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Different Splinting Time for Carpal Tunnel Syndrome in Women: Comparative Study

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Abstract:
Study objective: *To define the best splinting wear times, night or day, in pain relief for female patients with idiopathic chronic CTS in exacerbation phase.*
Design: *Quasi experimental comparative design.*
Method and measurements: *24 female patients (42 wrists) from military hospital in Riyadh participated in this study. Their CTS was diagnosed by the nerve conduction velocity (NCV). On basis of splint wear time patients were divided into two groups; day time and night time. Thermoplastic, custom-made,neutral wristsplints were given to both groups (21 wrists each). Patients completed 3 consecutive weeks of follow-up. Pain (pressure) threshold through, algometer, was used to measure the pain in both groups. Four measurements were applied; one at the initial assessment and 3 during follow-up weeks.*
Results: *The current study showed a statistical significant improvement (p = 0.0001) in pain threshold with splint wear. This was true for both groups. Patients received splint in day time showed little increase in pain threshold when compared with night time wear instruction but without significant difference.*
Conclusion: *Wrist splint is an effective conservative treatment for CTS. No difference was found between night or day time splint wear. Patient should wear the splint at their most adherent time.*
Keywords: *Carpal Tunnel Syndrome, Splinting, Splint Wear Time, Algometer.*

I. Introduction:

Carpal tunnel syndrome (CTS) is a neurological disorder involving compression of median nerve in carpal tunnel of wrist[1,2]. It is considered the most common entrapment neuropathy[3,4]. Numbness, tingling and pain in the hand, forearm, elbow or even shoulder, and weakness of the hand are common symptoms of CTS[5,6], the patient also may experience an electric-like shocking feeling. These impairments may cause a disability in the performance of activities of daily living[7,8]. The syndrome shows improvement with rest and worsen at night[6,7,9], or with repetitive upper extremity activity[2,10]. It is more common in women than men[9,11] and affects up to 10% of population[9]. Atroshi et al.(1999), reported that CTS estimated 3% of adult population [12]. According to Al-Rajeh (1994), the peripheral neuropathy in Saudi Arabia was 2.7% of population[13]. In 2009-2010 data base of the Military hospital, Riyadh, CTS was estimated about 30% - 31% of the Neurological disease. Although repetitive activity is an identified precipitating factor for the development of CTS, the exact etiology remains unclear[6,9]. Other factors believed to be related to CTS onset include ergonomic stressors, systemic/endocrine disorders (such as: diabetes mellitus, renal failure, thyroid disease, and rheumatoid arthritis, obesity), acute trauma, pregnancy, and psychosocial factors[1,11].

Idiopathic CTS can be relieved with surgical or conservative intervention[4,]. Current conservative treatments include splints[2,3,4,7,14], activity modification[4,15], non-steroidal anti-inflammatory drugs[4,16] and local injection of corticosteroids[1,7]. In addition, physical modalities like Ultrasound[17], nerve gliding exercises[14,18,], acupuncture[6,10,19] and laser treatment have also been used[20]. Splinting the wrist is the most common conservative intervention[10,9,12,15]. The rationale for wrist splints was originally based on observations that CTS symptoms improve with rest and worsen with activity[2,21]. The purpose of splint is to decrease pain, slow disease progression and improve physical function[22]. Researchers have suggested that the

therapeutic effect of wrist splinting arises from minimizing carpal tunnel pressure[3,16] which is strongly implicated in the pathophysiology of CTS, that pressure increases with wrist positions other than neutral[2,10,7,14,21]

The aim of this study was to define the best splinting wear times, night or day, in pain relief for female patients with idiopathic chronic CTS in exacerbation phase.

II. Methods:

Subjects': 42 female patients with idiopathic chronic CTS, during exacerbation phase participated in this study. Their age ranged from 30 to 45 years (37.93 ± 5.24 years) and were recruited from Riyadh Military Hospital. The inclusion criteria was: female patients aged between 30-45 years, patients with idiopathic chronic carpal tunnel syndrome as diagnosed with nerve conduction study, patients who were in the exacerbation phase (acute) but not under any anti-inflammatory medication, patients who didn't receive physiotherapy since 3 months, and patients adherence to splint wear at least 70% for continuous 3 weeks. The exclusion criteria was: patient with secondary entrapment neuropathies, trauma in the wrist area, muscle wasting or atrophy, patients with inflammatory arthritis, hypothyroidism, congestive cardiac failure, diabetes mellitus, obesity (Body max Index (BMI) > 30), patients who were pregnant and patients who received surgery. The research proposal was approved by the Rehabilitation Health Science (RHS) department of King Saud University (KSU) and the Physical and Occupational therapy departments in Military Hospital.

Design : Quasi experimental comparative design, of two groups, with day time and night time splinting and pain threshold evaluation with pressure Algometer.

Equipments and measuring tools:
Algometer, Sheets, Diaries, Exercises ball,

Procedure:

a) Participants Recruitment: Patients were diagnosed by nerve conduction study in the neurophysiology department. They were referred by physicians from Orthopedic, Neurologic and Plastic Surgery clinics to the Physiotherapy or Occupational therapy departments. Aim and methods of the study were explained to all participants before they sign the consent form. On basis of splint wear time patients were divided into two equal groups of 21 wrists according to the patient preference. Group one wore splint for day time and group two wore it for night time.

b) Therapeutic procedures:

Splint**:** Custom-made, thermoplastic, lightweight, neutral-positioned wrist splints (figure1) were given to patients provided by the hospital, and made by the occupational therapist at the occupational therapy department. The researcher instructed the patients to wear the splints daily depending on their groups, for continuous successive 3 weeks. First group wore splint during day time and the second group wore it for night time, the minimum hours of splint wear in both groups were from 6-8 hours.

Figure (1): Custom made, thermoplastic, light weight and neutral position wrist splint. A) Palmer view, B) Dorsal view.

Exercises: Patients were educated how to perform strengthening exercises to maintain their hands muscles power and self stretching exercises to stretch the flexor retinaculum. Patient were trained at first session and supplied by a researcher-designed brochure that describes the exercises, which were repeated during each visit and used as home program exercises.

During the strengthening exercises, patients were asked to squeeze the ball (figure 2) and hold for 10 seconds while sitting on a chair with supported hand on padded table, keeping neck and shoulder in neutral position, forearm in supination and elbow 90^{o} of flexion.

During self stretching exercises patients were asked :1) to bring palms together with fingers pointed up toward ceiling and slowly slide them down until she felt a stretch in the inner wrist area[23], hold 20-30 second , then relax for 10 seconds and repeat the exercises. 2) to extend their affected arm straight so their palm is faced away from them, then used the other hand to gently pull their fingers toward them, to stretch the carpal tunnel area [23], hold 20-30 seconds , then relax for 10 seconds and repeat the exercises. 3) to interlace their fingers and stretched their arms out in front of them[23], hold for 20-30 seconds , then relax for 10 seconds and repeat the exercises. All these exercises were repeated 10 times, five sessions daily for 3 weeks.

Figure (2): Hand strengthening exercises using Egg squeeze ball.

Assessment procedures

Pain threshold was measured by pressure algometer using Bonci[24] protocol, while the patient is in sitting position, the forearm was in supination and with elbow 90^{o} of flexion, the painful wrist was placed on a padded table with palm up. The researchers stood at the side of the painful wrist and hold the algometer with her hand, then applied a perpendicular pressure on the palmer aspect of the patient's wrist (figure 3), the patient informed the researcher at the point when the sensation of "pressure" began to feel "painful". Average of 3 trails was recorded as threshold value .

Figure (3): Patient and Researcher position during pain threshold assessment test.

Pain was assessed using algometer first session and at 3 sessions of follow up. Patient was instructed to record whether she had been adherent to splint or not using daily diaries . At the final visit (3^{rd} week), patients gave the diaries to the researcher.

Subjects were contacted by the researcher through phone calls to assure that they wore the splint and they continued to perform prescribed exercises aiming to motivate and improve their adherence. After 3 months follow-up phone calls to patients was performed to assess the splint effect on the pain.

Data Analysis:

Statistical Package for the Social Sciences program (SPSS) (version 16) was used for statistical analysis. Independent t-tests were used to compare the demographics of the two groups. Repeated measure ANOVAs were used to evaluate the progression of pain threshold. The percentage of change of pain threshold between the two groups was calculated and their means were compared by independent t-test. In addition the Mixed Model ANOVA was used to evaluate the effect of patient's group on the progression of pain threshold through the initial, 1^{st} visit, 2^{nd} visit and 3^{rd} visit pain threshold measurements.

Chi-Square tests were used to compare between the two groups regarding the adherence to splint wear and job statues of the participants.

III. Findings:

Table (1): Comparison of demographic data between Day and Night time groups.

Viable	Splint wear time		p
	Day time	Night time	
	Mean (SD)	Mean (SD)	
Age	36.7 (5.14)	39.0 (5.19)	**0.152**
BMI	27.1 (2.80)	26.1 (2.62)	**0.223**
Initial pain threshold	88.4 (14.60)	85.2 (14.57)	**0.468**

Table (2): Progression of pain threshold in CTS patients' groups wearing day time and night time splint (Mixed Model ANOVA test).

Splint wear time	Pain threshold values				
	Initial assessment	1^{st} visit assessment	2^{nd} visit assessment	3^{rd} visit assessment	p
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Day time	88.4 (14.60)	94.4 (14.7)	98.8 (12.33)	102 (10.9)	**0.0001**
Night time	85.2 (14.57)	91.16 (14.33)	93.73 (14.83)	98.329 (15.27)	**0.0001**

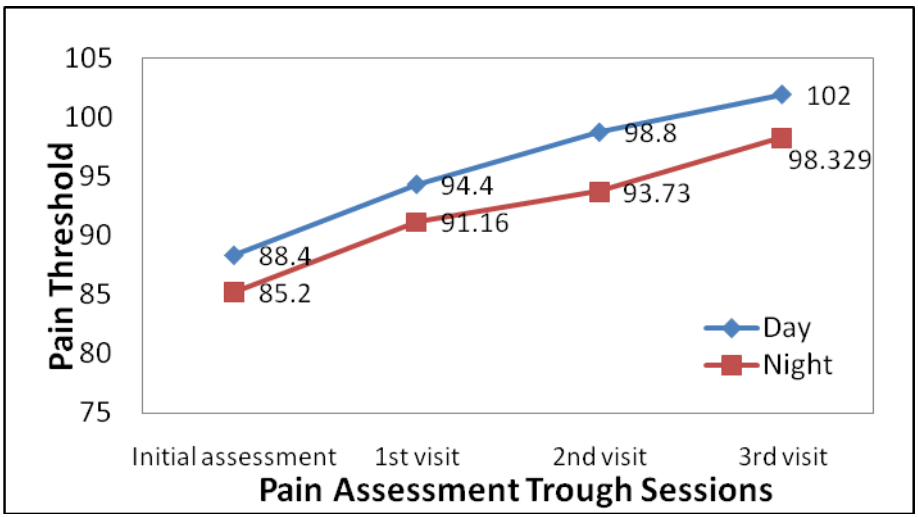

Figure (4): The progressive increase in pain threshold through 4 assessments in day & night.

Table (2) and figure (4) shows significant progressive increase in pain threshold values from the initial assessment, 1^{st}, 2^{nd}, to 3^{rd} visit assessments. This progressive increase in pain threshold is applied for day time group as well as night time group with p= 0.0001 for both groups.

Table (3): The percentage of change of pain threshold between day and night time groups.

Splints groups	**Mean(SD)**	**p**
Day time	17.25(12.68)	**0.744**
Night time	16.145(8.86)	

Table (3) showed that there were no significance differences in the percentage of change of the pain threshold between day and night time groups (p = 0.744).

Table (4): Different pain assessments for day & night time groups.

	Group	**Mean (SD)**
Initial pain assessment (N)	Day	88.4 (14.60)
	Night	85.2 (14.57)
1st visit pain assessment	Day	94.4 (14.7)
	Night	91.16 (14.33)
2nd visit pain assessment	Day	98.8 (12.33)
	Night	93.73 (14.83)
3rd visit pain assessment	Day	102 (10.9)
	Night	98.329 (15.27)
Pain assessments * groups	**P = 0.328**	

Table (4) shows that patient's grouping is not a significant factor (p= 0.328) affecting the pain threshold progression from initial to1st, 2nd, and 3rd pain assessments.

Table (5): Comparisons of percentage of adherence to splint wear and exercises between day and night time groups (Independent t-test).

Variables	Day time	Night time	p
	Mean (SD)	Mean (SD)	
% Adherence to splint wear	80.63(10.17)	93.03 (9.35)	**0.0001**
% Adherence to exercises	65.3(22.45)	75.07(17.84)	**0.126**

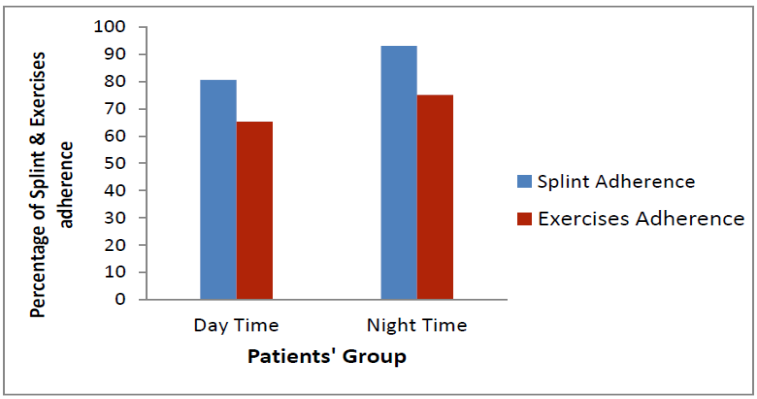

Figure (5): Comparisons of percentage of adherence to Splint wear and Exercises between day & night groups

Table (5) and figure (5) represented that night time group showed more adherence to splint wear as well as to exercises but with only statistical significance for splint wear (p= 0.0001).

Table (6): Job status of the day and night time groups (Chi-square tests).

	Working (%)	Housewives (%)	Total	P
Day time	7(33%)	14(66%)	21(100%)	**0.0001**
Night time	19(90.5%)	2(9.5%)	21(100%)	

The association between splint wearing time and job status is significant (p= 0.000). The majority (90.5%) of night time splint wear group are working, while, 2 thirds (66%) of day time splint wear group are housewives.

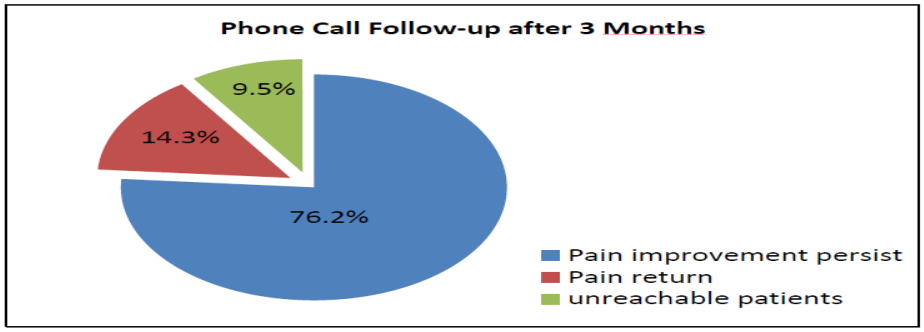

Figure (6): Phone call follow-up after 3 months

Figure (6) showed that splint effect persist after 3 months in 76.2% of patients, but pain returned in 14.3% of the patients, while 9.5% of patients can't be reached at that time.

IV. Discussion

The aim of this study was to define the best splinting wear time, day or night, for pain relief in female patients with idiopathic chronic CTS in exacerbation phase. The results showed that splinting wear produced significant improvement in form of increasing pain threshold of the patients in both groups. However, the day time group showed more increase in pain threshold than night time group, there was no statistical significant difference between the two groups.

In this study, fair inclusion and exclusion criteria were used to ensure validity of the results. Only females were included to overcome the gender factor effect. It was approved that females have lower thresholds of pain, greater abilities to discriminate pain, and higher pain ratings or less tolerance of noxious stimuli than males[25,26]. Women generally have an increased sensitivity to experimental pain when compared to men[26].

Current study was concerned more with the short term effect of splint. Pain threshold was measured through 3 consecutive weeks and result showed significant pain threshold improvement. This short term pain threshold improvement was similar to many studies[14,27]. Furthermore, the results proved that splint effect can persist for longer time. 3 months phone call-follow up showed that 76.2 % of the patients reported that their pain is still controlled while 14.3% of them reported pain return and only one patient approached surgical treatment. This was not surprising because a lot of studies have approved the long effect of splint in CTS patients'[21,28]

In the current study, the researcher believes that the underlying mechanism of day time splint wear in increasing the pain threshold in CTS patients could be due to prevention of repetitive movement during the patients activity and this is seen usually at the day time more than the night time, and that was in agreement with a lot of authors who found that splinting during repetitive movement which is usually at the day time was effective in relieving symptoms[12,14], Nobuta et al. (2008), reported that CTS improved with rest and worsen with activity and the CT pressure elevated during repetitive hand activity[29]. Also Love (2003), reported that CTS is an overuse injury and splint must be used when performing any task required wrist flexion[11].

Carleson et al. (2010), stated that CTS has been associated with forceful, repetitive hand and wrist activities and splint minimizes it during day time and limits prolonged periods of excessive wrist flexion

or extension during sleep[10]. Kasdan et al. (2002), reported that CTS is repetitive motion disorder and symptoms tend to exacerbated by activities that place loads on the tendons passing through the canal such as holding book, driving car, and using hand held tools[30]. Moreover Goodyear and Arroll (2004), stated that splinting when in bed is likely to be more accepted and tolerated by patients than splinting during the day[31] and Walker et al. (2000), reported that day time splint wear may lead to decrease upper extremity activities and contribute to the therapeutic effect of splint[2]. The researcher also believed that the CTS is due to overload of the repetition activity and wear splint would prevent and reduce the pain, so she hypothesized that wearing splint during night time is giving the chance for recovery after day of a lot or repetitive movements, and patients adherent usually is better during night splint wear. This researcher hypothesis is strengthened with the result, which showed that night time group were significantly more adherent to splint wear than day time group.

This research work was developed to discover the best timing for splint wear and the researcher found that wrist splint for CTS was effective, with no doubt, whether it is day time or night time.

It is difficult to get a specific treatment effect without appropriate use and restrict to its protocol. Successful clinical outcome depends essentially on adherence to its management protocol[32,33]. Current study results showed that day time patients were less adherent to the splint wear than night time patients and this would affect the day time splint wear outcome and cause limitation in pain improvement. Although patients of the day time splint wear was less adherent, result showed more pain threshold improvement in day time patients more than the night time patients. However this improvement was with no statistical significance. In addition the percentage of different between the initial assessment and 3rd visit pain assessment of the two groups were very close to each other and no significant difference found between them. The observed of increase in pain threshold of the day time group at the 3rd visit assessment is actually due to the higher pain threshold in the initial assessment for day time group than night time group. Since splint wear as a management of CTS considered as poor adherence procedure[31] and based on the results of this current study, the researcher believes that patients with CTS should wear the splint at the time they prefer and they will be more adherent to it no matter if it's night time or day time. And that is supported by Viera (2003), who mentioned that optimal splinting regimen depends on the patient's preferences[9]. As for the splint wear, study results showed that night time group were a little more adherent to exercises (75.07), than day time group (65.3) although there was no statistical significant difference ($p= 0.126$). The researcher believes that the CTS is due to overload of repetitive activity and working. Repetitive activities are job or house held activities. This activity would decrease the pain improvement with splint wear and the researcher agrees with a lot of studies which considered that CTS is work related syndrome[34,35,36]. In fact, the effect of women's job status was out of the scope of the current study but the result showed the majority 90.5% of the night time splint wear were working ladies while more than two thirds (66%) of the day time splint wear patients were housewives. Moreover chi-square test showed significant association between job status and patients groups. Tang et al. (1999) considered doing housewife activity as work[37]. On the other hand, a lot of authors don't consider CTS as work related syndrome[38,39,40], so it was difficult in this study to confirm whether or not the work was associated factor with the pain improvement. It is recommended in future to control the job in both groups and consider its effect in CTS. That's why one limitation of this study is that random assignment of women into the day and night time groups was not applied and this would affect the relation between splints wear and job status. In addition, only the pain of the symptoms was studied and there is other symptoms which can be considered in future researches such as the numbness and the hand strength. Follow up after 3 months was taken verbally and should be taken with the same outcome measure; pain threshold.

Due to limitation in published related articles, the result of this study cannot be compared. Because no studies compared the difference between the day and night time splint wear effects in improving the pain threshold in CTS patients. Majority of the studies compared only between splint and other modalities.

V. Conclusion:

Splinting is an effective conservative treatment to relief pain and increase pain threshold in female patients with idiopathic CTS during exacerbation phase, and it has long term effect as well as short term relief of pain in CTS patients. No significant difference was found in increasing pain threshold in both groups, day or night time splint wear, in female patients with idiopathic chronic CTS during exacerbation phase. Splint wear time is according to the patients preference.

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