International
Journal of Medical and Exercise Science
(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

EFFECTIVENESS OF PHYSIOTHERAPY INTERVENTIONS ON SYMPTOM SEVERITY AND HAND FUNCTION IN PATIENTS WITH IDIOPATHIC CTS

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ABSTRACT

Background of the study: Extracorporeal shock wave therapy (ESWT) has been reported as valuable and beneficial treatment for musculoskeletal disorder. Over the last few years, ESWT became more widely employed in clinical practice, with certain clinical studies confirming significant efficacy. Clinically, ESWT has been utilised to treat a variety of musculoskeletal and peripheral neuropathy disorders, including CTS. ESWT's low energy was proven effective in mild to moderate CTS. The aim of the study is to analyse the effect of three physiotherapy intervention on symptom and hand functions in patients with carpal tunnel syndrome. **Methodology:** This study consisted of 52 male and female who had pain in their hands, either bilaterally or unilaterally. They were allotted into of three groups, Group A; received Ultrasound therapy (UST) combined with nerve and tendon gliding exercise,Group B; received Shock wave therapy (ESWT) combined with nerve and tendon gliding exercise and Group C; received only nerve and tendon gliding exercise, two times per week for four weeks. The outcome measure used was Boston Carpal Tunnel Questionnaire (BCTQ) to evaluate the symptom severity and functional status scale among the participants. The evaluation was performed at baseline, 2 weeks, 4 weeks and follow-up. **Results:** Repeated measure ANOVA shows significant improvement ($p<0.005$) in all comparison based on time. The overall improvement in Group B from baseline to follow-up was a reduction of 48.43% in the symptoms and 55.2% increase in the functions and was significant ($p<0.005$). **Conclusion:** This study concludes that the ESWT is an effective modality for idiopathic mild to moderate CTS. The beneficial effect of this non-invasive modality is safe and valuable to be used as one of physiotherapy modality in Malaysia.

Keywords: Carpal Tunnel Syndrome; Shock Wave Therapy; Ultrasound Therapy; Nerve and Tendon Gliding Exercise; Hand function; Idiopathic.

Received on 26th April 2022, Revised on 24th May 2022, Accepted on 28th May 2022
DOI:10.36678/IJMAES.2022.V08I02.005

INTRODUCTION

Carpal Tunnel Syndrome (CTS) is a non-traumatic hand disorder caused by entrapment of the median nerve as it travels through the wrist's carpal tunnel[1]. It's a type of peripheral neuropathy that can be caused by a variety of things [2,3].Mechanical stress, elevated pressure, and ischemia injury to the median nerve within the carpal tunnel are all factors in the pathophysiology of CTS[4]. The specific cause is unknown, however compression[5]and swelling of the median nerve in the carpal tunnel[6,7,8]may be to blame.

CTS is more common in all nations[9,10] including Malaysia[9-12].There is no universally accepted gold standard for diagnosing CTS. A medical history and physical examination, with or without the use of diagnostic questionnaires, electrodiagnostic studies, MRI, and ultrasound, can be used to determine it[13,14,15]. In the general population, the prevalence and incidence range from 0.6 percent to 14.4 percent, with women having a higher preva-lence than men[2,3,10].

There are three levels of CTS: mild, moderate, and severe[16]. The sensory component of the median nerve causes symptoms such as a loss of light and discriminative touch sensations at first[17]. In advanced cases, it damaged the motor component of the hand and upper limb, leading in a loss of grip and pinch strength[17,18].

Surgical and nonsurgical treatments are available for CTS. For mild to moderate CTS, conservative treatment is often preferred whereas surgical decompression is a possibility for moderate to severe symptoms[19,20,21].

Several studies have found that conservative treatment is beneficial and appropriate for patients with mild to moderate CTS symptoms [22,23,24]. Ultrasound[25,26], laser[25,27], hand activities[28], paraffin wax therapy[29], flexible wrist splints or kinesiotaping [30], steroid injections[21], night splints, oral steroids[31], electromagnetic field therapy[32],workplace adaptability, and cupping therapy [33] are some of the treatments used Physiotherapy intervention is widely used as a noninvasive procedure and a conservative therapeuticchoice. Physiotherapy started as soon as feasible to avoid difficulties induced by decompression of the median nerve within the carpal canal [34].

The main risk factors have been identified as mechanical, anatomical and physiological variables. Gender, age (adult) obesity, and type of occupation are all major predictors, according to several studies, while secondary risk factors include carpal tunnel syndrome, metabolic causes and infection[35].

The consequences of CTS may include missed workdays, a change of career, and significant healthcare management costs. The patient with CTS must spend as much time away from work as they meet the symptoms as a result of persistent symptoms [36]. Extracorporeal shock wave therapy (ESWT) has been reported as a valuable and beneficial treatment for musculoskeletal disorders in recent years, with certain clinical studies demonstrating significant efficacy.

Several examples of musculoskeletal injuries [9,37] and peripheral neuropathy, such as CTS, have been successfully treated using ESWT. Patients with mild to severe CTS can benefit from ESWT, which is a noninvasive treatment and evidence based physical method[38]. According to Seok and Kim (2013), the ESWT may be as effective as a local steroid injection in treating CTS symptoms[39].

There are two types of EWST in the therapeutic setting: focused EWST (fESWT) and radial ESWT (rEWST). The fESWT produces a lot of energy, which some patients can't handle and may require a local anaesthetic[40,41]. In other investigations, the ESWT's low energy is expressed as rESWT [41]. In treating CTS studies, rEWST has greater advantages than fESWT because to the energy dispersed over a large treatment region [41]. It has both direct (physical) and indirect (biological) impacts on the tissue being treated [37,42].

The anti-inflammation [43], pro-angiogenic, regenerative, and healing effects of ESWT on the mechanotransduction pathway [44]. In various research [45,46] the cumulative effect of ESWT has been demonstrated, indicating that multiple sessions of ESWT may be more effective than a single treatment [45]. ESWT has been found to be effective in CTS of varied severity [47] and improve symptoms, functional outcomes and electrophysiologic parameters.

The objective of this study is to determine the effects of different physiotherapy interventions on idiopathic CTS. To our knowledge, ESWT has still not been used and reported in clinical practise in Malaysia to treat CTS cases. The findings from this study could be used to better decide which parameters should be applied to treat CTS in Malaysia.

MATERIAL AND METHOD

Study design:

A randomized clinical trial study was conducted.The sample size was calculated using G*Power 3.1.9.2. The sample size calculation using A priori with an effect size of 0.25, α error probability of 0.05 and power of 0.80 resulted in about 52 participants. Before participating in this study, the participants were given a thorough briefing and given written informed consent.

This study was conducted at Physiotherapy Units, Faculty of Health Sciences, Universiti Sultan Zainal Abidin (UniSZA) at Gong Badak Campus, Kuala Terengganu and Rehabilitation Center at Seberang Takir, Kuala Terengganu.

Participants:

Initially, 75 CTS patients were referred to the Physiotherapy Unit, however only 60 participants were chosen because they met the criteria. They were chosen at random as they fulfilled the inclusion criteria. The inclusion criteria includeage 30 and 60 years old, having symptom (numbness, tingling, pain with or without weakness or at unilateral or bilateral hand), confirm diagnosis as CTS by doctor, mild to moderate symptoms, no thenar atrophy at affected hand, positive clinical provocative test (Phalen's test, Tinel's sign or Durkan's test), never received any CTS intervention and not used splint.

The exclusion criteria included previous wrist trauma or surgery at affected hand, diagnosis as sensory and motor neuropathy due to other causes (example: Cervical stenosis, cervical spondylosis and etc.), underlying medical disorders (E.g.: Diabetes mellitus, renal failure, autoimmune disease, rheumatoid arthritis or hypothyroidism), pregnancy, open wound or skin condition at affected hand, require regular analgesic or anti-inflammatory drugs and had steroid injection with current CTS symptom.

The randomisation technique was performed using research randomiser software to allocate the subjects into groups. Each group comprised of 20 subjects; two groups were designated as intervention groups (Group A and B), while the remaining were designated as control groups

(Group C). Male and female participants with bilateral or unilateral pain in their hands took part in the study. Following the completion of the intervention period for four weeks, 8 participants withdrew from this study.

Outcome Measure: The outcome measure was conducted for baseline, 2-weeks, 4 weeks and follow up (4 weeks post-intervention).

Boston Carpal Tunnel Questionnaire: Levine et al., (1993) established the BCTQ as a self-administered outcome measure to quantify the intensity of symptoms and functional status of clients with CTS [48]. The original BCTQ was prepared in English and provided a standard severity and function measure for patients. The validity, reliability, and responsiveness of the BCTQ have lately been documented in other languages.

This study used the M-Boston Carpal Tunnel Questionnaire (M-BCTQ), which is a valid and reliable Malay version of the M-Boston Carpal Tunnel Questionnaire (M-BCTQ) [49]. BCTS is a disease-specific, patient-focused CTS instrument that delivers important data from the patient's perspective and may be used individually or in large groups [49]. It is easy to administer because it is quick and straightforward[49], it is recommended to be used in any kind of CTS research. The Symptom Severity Scale (SSS) is used to determine the severity of symptoms, whereas the Functional Status Scale (FSS) is used to determine a subject's functional status.

The SSS features 11 questions with a five-point rating scale, whereas the FSS has eight things with a five-point rating scale for difficulty. Each scale produces a final score that varies from 1 to 5 (total of individual scores divided by number of elements). On a Likert scale, 1 indicates a low level of symptom (SSS) or a high level of difficulty (FSS), and 5 indicates a high level of symptom (SSS) and inability to function (FSS).

Intervention: They were instructed to perfo-rmed nerve and tendon gliding exercises developed by Totten and Hunter (1991)[50]. The participants also obtained a brochure with instructions and illustrations describing the exercises. These exercises were presented by the physiotherapist and then performed by the patient with the supervision of the therapist.

Nerve gliding exercise: Each position will be maintained for 5 seconds before being repeated 10 times. The exercise required maintaining the fingers and hand in six different positions for six minutes[50,51].

a. With the wrist in neutral and the fingers and thumb in flexion (grasp)
b. With finger extension
c. With the wrist and fingers extended and the thumb in neutral
d. With the wrist, fingers, and thumb extended
e. As the fourth position with the forearm in supination
f. As the fifth position and the other hand gently stretching the thumb

Tendon Gliding Exercise: During tendon gliding exercises, the fingers were placed in five distinct positions. Straight, hook, fist, tabletop, and straight fist these were techniques. Each position was sustained for a total of 7 seconds. All groups were instructed to perform 5 repetitions of the exercise and repeat for 3 sets of tendon gliding exercises twice a week for four weeks[24,52].

Ultrasound Therapy: Subjects in this group were treated with ultrasound therapy by Gymna Pulson 100. The machine was set to a frequency of 1 MHz, an intensity of 1.0 W/cm2, and a pulsed mode (1:4) with a 5 cm^2 focus transducer[25,29,53]. The duration of the procedure was 5 minutes each session. During the procedure, the transducer is placed across the wrist carpal tunnel area from the wrist crease to the palmar region.

The transducer moves in a circular motion, gently pressing on the affected area. A direct-contact method was utilised with a water-based gel as a coupling agent. Subjects must be in a comfortable position and have no experience of pain during the procedure. The subjects were then instructed to do Totten and Hunter's nerve and tendon gliding exercises (1991)[51]. Exercise in the same manner as described in Nerve and tendon gliding exercise.

ESWT: The patients were treated with ESWT combined with standard hand exercise (nerve and tendon gliding exercise). They received 1000 shocks, 2 BAR (0.09 mj/mm^2), and 3Hz by Zimmer Medizin System's enPuls version 2.0 machine twice a week for four weeks. Shock wave therapy does not have a specific duration, but 1000 shocks take 5 minutes to complete in each session.The treatment was given by a qualified physiotherapist. The probe was held perpendicular to the patient's palm throughout the procedure, and gel was used as a coupling agent. There was no need for extra anaesthetic or painkillers because the treatment was painless and safe[54].

The subjects were then instructed to do Totten and Hunter's nerve and tendon gliding exercises (1991)[51]. Exercise in the same manner as described in Nerve and tendon gliding exercise.

Data Analysis: Descriptive analysis was used to establish the demographic data of the subjects as well as the mean value outcome measures for baseline, 2 weeks, 4 weeks, and follow-up (8 weeks). The normality of the data was checked using Shapiro-Wilk test. The assumptions for RM ANOVA were checked. The Repeated Measure ANOVA was performed to determine the time effect. The differences were considered significant at $p<0.05$.

RESULT

At the beginning of the study, sixty subjects (n=60) with hand treated (n=104) involved after fulfilling the inclusion criteria stated. However, during the 4 weeks of intervention period, 8 subjects withdrew from this study (Group A: n=3, Group B: n=2 and Control: n=3). Finally, the total of the subjects remain for data analysis of this study were n=52 and hand treated n=90. Majority of the subjects were female 73.1% while male with 26.9%. Table 1 shows the summary of the demographic data for the participants. In all comparison for outcome measures based on time, the results reveal a significant improvement ($p<0.005$).Descriptive analysis of SSS and FSS for the participants based on groups is presented in Table 1.

Repeated measure ANOVA within group analysis was applied followed by pairwise comparison with 95% confidence interval (CI) adjustment by Bonferroni correction to evaluated the SSS and FSS among the participants each group based on time (time effect) showed in Table 3. In order to determine the treatment effect among the participants between the groups, repeated measure ANOVA between group analysis was applied followed by post-hoc multiple comparisons using Scheffe method was

conducted on SSS (F-stat (df)=121.63(2), p-value <0.001) and FSS (F-stat(df)=103.41(2), p-value <0.001) of this study. The detailed result was presented in Table 4.A profile plot was produced to interpret the interaction of three Physiotherapy interventions on SSS and FSS between the three different groups based on time. Therefore, the intervention of Group B (ESWT combined with nerve and tendon gliding exercise) shows decreasing level of SSS and increase FSS over time compared to other groups.

	No. of Subjects (n=)	Percentage (%)	Mean (SD)	Min-max
Age (Years)				
30 -60	-	-	50.71(8.31)	31,60
Gender				
Female	38	73.1		
male	14	26.9		
Height (cm)	52		157.60(8.55)	145,172
Weight (kg)	52		68.61(8.22)	54, 86
BMI (kg/m2)			27.79(2.67)	24,39
Race				
Malay	52	100		
Other	0	0		
Religion				
Muslim	52	100		
Non-Muslim	0	0		
Marital status				
Married	51	98.1		
Single	1	1.9		
Dominant hand				
Right	45	86.5		
Left	7	13.5		
Affected Hand				
Bilateral	38	73.1		
Unilateral	14	26.9		
Occupational				
Housewife	12	23.1		
Teacher	10	19.2		
Office	8	15.4		
Driver	10	19.2		
Tailor	6	11.5		
labour	6	11.6		
Experimental Groups				
Group A	17	32.7		
Group B	18	34.6		
Group C	17	32.7		

Note: SD: Standard Deviation, BMI: Body mass index

Table 1:Demographic data of the participants.

Boston Carpal Tunnel Questionnaire	Time	Group A (UST)	Group B (ESWT)	Control	F stat (df)	P value
		(n=30)	(n=31)	(n=29)		
		Mean (SD)	Mean (SD)	Mean (SD)		
SymptomSeverity Scale	Baseline	38.63(4.11)	37.10(3.87)	36.41(3.86)	2.45(2,87)	0.092
	2 weeks-intervention	36.40(3.44)	30.55(1.74)	34.04(4.19)	26.78(2,87)	<0.001
	4 weeks-intervention	29.83(2.68)	19.00(2.49)	34.76(3.70)	219.76(2,87)	<0.001
	Follow-up	29.90(2.72)	19.13(2.23)	34.45(4.26)	186.86(2,87)	<0.001
Functional Status scale	Baseline	26.10(2.96)	26.58(2.72)	25.89(3.10)	0.44(2,87)	0.648
	2 weeks-intervention	24.40(3.02)	21.94(1.34)	24.58(2.96)	10.28(2,87)	<0.001
	4 weeks-intervention	21.17(3.52)	10.62(2.67)	26.72(5.77)	116.81(2,87)	<0.001
	Follow-up	18.97(2.58)	11.90(1.85)	19.35(4.55)	53.12(2,87)	<0.001

Table 2: Descriptive analysis of Symptom Severity and Functional Status Scalefor baseline, 2 weeks, 4 weeks, and follow-up according to groups

Boston Carpal Tunnel Questionnaire	Time	Group A (UST)	Group B (ESWT)	Control	F stat (df)	P- value
		(n=30)	(n=31)	(n=29)		
		Mean (SD)	Mean (SD)	Mean (SD)		
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	4 weeks-intervention	29.83(2.68)	19.00(2.49)	34.76(3.70)	219.76(2,87)	<0.001
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	4 weeks-intervention	21.17(3.52)	10.62(2.67)	26.72(5.77)	116.81(2,87)	<0.001
	Follow-up	18.97(2.58)	11.90(1.85)	19.35(4.55)	53.12(2,87)	<0.001

Table 3: Comparison of Symptom and Functional Severity Scale within each groups of idiopathic CTS based on time (Time effect) (n=90)

Comparison (Group)		Mean difference (95 %CI)	p-value
BCTQ	GROUP		
Symptom Severity Scale	Group A - Group B	7.25 (5.75, 8.74)	<0.001
	Group A - Group C	1.55 (0.03, 3.07)	0.045
	Group B - Group C	8.80 (7.29, 10.31)	<0.001
Functional Status Scale	Group A - Group B	4.90 (3.75, 6.05)	<0.001
	Group A - Group C	1.47 (0.31, 2.65)	0.009
	Group B - Group C	6.38 (5.22, 7.54)	<0.001

Note:Significant at <0.05

Table 4: Overall mean difference of Symptom Severity And Functional StatusScale among three groups (treatment effect) (n=90)

DISCUSSION

Numerous studies shown that the CTS is a common compression disease and debilitating disorder in ambulatory clinic visits in primary care[55,56]. The syndrome is characterized by pain in the hand, numbness, and tingling in the distribution of the median nerve. The painful feelings may result in a reduction in grip strength and hand function[4]. If not treated, it can cause median nerve damage and as a result, loss of hand function[57].This present study used Boston Carpal Tunnel Syndrome Questionnaire (BCTQ) as an outcome measurement to determine the effectiveness on symptom and hand function. Previously, several studies used the questionnaire for the measurement of the severity of symptoms and functional status due to reproducibility, internal consistency, and validity in patients with CTS[46,47]. The used of this self-administer questionnaire is recommended in any types of CTS research due to quick and easy to administer[58].

The SSS which has questions consists of 11 items assessing pain, paresthesia, numbness, weakness, nocturnal symptoms, and difficulty of grasping. The FSS contains eight items, which assess functional deficits in the following domains: writing, buttoning clothes, holding a book while reading, gripping a telephone handle, opening jars, performing household chores, carrying grocery bags, bathing, and dressing[59].

ESWT paired with hand exercise (nerve and tendon gliding exercise) enhanced SSS and FSS, in the current study. The results reveal a significant improvement ($p<0.005$) in all time comparisons. Several studies have found comparable findings, including this one, which demonstrated significant reductions in symptom and function after two or more ESWT sessions[46,47]. In the treatment of CTS symptoms, one session of ESWT is as effective as a single corticosteroid injection[39].

As a result, clinical evidence suggests that many ESWT sessions are more effective than a single application[46]. ESWT has been proven to have a cumulative impact in several studies[46]. Both fESWT and rESWT have recently gained popularity as a safe and new treatment for CTS[39,40,47]. After several tries, Murata et al. (2006)[60] discovered a cumulative effect on free nerve endings in rats with a longer lasting antinociceptive consequence. The cumulative effect of ESWT was established in a study by Ke et al., (2016)[46].

Repeated ESWT sessions could keep the analgesic benefits for at least four weeks, according to their findings. In contrast, a single session of ESWT has only a five-day efficacy against mechanical and thermal hyperalgesia. In mild to severe CTS, ESWT appears to activate a more analgesic and anti-inflammatory mechanism. They show in their study that repeated ESWT sessions may keep the analgesic effects for at least four weeks. A single session of ESWT, on the other hand, only has a five-day efficacy against mechanical and thermal hyperalgesia. For a mild to moderate CTS, ESWT appears to trigger a greater analgesic and anti-inflammation mechanism. In this study, the therapeutic benefit of ESWT for mild to moderate CTS was established. In previous research, low-energy ESWT was shown to improve pain and hand function in patients with mild to moderate CTS[61,62,63].

In the current investigation, ESWT was found to considerably improve the symptom. Eight

sessions of ESWT with pneumatic wave have been shown to offer good benefits for patients[47,64,65]. However, there is currently no published evidence for using ESWT in CTS[47], and the test is not yet available in Malaysia.Gliding exercises for the nerves and tendons are a frequent exercise for CTS patients[24,28]. These exercises have been utilised to manage both postoperative and conservative management[66].

In order to improve the efficacy of conservative treatment for CTS, nerve and tendon gliding exercises were devised as a supplemental technique to traditional conservative treatment[28]in the clinical environment. According to the findings, the ESWT was effective in treating mild to moderate symptoms. The ESWT improved symptom and function, according to the present study's findings, which were backed up by several clinical trials. ESWT appears to be a safe and effective conservative treatment for relieving pain and impairment in CTS patients with no side effects[39,42,67].

Ethical clearance: There was no risk of conducting this study. Ethical approval for the study was granted by UniSZA Human Research Ethics Committee of Universiti Sultan Zainal Abidin (UHREC): UniSZA/UHREC/2019/108.

Conflicts of Interest: There is no conflict of interest to conduct this study.

Fund for the study: This is self funded study.

CONCLUSION

This result implies that the ESWT is an effective modality in treating mild to moderate CTS in a clinical setting in Malaysia. ESWT can be used to reduce the symptoms and improve the hand functions in patients with CTS.

REFERENCES

1. Padua, L., Aprile, I., Pazzaglia, C., Frasca, G., Caliandro, P., Tonali, P., & Martinoli, C. (2007). Contribution of ultrasound in a neurophysiological lab in diagnosing nerve impairment: a one-year systematic assessment. Clinical neurophysiology 118 (6), 1410-1416.
2. Chammas, M., Boretto, J., Burmann, L. M., Ramos, R. M., Santos Neto, F. C. D., & Silva, J. B. (2014). Carpal tunnel syndrome-Part I (anatomy, physiology, etiology and diagnosis). Revista brasileira de ortopedia, 49, 429-436.
3. Armstrong, T., Dale, A. M., Franzblau, A., & Evanoff, B. A. (2008). Risk factors for carpal tunnel syndrome and median neuropathy in a working population. Journal of Occupational and Environmental Medicine, 1355-1364.
4. Genova, A., Dix, O., Saefan, A., Thakur, M., & Hassan, A. (2020). Carpal tunnel syndrome: a review of literature. Cureus, 12(3).
5. Werner, R. A., & Andary, M. (2002). Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. Clinical Neurophysiology, 113(9), 1373-1381.
6. Hobson-Webb, L. D., & Padua, L. (2009). Median nerve ultrasonography in carpal tunnel syndrome: findings from two laboratories. Muscle & nerve, 40(1), 94-97.
7. Beekman, R., & Visser, L. H. (2003). Sonography in the diagnosis of carpal tunnel syndrome: a critical review of the literature. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine, 27(1), 26-33.
8. Nakamichi, K. I., & Tachibana, S. (2000). Enlarged median nerve in idiopathic carpal

tunnel syndrome. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine, 23(11), 1713-1718.

9. Wang, C. J., Wang, F. S., Yang, K. D., Weng, L. H., Hsu, C. C., Huang, C. S., & Yang, L. C. (2003). Shock wave therapy induces neovascularization at the tendon bone junction. A study in rabbits. Journal of Orthopaedic Research, 21(6), 984-989.
10. Atroshi, I., Gummesson, C., Johnsson, R., Ornstein, E., Ranstam, J., & Rosén, I. (1999). Prevalence of carpal tunnel syndrome in a general population. Jama, 282(2), 153-158.
11. Bahar-Moni, A. S., Abdullah, S., Fauzi, H., Chee-Yuen, S. Y., Abdul-Razak, F. Z., & Sapuan, J. (2019). Demographics of patients undergoing carpal tunnel release in an urban tertiary hospital in Malaysia. Malaysian orthopaedic journal, 13(3), 53.
12. Munirah, M. A., Normastura, A. R., Azizah, Y., & Aziah, D. (2014). Prevalence of probable carpal tunnel syndrome and its associated factors among dentists in Kelantan. International Journal of Collaborative Research on Internal Medicine & Public Health, 6(8), 0-0.
13. Zamborsky, R., Kokavec, M., Simko, L., & Bohac, M. (2017). Carpal tunnel syndrome: symptoms, causes and treatment options. Literature reviev. Ortop Traumatol Rehabil, 19(1), 1-8.
14. Fowler, J. R., Cipolli, W., & Hanson, T. (2015). A comparison of three diagnostic tests for carpal tunnel syndrome using latent class analysis. JBJS, 97(23), 1958-1961.
15. Wiesler, E. R., Chloros, G. D., Cartwright, M. S., Smith, B. P., Rushing, J., & Walker, F. O. (2006). The use of diagnostic ultrasound in carpal tunnel syndrome. The Journal of hand surgery, 31(5), 726-732.
16. Werner, R. A., & Andary, M. (2011). Electrodiagnostic evaluation of carpal tunnel syndrome. Muscle & nerve, 44(4), 597-607.
17. Moscony, A. M. (2007). Common peripheral nerve problems. Fundamentals of Hand Therapy: Clinical Reasoning and Treatment Guidelines for Common Diagnoses of the Upper Extremity. Philadelphia: Mosby Elsevier, 201-250.
18. Aroori, S., & Spence, R. A. J. (2008). Carpal tunnel syndrome. Ulster Med J., 77(1), 6–17.
19. Page, M. J., O'Connor, D., Pitt, V., & Massy-Westropp, N. (2013). Therapeutic ultrasound for carpal tunnel syndrome. Cochrane Database of Systematic Reviews, (3).
20. Huisstede, B. M., Hoogvliet, P., Randsdorp, M. S., Glerum, S., van Middelkoop, M., & Koes, B. W. (2010). Carpal tunnel syndrome. Part I: effectiveness of nonsurgical treatments A systematic review. Archives of physical medicine and rehabilitation, 91(7), 981-1004.
21. Marshall, S. C., Tardif, G., & Ashworth, N. L. (2007). Local corticosteroid injection for carpal tunnel syndrome. Cochrane Database of Systematic Reviews, (2).
22. Hamamoto Filho, P. T., Leite, F. V., Ruiz, T., & de Lima Resende, L. A. (2009). A systematic review of anti-inflammatories for mild to moderate carpal tunnel syndrome. Journal of Clinical Neuromuscular Disease, 11(1), 22-30.
23. Dakowicz, A., & Latosiewicz, R. (2005). The value of iontophoresis combined with ultrasound in patients with the carpal tunnel syndrome. Rocz Akad Med Bialymst, 50(Suppl 1), 196-198.
24. Rozmaryn, L. M., Dovelle, S., Rothman, E. R., Gorman, K., Olvey, K. M., & Bartko, J. J.

(1998). Nerve and tendon gliding exercises and the conservative management of carpal tunnel syndrome. Journal of Hand Therapy, 11(3), 171-179.

25. Bakhtiary, A. H., & Rashidy-Pour, A. (2004). Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. Australian Journal of Physiothera-py, 50(3), 147-151.
26. Oztas, O., Turan, B., Bora, I., & Karakaya, M. K. (1998). Ultrasound therapy effect in carpal tunnel syndrome. Archives of physical medicine and rehabilita-tion, 79(12), 1540-1544.
27. Yagci, I., Elmas, O., Akcan, E., Ustun, I., Gunduz, O. H., & Guven, Z. (2009). Comparison of splinting and splinting plus low-level laser therapy in idiopathic carpal tunnel syndrome. Clinical rheumatology, 28(9), 1059-1065.
28. Akalin, E., El, Ö., Peker, Ö., Senocak, Ö., Tamci, S., Gülbahar, S., & Öncel, S. (2002). Treatment of carpal tunnel syndrome with nerve and tendon gliding exercises. American journal of physical medicine & rehabilitation, 81(2), 108-113.
29. Chang, Y. W., Hsieh, S. F., Horng, Y. S., Chen, H. L., Lee, K. C., & Horng, Y. S. (2014). Comparative effectiveness of ultrasound and paraffin therapy in patients with carpal tunnel syndrome: a randomized trial. BMC musculoskeletal disorders, 15(1), 1-7.
30. Rempel, D., Manojlovic, R., Levinsohn, D. G., Bloom, T., & Gordon, L. (1994). The effect of wearing a flexible wrist splint on carpal tunnel pressure during repetitive hand activity. The Journal of hand surgery, 19(1), 106-110.
31. Viera, A. J. (2003). Management of carpal tunnel syndrome. American family physic-cian, 68(2), 265-272.
32. Colbert, A. P., Markov, M. S., Carlson, N., Gregory, W. L., Carlson, H., & Elmer, P. J. (2010). Static magnetic field therapy for carpal tunnel syndrome: a feasibility study. Archives of physical medicine and rehabilitation, 91(7), 1098-1104.
33. Farhat, A., & Mughal, S. M. (2021). Is There a Role of Cupping Therapy in the Treatment of Carpal Tunnel Syndrome in Primary Care Setting?. Cureus, 13(1).
34. Soyuer, F. (2021). Effectiveness of current physiotherapy in carpal tunnel syndrome. Int J Fam Commun Med, 5(3), 87-89.
35. Samii, K., Cassinotti, P., de Freudenreich, J., Gallopin, Y., Le Fort, D., & Stalder, H. (1996). Acute bilateral carpal tunnel synd-rome associated with human parvovirus B19 infection. Clinical infectious dise-ases, 22(1), 162-164.
36. Feuerstein, M., Burrell, L. M., Miller, V. I., Lincoln, A., Huang, G. D., & Berger, R. (1999). Clinical management of carpal tunnel syndrome: A 12-year review of outcomes. American Journal of Industrial Medicine, 35(3), 232-245.
37. Ogden, J. A., Alvarez, R., Levitt, R., Cross, G. L., & Marlow, M. (2001). Shock wave therapy for chronic proximal plantar fasciitis. Clinical Orthopaedics and Related Research®, 387, 47-59.
38. Vahdatpour, B., Kiyani, A., & Dehghan, F. (2016). Effect of extracorporeal shock wave therapy on the treatment of patients with carpal tunnel syndrome. Advanced biomedical research, 5.
39. Seok, H., & Kim, S. H. (2013). The effective-ness of extracorporeal shock wave therapy vs. local steroid injection for management of carpal tunnel syndrome: a randomized controlled trial. American journal of

physical medicine & reha-bilitation, 92(4), 327-334.

40. Rompe, J. D., Bürger, R., Hopf, C., & Eysel, P. (1998). Shoulder function after extra-corporal shock wave therapy for calcific tendinitis. Journal of Shoulder and Elbow surgery, 7(5), 505-509.
41. Cleveland, R. O., Chitnis, P. V., & McClure, S. R. (2007). Acoustic field of a ballistic shock wave therapy device. Ultrasound in medicine & biology, 33(8), 1327-1335.
42. Paoloni, M., Tavernese, E., Cacchio, A., D'orazi, V., Ioppolo, F., Fini, M. & Mangone, M. (2015). Extracorporeal shock wave therapy and ultrasound therapy improve pain and function in patients with carpal tunnel syndrome. A randomized controlled trial. Eur J Phys Rehabil Med, 51(5), 521-528.
43. Leu, S., Huang, T. H., Chen, Y. L., & Yip, H. K. (2018). Effect of extracorporeal shockwave on angiogenesis and anti-inflammation: Molecular cellular signaling pathways. In Shockwave Medicine (Vol. 6, pp. 109-116). Karger Publishers.
44. d'Agostino, M. C., Craig, K., Tibalt, E., & Respizzi, S. (2015). Shock wave as biological therapeutic tool: From mechanical stimul-ation to recovery and healing, through mechano transduction. International journ-al of surgery, 24, 147-153.
45. Ke, M. J., Chen, L. C., Chou, Y. C., Li, T. Y., Chu, H. Y., Tsai, C. K., & Wu, Y. T. (2016). The dose-dependent efficiency of radial shock wave therapy for patients with carpal tunnel syndrome: a prospective, rando-mized, single-blind, placebo controlled trial. Scientific reports, 6(1), 1-10.
46. Wu, Y. T., Ke, M. J., Chou, Y. C., Chang, C. Y., Lin, C. Y., Li, T. Y. & Chen, L. C. (2016). Effect of radial shock wave therapy for carpal tunnel syndrome: A prospective random-ized, double-blind, placebo- controlled trial. Journal of Orthopaedic Research, 34(6), 977-984.
47. Fischer, J., Thompson, N. W., & Harrison, J. W. (2014). A self-administered question-naire for the assessment of severity of symptoms and functional status in carpal tunnel syndrome. In Classic Papers in Orthopaedics (pp. 349-351). Springer, London.
48. Sezgi˙ n, M., İncel, N. A., Sevi˙ m, S., Çamdevi ren, H., As, İ., & ErdoĞan, C. (2006). Assessment of symptom severity and functional status in patients with carpal tunnel syndrome: reliability and validity of the Turkish version of the Boston Questionnaire. Disability and rehabilitation, 28(20), 1281-1286.
49. Abdullah, A., Daud, A. Z. C., Dahlan, A., & Nawawi, R. F. M. (2019). Cross-Cultural Adaptation, Validity and Reliability of Malay Version Boston Carpal Tunnel Questionnaire. Environment Behaviour Pr-oceedings Journal, 4(12), 149-156.
50. Totten, P. A., & Hunter, J. M. (1991). Therapeutic techniques to enhance nerve gliding in thoracic outlet syndrome and carpal tunnel syndrome. Hand Clinics, 7(3), 505-520.
51. Bartkowiak, Z., Eliks, M., Zgorzalewicz-Stachowiak, M., & Romanowski, L. (2019). The effects of nerve and tendon gliding exer-cises combined with low-level laser or ultrasound therapy in carpal tunnel syndr-ome. Indian journal of orthopaedics, 53(2), 347-352.
52. Horng, Y. S., Hsieh, S. F., Tu, Y. K., Lin, M. C., Horng, Y. S., & Wang, J. D. (2011). The comparative effectiveness of tendon and nerve gliding exercises in patients with carpal tunnel syndrome: a randomized trial.

American journal of physical medicine & rehabilitation, 90(6), 435-442.
53. Baysal, O., Altay, Z., Ozcan, C., Ertem, K., Yologlu, S., & Kayhan, A. (2006). Comparison of three conservative treatm-ent protocols in carpal tunnel syndrome. International journal of clinical practice, 60(7), 820-828.
54. Rompe, J. D., Meurer, A., Nafe, B., Hofmann, A., & Gerdesmeyer, L. (2005). Repetitive low-energy shock wave application without local anesthesia is more efficient than repetitive low-energy shock wave application with local anesthesia in the treatment of chronic plantar fasciitis. Journal of orthopaedic research, 23(4), 931-941.
55. Wang, L. (2018). Guiding treatment for carpal tunnel syndrome. Physical Medicine and Rehabilitation Clinics, 29(4), 751-760.
56. Wipperman, J., & Goerl, K. (2016). Carpal tunnel syndrome: diagnosis and manage-ment. American family physician, 94(12), 993-999.
57. Kamolz, L. P., Beck, H., Haslik, W., Högler, R., Rab, M., Schrögendorfer, K. F., & Frey, M. (2004). Carpal tunnel syndrome: a question of hand and wrist configurations?. Journal of hand surgery, 29(4), 321-324.
58. Leite, J. C., Jerosch-Herold, C., & Song, F. (2006). A systematic review of the psychometric properties of the Boston Carpal Tunnel Questionnaire. BMC musculoskeletal disorders, 7(1), 1-9.
59. Multanen, J., Ylinen, J., Karjalainen, T., Kautiainen, H., Repo, J. P., & Häkkinen, A. (2020). Reliability and validity of the Finnish version of The Boston Carpal tunnel questionnaire among surgically treated Carpal Tunnel Syndrome patients. Scandinavian Journal of Surgery, 109(4), 343-350.
60. Murata, R., Ohtori, S., Ochiai, N., Takahashi, N., Saisu, T., Moriya, H., .& Wada, Y. (2006). Extracorporeal shockwaves induce the expression of ATF3 and GAP-43 in rat dorsal root ganglion neurons. Autonomic Neuroscience, 128(1-2),96-100.
61. Xu, D., Jiang, W., Huang, D., Hu, X., Wang, Y., Li, H., ... & Ma, W. (2020). Comparison between extracorporeal shock wave therapy and local corticosteroid injection for plantar fasciitis. Foot & ankle international, 41(2), 200-205.
62. Habibzadeh, A., Mousavi-Khatir, R., Saadat, P., & Javadian, Y. (2022). The effect of radial shockwave on the median nerve pathway in patients with mild-to-moderate carpal tunnel syndrome: a randomized clinical trial. Journal of Orthopaedic Surgery and Research, 17(1), 1-9.
63. Kim, J. C., Jung, S. H., Lee, S. U., & Lee, S. Y. (2019). Effect of extracorporeal shockwave therapy on carpal tunnel syndrome: A systematic review and meta-analysis of randomized controlled trials. Medicine, 98(33).
64. Romeo, P., d'Agostino, M. C., Lazzerini, A., & Sansone, V. C. (2011). Extracorporeal shock wave therapy in pillar pain after carpal tunnel release: a preliminary study. Ultrasound in medicine & biology, 37(10), 1603-1608.
65. Gesslbauer, C., Mickel, M., Schuhfried, O., Huber, D., Keilani, M., & Crevenna, R. (2021). Effectiveness of focused extracorp-oreal shock wave therapy in the treatment of carpal tunnel syndr-ome. Wiener klinische Wochenschrift, 133(11), 568-577.
66. Sawan, S. A., Sayed Mahmoud, H. M., & Hussien, M. M. (2013). Effect of different physical therapy modalities on post-operative recovery following transverse carpal ligament release: A randomized

controlled trial. Physiotherapy Practice and Research, 34(2), 75-82.

67. Rashad, U. M., Kishk, N. A., Mansour, W. T., Nawito, A. M., Khalil, A. S., Helmy, H., & Zayed, T. K. (2020). Effect of extracorporeal shock wave therapy on different severities of carpal tunnel syndrome. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery, 56(1), 1-6.

Citation:

Hazliza Razali, Naresh Bhaskar Raj, Wan-Arfah N, Zakaria Yusoff, Vinodhkumar Ramalingam (2022). Effectiveness of Physiotherapy Interventions on Symptom Severity and Hand Function in Patients with Idiopathic CTS , ijmaes; 8 (2); 1287-1301