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Carpal Tunnel Syndrome: A Randomized Comparative Study of Magnetic Field Therapy and Ultrasound Therapy

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Abstract

Background: Carpal tunnel syndrome is a frequently observed condition affecting the wrists and fingers, characterized by numbness, tingling, and sometimes pain.

Objective: To evaluate and compare the efficiency of magnetic field therapy and ultrasound therapy in rehabilitating women with carpal tunnel syndrome (CTS).

Patients and Methods: Forty women with mild to moderate CTS were included in the study, and an electromyography (EMG) and examination confirmed the diagnosis. The participants were assigned into two groups. Group A received magnetic field therapy, and Group B received ultrasound therapy. Patients for each group received a six-session clinical evaluation. The outcomes included the Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ), handgrip strength, wrist joint movements (flexion and extension), as well as the Visual Analogue Scale (VAS).

Results: The paired t-test analyses demonstrate a significant improvement in the Boston questionnaire and VAS in both intervention groups at a P-value ≤0.05. The independent sample t-test analysis for post-intervention for both groups showed superiority for magnetic field therapy; no significant differences were observed in the improvement of wrist movement (Flexion = 0.66, Extension = 0.71); the Visual Analog Scale (VAS) has been improved in both treatment groups with dominance for ultrasound therapy.

Conclusion: Both magnetic field and ultrasound therapy effectively treat women with carpal tunnel syndrome. Magnetic field therapy was statistically superior to ultrasound.

Keywords: Carpal Tunnel Syndrome, Magnetic Field Therapy, Ultrasound Therapy.

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Introduction

Carpal tunnel syndrome is a frequently observed condition affecting the wrists and fingers, characterized by numbness, tingling, and sometimes pain due to Pressure on the median nerve in the carpal tunnel, causing neuropathy. Based on clinical diagnosis, the general population exhibits a 3.8% carpal tunnel syndrome prevalence rate, whereas neurophysiological diagnosis indicates a lower prevalence rate of 2.7% [1]. Middle-aged females are more vulnerable to CTS, with a an incidence rate of 70%, compared to

ORIGINAL RESEARCH
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men [2]. Typically, carpal tunnel syndrome results from various conditions, for instance, edema due to pregnancy or injury, lipoma, nodes associated with tendon sheaths, muscle, tendon, and blood vessel anomalies that compress the median nerve, etc. [3]. Several experimental studies have been carried out to evaluate the efficiency of various therapeutic modalities for managing this condition through its mild and moderate stages, including laser therapy, ultrasound therapy, magnetic field therapy, shock wave therapy, wrist splint, paraffin bath, and manual therapy [4-6]. Alterations in blood circulation, cellular metabolism, nerve response, flexibility of connective tissue, and the permeability of biological membranes are some of the effects seen on mammalian tissues when exposed to ultrasound therapy [7]. Temperature can influence the rate of nerve regeneration [8]. The ability of nerve fibers to generate an action potential is affected by the mechanical and thermal properties of ultrasound [7]. Ultrasound therapy was used as part of a combination of carpal tunnel syndrome therapies for many years [4, 5, 9]. Treatment with ultrasound may induce different biophysical effects in the tissue and alleviate nerve compression by enhancing tissue function [10]. The neuropathic pain associated with carpal tunnel syndrome, which is characterized by numbness, tingling, and burning sensations, is thought to be caused by abnormal firing of nociceptive nerve fibers(C-fiber) that lack myelin and deteriorate from a physiological perspective [11]. Microneurography have revealed that the improper regulation of sodium and calcium channels, which gather at the location of the injury, result in abnormal depolarization occurring. Magnetic fields can create changes in living organisms by causing eddy electrical currents to flow through the tissues at a low frequency, which can impact the activity of neurons by altering their membrane potential. Research has demonstrated that exposure to magnetic fields can significantly reduce short- and long-term pain in individuals suffering from Carpal Tunnel Syndrome while improving objective neuronal function in a mild manner [12]. The current study has two primary goals: first, to assess the efficacy of ultrasound and magnetic field therapy for treating pain, the status of functioning, and the severity of symptoms in CTS patients. Second, to determine which approach is more effective. In this study, the researchers assumed that there would be differences between the clinical results of CTS patients treated with ultrasound or magnetic field therapy.

Patients and Methods

Al-Rusafa Health Directorate, Research and the Development Committee reviewed the study protocol and granted approval for conducting the research (document no. 24147); the researchers obtained informed consent from subjects before participating. This study recruited forty eligible women (47 hands) who matched the selection criteria and were clinically diagnosed and electromyography confirmed with carpal tunnel syndrome from the Medical Rehabilitation and Rheumatology Center from February 2021 to January 2022 to conduct a randomized comparative trial. Pregnant women, cancer, pacemakers, history of wrist injury or surgery, local corticosteroid injections for six months, use of NSAIDs

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during the research period, and patients who did not want to participate were excluded from the study. In contrast, the inclusion criteria involve subjects with a positive Phalen's and Tunnel test and patients with objective symptoms such as numbness, pain, and paresthesia. Verbal consents were obtained from patients to participate in the study and all the subjects were assigned randomly into two groups using numbered papers, with each participant having the opportunity to select the intervention group. Patients in the group (A) receive six sessions, three sessions per week, for two weeks of ultrasound with the following treatment parameters: frequency 0.8 MHz, duty cycle 1:4, treatment intensity 0.5–1.0 W/cm^2, 10 min. Per session, transducer with surface area 5 cm^2, Sono5 Zimmer with ultrasound gel. Group (B) received six sessions, three times a week, for two weeks of magnetic field therapy with the following treatment parameters: frequency 50 Hz, Intensity max. 50 gausses, for 15 minutes per session); R980 magnetic, cosmogamma.

Outcome Measures

The pain intensity, handgrip strength, severity of symptoms, and general status of functional of patients with carpal tunnel syndrome were measured before and after a two-week treatment course utilizing the visual analogue scale (VAS), Jamar hydraulic hand dynamometer, pneumatic handheld dynamometer, and Boston Carpal Tunnel Questionnaire (BCTQ).

Pain assessment: The visual analogue scale (VAS) is a reliable and valid psychometric tool for measuring pain. It typically involves a 100-millimeter straight line with anchor points on either end, arranged from left to right (no pain to most severe pain) or vice versa [13].

Grip strength assessment: The study used Baseline Bulb Pneumatic Dynamometers (30 PSI, 12-0291, U.S.A.) and Jamar Hydraulic Hand Dynamometers (Preston Corp. Jackson, MI 49203, U.S.A.) to measure grip strength. Three trials were performed with a 20-second interval between each, with patients told to squeeze the dynamometer to achieve the most significant possible contraction; the average of the values was used for analysis.

Boston carpal tunnel syndrome questionnaire (BCTSQ): The questionnaire is designed to be self-reported by the respondent. It is used to evaluate the pain, numbness, weakness, and hand functional level among patients who suffer from carpal tunnel syndrome; it comprises two domains: the severity of symptom domain (11 items) and functional status domain (8 items). To evaluate each item, a five-degree Likert scale is used from 1 (no symptoms, no difficulties) to 5 (Very serious, intense problem); the mean is calculated of each scale to determine a score ranging from 1 to 5. The higher the score, the more severe the symptoms or impaired functioning.

Wrist movements: The effectiveness of both intervention groups was evaluated by measuring the wrist's range of motion, including flexion and extension.

Statistical Analysis

SPSS 24.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. The Kolmogorov–Smirnov test was used to determine the normality of the distribution. The t-test was used to compare quantitative values. To identify whether there were any significant differences within

ORIGINAL RESEARCH
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groups, a paired sample t-test was used. When analyzing the treatment effect, an independent sample T-test was employed to account for covariance in baseline outcomes among the groups. The statistical significance was determined to be $P < 0.05$.

Results

According to the study results illustrated in Table (1), Patients' average age in the magnetic group was (38.7 ± 12.9) y.o., while the ultrasound group (43.8 ± 7.1) years. Generally, the patients were between the ages of 20 and 60 years. More than half of the patients in the ultrasound group were housewives, 55%, compared with 65% of those in the magnetic group. Statistical analysis found that the right hand was more affected for most participants from both groups; many patients reported that their hand dexterity had been affected and lost when asked about its effects.

Table (1): A comparison of sociodemographic characteristics between the two experimental groups for patients with CTS

SDCv.	Groups	Magnetic		Ultrasound		C.S. P-value
	Response	No.	%	No.	%	
Age Groups	20 - 29	7	35	0	0.00	χ^2= 11.667 P=0.009 (H.S.)
	30 -39	1	5	5	25	
	40 -49	5	25	10	50	
	50 - 60	7	35	5	25	
	Mean ± SD	38.75 ± 12.92		43.80 ± 7.13		
	Total	20	100	20	100	
Occupation	Free Business	2	10	0	0.00	χ^2= 11.958 P=0.018 (S.)
	Housewife	2	10	11	55	
	Employer	13	65	9	45	
	Student	2	10	0	0.00	
	Retired	1	5	0	0.00	
	Total	20	100	20	100	
Education Levels	Illiterate	0	0.00	3	15	χ^2= 20.738 P=0.000 (H.S.)
	primary school	0	0.00	6	30	
	high school	1	5	6	30	
	graduate	19	95	5	25	
	Total	20	100	20	100	
Family History	Yes	8	40	5	25	χ^2= 4.433 P=0.109 (N.S.)
	No	12	60	15	75	
	Total	20	100	20	100	
Affected Side	Right	12	60	17	85	χ^2= 4.433 P=0.109 (N.S.)
	Left	2	10	2	10	
	Both	6	30	1	5	
	Total	20	100	20	100	
Loss of manual dexterity	Yes	15	75	11	55	χ^2= 1.758 P=0.185 (N.S.)
	No	5	25	9	45	
	Total	20	100	20	100	

*SDCv: sociodemographic characteristic, C.S.: comparison significant (*) One-sample chi-square and binomial tests used for statistical analysis; H.S.: Highly Significant at P<0.01; S: Significant at P<0.05; NS: Non-Significant at P>0.05

ORIGINAL RESEARCH
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It can be seen from the data in Table 2., that differences among the intervention groups showed a high significance at a P-value1 < 0.05. Both groups showed significant improvements following the BCTQ scale and VAS intervention. There was a reduction in the mean value of the symptoms severity scale in pre and post-treatment for the magnetic group (3.09 to 1.71) and ultrasound (3.73 to 2.42). Based on an independent sample t-test, significant differences were observed in the symptoms severity scale, functional status scales, and the visual analogue scale among both studied groups Figure (1).

Table (2): A Comparison of Mean and the Standard Deviations of the BCTQ Questionnaire and the Visual Analogue Scale pre and post-intervention

	Magnetic field therapy N=20	**Ultrasound therapy N=20**
Symptoms Severity Scale	**Mean ±SD**	**Mean ±SD**
Pre Intervention	3.09±0.52	3.73±0.50
Post Intervention	1.71±0.52	2.42±0.46
The difference between (pre and post-treatment)	-1.38± 0	-1.31± -0.04
P value[1]	0.000	0.000
P value[2]	0.000* **(H.S.)**	
Functional Status Scale		
Pre Intervention	3.20±0.65	3.10±0.69
Post Intervention	1.79±0.58	2.43±0.80
The difference between (pre and post-treatment)	-1.41± -0.7	-0.67± 0.11
P value[1]	0.000	0.002
P value[2]	0.007** **(H.S.)**	
Visual Analog Scale		
Pre Intervention	6.55±0.94	5.55±1.70
Post Intervention	3.2±1.50	1±0.92
The difference between (pre and post-treatment)	-3.35± 0.56	-4.55± -0.78
P value[1]	0.000	0.000
P value[2]	0.000** **(H.S.)**	

* BCTQ (Boston Carpal Tunnel Questioner); SSS Symptom Severity Scale; FSS Functional state scale; VAS Visual Analogue Score; SD standard deviation; (**) HS: Highly Sig. at P<0.01, (*) S: Sig. at P<0.05, NS: Non-Sig. at P>0.05, 1 Paired Sample t-test, 2 Independent Sample t-test.

ORIGINAL RESEARCH
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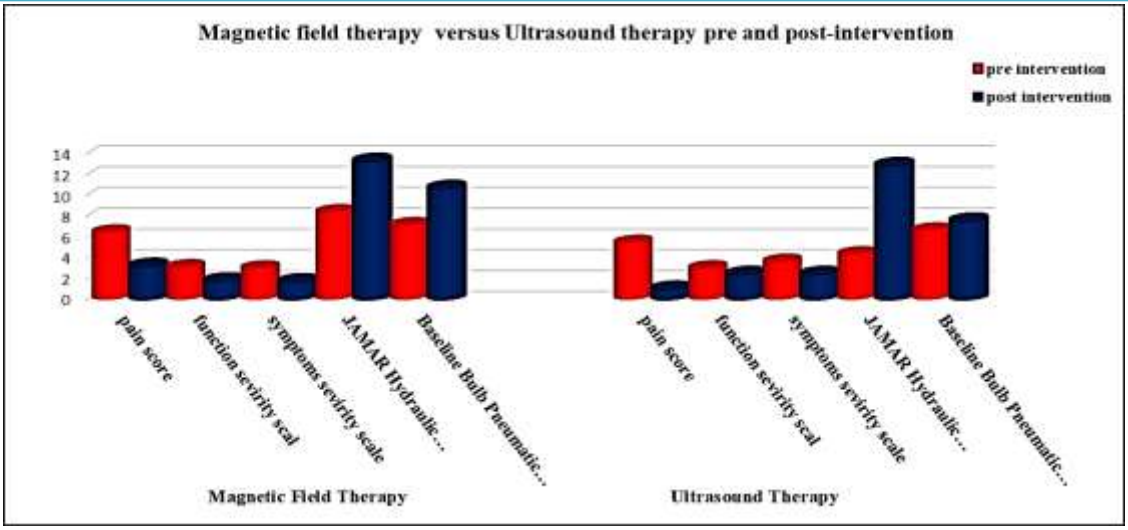

Figure (1): Comparison between magnetic field therapy and ultrasound therapy pre and post-intervention

Table (3) Comparing the results obtained from the preliminary measurement analysis for handgrip strength and wrist movements, magnetic field therapy and ultrasound therapy groups showed highly significant improvements in the hand grip strength test after the intervention period had ended (P=0.000); however, the ultrasound group did not show improvement in the Wrist movements at P-value >0.05 (Flexion P= 0.09) (Extension P=0.142). The Independent sample t-test showed significant differences at P value2 < 0.05 for both handgrip strength tests. However, no significant differences were observed for wrist movements Figure (3).

Table (3): A Comparison of Mean and Standard Deviations of handgrip strength and the range of motion pre and post-intervention

	Treatment group	
	Magnetic field therapy N=20	**Ultrasound therapy N=20**
JAMAR Hydraulic Hand Dynamometer	**Mean ±SD**	**Mean ±SD**
Pre Intervention	8.5±2.78	4.45±1.76
Post Intervention	13.3±5.46	12.90±5.18
Difference between(pre and post-treatment)	4.8±2.68	8.45±3.42
P value[1]	0.000	0.000
P value[2]	0.813 **(N.S.)**	
Baseline Bulb Pneumatic Dynamometers		
Pre Intervention	7.25±3.49	6.75±2.22
Post Intervention	10.7±5.82	7.55±2.09
Difference between(pre and post-treatment)	3.45±2.33	0.8± -0.13
P value[1]	0.000	0.000
P value[2]	0.03* **(S.)**	
R.O.M. Wrist Flexion		

ORIGINAL RESEARCH
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Pre Intervention	70.85±15.01	70.1±6.95
Post Intervention	81.35±8.49	82.3±4.98
Difference between(pre and post-treatment)	10.5± -6.52	12.2± -1.97
P value[1]	0.000	0.09
P value[2]	0.66(**N.S.**)	
R.O.M. Wrist Extension		
Pre Intervention	59.5±9.32	53.4±6.86
Post Intervention	64.35±8.34	63.55±5.08
Difference between(pre and post-treatment)	4.8± -0.98	10.15± -1.78
P value[1]	0.000	0.142
P value[2]	0.71 (**N.S.**)	

* ROM (Range Of Motion); SD standard deviation; 1Paired Sample t-test., (**) HS: Highly Sig. at P<0.01, (*) S: Sig. at P<0.05, NS: Non-Sig. at P>0.05, 2Independent Sample t-test

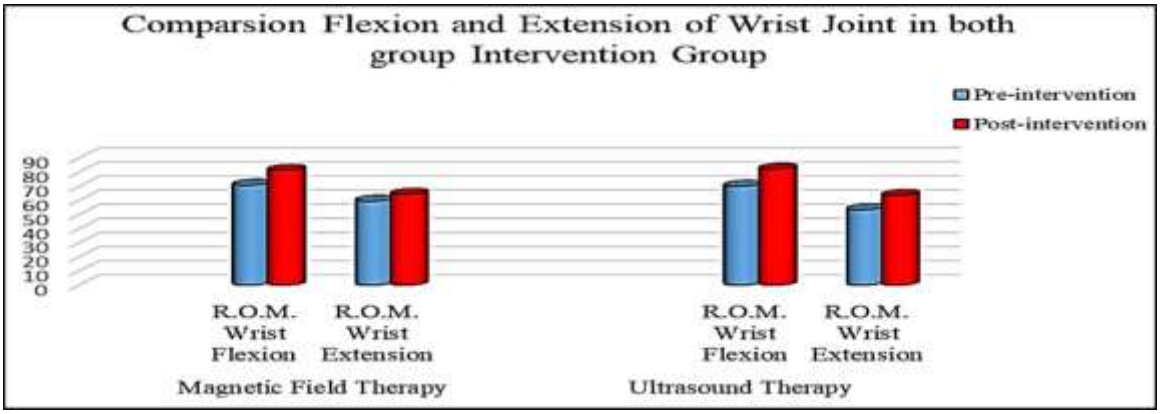

Figure (2): Comparison of flexion and extension pre and post-treatment in both intervention groups

Discussion

Carpal Tunnel Syndrome (CTS) is a condition can cause numbness, pain, and tingling in the hand and fingers, and, in severe cases, wasting of the handgrip. Moreover, the painful sensation affects hand function and grip strength [14]. The American Academy of Orthopedic Surgeons (AAOS) recommends that a non-surgical course be considered for CTS patients [15]. Several conservative treatments have been used to treat this condition, varying from ultrasound therapy, laser, paraffin wax, magnetic field therapy, splints, manual treatments, shock waves, and local injection. The influence of various approaches to managing carpal tunnel syndrome was assessed through a systemic review. The study concluded that the evidence supporting this claim was insufficient about the efficacy of ultrasound, yoga, lasers, vitamin B6, and exercise in the treatment [16]. However, previous studies have reported that ultrasound therapy positively influences carpal tunnel syndrome [4, 9, 17] and Postnatal women with CTS experience a more significant improvement from magnetic field therapy than therapeutic ultrasound [5]. Our study was designed to assess which of the two intervention groups for carpal tunnel syndrome is more efficient. Several outcome measures assess pain and functional abilities,

ORIGINAL RESEARCH
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including a Boston carpal tunnel syndrome questionnaire, visual analogue scale, handgrip strength, and active wrist movements (flexion and extension). According to the paired t-test, the group of the magnetic field reveals that the severity of symptoms, scale of functional status, visual analogue scale, and strength of grip with the hydraulic handheld and bulb pneumatic dynamometer and wrist movement were significantly improved at the P-values ≥0.05, as shown in Tables (2) and (3). This finding agrees with [5], who showed in a comparative study that magnetic field therapy reduced pain and improved grip strength among women with carpal tunnel syndrome following childbirth more effectively than ultrasound therapy [5]. Similarly, [18] compared low-level laser and magnetic field therapy for CTS. The researchers found that pain intensity and paresthesia significantly decreased following two weeks of magnetic field therapy exposure. (6 months) of the final series [18]. For the ultrasound treatment group, a comparison of results for all measured outcomes, except range of motion, revealed statistically significant variations between the intervention group's pre- and post-treatment data. The wrist movement is typically affected in individuals with carpal tunnel syndrome, as it can be painful and limited. Furthermore, the compression in the tunnel increases, resulting in further compression of the nerve [19]. The wrist joint range of motion (Flexion and Extension) revealed that no significant differences were discovered with a p-value ≤ 0.05. The results of this study are presented for the first time since previous research did not investigate the wrist joint range of motion and the degree of limitation in flexion and extension movements. Research was conducted to determine which intervention was more effective in treating carpal tunnel syndrome; a t-test was conducted to compare the post-test findings of the two groups on an independent sample basis. The results indicated a significant difference between magnetic field therapy and ultrasound therapy in the Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ), with a superior effect for the magnetic field therapy group by mean and standard deviation differences before and after treatment. In contrast, previous research conducted by [5] has shown no significant difference between pulsed magnetic therapy and ultrasound for the functional status scale at a P-value equal to or greater than 0.05. (5) the visual analogue scale (VAS) demonstrated significant enhancement in both groups following treatment for pain assessment. The magnetic field caused a reduction of 3.35 points in the VAS, whereas the ultrasound group had a reduction of 4.55 points, in favor of the ultrasound group. Ultrasound therapy has been found effective in treating pain for various musculoskeletal diseases, according to several clinical studies. Ultrasound at non-thermal levels can alter cellular proliferation, modulate membrane properties, and increase proteins related to inflammation and injury repair [20]. The findings of this research agree with those observed in earlier studies, which concluded that the application of ultrasound therapy significantly improved pain severity [7, 21]. A hydraulic hand dynamometer and a baseline bulb pneumatic dynamometer were used to assess grip strength. Based on the Hydraulic Hand

ORIGINAL RESEARCH
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Dynamometer results, It was determined that the magnetic and ultrasound therapy groups did not differ significantly on an independent sample t-test. These results were contradicted by the experiments of [5], who observed a significantly Improved strength of hand grips in the pulse magnetic field group compared to the ultrasound group [5]. However, the grip strength values in a group of magnetic therapy show a significant difference and superiority compared to ultrasound therapy when using the baseline bulb pneumatic dynamometer. To our knowledge, no previous study has assessed the grip strength using a bulb pneumatic dynamometer, and it was the first time these results were discussed. Another important outcome from this study, and for the first time mentioned, was the evaluation of wrist activity for flexion and extension range. The independent sample t-test shows that no superiority was identified between the application of ultrasound and magnetic therapy, as the mean showed that the differences are not significant in post-treatment flexion and extension of the wrist in both intervention groups. Finally, it is necessary to consider several significant limitations. Firstly, the number of participants was relatively small. Secondly, the long-term effects of the intervention have not been evaluated. Thirdly, there is a lack of references and information regarding magnetic field therapy and its experiments on carpal tunnel syndrome. Fourthly, we could not evaluate certain outcome measures, such as electromyography and nerve conduction velocity, due to the unavailability of the equipment at the study centre. Fifthly, this study was performed on patients with mild to moderate symptoms, so our findings cannot be applied to patients who exhibit more intense symptoms; thus, they should not be generalized.

Conclusions

The present study makes several noteworthy contributions and extends our knowledge of the effectiveness of the magnetic field and ultrasound therapy for patients with carpal tunnel syndrome.

Research has shown that women suffering from carpal tunnel syndrome (CTS) have better results when treated with magnetic field therapy than therapeutic ultrasound.

This more significant effect was observed in the decrease in the symptom severity scale, the enhancement in the functional status scale, and the hand grip strength (when using a bulb pneumatic dynamometer). While the visual analog scale showed improvement and superiority in the ultrasound treatment group over the magnetic field, there were no statistically significant differences in the increase of the range of motion of the wrist joint for flexion and extension movements.

Recommendations

Future studies could assess the effectiveness of incorporating nerve glide exercises or wrist orthoses into the program. Research is required to determine the efficacy of magnetic field therapy on a large population. Adding more outcome measures, for instance, electromyography and nerve conduction velocity would be beneficial to obtain more accurate results.

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Ethical clearance: The study was conducted according to the approval of the Research and the Development Committee in the Al-Rusafa Health Directorate and in accordance with the ethical guidelines of the Declaration of Helsinki (document no. 24147).

Conflict of interest: Nil

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متلازمة النفق الرسغي: دراسة مقارنة عشوائية بين العلاج بالمجال المغناطيسي والعلاج بالموجات فوق الصوتية

رائد فاروق خليل[١] , محمد باسم الخفاجي [٢]

الملخص

خلفية الدراسة: متلازمة النفق الرسغي هي حالة شائعة تؤثر على الرسغين والأصابع، وتتميز بالخدر والوخز والألم في بعض الأحيان.

اهداف الدراسة: لتقييم ومقارنة كفاءة العلاج بالمجال المغناطيسي والعلاج بالموجات فوق الصوتية في إعادة تأهيل النساء المصابات بمتلازمة النفق الرسغي (CTS)

المرضى والطرائق: تم تضمين أربعين امرأة مصابات بمتلازمة النفق الرسغي الخفيفة إلى المتوسطة في الدراسة، وأكد التشخيص تخطيط كهربية العضلة (EMG) والفحص السريري. تم تقسيم المشاركين إلى مجموعتين. تلقت المجموعة (أ) العلاج بالمجال المغناطيسي، وتلقت المجموعة (ب) العلاج بالموجات فوق الصوتية. تلقى المرضى في كل مجموعة ست جلسات، التقييم السريري للنتائج شمل استبيان متلازمة النفق الرسغي بوسطن (BCTSQ)، وقوة قبضة اليد، وحركات مفصل الرسغ (الثني والبسط)، بالإضافة إلى المقياس التناظري البصري للالم (VAS).

النتائج: اظهر تحليل اختبار t المقترنة تحسناً ملحوظاً في استبيان بوسطن والمقياس الناظري البصري للألم في كلا مجموعتي التدخل عند القيمة $P \geq 0.05$. أظهر تحليل اختبار t للعينة المستقلة لمرحلة ما بعد التدخل لكلا المجموعتين التفوق في العلاج بالمجال المغناطيسي؛ لم يلاحظ أي فروق ذات دلالة إحصائية في تحسين حركة المعصم (الانثناء = ٠,٦٦، الامتداد = ٠,٧١)، وقد لوحظ تحسن المقياس التناظري البصري (VAS) للألم في كلا المجموعتين العلاجيتين مع فوقية للعلاج بالموجات فوق الصوتية.

الاستنتاجات: يعالج كل من المجال المغناطيسي والعلاج بالموجات فوق الصوتية بشكل فعال النساء المصابات بمتلازمة النفق الرسغي. العلاج بالمجال المغناطيسي اظهر تفوقا إحصائيًا على الموجات فوق الصوتية.

الكلمات المفتاحية: متلازمة النفق الرسغي , العلاج بالمجال المغناطيسي, العلاج بالأمواج الصوتية

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