Efficacy of night splinting and ultrasound in Carpal Tunnel Syndrome. A randomized controlled clinical trial

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ABSTRACT

Objective: To compare the efficacy of night wrist immobilization using an ulnar splint in neutral angle versus the use of ultrasound (US) in patients with mild and moderate Carpal Tunnel Syndrome (CTS). **Materials and Methods:** Study population included over 18 years of age that were treated for electromyography-confirmed CTS between October 2007 and March 2010 at a Buenos Aires hospital. A sex- and age-stratified randomization was performed by using randomly permuted blocks, allocating patients into the experimental group (EG) and control group (CG). Pulsed US therapy was administered for 15 minutes to all patients three times a week for six weeks at a frequency of 1 MHz. In addition, EG patients were also prescribed night splint. Pain and paresthesia were evaluated using a 100mm Visual Analogue Scale (VAS), the Patient Specific Functional Scale (PSFS), and the Moberg pickup test (MPUT) at baseline, at 3 and 6 weeks, and follow-up at 1, 3 and 6 months after treatment by a blinded investigator. **Results:** Study population consisted of 85 cases (65 patients) that were randomly allocated to CG (n=42) or EG (n=43). Twenty were eliminated, so 32 in the CG and 33 in EG were analyzed. Improvement of all the variables was observed at the end of treatment in both groups, with a 1.64 (95% CI: 0.38-2.91, P=0.012) statistically significant difference in means for pain in favor of the EG at 3 weeks of treatment, but without a significant clinical difference. No adverse effects were observed. **Conclusion:** The efficacy of combined night splint and US therapy is not superior to the US alone treatment in CTS patients.

Key words: Key words: Carpal Tunnel Syndrome; therapeutics; splints; ultrasound therapy.

Level of Evidence: II

Eficacia de la férula nocturna y el ultrasonido para tratar el síndrome del túnel carpiano. Estudio clínico controlado y aleatorizado

RESUMEN

Objetivo: Comparar la eficacia de la inmovilización nocturna de la muñeca con una férula cubital en ángulo neutro junto con la aplicación de ultrasonido en pacientes con síndrome del túnel carpiano leve y moderado. **Materiales y Métodos:** Entre octubre de 2007 y marzo de 2010, se incluyó a pacientes >18 años con síndrome del túnel carpiano confirmado por electromiografía en un hospital de Buenos Aires. Se realizó una aleatorización estratificada, con bloques permutados aleatorios, y apareamiento por sexo y edad. Los pacientes fueron asignados al grupo experimental (GE) o al grupo de control (GC). Ambos grupos recibieron ultrasonido de 1 MHz pulsante por 15 min, 3 veces por semana, durante 6 semanas. Los pacientes del GE, además, utilizaron una férula nocturna. Se evaluaron el dolor y la parestesia con la escala analógica visual de 100 mm, la PSFS y el test de Moberg, al comenzar, a las 3 semanas y, al finalizar, a las 6 semanas, y durante el seguimiento, al mes, y a los 3 y 6 meses, con evaluador ciego. **Resultados:** Se analizó a 32 pacientes del GC y a 33 del GE. Al finalizar el tratamiento, todas las variables habían mejorado en ambos grupos, con diferencia de medias estadísticamente significativa para el dolor a favor del GE a las 3 semanas de tratamiento 1,64 (IC95% 0,38-2,91; p = 0,012), pero sin diferencia clínica significativa. No se informaron efectos adversos. **Conclusión:** El tratamiento con una férula nocturna y ultrasonido no es superior al ultrasonido solo en pacientes con STC.

Palabras clave: Síndrome del túnel carpiano; tratamiento; férulas; terapia con ultrasonido.

Nivel de Evidencia: II

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INTRODUCTION

CTS is the median nerve compression neuropathy at the wrist and accounts for approximately 90% of all entrapment neuropathies. CTS is a widely recognized occupational health condition, with a high cost to the health care system. The incidence and prevalence vary, from 0.125% to 1% and from 5% to 16%, depending on the diagnostic criteria. There is a higher CTS prevalence in patients from 40 to 60 years, and there is a female preponderance in prevalence.[1]

Mechanical compression of the nerve in the carpal tunnel results from several factors such as exertion strain, overuse, prolonged wrist extension and/or unaccustomed manual work. Extraneural compression may decrease intraneural vascular flow, axonal transport and nerve function and may cause endoneurial edema and demyelination. It slowly impairs the ability to transmit nerve impulses, eventually developing fibrous tissue within the nerve or structural changes in the nerve adjacent tissues. Although CTS is idiopathic, it is commonly associated with some conditions including diabetes, pregnancy, rheumatoid arthritis, distal radius fracture, obesity, dialysis, hypothyroidism, and oral contraceptives or other medications that cause fluid retention. Mild and infrequent symptoms of CTS onset include paresthesia, pain, sensory loss or weakness, which are often worst at night and may wake the patient. Untreated CTS symptoms commonly increase their frequency and gradually deteriorate to numbness, weakness and muscle atrophy. These symptoms lead to impairments in performing fine motor tasks involving the hand, such as gripping and pinching, thus compromising the patient's quality of life. Diagnosis is based on clinical evaluation and confirmed by electromyography.[1-3]

CTS treatment may be surgical or conservative. Surgery is commonly indicated to patients with persistent symptoms, severe sensory disturbance or thenar motor weakness. There are many non-surgical options for the treatment of CTS, the therapeutic US being one of them. Therapeutic US at 0.5-2.0 W/cm^2 intensity may promote various biophysical effects on tissues, including an anti-inflammatory effect, increased blood flow and membrane permeability, nerve recovery, and nerve conduction.[1,4-7] Another commonly used conservative treatment that has been proven effective by some studies is splinting. Immobilization of the wrist in a neutral position with a splint maximizes carpal tunnel volume and minimizes pressure on the median nerve, reducing the complaints caused by nerve compression, especially at night when the wrist is held in a flexion position.[8-12]

Due to the lack of consensus regarding the best way to manage CTS, the inadequate evidence to support US alone therapy or combined with other conservative treatments, such as splinting, and the warrant for further randomized controlled studies on conservative treatments,[7,10] the purpose of this study was to compare the efficacy of wrist immobilization using an ulnar plaster splint in a neutral position during night rest combined with US versus US alone in mild and moderate CTS clinical and electromyography diagnosed patients.

MATERIALS AND METHODS

We conducted a randomized controlled clinical trial with parallel group and blinded evaluator between October 2007 and March 2010. Study population was composed of consecutive patients over 18 years of age diagnosed with CTS who had been referred by an orthopedist to our center for physical therapy management. Inclusion criteria were diagnosis based on clinical findings and confirmed by electromyography, presence of subjective symptoms (pain, paresthesia and/or hypesthesia) in the median nerve innervation area, and at least one positive clinical provocative test of the following: the Phalen's test (wrist flexion provoking numbness or tickling within 60 seconds), the Tinel's sign (percussion of the median nerve at wrist level provoking tingling and tickling), and the Durkan carpal compression test (compression over the carpal tunnel with the thumbs provoking numbness or tickling within 30 seconds).[13]

Patients with history of metabolic conditions (diabetes and/or hypothyroidism), rheumatoid arthritis, corticosteroid injection, surgery, dialysis, wrist trauma or fracture, split use, compression problems, severe thenar atrophy and/or those pregnant, undergoing other CTS treatment (pharmacological or otherwise) or experiencing hand pain unrelated to CTS were excluded.

Patients who failed to attend 2 consecutive sessions or 3 non-consecutive sessions within the treatment period, those who were administered with any other CTS treatment or were diagnosed with a systemic or upper extremity condition, those who failed to attend a study evaluation during treatment, those who used the splint after treatment, and drop-outs were also excluded.

Our hospital Independent Ethics Committee approved this study and all study patients signed a written informed consent form in compliance with the ethical guidelines of the 1975 Declaration of Helsinki.

Study variables were: pain, paresthesia, the PSFS, and the MPUT. Pain and paresthesia were evaluated using a 100mm VAS for each parameter independently, rating pain and paresthesia intensity on a 10cm scale line, 0 being no pain or paresthesia and 10 being maximum pain or paresthesia possible.[14]

The PSFS is a self-assessment measurement tool that seeks to establish the patient's functional status and major limitations. The evaluator asks the patient to list 5 important activities that are limited by CTS and then to rate from 0 to10 (where 0 is being unable to perform the activity and 10 is being able to perform with no problem).[15,16] For this study we followed a translated version of the PSFS (Annex).

ANNEX

The Patient-Specific Functional Scale

Clinician to read and fill in below. Complete at the end of the history and prior to physical examination.

Initial assessment:
I am going to ask you to identify up to five important activities that you are unable to do or are having difficulty with as a result of your _____ problem.
Today, are there any activities that you are unable to do or having difficulty with because of your problem? (Show the scale to the patient and have the patient rate each activity)

Follow-up assessment:
When I assessed you on (state previous assessment date), you told me that you had difficulty with (read all activities from list of the previous assessment).
Today, do you still have difficulty with: (read the list of activities and have patient score each item in the list again)?

Patient-specific activity scoring scheme (choose one number):

0	1	2	3	4	5	6	7	8	9	10
Unable to perform the activity									Able to perform the activity at the same level as before the problem	

Date, session, score

ACTIVITY	INITIAL					
1						
2						
3						
4						
5						
Additional						
Additional						

The MPUT assesses functional sensibility by asking the patient to pick up 12 objects using tweezers and putting them into a container.[17,18] This study MPUT was only performed on the affected side and with open eyes. Objects included: wing screw, screw, key, pin, large hex nut, small hex nut, small square nut, large coin, small coin, washer, safety pin, and paper clip. The patient was instructed to pick up one object at a time using the tweezers and to put them as quickly as possible inside the container, which was placed on the affected hand side, and was not allowed to slide the objects in order to pick them up. The patient was then asked to identify and name the objects with the eyes close while time was taken with a stopwatch and the number of errors recorded.

Stratified randomization with random permuted blocks was performed by sex and age (<55 and ≥55 years) using 4 boxes (for each matched pairing) with 6 opaque sealed envelopes for each box (3 per group). Randomization was run by a physical therapist who was not involved in the result evaluation. Patients were allocated into 2 groups: EG patients were administered US therapy and night splinting and CG patients were administered US alone therapy.

Bilateral cases had the most symptomatic side treated first, and following the treatment period (6 weeks) and if inclusion criteria were met, the other wrist was treated as a new CTS case.

A study physical therapist was in charge of evaluating patients at treatment baseline (T0), 3 weeks after institution of treatment (T1), and at treatment endpoint (6 weeks, T2). Further evaluations were at 1-month (T3), 3-month (T4), and 6-month follow-up (T5). Baseline evaluation included the study variables, demographics (age, sex, dominant side), pain characteristics, sleep habits and disturbances, symptoms evolution, electromyographic data, provocative tests, Spurling test, cervical distraction test, shoulder abduction test, Katz diagram, and prior conditions. The following evaluations only addressed the study variables.

Evaluators were blinded to the patients' study group allocation.

The treatment lasted 6 weeks, with US therapy sessions of 15 minutes per session thrice a week (18 sessions). US therapy was administered to the area over the carpal tunnel at a frequency of 1MHz (Sonotherp 990®, Meditea Electromédica S.R.L.) and an intensity of 1.0W/cm^2, with pulsed mode and a 5cm^2 transducer, using a water-based, pH neutral gel as the couplant between transducer and skin. All sessions were performed with a static system configuration. EG patients were also administered wrist immobilization using a custom-made plaster splint (8 layers thick) in a neutral position. The splint is shaped to conform to the forearm ulnar aspect into a canal configuration from the proximal, medial third to the middle palmar crease, not covering the thenar eminence nor the fingers, wrapped with cotton batting and glued to the inside, dressing on the splint edges and fixed to the wrist by three Velcro straps. Patients were instructed to use it during night rest for 6 weeks and to contact the physical therapist if the splint needed adjustments, pain increased while wearing it or they experienced adverse effects (Figure 1).

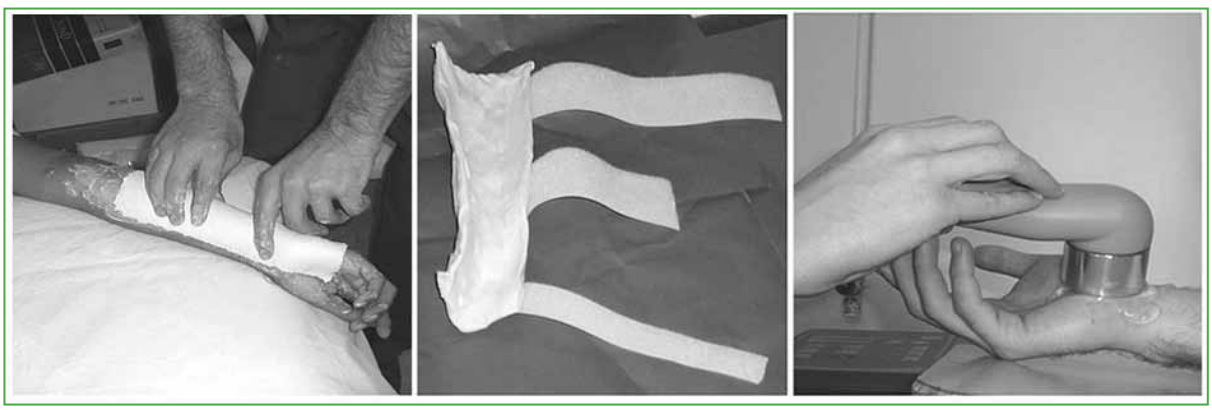

Figure 1. Experimental-group treatment. Nocturnal neutral angle wrist plaster splinting and US therapy.

Continuous variables were described as mean and standard deviation (SD), unless otherwise reported. Categorical variables were described as absolute and relative values. Groups demographics were compared using the Student t test or the Mann–Whitney U test, according to the variable distribution. Categorical variables were analyzed using the Chi-square test or Fisher's exact test, as suitable. The primary analysis was performed and is reported according to the Principle of intention-to-treat. Missing single item values were replaced by the patient's last value for that item. The relevant analyses of sensitivity were conducted to check the robustness of the results. Both groups referred pain, paresthesia severity, function, and MPUT values were compared using an analysis of covariance (ANCOVA) adjusted for sex, age, upper-extremity dominant side, time of disease progression, and each variable baseline values. A mixed-effects model for repeated measurements was used to analyze referred pain, paresthesia severity, function, and MPUT values. The model considered sex, age, upper-extremity dominant side, time of disease progression, and variable baseline values as covariates. Results are presented as differences in mean change and their associated 95% CI. Values were considered to be statistically significant at $P < 0.05$. Statistical analysis was performed using IBM SPSS Statistics 23.0 (IBM Corp. Armonk, NY, USA).

RESULTS

Study population consisted of 65 patients, of which 20 had bilateral CTS (16 females, 4 males). The 85 CTS cases were randomly allocated into the CG (42 cases) and the EG (43 cases). Following randomization, patients began treatment within a week. Twenty patients were excluded, 19 of which did not complete the first 3 weeks of treatment. After patient exclusion, the final groups consisted of 32 CG patients and 33 EG patients (Figure 2).

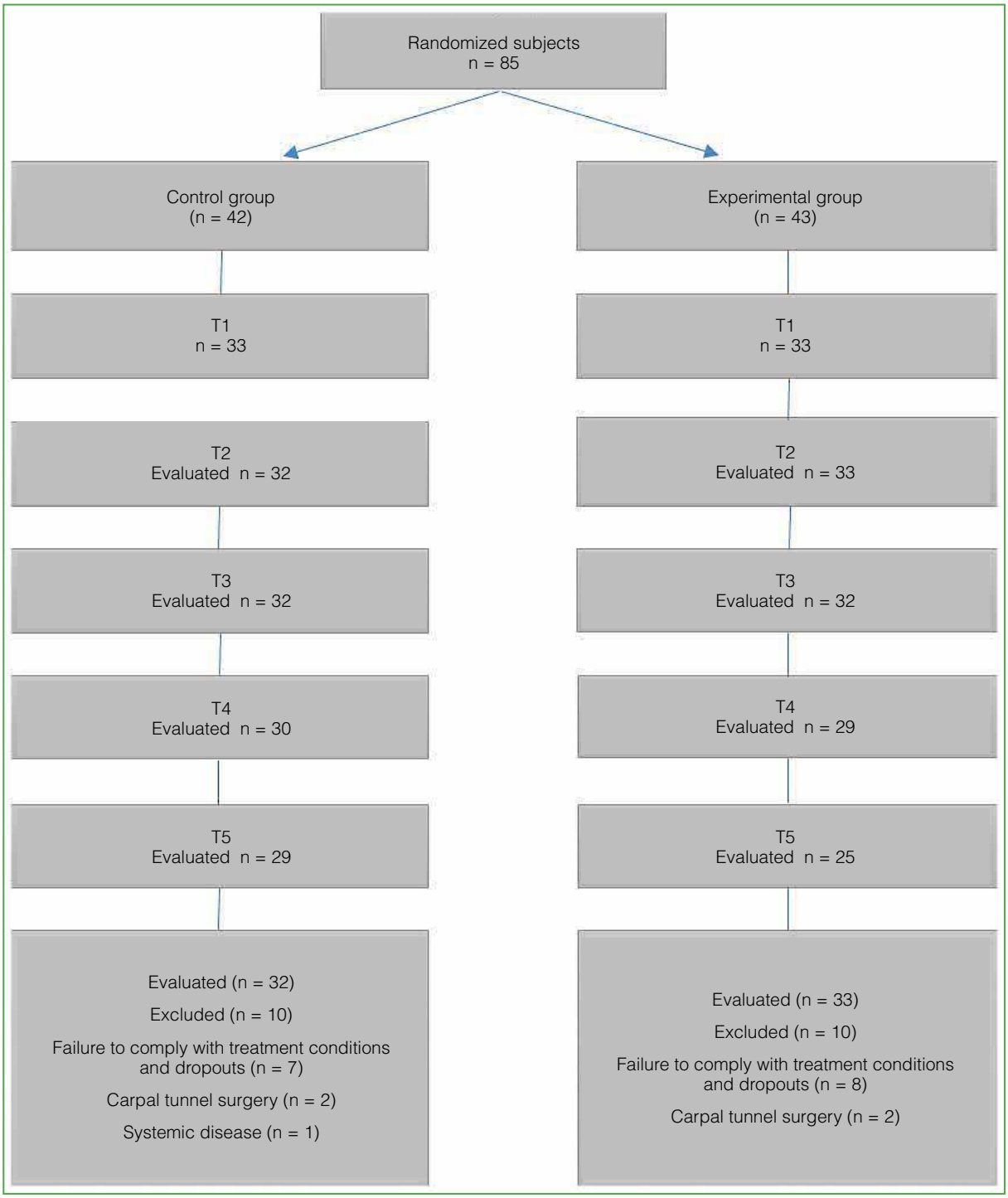

Figure 2. Flow sheet of the study population.

Fifty-four cases (83%) complied with the 6-month follow-up. Both groups' baseline parameters were similar except for the electromyography nerve conduction velocity, which was slightly superior in the EG (53m/s vs 51m/s; P=0.048). The other baseline characteristics are shown in Table 1. Tables 2 and 3 show pain and paresthesia variables. In the long term, both treatments showed pain improvement, with statistically significant differences at week 6 (1.78 means difference, 95% CI: 0.28-3.27, P=0.009) and at 1-month follow-up (1.77 means difference, 95% CI: 0.46-3.08, P=0.002).

Table 1. Patients' baseline characteristics

Characteristics	Experimental group (n=33)	Control group (n=32)	P
Females	84.8%	75.8%	0.35
≥55 years	30.3%	33.3%	0.79
<55 years	69.7%	66.7%	0.79
Evolution time of symptoms (median, IQR)	12 (5.5-30)	12 (4,5-42)	0.99
Right side affected	63.6%	42.4%	0.08
Right dominant arm	97%	97%	0.75
Night pain	63.6%	66.7%	0.8
Pain at rest	39.4%	48.5%	0.46
Pain during activity	66.7%	75.8%	0.41
Positive Phalen's test	97%	84.8%	0.098
Positive Tinel's sign	36.4%	45.5%	0.45
Positive Durkan carpal compression test	90.9%	84.8%	0.35
Sleep habits (median, IQR)	7 (6-8)	7 (5-7,8)	0.69
Sleep disturbances (median, IQR)	1.5 (0-2.5)	1,5 (0-3)	0.62
Classical Katz diagram	12.5%	12.1%	0.22
Probable Katz diagram	87.5%	78.8%	
Possible Katz diagram	0%	9.1%	

IQR= interquartile range

Table 2. Pain Visual Analog Scale

Time	Control group	Experimental group	Means difference (95% CI)[a]	P	Mean time difference (95% CI)[b]	P
Baseline	4.71 (3.11)	5.01 (3.14)	-0.42 (-2; 1.14)	0.59	Reference	-
3 weeks	4.83 (2.69)	3.03 (2.45)	1.64 (0.38; 2.91)	0.012	0.93 (-0.5; 2.36)	0.76
6 weeks	2.96 (2.9)	3.2 (3.04)	-0.14 (-1.64; 1.37)	0.86	1.78 (0.28; 3.27)	0.009
1 month after treatment	3.4 (2.54)	2.78 (2.88)	0.79 (-0.52; 2.1)	0.23	1.77 (0.46; 3.08)	0.002
3 months after treatment	3.89 (3.09)	3.44 (3.21)	0.58 (-0.99; 2.16)	0.43	1.19 (-0.32; 2.71)	0.28
6 months after treatment	4.57	3.72	1.12 (-0.44; 2.69)	0.16	0.71 (-0.7; 2.13)	NS

[a]Analysis of covariance adjusted for baseline factors. bMixed-effect analysis on the time differences between both groups, adjusted for baseline factors.
NS: not significant.

Table 3. Paresthesia Visual Analog Scale

Time	Control group	Experimental group	Means difference (95% CI)[a]	P	Mean time difference (95% CI)[b]	P
Baseline	6.02 (3.07)	6.47 (7.18)	-0.41 (-3.21; 2.38)	0.77	Reference	-
3 weeks	4.22 (3.45)	3.77 (3.02)	0.47 (-1.01; 1.95)	0.53	2.25 (0.25; 4.25)	0.016
6 weeks	3.64 (3.21)	3.39 (2.95)	0.32 (-1.09; 1.73)	0.65	2.73 (0.53; 4.92)	0.005
1 month after treatment	3.64 (3.02)	3.5 (3.15)	0 (-1.44; 1.44)	NS	2.68 (0.34; 5.02)	0.013
3 months after treatment	4.14 (3.41)	3.3 (3.19)	1.04 (-0.5; 2.6)	0.18	2.52 (0.16; 4.89)	0.027
6 months after treatment	4.66 (3.72)	3.61 (3.21)	1.16 (-0.5; 2.82)	0.17	2.12 (-0.21; 4.44)	0.11

[a]Analysis of covariance adjusted for baseline factors. [b]Mixed-effect analysis on the time differences between both groups, adjusted for baseline factors.
NS: not significant.

These differences were not observed at T4 and T5. Comparison analysis between CG and EG yielded no statistically significant for any of the study variables, except for pain in favor of the EG at 3 weeks of treatment (1.64 means difference, 95% CI: 0.38-2.91, P=0.012) (Figure 3A).

Baseline paresthesia means were 6.02 (SD, 3.07) for CG patients and 6.47 (SD, 7.18) for EG patients (P=0.77). Paresthesias improved over time in both groups with statistically significant differences observed at all evaluations except at T5. There were no statistically significant differences between both groups (Figure 3B).

The average times to perform the MPUT at baseline were 25.88 seconds (SD, 13.94) for CG patients and 25.39 seconds (SD, 10.23) for EG patients (P=0.98). Both groups MPUT performance improved over time compared with their baseline performance, but statistically significant differences were only observed as from T2 (Figure 3C). There were no statistically significant differences between both groups at any evaluation period in terms of performance time, object identification time, and number of errors.

The most frequent PSFS activities were: lifting heavy objects (38 patients), wringing cloths (32 patients), and hand-washing clothes (18 patients). Both groups PSFS results improved over time compared with their baseline scores with statistically significant differences within groups but no statistically significant differences between groups (Figure 3D). The only statistically significant difference was observed for Activity 1 at T5 (EG=8 and CG=5, P=0.038). No adverse effects were observed.

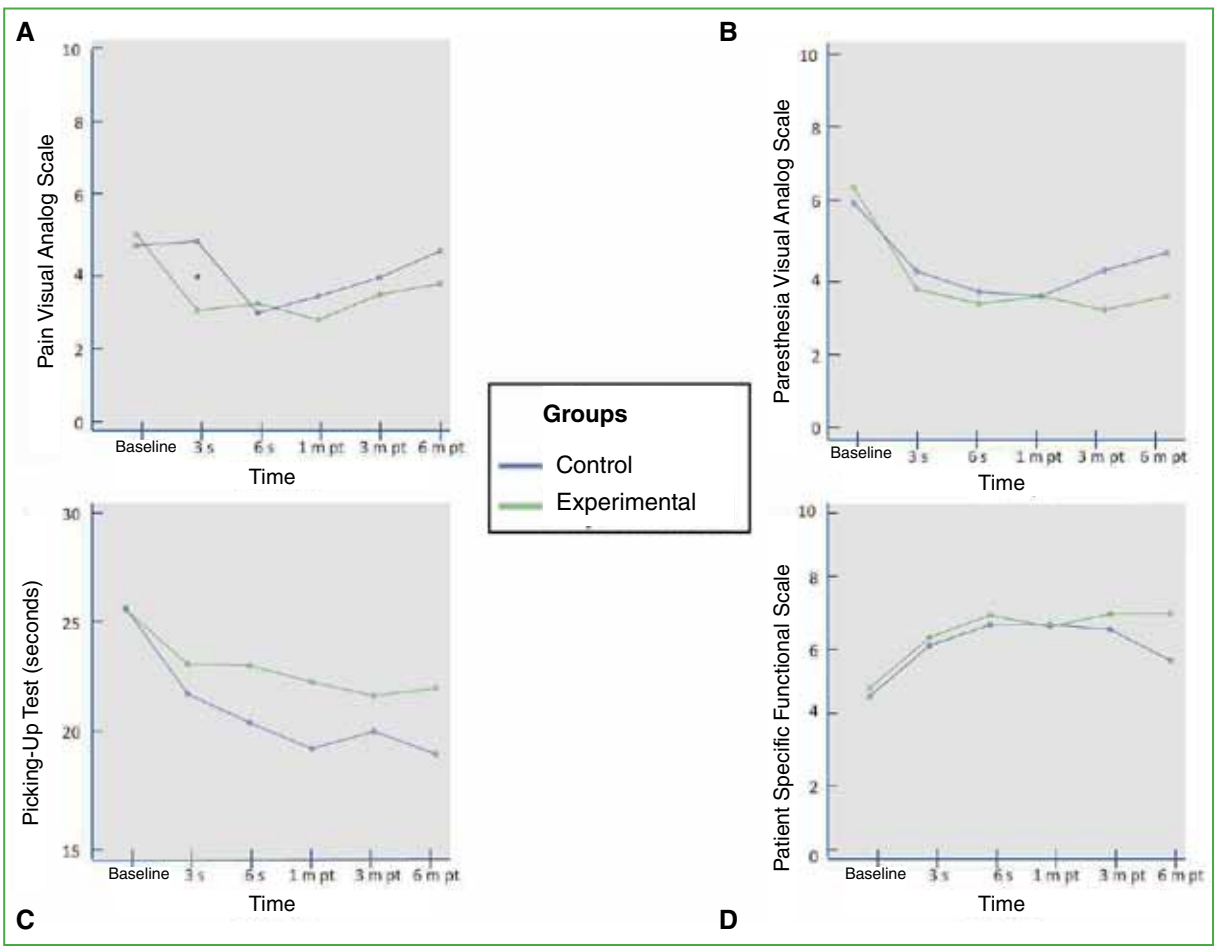

Figure 3. Variables behavior over time. Pain, paresthesia, Moberg pickup test, and Patient Specific Functional Scale. *Significative; w=weeks, mat= months after treatment.

DISCUSSION

These study results suggest that night immobilization using neutral angle wrist plaster splinting and US therapy may be beneficial in CTS treatment.

CTS occurs most commonly in adults older than 30 years, particularly women.[19] This statement is consistent with our study population, where 80% of cases were females and no case involved a patient under 30 years of age.

There are no unified criteria regarding CTS initial treatment, which may be surgical or conservative. Choosing a standard conservative treatment is controversial as several treatments have proven to be ineffective or limited, or to produce contradictory outcomes.[1,7,11,19,20] However, physicians are prone to the conservative treatments due to the risks and high recurrence rates seen with surgical procedures, the natural history of CTS (with patients sometimes spontaneously recovering), and the lower costs and rarity of complications seen with more conservative treatments. Therefore, the recommendation for initial CTS treatment is conservative management, especially in mild to moderate cases.[21,22]

There being no gold standard for conservative CTS treatment, CG and EG patients underwent US therapy, using affordable physiotherapy devices that are widely used in physiotherapy practice. Management involving US therapy has been proven more effective than non-US therapy management and those involving other treatments. There is no literature consensus on optimal US dosages for CTS treatment.[6,7,23-25] In this study, the US therapeutic modality was of 1 MHz and pulsed mode at 1.0 W/cm2, for 15 minutes, 3 times a week, for 6 weeks (18 sessions), as it has proven to be an effective therapy with satisfactory short- and medium-term outcomes for mild to moderate idiopathic CTS.[6,7,25] This study US therapy resulted in significant changes both in CG and EG patients at the end of treatment. These findings are consistent with Ebenbichler *et al*. study, where after 20 pulsed US sessions they found significant differences compared to the placebo group.[6]

Splinting is another commonly used treatment with no evidence supporting full-time use or night-only use to be more effective.[23] This study implemented wrist immobilization using a custom-made ulnar plaster splint in a neutral position for nocturnal use. This management was chosen because the activity decrease and wrist mal-position during sleep may result in venous return decrease and carpal tunnel pressure increase, which may account for CTS patient's night symptoms frequency, while the neutral position has proven to be the one that minimizes pressure on the carpal tunnel and the median nerve. Splints shaped to conform to the forearm ulnar aspect into a canal configuration are preferred over volar splints extends up to the fingertips as they do not cover the fingers and allow for some use of the hand.[8-12,21] Splinting was performed with plaster due to its low cost and as it was the only available material at a public health-care center. Night splinting in EG patients resulted in significant changes at the end of the treatment period, which was consistent with other studies.[9-11] However, any improvement in the EG cannot be exclusively associated with splinting as US therapy was also administered.

Taking into account that untreated CTS symptoms commonly increase and both US therapy and splinting have proven to be more effective than non-treatment,[2,23] no placebo group was included in the design of this study as we considered unethical to withhold treatment knowing there is scientific evidence supporting existing treatments.

Only a few studies assess the outcomes following a 3-month period after US therapy or splint treatment in CTS patients. This study reports up to 6-month follow-up outcomes with no adverse effects nor complications associated with US therapy or splinting, which is consistent with the literature.[7,10]

These study results agree with those of some studies where US and/or splint management improved CTS symptoms.[6,9,11,19,21,25] Comparison analysis within CG and EG yielded significant differences between T0 and T3, and T0 and T4 for all study variables, except for MPUT performance time.

Comparison analysis between CG and EG yielded no statistically significant for any of the study variables, except for pain in favor of the EG at 3 weeks of treatment (1.64 means difference, 95% CI: 0.38-2.91, P=0.012). However, this difference was minor and not enough to be considered a significant clinical difference. The intensity of pain and depression are associated with hand function. Depression is a psychological factor associated with the intensity of pain, and it was not assessed in our study, which may have affected its results.

These study MPUT results should not be compared with those of other studies as, despite being a simple and quick test for hand function, it had not been used in CTS patients. This study MPUT was only performed on the affected side and with open eyes. Both groups improved their performance in comparison to their baseline performance. Statistically significant differences were only observed as from T2 in the CG, but no statistically significant difference was observed between groups at any evaluation (object identification time and number of errors).

The PSFS revealed no significant differences at any evaluation between groups, except at T5, where Activity 1 yielded a significant difference in favor of EG.

Splinting in CTS patients is recommended within 3 months from symptoms onset, as it has been proven to be more effective.[9] Our study did not consider the evolution time of symptoms at the time of the allocation. The limitations of this study also include: a limited study population, a high dropout rate, not taking into account psychosocial variables nor symptom intensity (which may have affected the results), using a PSFS that was at the time neither adapted nor validated for its use in Argentina, and not evaluating treatment response in terms of night symptoms relief, which has been proven in other studies.[7,11] From the initial 85 cases, 23.5% were excluded. The most common causes were failure to comply with treatment conditions, dropouts (with no reported explanation), and undergoing surgery, which is consistent with similar studies.[6,11,19]

This study was conducted at a Physical Therapy Department, where patients commonly present with mild to moderate symptoms. As such, it requires caution to generalize the present results to more severe symptoms. It should be considered that, in the setting of a public hospital that provides healthcare to patients that may reside at a great distance, cost for transportation (time and money), treatment length, patients' need to return to work or to other responsibilities as soon as possible hinder long-term follow-ups in our clinical practice, which may account to some degree for the high dropout rate.

CONCLUSIONS

This study shows that the efficacy of wrist immobilization using an ulnar plaster splint in a neutral position during night rest combined with US is not superior to the US alone treatment in mild and moderate CTS patients at 1-month and 3-month follow-up. Further studies are warranted to establish the efficacy of the US and splinting combined management for CTS as well as other conservative treatments.

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REFERENCES

1. Aroori S, Spence RA. Carpal tunnel syndrome. *Ulster Med J* 2008;77(1):6-17. PMID: 18269111
2. Burke FD, Ellis J, McKenna H, Bradley MJ. Primary care management of carpal tunnel syndrome. *Postgrad Med J* 2003;79(934):433-7. https://doi.org/10.1136/pmj.79.934.433
3. Jablecki CK, Andary MT, Floeter MK, Miller RG, Quartly CA, Vennix MJ, et al. Practice parameter: Electrodiagnostic studies in carpal tunnel syndrome. Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation. *Neurology* 2002;58(11):1589-92. https://doi.org/10.1212/wnl.58.11.1589
4. Currier DP, Greathouse D, Swift T. Sensory nerve conduction: effect of ultrasound. *Arch Phys Med Rehabil* 1978;59(4):181-5. PMID: 646607
5. Kramer JF. Effect of therapeutic ultrasound intensity on subcutaneous tissue temperature and ulnar nerve conduction velocity. *Am J Phys Med* 1985;64(1):1-9. PMID: 3970155
6. Ebenbichler GR, Resch KL, Nicolakis P, Wiesinger GF, Uhl F, Ghanem AH, et al. Ultrasound treatment for treating the carpal tunnel syndrome: randomised "sham" controlled trial. *BMJ* 1998;316(7133):731-5. https://doi.org/10.1136/bmj.316.7133.731
7. Page MJ, O'Connor D, Pitt V, Massy-Westropp N. Therapeutic ultrasound for carpal tunnel syndrome. *Cochrane Database Syst Rev* 2013;2013(3):CD009601. https://doi.org/10.1002/14651858.CD009601.pub2
8. Werner CO, Elmqvist D, Ohlin P. Pressure and nerve lesion in the carpal tunnel. *Acta Orthop Scand* 1983;54(2):312-6. https://doi.org/10.3109/17453678308996576
9. Kruger VL, Kraft GH, Deitz JC, Ameis A, Polissar L. Carpal tunnel syndrome: objective measures and splint use. *Arch Phys Med Rehabil* 1991;72(7):517-20. PMID: 2059127
10. Page MJ, Massy-Westropp N, O'Connor D, Pitt V. Splinting for carpal tunnel syndrome. *Cochrane Database Syst Rev* 2012;2012(7):CD010003. https://doi.org/10.1002/14651858.CD010003
11. Halac G, Demir S, Yucel H, Niftaliyev E, Kocaman G, Duruyen H, et al. Splinting is effective for night-only symptomatic carpal tunnel syndrome patients. *J Phys Ther Sci* 2015;27(4):993-6. https://doi.org/10.1589/jpts.27.993
12. Armenteros Pedrero J, Justo García G, Rey Pita ML, Gallego González S, Buján de Gonzalo A, Tobío Iglesias A. Tratamiento conservador del síndrome del túnel carpiano mediante inmovilización con férulas. *Rehabilitación (Madr)* 2000; 34(4): 313-9. https://www.elsevier.es/es-revista-rehabilitacion-120-articulo-tratamiento-conservador-del-sindrome-del-10017830
13. Massy-Westropp N, Grimmer K, Bain G. A systematic review of the clinical diagnostic tests for carpal tunnel syndrome. *J Hand Surg Am* 2000;25(1):120-7. https://doi.org/10.1053/jhsu.2000.jhsu025a0120
14. Gallagher EJ, Liebman M, Bijur PE. Prospective validation of clinically important changes in pain severity measured on a visual analog scale. *Ann Emerg Med* 2001;38(6):633-8. https://doi.org/10.1067/mem.2001.118863
15. Stratford P, Gill C, Westaway M, Binkley J. Assessing disability and change on individual patients: a report of a patient specific measure. *Physiother Can* 1995;47(4):258-63. https://doi.org/10.3138/ptc.47.4.258
16. Hefford C, Abbott JH, Arnold R, Baxter GD. The patient-specific functional scale: validity, reliability, and responsiveness in patients with upper extremity musculoskeletal problems. *J Orthop Sports Phys Ther* 2012;42(2):56-65. https://doi.org/10.2519/jospt.2012.3953
17. Ng CL, Ho DD, Chow SP. The Moberg pickup test: results of testing with a standard protocol. *J Hand Ther* 1999;12(4):309-12. https://doi.org/10.1016/s0894-1130(99)80069-6
18. Stamm TA, Ploner A, Machold KP, Smolen J. Moberg picking-up test in patients with inflammatory joint diseases: a survey of suitability in comparison with button test and measures of disease activity. *Arthritis Rheum* 2003;49(5):626-32. https://doi.org/10.1002/art.11378
19. Baysal O, Altay Z, Ozcan C, Ertem K, Yologlu S, Kayhan A. Comparison of three conservative treatment protocols in carpal tunnel syndrome. *Int J Clin Pract* 2006;60(7):820-8. https://doi.org/10.1111/j.1742-1241.2006.00867.x
20. Armagan O, Bakilan F, Ozgen M, Mehmetoglu O, Oner S. Effects of placebo-controlled continuous and pulsed ultrasound treatments on carpal tunnel syndrome: a randomized trial. *Clinics (Sao Paulo)* 2014;69(8):524-8. https://doi.org/10.6061/clinics/2014(08)04
21. Dincer U, Cakar E, Kiralp MZ, Kilac H, Dursun H. The effectiveness of conservative treatments of carpal tunnel syndrome: splinting, ultrasound, and low-level laser therapies. *Photomed Laser Surg* 2009;27(1):119-25. https://doi.org/10.1089/pho.2008.2211

22. Fernández-de-Las-Peñas C, Ortega-Santiago R, Díaz HF, Salom-Moreno J, Cleland JA, Pareja JA, et al. Cost-effectiveness evaluation of manual physical therapy versus surgery for carpal tunnel syndrome: evidence from a randomized clinical trial. *J Orthop Sports Phys Ther* 2019;49(2):55-63. https://doi.org/10.2519/jospt.2019.8483
23. Huisstede BM, Hoogvliet P, Randsdorp MS, Glerum S, van Middelkoop M, Koes BW. Carpal tunnel syndrome. Part I: effectiveness of nonsurgical treatments—a systematic review. *Arch Phys Med Rehabil* 2010;91(7):981-1004. https://doi.org/10.1016/j.apmr.2010.03.022
24. Huisstede BM, Hoogvliet P, Franke TP, Randsdorp MS, Koes BW. Carpal tunnel syndrome: effectiveness of physical therapy and electrophysical modalities. An updated systematic review of randomized controlled trials. *Arch Phys Med Rehabil* 2018;99(8):1623-34.e23. https://doi.org/10.1016/j.apmr.2017.08.482
25. Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother* 2004;50(3):147-51. https://doi.org/10.1016/s0004-9514(14)60152-5