

Comparison of the Effects of Volar-Assisted and Elastic Wrist Splints on Edema, Pain, Grip Strength, and Functionality in Pregnant Women With Carpal Tunnel Syndrome

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Abstract

Background: Carpal tunnel syndrome (CTS) is a common musculoskeletal problem in pregnancy. The aim of this study is to compare the effects of rigid and elastic wrist splints on edema, pain levels, grip strength, and upper-extremity functionality in pregnant women with CTS. **Methods:** Forty-one pregnant women in the last trimester of pregnancy who were diagnosed with CTS were included in the study. The grip strength was evaluated with the Jamar hand dynamometer, functionality with the Quick Disabilities of the Arm, Shoulder, and Hand and Boston Carpal Tunnel Syndrome Questionnaire, pain with the Visual Analog Scale (VAS), and edema with the water overflow method. **Results:** The mean age of the participants was 31.71 ± 5.78 years, body mass index was 28.85 ± 3.63 kg/m², duration of pain was 2.24 ± 0.79 months, and their pain intensity was 6.63 ± 1.69 according to the VAS. As a result of the study, reductions in pain ($P = .001$), increases in functionality values ($P = .001$), increases in grip strength ($P = .001$), and decreases in edema ($P = .001$) were observed in both groups after the treatment. However, there was no significant difference in pain, functionality, or grip strength values between the groups after the treatment ($P > .05$). **Conclusion:** In this study comparing the effects of a wrist splint to those of an elastic splint, both treatment methods for pregnant women with CTS decreased pain and edema, increased grip strength, and improved upper-extremity functionality. Considering individual needs, characteristics, and living conditions, both splints can be recommended for pregnant women with CTS.

Keywords: carpal tunnel syndrome, pregnancy, splints, wrist, pain, hand strength, upper extremity, functionality

Introduction

Carpal tunnel syndrome (CTS) is a pathological condition with symptoms that occur due to compression of the median nerve during its passage through the carpal tunnel.¹ The syndrome is also known as the most common neuropathy of the upper extremities and has been reported to affect approximately 3% of the adult population. In addition, it is stated that CTS is three times more common in females.^{2,3} In addition, CTS is recognized as a common musculoskeletal problem during pregnancy. The prevalence of CTS in the third trimester of pregnancy has been determined to be approximately 63%. Those for whom 53% of the cases were reported as unilateral.⁴ Causes of CTS in pregnancy include changes in the musculoskeletal system due to hormonal changes and gestational edema. Gestational diabetes may also contribute to the occurrence of CTS by causing slowing of nerve conduction velocity via focal compression under the transverse carpal ligament.⁵

Symptoms of CTS usually become more severe in the evening and may include pain, numbness, and tingling in the

hand. The pain is usually felt on the median nerve pathway, but it can also affect the whole hand and radiate to the arm and shoulders. Symptoms usually start with a loss of sensation in the distal fingers, followed by muscle weakness, which causes the loss of palmar abduction of the thumb.⁶

Carpal tunnel syndrome in pregnancy is generally less severe than non-pregnancy-related CTS. In a study of both pregnant and nonpregnant women diagnosed with CTS, it was found that pregnant patients recovered nearly about 3 to 4 times faster than nonpregnant patients.^{7,8} Generally treatment approach to the CTS is conservative. The conservative treatment of CTS includes local steroid injection,

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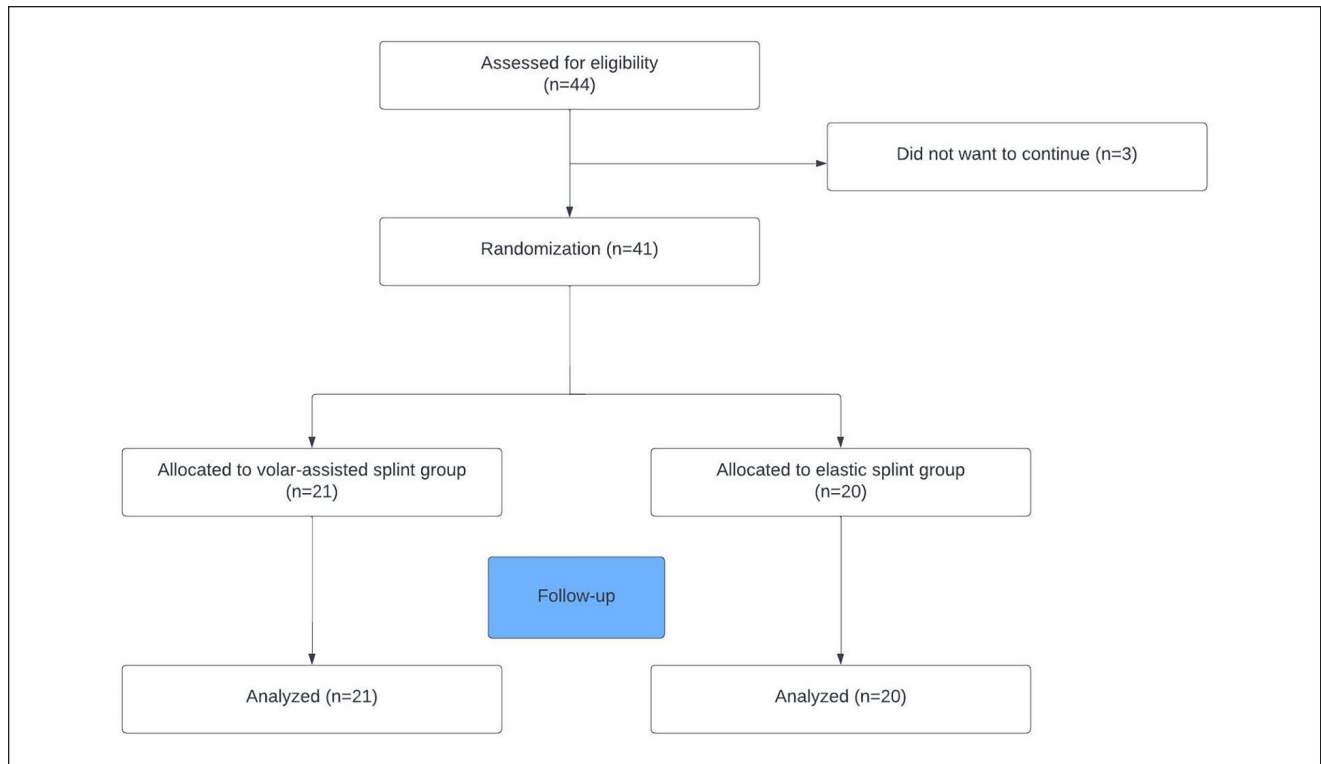


Figure 1. Flowchart diagram of the study.

nonsteroidal anti-inflammatory drugs, splinting, modification of activities of daily living, tendon-nerve shifting exercises, manipulation, acupuncture, and vitamin B₆.⁹

Splinting, which is one of the conservative treatment options, limits the movements of the wrist and keeps the hand in a neutral position, which helps to reduce symptoms. In the treatment of CTS, different types of splints that keep the wrist in extension or neutral position can be used.¹⁰ In the literature, it has been reported that the splints used at night could be safe and effective in the treatment of CTS.¹¹ It is also known that splinting in addition to physical therapy modalities is more effective in reducing symptoms than nonsplinted approaches.^{12,13} We did not find a study comparing two different splint types in CTS during pregnancy. Considering the different specificity of the two splints, such as the elastic splint compresses the wrist region but allows movement while the volar-assisted splint quite a lot limits joint movements, the aim of this study was to compare the effects of volar-assisted wrist splinting and elastic splinting on edema, pain, grip strength, and upper-extremity function in pregnant women with CTS.

Materials and Methods

Study Design and Participants

This study was designed as a prospective study investigating the effect of volar-assisted splint and elastic splint in

patients with CTS. The subjects were informed about the purpose and content of the study. This study was registered at ClinicalTrials.gov (registration number NCT06131996). All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

The study was conducted with 44 pregnant women who met the inclusion criteria, were diagnosed with CTS, and voluntarily agreed to participate in the study. CTS was diagnosed by a physician with a nerve conduction velocity test and other clinical tests specific to CTS. Three of them were excluded from the study because they did not want to continue. The remaining 41 individuals were divided into two groups, the volar-assisted splint group and the elastic splint group, by the closed envelope method. The flowchart of the study is shown in Figure 1. The inclusion criteria were as follows: being in the last trimester of pregnancy, having a diagnosis of CTS, positive Tinel and Phalen tests, pain, tenderness, and numbness symptoms in the median nerve neurodynamic test, pain of at least a severity level of 4 according to VAS, and edema due to pregnancy. Individuals in the first or second trimester of pregnancy, those with pain complaints below 4 according to VAS, those with a history of CTS before pregnancy, those who had undergone surgery in

the hand-wrist region, and those diagnosed with cervical radiculopathy were excluded from the study. Participants were excluded from the study if they voluntarily left the study, experienced pain or other health problems during the research process that could affect the evaluations, refused to participate in the evaluations, failed to meet the aforementioned criteria during the research process, or gave birth prematurely. The patients were not treated with any other medications to help with the swelling from pregnancy and carpal tunnel before or during the treatment process.

Outcome Measurements

Age, gender, height, weight, and body mass index (BMI; kg/m²) were recorded as demographic data. All measurements were taken by an experienced physiotherapist before and 4 weeks after the treatment.

Pain Assessment

The quantitative severity of wrist rest pain was evaluated using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (intolerable pain). Participants were asked to mark the severity of pain on a 10-cm-long line, and pain severity was recorded in centimeters.¹⁴ The minimum clinically significant change in the patient's pain intensity measured with a VAS is 13 mm.¹⁵

Quick Disabilities of the Arm, Shoulder, and Hand

The questionnaire quantifies patients' physical disability and symptoms in musculoskeletal disorders of the upper limb. The 11-item Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) is an abbreviated version of original DASH. Each item of the questionnaire has a 5-point scale where the patient can select the appropriate number corresponding to his/her function level. Based on item scores, scale scores are calculated ranging from 0 (no disability) to 100 (most severe disability).¹⁶ The minimum detectable change at the 90% confidence level was 12.85 points for the Q-DASH.¹⁷

Boston Carpal Tunnel Questionnaire

The Boston Carpal Tunnel Questionnaire (BCTQ) is self-administered and evaluates the severity of symptoms and the functional status of CTS patients during daily living. The questionnaire has two parts. The symptom severity scale consists of 11 questions (BCTQ 1), and the functional status scale consists of 8 questions (BCTQ 2). Each question has a 1-to-5 scale, in which 1 indicates no symptom and 5 indicates severe symptoms. The symptom severity scale assesses

the symptoms with respect to severity, frequency, time, and type.¹⁸

Grip Strength

A 2-setting Jamar hand dynamometer (Jamar, Jackson, Mississippi) is used for measuring hand grip strength while the patient is in a sitting position with shoulder adduction and neutral rotation, 90° elbow flexion, and neutral wrist position. This device is recognized as a gold standard for measuring hand grip strength. Hand grip measurements were taken, and the average of three trials was recorded in kilograms.¹⁹ Changes of 5.0 to 6.5 kg may be reasonable estimates of significant changes in grip strength.²⁰

Volumetric Measurement

Volumetric measurements were taken on the patients in a container filled with room temperature water that did not overflow, with the subject in full extension from distal to proximal, and the forearm sank to the elbow level. The volume of the forearm was determined in milliliters by collecting the spilling water in a graduated cup. The volume of water overflowing out of the container represents the volume of the extremity. This measurement method was used to compare the volume of water overflow between affected and unaffected extremities.²¹

Intervention

The first group used a volar-assisted wrist splint, and the second group used an elastic wrist splint during sleep everyday for 4 weeks (Figure 2). In addition, home exercise was performed for 12 sessions (3 sessions of exercises per week). In both groups, tendon-gliding-based exercises were carried out by the participant. These exercises were actively performed by the participants who maintained each position for 7 seconds and repeated them 5 times in each set for 3 sets, keeping 1-minute rest between sets, and performed the exercises 3 times per week for 3 weeks consecutively. The exercise techniques were explained to the patients in detail, and a brochure with visual content was presented to them. All the patients were followed up by phone calls, and they were evaluated in terms of pain, edema, grip strength, and functional levels before the treatment and 4 weeks after the treatment.

Statistical Analysis

Statistical analyses were performed with the SPSS (Statistical Package for the Social Sciences) 22.0 statistical package program. For descriptive analyses, variables with numerical values were expressed as the arithmetic mean and standard deviation ($X \pm SS$). The analysis of nonnumeric variables

Table 1. The Comparison of Participants According to Demographic Characteristics.

	Group 1 (n = 21) X ± SD	Group 2 (n = 20) X ± SD	t	P-value
Age (years)	30.14 ± 6.15	33.35 ± 4.98	-1.827	.075
BMI (kg/m ²)	25.16 ± 4.24	26.59 ± 2.77	-1.269	.212

Note. *P* = independent sample *t* test; X ± SD = mean ± standard deviation; BMI = body mass index.

was based on frequency values and expressed as the number of patients (n, %). The normal distribution analysis of data was performed by Skewness-Kurtosis, histogram graphs, mean ± standard deviation (SD), Q-Q plots, and Kolmogorov-Smirnov test. An independent sample *t* test was used to compare the parameters between the groups, and a paired *t* test was used for the comparison of the values before and after treatment within the groups. The significance level was accepted as *P* < .05 in all statistical analyses.

A power analysis was performed with α = 0.05 and 1-β (power) = 0.80 using G-Power version 3.1 to determine the number of samples to be included in the study. The calculation was made by assuming the difference between VAS scores (1.4 ± 0.5 cm) before rehabilitation and after rehabilitation in individuals with CTS.²² It was determined that a total of 40 people, including at least 20 people in each group, should be included.

Results

Baseline Characteristics

The mean age of all individuals was 31.7 ± 5.8 years, the mean height was 167.7 ± 4.8 cm, the mean weight was 72.6 ± 10.6 kg, and the mean BMI was 25.9 ± 3.6 kg/m². The dominant hand of 81% of the participants was right, and the same ratio of participants had an affected dominant hand. Most of the participants (80%) have a unilateral disease. Group 1 refers to the volar-assisted wrist splint group, and group 2 refers to the elastic splint group. The mean age, height, weight, and BMI of the groups were similar (*P* > .005; Table 1).

Outcomes of Individuals

A comparison of intergroup and intragroup values of VAS, Q-DASH, BCTQ, grip strength, and volumetric measurements is shown in Table 2 and Figure 2. A significant decrease was observed in both groups in terms of VAS score after a 4-week follow-up (*P* < .001, Table 2). An increase was observed in the intragroup values of both groups when the changes in Q-DASH score were analyzed before and after treatment (*P* < .001, Table 2). Both treatments showed a significant improvement in BCTQ score. In addition, it

was observed that there was a significant increase in grip strength in both groups after treatment (*P* < .001, Table 2). It can be said that both splints provided an increase in grip strength. Volumetric measurement values decreased in both groups after splinting. Both splints were beneficial in terms of edema (*P* < .001, Table 2).

Pain, functionality (BCTQ 1-2), and grip strength values of the groups were compared after the treatment. It was observed that pain decreased in both groups after splinting, but there was no difference between the groups in terms of pain values (*P* > .05). There were increases in hand grip strength values after the use of both types of splints in the groups, but no difference was observed between the groups (*P* > .05). In terms of the functionality scores (BCTQ 1-2) of the groups, it was observed that both groups had similar pretreatment and posttreatment values (*P* > .05). Similarly, in the volumetric measurements of edema evaluation, there was no difference between the groups before and after treatment (*P* > .05).

In the comparison of the delta change values before and after treatment between the groups, it was found that group 2 showed more change in VAS score, BCTQ 1-2, and grip strength values than group 1 (*P* = .018, *P* = .003, *P* = .002, *P* = .001, respectively; Figure 3).

Discussion

This study was carried out on pregnant women in the last trimester of pregnancy with CTS to compare the effects of volar-assisted and elastic wrist splints. The obtained results showed that both splints were effective in the management of CTS symptoms. Both treatment modalities reduced pain and edema levels and increased grip strength and upper-extremity functionality. It was observed that the elastic splint group had more change in delta values in terms of pain, functionality, and the effect on grip strength than the volar-assisted splint group.

In the literature, there are various results of splinting in CTS in terms of pain. As an example, Calandruccio and Thompson²³ stated that splinting and steroid injections are important healing modalities for reducing CTS symptoms and improving functionality. Karjalainen et al²⁴ reported that neurodynamic stretching techniques help reduce pain in patients with CTS. However, they did not provide specific information about the direct effect of splint use on pain. Šošić et al²⁵ stated detailed information about night splint use in chronic CTS, and they determined that splinting provides healing in pain. Moreover, Atroshi et al²⁶ reported that, despite its limited effect, splint use may reduce pain. In another study, Lewis et al²⁷ showed that a therapist-guided education, splinting, and home exercise program reduced the likelihood of resorting to surgery in individuals with CTS. Furthermore, Halac et al²² reported a significant improvement in the pain levels of individuals diagnosed

Note. Group 1 = volar-assisted splint group; Group 2 = elastic splint group; P^a = comparison of groups before treatment (independent sample t test); P^b = comparison of groups after treatment (independent sample t test); P^c = delta comparison of the groups; BT = before treatment; AT = after treatment; $X \pm SD$ = mean $\pm$ standard deviation; VAS = Visual Analogue Scale; Q-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; GS = grip strength; BCTQ = Boston Carpal Tunnel Questionnaire; VM = volumetric measurement. $^a p < .001$ is statistically significant (intragroup comparisons by paired t test). $^{b,c} p < .05$ is statistically significant (independent sample t test).



Figure 2. (a) Elastic splint. (b) Volar-assisted splint.

with CTS after 90 days of splint use. The results in the literature seem similar to the results that we obtained in our study. It was concluded that the use of both types of splints helped to reduce the pain and increase healing. Although both splinting approaches reduce pain in CTS patients, the rigid volar splinting affected pain healing more than elastic splinting, which may be a reason for the better stabilization effect and limited functionality of the volar-assisted splint. We think that this could be a cause for a lower pain-change delta value for volar-assisted splinting than for elastic splinting.

In addition to healing pain, the studies demonstrate the contribution of splinting to functionality as an indirect effect of reducing pain. In a study, Calandruccio and Thompson²³ reported that splint use was helpful in improving CTS symptoms and functionality but emphasized that more data are needed to determine the specific effects of splint use on functionality. Similarly, a study by Farahmand et al²⁸ found that splints that help patients with CTS perform activities of daily living reduce symptoms and pain. In another study, it was stated that neurodynamic techniques in the treatment of CTS may have a clinically significant effect on functionality.²⁴ In addition, Šošić et al²⁵ stated in their study that night splinting may reduce symptoms of CTS and lead to functional improvement. Some researchers emphasize that the use of splints does not have a direct impact on

functionality but alleviates the symptoms of CTS in general.²⁶ Lewis et al²⁷ examined the CTS patients in terms of functionality, and they found that there were more positive results in the study group than in the control group. Gatheridge et al²⁹ also found that wrist splinting used for 6 weeks in individuals with mild or moderate CTS provided a significant improvement in functionality. In a study comparing two types of splints in individuals with CTS, De Angelis et al¹³ reported improved functionality in both splint types according to the results of the BCTQ. Çalış et al³⁰ compared the efficacy of kinesiotaping and splinting in CTS and reported that Q-DASH scores decreased significantly and that functionality improved in both groups. Manente et al³¹ reported significant improvements in CTS symptoms and functional limitations in patients treated with splinting for 4 weeks. It seems that splinting in CTS has been an important intervention in reducing mild and moderate symptoms and increasing functionality.³² Studies have shown that splinting, which is one of the nonoperative treatment methods, reduces symptoms, reduces pain, and helps to perform daily activities. In accordance with the studies in the literature and our study results, we can say that splinting is effective in improving CTS symptoms and functionality. The fact that the BCTQ change value, which is related to functionality, was higher in the elastic splint group than that in the volar-supported hand splint group suggests that the support in the volar region may have created a restriction of movement, which may have affected the functionality. Moreover, Šošić et al²⁵ also emphasized the effect of splint use on grip strength in patients with CTS and stated that it provided improvement in hand grip strength in patients after treatment. In addition, Öncü et al³³ compared the efficacy of kinesiotaping and splinting in patients with CTS and concluded that the use of splinting with kinesiotaping in treatment may improve grip strength not only in the early period but also for a longer period. Similarly, Çalış et al³⁰ concluded that splint use increased grip strength in their study. Studies investigating the effect of splint use on grip strength in pregnant women with CTS are rare. In one of these studies, it was reported that grip strength increased 1 week after intervention, and symptoms improved in 76% of the pregnant women at the first month postpartum control.³⁴ Similar to the literature, it was seen that splinting increased the hand grip strength of individuals in our study. The change in handgrip strength was higher in the elastic splint group, and this difference can be explained by the fact that the splints are functionally different. Since the volar-supported splint is relatively more rigid than the elastic splint, this may have indirectly affected the hand grip strength by affecting the hand movements.

The diagnosis of edema in CTS is defined by ultrasound or magnetic resonance imaging. In the previous studies, the researchers emphasized that if the edema condition is prolonged, intraneural edema may lead to irreversible fibrotic

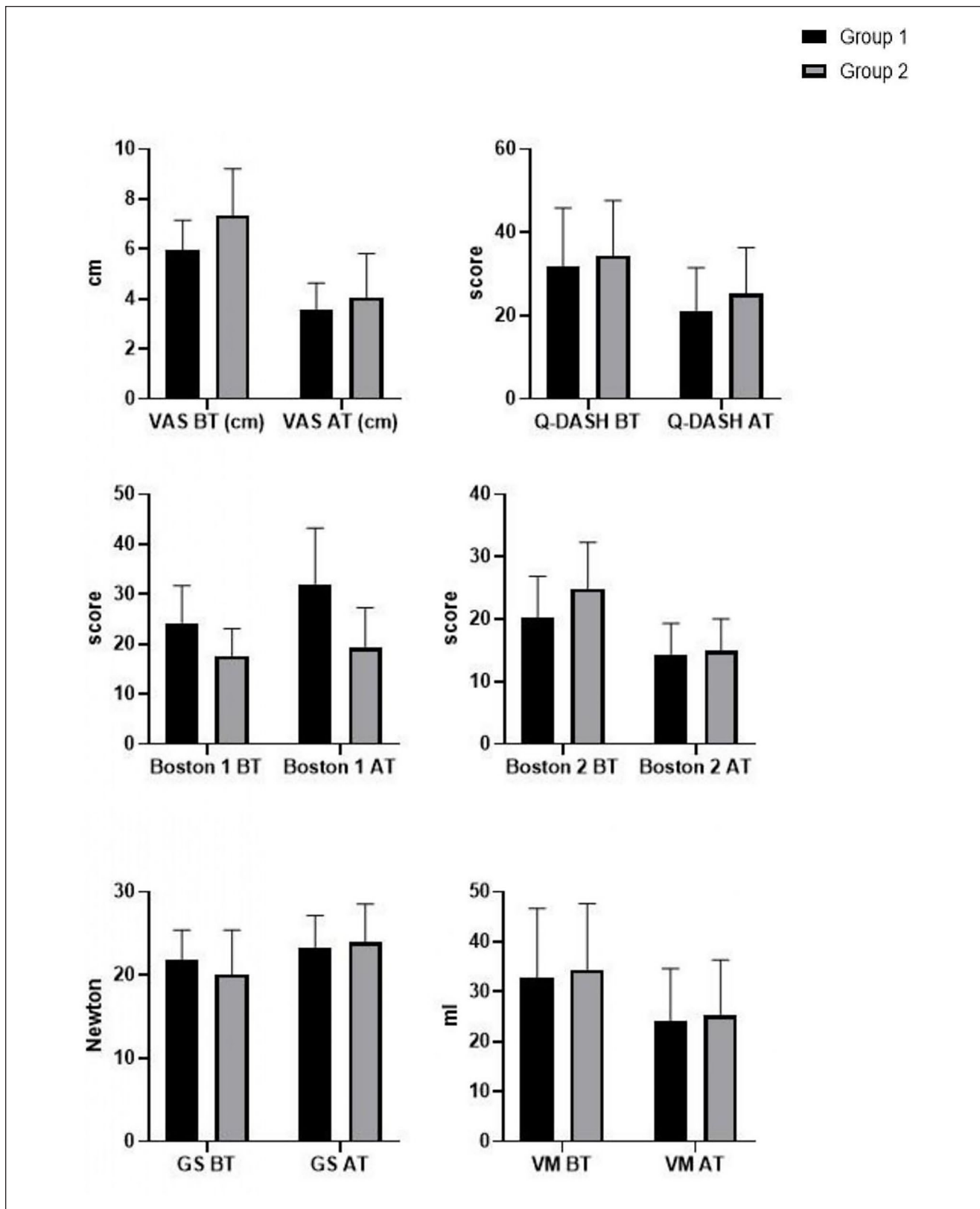


Figure 3. Comparison of intergroup and intragroup values of VAS, Q-DASH, BCTQ, grip strength, and volumetric measurements. Note. VAS = Visual Analog Scale; Q-DASH = Quick Disabilities of the Arm, Shoulder, and Hand; BCTQ = Boston Carpal Tunnel Questionnaire; BT = before treatment; AT = after treatment; GS = grip strength; VM = volumetric measurement.

changes, causing CTS to become stronger. Therefore, Schmid et al³⁵ stated the importance of investigating treatment methods that reduce edema in the treatment of CTS. Based on the idea that neural mobilization techniques may help reduce inflammation of nerve tissue and improve nerve health, Schmid et al³⁵ reported that 1 week of splinting, neural mobilization, and tendon-gliding exercises in patients with CTS led to a reduction in intraneural edema in the median nerve. However, their studies do not provide specific information about the direct effect of splinting on edema.³⁵ Šošić et al²⁵ found a relationship between the relaxation of symptoms and the reduction of median nerve edema in patients with CTS after splinting and exercise. The findings of our study are similar to those of previous studies. We think that decreased pain increases functionality, and increased functionality decreases edema. However, more research is needed to determine the direct effect of splint use on the reduction of edema.

This study has a few limitations. First, there is no control group in the study because of pandemic conditions. In addition, as the study was conducted in the last trimester of pregnancy, it was difficult to find pregnant women to participate in the study. The results of the current study are limited to pregnant women only. The collected information about the follow-up home exercises is assumed to be true, and the subjects involved in the study were assumed to give their answers honestly.

In conclusion, both treatment modalities were found to reduce pain and edema, increase grip strength, and improve upper-extremity functionality. Thus, these findings support the idea that both splint types are potential treatment modalities for pregnant women with CTS. It can be said that our study contributed to the understanding of potential splinting options for pregnant women with CTS. However, elastic splinting reduces pain, improves functionality, and increases hand grip strength more than volar-assisted splinting, so it may be recommended that patients prefer elastic splinting. In addition, we believe that finding effective treatment strategies for CTS during pregnancy is critical both to improve patients' quality of life and to reduce the burden on health services. We also think that our results will provide clinicians with an idea about the efficacy of volar-assisted and elastic wrist splints and increase their awareness about the importance of CTS as well as other problems during pregnancy.

Ethical Approval

Ethical approval was obtained from the ethical committee of Hasan Kalyoncu University (Ethics committee decision No: 2021/007, date of approval: 3 March 2021).

Statement of Human and Animal Rights

No experiments on animals were performed for this study. No experimental procedures were performed in any human subject for this study.

Statement of Informed Consent

Written informed consent was obtained from the patient for her anonymized information to be published in this article.

Declaration of Conflicting Interests

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