a space-limited osteofibrous canal (carpal tunnel) [1]. CTS is the most common entrapment syndrome in the general population [2–4]. The prevalence has been estimated at 6 to 12% [5] and the incidence is stated to be from 180 to 346 diagnosed cases per 100,000 people. It is one of the most frequent occupational diseases [6].

The aetiology of CTS is multifactorial; structural as well as functional factors operate in its occurrence, combining in different stages [7]. The direct cause of the occurrence of the typical symptoms of CTS is a pathological increase of intracarpal pressure. The compression of the well-developed microvascular system of blood vessels results in dysfunction of the affected nerve. If the disorder of the epineural blood flow lasts long enough, an oedema occurs in the epineurium and endoneurium, with a subsequent axonal transport blockade. Gradually, structural changes of the nerve also occur, especially segmental demyelination and remyelination of the compressed fibre [3,8].

To confirm the CTS, electrodiagnostic (electrophysiological) testing together with clinical evaluation is used most commonly. An EMG represents an available sensitive standardized method for examining median nerve dysfunction.

In an EMG for CTS, the values of distal motor latency, sensory nerve action potential and sensory conduction velocity are considered to be the most important indicators of the function of the median nerve [9–11]. Moderate CTS is diagnosed in cases of velocity of conduction via the sensitive fibres of the median nerve from the wrist to the 2nd or the 3rd finger as measured with an EMG reduced at least to 38 m/s, or the response not being present. In addition, it is necessary to have a normal finding of distal motor latency and the conduction via sensitive fibres to the 5th finger by the ulnar nerve. Another necessary finding in this type of affection is either distal motor latency of the median nerve prolonged to 5.3 ms and more or the response not being present, and/or the finding of permanent abnormal spontaneous activity in a needle EMG in the musculus abductor pollicis brevis, in at least two locations [9].

There are several therapeutic options for patients with CTS depending on various factors, including the stage of the disease, the severity of the symptoms and patients' preferences. Non-surgical intervention is recommended as the first-line treatment in cases of mild to moderate CTS. Conservative therapy includes medical and physical therapy [8,12]. Surgery is reserved for patients with severe CTS and those who have experienced a failure of conservative treatment. [12,13]. Surgical treatment consists of releasing the carpal tunnel content by transection of the transverse carpal ligament [4].

Vacuum-compression therapy (VCT) represents one of the methods used for physical therapy. The procedure, with cycles of vacuum and subsequent compression leads to increased capillary filling [14]. Therefore, the effects of VCT might target the primary cause of the occurrence of several types of CTS. However, no study has been conducted thus far which has documented the effect of this therapy on the improvement of CTS. The aim of this pilot study was therefore to assess the effect of a combination of kinesiotherapy and VCT in the treatment of CTS. The finding that the combination of kinesiotherapy and VCT has a positive effect might help to include this method in the CTS treatment algorithm.

Methods

Participants

Ten patients (six women; age 55.0 ± 12.7 years) with a diagnosis of idiopathic CTS in 18 hands, who had undergone conservative treatment, were included in the study. There were eight patients with bilateral symptoms and two patients with unilateral symptoms. All the patients presented with symptoms of median nerve compression. The symptoms included volar wrist pain, numbness, dysaesthaesia and paraesthaesia in the median nerve distribution. When the neurologist according to the EMG confirmed the diagnosis of moderate CTS and ruled out another neurological disease, all the patients were indicated for surgical treatment.

This study was conducted according to the principles for human experimentation of the Declaration of Helsinki. All the subjects provided written informed consent.

Procedure

The EMG was performed by an experienced neurophysiologist at a clinical site using a Keypoint machine (Medtronic Inc., Minneapolis, MN, USA) according to the methodology recommended by the Czech Neurological Society [9,10]. The median nerve was stimulated by a surface electrode in the area of the wrist and the motor response was read from the abductor pollicis brevis muscle. The technique of antidromic conduction with stimulation of the median nerve in the area of the wrist was used to examine sensitive conduction and the response was read by ring surface electrodes from the index finger. The measured EMG parameters were distal motor latency, sensory nerve action potential and sensory conduction velocity of the median nerve. This examination was carried out no later than one month prior to starting the therapy and from one to three months after the therapy.

The therapy included 6 sessions of individual kinesiotherapy lasting 30 min each and 10 sessions of VCT. Individual kinesiotherapy was based on Dynamic Neuromuscular Stabilization, which is a manual and rehabilitative approach to optimize the movement system based upon the scientific principles of developmental kinesiology [7,15]. The machine used for VCT – Vasotrain-447 (Enraf-Nonius, Rotterdam, The Netherlands) can produce both positive and negative pressure, which have been used intermittently in vascular reeducations [14]. The involved upper limb was placed into the Vasotrain-447, the proximal part of the cylinder was fixed around the midpart of the upper arm with a rubber balloon and the machine was set for vascular disease. Treatment was started with 0.10 bar of negative pressure for 60 s, followed by 0.01 bar of overpressure for 60 s. These parameters were then increased by 0.01 bar in each session. However, the pressure was not further increased when it was no longer within the patient's tolerance and comfort or the colour of the skin on the forearm in the machine changed.

The overall length of the therapy did not exceed one month.

After one year had elapsed after the second EMG examination, a further course of treatment was inquired about by an outpatient neurological department.

The pain intensity was assessed by a Visual Analogue Scale (VAS) before starting the therapy and 1–3 months after the therapy as a part of EMG examination.

Statistical analysis

Statistical analyses were performed using the Statistica version 12.0 (StatSoft, Inc., Tulsa, OK, USA) software. The normality of the data distribution was assessed using the Lilliefors

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test. Because the data were not normally distributed, the Mann-Whitney U test was used to compare the outcomes at baseline and after the therapy. The value of the r score (rsc = Z/sqrt[N], where N is the total number of observations) was used to evaluate the effect size; the effect size was considered large for values ≥ 0.5 and moderate for values ≥ 0.3 and < 0.5 [16]. A correlation analysis (Spearman correlation coefficient) was used to assess the relationship between the VAS and the distal motor latency, sensory nerve action potential and sensory conduction velocity of the median nerve. The significance level was set at 0.05 for all statistical tests.

Results

Effect of the intervention

The basic statistical characteristics of the monitored parameters are given in Tab. 1.

Table 1 shows that after the therapy there were no statistically significant changes in the EMG parameters. However, the subjective difficulties decreased significantly after 1–3 months when compared to the baseline (P = 0.003, rsc = 0.706).

Relationship between EMG parameters and VAS

In the follow-up measurement after 1–3 months, we found a significant relationship between the intensity of the subjective difficulties and the sensory conduction velocity (r = – 0.659, P = 0.004) and between the intensity of the subjective difficulties and the distal motor latency (r = 0.704, P = 0.002).

Discussion

Carpal tunnel syndrome is a multifactorial disease which includes functional and structural aetiology in different proportions. This proportion should be determined in order to determine the options for treatment, either conservative or surgical. The positive effect of conservative therapy of CTS has been demonstrated repeatedly [17–20], in improved function as well as nerve conduction [21].

The decrease of typical symptoms of CTS, which occurs after conservative therapy is, in many cases, only temporary [22]. Therefore, in our study we tried to add conservative therapy with another method – VCT, which could support the results of conservative therapy and lead to a longer-term effect. All the patients were indicated for the surgical treatment of CTS based on their symptoms and the results of the EMG.

Tab. 1. Descriptive statistics (mean ± standard deviation) and comparison of the measured parameters.

Parameter	Patient group at baseline	Patient group after 1–3 month	P
distal motor latency (ms)	4.7 ± 0.78	4.9 ± 0.97	0.989
sensory nerve action potential (mV)	8.2 ± 4.35	9.1 ± 4.0	0.813
sensory conduction velocity (m/s)	39.6 ± 7.57	40.0 ± 7.92	0.469
Visual Analogue Scale	61.9 ± 25.8	28.3 ± 25.8	0.003

The results of our study did not show any significant change in the EMG parameters, but there was a statistically significant improvement of the subjective CTS symptoms. The improvement of the subjective clinical symptoms may have been induced by the improved movement stereotype in the area of the upper limb, i.e. the influence of the functional aetiology of CTS, whereas the actual regeneration of the peripheral nerve, which would be measurable objectively, requires a longer time [23]. Functional disorders of the musculoskeletal system may also contribute to the clinical manifestation of CST [7].

A statistically significant relationship was found between changes in subjective symptoms and in distal motor latency. Such a finding is interesting, because in clinical practice, we meet patients with moderate CTS and minimal typical symptoms and conversely, also patients with mild CTS and very strong clinical problems. Therefore, we do not find it common that these two indicators must necessarily correlate.

The use of VCT for the treatment of CTS has not been described in available literature. Nevertheless, this treatment with a physical appliance using the energy of computer-controlled switching of the local hyperbaric and hypobaric environments is demonstrably effective in peripheral disorders of blood perfusion [14]. This is also confirmed by the results of a randomized study by Khadir et al [24] with the examination of peripheral vascular functions before and after the therapy. VCT may reduce the increased pressure in the carpal tunnel in CTS through its antioedematous effect, and during conservative therapy, it may support the regeneration of a nerve damaged by compression. However, it should not be indicated as monotherapy, as it does not aim at the cause of the occurrence of CTS. The study by Pitr et al [25] represents a comprehensive study including the results of biophysical experiments as well as a number of case studies. By marking the erythrocytes with technetium radionuclide and subsequently scanning the limb with a gamma camera, the authors demonstrated an improvement in the blood perfusion of the treated limb. This was also confirmed by experiments showing the improvement of microcirculation in the skin using skin remission spectrophotometry *in vivo*. Both mechanisms are important from the point of view of supplying oxygenated blood to the limb. A study quantifying the impact of VCT on the increased amount of oxygen being supplied to the treated limb was published by Ticháček et al [26]. This study used the results of earlier biomedical experiments and evaluated them afresh, using the findings from physiology and simulating methods of medical biophysics. The resulting findings confirm the significant impact of VCT on the support of peripheral perfusion, also suggesting a positive impact on the support of perfusion in the area of the vasa nervorum, therefore supporting the regeneration of the ischemized peripheral nerve.

Treatment of CTS by VCT and physiotherapy represents only one of the options of evidence-based conservative treatment, which also includes splinting and local injections of corticosteroids. VCT should be reserved for patients with mild to moderate CTS who are not indicated for surgery. In the pilot study, VCT therapy did not lead to the improvement of objective electro-physiological parameters in 1–3 months after the initiation of treatment.

Limitations of the study and therapy

When VCT is applied with the Vasostrain, the pressure in the rubber balloon does not change with the change of pressure in the cylinder. The patients perceive this pres-

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sure as very unpleasant. Optionally, it is possible to use the Extremiter (Madisson s.r.o., Prague, Czech Republic) appliance, which changes the pressure in the sleeve during the changes of the individual stages of overpressure and under pressure, and therefore the vascular connection with the proximal part of the upper limb outside the cylinder is not altered as much.

We are aware that the study lacked a control group of patients. Due to the high pain intensity, the majority of the patients from the control group (kinesiotherapy only) opted for surgical treatment before the end of the experiment and therefore a comparison with the experimental group was not possible.

A 2-week course of physiotherapy or, more precisely, six therapeutic sessions, was determined experimentally on the basis of the therapist's empirical experience, with respect to the possibilities the site offered. However, the number of therapeutic sessions is highly individual and does not allow for fixed setting. It is possible that some patients may need a higher number of therapeutic sessions to achieve a positive effect on the functions of the deep stabilization system.

The limit may also be a combination of therapeutic procedures, specifically physiotherapy and VCT. Nevertheless, the effect of both methods is mutually potentiated and they should therefore be applied in combination.

Conclusion

The application of the combination of kinesiotherapy and VCT decreased the intensity of pain but did not change the EMG parameters in patients with moderate forms of CTS. This application had a positive influence on the course of further therapy, so that the patients were no longer indicated for surgical treatment at the time of the neurological examination from 1 to 3 months after therapy. In addition, none of the patients underwent surgical treatment for 1 year after the discontinuation of treatment.

Further research using a larger sample size is necessary to confirm the therapeutic effect of VCT for CTS treatment; until then, VCT should always be indicated with physiotherapy only as a complement to conservative treatment.

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