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The effectiveness of combining ultrasound therapy with splinting and exercise therapy for patients with carpal tunnel syndrome

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ABSTRACT

Background: Carpal tunnel syndrome (CTS) can cause patients to experience negative symptoms that can significantly affect their ability to use their hands to perform daily activities. This study aimed to compare the effectiveness of a combination of splinting and exercise therapy with or without ultrasound therapy in improving CTS symptoms and the functional status of patients.

Methods: This randomized pre and post-test control group design study was conducted in private physiotherapy practices in the Denpasar area from August to September 2022. Twenty-four subjects with unilateral CTS were randomly divided into an Intervention Group (n=12; splinting, exercise therapy, and ultrasound therapy) and a Control Group (n=12; splinting and exercise therapy only). Splinting was used all day and night for four weeks. Exercise therapy was given three times per week for four weeks. Ultrasound therapy was given once a day, three times per week, for four weeks. The subject's symptoms and functional status before and after treatment were evaluated using the Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ), which consists of the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS).

Results: Significant improvements were found in SSS and FSS in Group 1 (SSS: p=0.000; FSS: p=0.000) and Group 2 (SSS: p=0.000; FSS: p=0.000), and a significant between-group difference was found in SSS (p=0.000) and FSS (p=0.001).

Conclusion: The addition of ultrasound therapy to splinting and exercise therapy is more effective than that in improving the symptoms and functional status of patients with CTS.

Keywords: Carpal tunnel syndrome, exercise therapy, splinting, ultrasound therapy.

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INTRODUCTION

Carpal tunnel syndrome (CTS) is a collection of symptoms and signs of disease due to the entrapment of the median nerve at the wrist.[1] Globally, it is estimated that CTS occurs in around 1-4% of the world population, and the incidence of CTS can reach 276/100,000 people annually.[2] People who suffer from CTS are generally aged 40-60 years, and women are three times more at risk than men.[3] In Indonesia, it was reported that the number of CTS sufferers in the population of garment industry workers in Jakarta reached 20.3%.[4]

Patients with CTS often experience pain, numbness, and other sensory disturbances in areas supplied by the median nerve. Weakness and atrophy of the thenar muscles can also occur in severe cases.[1] This can significantly affect the patient's ability to use their hands to perform activities of daily living (ADL) and work, harming productivity.[5]

Several treatment options are available to reduce median nerve compression in cases of CTS, both conservative and surgical. Lately, there has been increasing interest in choosing a more conservative treatment because there is evidence to support conventional therapy over surgery, with physiotherapy demonstrating superior effectiveness over surgery in the short and long term.[6,7]

Splinting is the most frequently used conservative method for CTS.[8,9] Previous studies reported that various types of wrist splints and different angles of immobilizing the wrist are effective in treating CTS.[8] Exercise therapy is also a physiotherapy approach that is often given in treating CTS. However, it is suggested that exercise alone may not relieve CTS symptoms such as pain and numbness. Exercise is more effective when combined with other treatments, such as splinting, so a combination of splinting and exercise is generally used to treat CTS.[9] Among other conservative therapies, ultrasound modality is said to have a biophysical effect on nerve tissue, which can reduce median nerve inflammation and assist nerve recovery by stimulating regeneration.[8,10] Several studies have reported that ultrasound therapy has a beneficial result on the treatment of CTS.[8,11]

Providing a single intervention is often ineffective in dealing with problems in CTS cases,

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so combining interventions can be an option. Often, patients are given a combination of several interventions with the assumption that the results are better than a single intervention due to the different roles of each intervention in reducing nerve inflammation and swelling.[10] The combination that can be given includes splinting and exercise therapy with or without ultrasound therapy.

Research on the effectiveness of adding ultrasound therapy to splinting and exercise therapy in improving CTS symptoms and the functional status of patients with CTS is still limited and yields varying results. It is hoped that the addition of ultrasound therapy can accelerate the improvement of CTS symptoms, improving functional status. Therefore, this study aimed to investigate whether adding ultrasound therapy to splinting and exercise therapy can improve CTS symptoms and the functional status of patients with CTS.

METHODS

This single-blinded, randomized pre-test and post-test control group design study were conducted in private physiotherapy practices in the Denpasar area, Bali, from August to September 2022. This study received ethical clearance from the Research Ethics Committee Faculty of Medicine Universitas Udayana (No: 2035/UN14.2.2.VII.14/LT/2022), and all subjects who agreed to participate in this study signed the informed consent.

The inclusion criteria of this study included: a) adult male and female patients aged ≥18 years old; b) Phalen test and Tinel's sign positive; c) patients diagnosed with CTS by a doctor; and d) patients experiencing numbness and tingling. The exclusion criteria in this study included: a) patients who experienced other types of neuropathy within the past year (CTS symptoms may be due to other causes, such as diabetes mellitus); b) patients who are pregnant patients (CTS symptoms may disappear following delivery); c) patients who have thenar muscle atrophy (this is indicative of severe CTS and surgery is suggested in most cases); d) patients with a history of steroid injection into the carpal tunnel and surgery to release the carpal tunnel within the past year. A total of 24 subjects with CTS fulfilled the eligibility criteria and were recruited.

The subjects were randomly divided into two groups, namely an Intervention Group (12 subjects) and a Control Group (12 subjects), using the block randomization method to ensure balance in the number of subjects in both groups. Block randomization was carried out using online randomization software (http://www.randomization.com/). Participants' characteristics, such as gender, age, and duration of CTS, were collected.

The Intervention Group received splinting, exercise therapy, and ultrasound therapy for four weeks, while the Control Group only received splinting and exercise therapy for four weeks. Splinting was provided by wearing a regular wrist splint, and the patient was told to wear the wrist splint all day and night for four weeks. Exercise therapy consisted of wrist flexion stretches, wrist extension stretches, tendon glides, and medial nerve glides. A brochure describing each exercise was also given to the patient. Exercise therapy was given three times per week for four weeks. Ultrasound therapy was given for 15 minutes per session with the following parameters: a frequency of 1 MHz, an intensity of 1.0 W/cm2, and a transducer size of 5 cm2. Aquasonic gel was used as a medium for conducting ultrasound waves. Ultrasound therapy was given once a day, three times per week, for four weeks.

Before the intervention (pre-test) and after the intervention (post-test), participants were assessed for their CTS symptoms and functional status using a self-reported Boston Carpal Tunnel Syndrome Questionnaire (BCTSQ), which comprises two scales, namely the Symptom Severity Scale (SSS) and the Functional Status Scale (FSS).[12] Octaviana et al.[13] have confirmed the reliability and validity of the Indonesian version of BCTSQ. The SSS consists of 11 questions evaluating CTS symptoms, and the FSS has eight questions to assess the well the patient can perform activities of daily living (functional status). All questions were answered with a score ranging from 1 (normal) to 5 (worst). The overall SSS score was the average of the 11 questions, and the overall FSS score was the average of the eight questions,[12] where higher scores indicated more severe symptoms or more significant disability. In this study, the assessor who collected the pre-test and post-test data was blinded and did not know the subject's group allocation.

Data were tested with the *Saphiro-Wilk* test in each group to evaluate whether the data were normally distributed. The data distributions were normal ($p>0.05$), so parametric tests were used for statistical analysis. The paired sample *t*-tests were used to compare each group's pre-test and post-test mean values of SSS and FSS variables. The independent *t*-test was then used to compare the between-group mean values of SSS and FSS variables. A *p*-value of <0.05 was considered significant.

Table 1. Subject characteristics

Characteristic	Intervention Group (Splinting, Exercise & Ultrasound)	Control Group (Splinting & Exercise)
Age (years)*	35.08±2.97	36±2.95
Gender**:		
Male	3 (25%)	2 (16.7%)
Female	9 (75%)	10 (83.3%)
Duration of CTS (months)*	7.41±1.51	7.08±1.73
SSS*	2.48±0.10	2.50±0.11
FSS*	2.40±0.18	2.42±0.14

*Presented as mean±SD
**Presented as n (%)

Table 2. Comparison of mean values of SSS and FSS in both groups at pre-test and post-test

Variable	Group	Pre-test	Post-test	*p*-value*
SSS	Intervention	2.48±0.10	1.64±0.16	0.000
	Control	2.50±0.11	2.20±0.95	0.000
	p-value**	0.717	0.000	
FSS	Intervention	2.40±0.18	1.91±0.14	0.000
	Control	2.42±0.14	2.16±0.19	0.000
	p-value**	0.764	0.001	

*Using Paired *T*-Test
**Using Independent *T*-Test

RESULTS

Twenty-four subjects with unilateral CTS fulfilled the eligibility criteria. Twelve patients received splinting, exercise therapy, and ultrasound therapy (Intervention Group), and 12 received splinting and exercise therapy only (Control Group). They received treatment for four weeks. Table 1 summarizes the subject characteristics of both groups at baseline.

The comparison of mean SSS and FSS values before treatment (pre-test) and after treatment (post-test) are summarized in Table 2. Both groups showed significant within-group differences in mean SSS and FSS values before and after treatment (p=0.000 in both groups). This shows that splinting and exercise therapy with or without ultrasound therapy can improve CTS symptoms and the functional status of patients with CTS.

When the mean SSS and FSS values were compared between groups, significant differences were found in both variables in favor of the Intervention Group (p=0.000 in SSS and p=0.001 in FSS), meaning that the addition of ultrasound therapy to splinting and exercise therapy is more effective compared to splinting and exercise therapy only in improving CTS symptoms and the functional status of patients with CTS.

DISCUSSION

Patients with CTS often experience pain, numbness, and other sensory disturbances in areas supplied by the median nerve. Weakness and atrophy of the thenar muscles can also occur in severe cases.[1] This can significantly affect the patient's ability to use their hands to perform activities of daily living (ADL) and work, harming productivity.[5] Therefore, effective treatment should be given to improve symptoms, which will improve functional status.

Conservative treatment with physiotherapy that can be provided for CTS conditions can include splinting, exercise therapy, and ultrasound therapy. Splinting is a method to immobilize the wrist or wrist joint using an external tool such as a wrist splint.[1] The wrist splint helps maintain the wrist in a neutral place, thereby maximizing carpal tunnel volume and minimizing the compression of the median nerve, reducing edema, and minimizing friction and compression on the nerve, which can assist in controlling CTS symptoms.[14,15] Pressure on the median nerve is thought to be the lowest when the wrist is in a neutral position and increases when the wrist is in a flexion and extension position.[1]

In addition, exercise therapy is also a physiotherapy approach often given in treating CTS, which can include wrist flexion stretches, wrist extension stretches, tendon glides, and medial nerve glides. It has been theorized that yoga can reduce nerve compression in the carpal tunnel, improve the posture of the joints, and increase blood circulation to the median nerve.[16] Exercises in the form of stretching for CTS are given for the same reason: to mobilize the median nerve in the carpal tunnel.[17] Gliding exercise can prevent

or stretch the adhesions between the tendons and the median nerve, reduce tenosynovial edema, and increase venous return, thereby reducing pressure in the carpal tunnel and improving symptoms.[15]

Ultrasound is a therapeutic modality commonly used by physiotherapists. It uses sound waves emitted by a transducer, which is absorbed by the surrounding tissue under the skin, such as ligaments and tendons.[18] In the present study, significant differences in SSS and FSS variables were found in favor of the Intervention Group, meaning that the addition of ultrasound therapy to splinting and exercise therapy is more effective than without ultrasound therapy to improve CTS symptoms and the functional status of patients with CTS. This could be due to the biophysical effect ultrasound has on the nerve tissue, where it can facilitate nerve recovery by stimulating regeneration.[8]

Early research demonstrated that ultrasound could reduce inflammation and has tissue-stimulating effects by increasing blood flow, increasing the permeability of cell membranes, and modifying the extensibility of connective tissue and nerve conduction through the thermal effect of ultrasound.[19–21] Yet, Yildiz et al.[22] referred to other studies that have shown ultrasound to have no anti-inflammatory effect, but instead, it speeds up the formation process and reduces pressure in the carpal tunnel.[18]

The results found in this study are consistent with previous studies. According to Ansar et al.,[23] concerning the impact of pulsed ultrasound and corticosteroid injections for CTSfour-week ultrasound therapy increased hand strength and improved symptoms more significantly than corticosteroid injections. Moreover, it was reported that continuous ultrasound at intensities of 1.5 W/cm^2 and 0.8 W/cm^2 significantly improved CTS symptoms and median nerve conduction velocity.[24] The pressure created by ultrasound can excite afferent nerve fibers C, dilating capillary blood vessels and hyperemia to aid tissue repair.[25]

Therefore, the results of the present study support the notion that a combination of several interventions is effective for treating CTS, which could be due to the different roles of each intervention in reducing nerve swelling and inflammation, as proposed by Sim et al.[10]

This study had several limitations. We could not control other possibly confounding variables, such as the intake of anti-inflammatory or analgesic medications, so it is unclear whether the improvement found in this study was solely due to the intervention or the result of the medications. It was also impossible to ensure patient compliance using the wrist splint according to our instructions. Hence we only depended on patients' reports. Non-compliance with using the wrist splint as instructed may affect the results of this study. Another limitation was that the patients and the therapist who provided the interventions were not blinded to the participant's group allocation, which may have increased the risk of bias in this study. In addition, this study did not include a follow-up period after the study ended, so the long-term effect of the intervention is unknown.

CONCLUSION

It can be concluded that combining splinting and exercise therapy can improve the symptoms and functional status of patients with CTS. Yet, adding ultrasound therapy to splinting interventions and exercise therapy is more effective than without ultrasound therapy in improving the symptoms and functional status of patients with CTS.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest.

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AUTHOR CONTRIBUTIONS

SAPT was responsible for conceiving the study, organizing study data, data analysis, writing the draft, and assembling the entire manuscript. PASS and MDSPB organized study data and reviewed the final manuscript.

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