Comparative Study of Therapeutic Ultrasound and Copaiba Oil Phonophoresis Therapies for Shoulder Tendinitis

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Abstract. Shoulder tendinitis is characterized by inflammation of the rotator cuff tendons, resulting in pain, instability, and limitation of shoulder movements. The injury can be caused by stress, excess movements in daily activities or excessive load on the muscles. The study aimed to evaluate the effectiveness of shoulder tendinitis treatment using therapeutic ultrasound associated with the Copaiba oil incorporated into the coupler gel. The study assessed 30 patients divided into groups: TUS–conventional ultrasound and CP–ultrasound with 10% Copaiba oil gel. Ultrasound parameters: 1 MHz acoustic frequency, 0.5 W/cm^2 intensity, 100 Hz repetition rate, 20% duty cycle, and 3.5 cm^2 irradiation area. Ultrasound was applied for 4 min each session, with 12 sessions treatment. The treatment was evaluated by the parameters: quality-of-life, pain intensity, muscle strength (abduction and flexion), and the amplitude of the joint movement of the shoulder (abduction, adduction, flexion, extension, medial and lateral rotations). The treatment evaluation was made by introducing the evolution score index, which compare the values measured post-treatment with the pre-treatment. The ANOVA and Student tests were used for intra and intergroup statistical analysis, respectively, with a significance level of $\alpha < 0.05$. Results show that the group of phonophoresis with Copaiba oil gel presented an improvement in functional capacity, with pain reduction, increase in muscle strength and in joint movement amplitude, when compared with therapeutic ultrasound ($p < 0.05$). Concluding, the anti-inflammatory and analgesic properties of ultrasound can be enhanced by phonophoresis using gel with Copaiba oil.

Keywords: Copaiba gel · Rotator cuff tendinitis · Phonophoresis · Therapeutic ultrasound · Pain relief · Muscle strength and shoulder motion improvements

J. L. B. Marques et al. (Eds.): CLAIB 2022/CBEB 2022, IFMBE Proceedings 101, pp. 203–211, 2024.
https://doi.org/10.1007/978-3-031-49410-9_20

1 Introduction

Shoulder tendinitis is a condition characterized by inflammation of the rotator cuff tendons, resulting in pain, instability, and considerable limitation of shoulder movements, such as the medial and lateral rotation movements. The injury can be caused by several factors, such as stress, excess movements in daily activities, excessive load on the muscles, or physical inactivity associated with old age [1, 2]. Shoulder pain, range of motion impair, and disability are the most common symptoms in patients with shoulder dysfunction [3]. In view of the increase of the population looking for sports and the excess of competitiveness within all sport competitions there is an increase in the rate of shoulder injuries caused by the practice of sports [4–7]. In this context, it is important to seek the best treatment of athletes' shoulder injuries.

Nam and Lee [8] reported that the conservative treatment of shoulder tendinitis should be always prioritized, i.e., the use of anti-inflammatory drugs, thereby improving quality-of-life without the need for surgical intervention. However, the use of anti-inflammatory drugs can cause adverse effects.

Among the various techniques for the treatment of shoulder tendinitis the therapeutic ultrasound (TUS) is very promising, it promotes a faster recovery process at the injured site [9–11]. Ultrasound generates acoustic waves that cause thermal effects like acceleration of metabolism, changes in nerve conduction velocity, increased blood flow, a temporary increase in the extensibility of collagen structures, and a reduction or control of pain [12]. To maximize the transmission of the mechanical energy of the ultrasound through the skin, a specific coupler gel is applied over the skin.

The addition of a drug to the coupler gel in ultrasound therapy promotes the transport of the active substances of the drug to the location of the lesion, resulting in greater efficacy of the treatment. This technique is non-invasive and without side effects and it is known as phonophoresis [13]. The action of the absorbed drugs depends on the anatomy of the treated area, the hydration degree of the skin, the presence of fat, the patient's metabolism, and how the ultrasound is applied [14].

Several studies have been published in the last few years comparing the effect of the phonophoresis using different drugs on the treatment of diverse musculoskeletal disorders. It is worthy to mention some of them, drug(s)–musculoskeletal disorder: Fish oil–Achilles tendon rupture [15], virgin olive and piroxicam–exercise induced knee pain [16], diclofenac and thiocolchioside gel–low back pain [17], piroxicam and dexamethasone sodium phosphate–carpal tunnel syndrome [18], among others.

In the present study, it is investigated the effect of adding an herbal medicine substance to the coupler gel, i.e., Copaiba oil, which has analgesic and anti-inflammatory properties, and it can improve the tendinitis recovery process. Copaiba oil is a natural substance extracted from trees of the species *Copaifera langsdorffii* Desf. (Leguminosae, Caesalpinioideae), and is characterized as a terpenoid [19, 20]. The main compound found in Copaiba oil is β-caryophyllene. This substance presents properties such as local analgesic, anti-inflammatory, and anti-microbial effect [21, 22].

The aim of the present study is to test the hypothesis that a phonophoresis using Copaiba oil enhances the effect of conventional ultrasound on the treatment of shoulder tendinitis.

2 Materials and Methods

A study was conducted experimental, randomized, blinded, controlled, and composed of 30 patients of both sexes suffering of chronic tendinitis of the shoulder for more than 6 months (patients' age: 60.6 ± 6.8 yr). The research project was approved by the University Ethics Committee under the code CAAE: 47345015.0.0000.5494. All patients signed a consent form, and they first underwent a clinical evaluation process by the responsible physiotherapist. Inclusion criteria were medical diagnosis as chronic tendinitis of the shoulder, age between 45 and 70 years, and not using anti-inflammatory or analgesic medication at the time of the study. Exclusion criteria, no chronic tendinitis of the shoulder, age out of the studied range, using anti-inflammatory or analgesic drugs, presenting other pathologies associated with tendinitis, and who were treated with other therapeutic methods recently.

2.1 Treated Groups

The study assessed 30 patients equally divided into two groups: TUS - treated with ultrasound using the conventional water-based gel, and CP–ultrasound with 10% of Copaiba oil added to the coupler gel.

2.2 Ultrasound Equipment

Therapy was conducted using IBRAMED equipment, Sonopulse model (IBRAMED Co, Amparo, São Paulo, Brazil), with 1 MHz acoustic frequency, Spatial Average–Temporal Average (SATA) intensity of 0.5 W/cm^2, pulsed with 100 Hz repetition rate and 20% duty cycle, and 3.5 cm^2 of Effective Radiation Area (ERA). The equipment was calibrated by the own factory.

2.3 Treatment Description

Copaiba oil (Bioflora, Itajubá, MG, Brazil) added to the coupler gel at a concentration of 10% was used in the present study. The ultrasound was applied by direct coupling with oscillatory rubbing movements for 4 min over an area of 5 × 5 cm, and 30 min of session, including the prior clinical evaluation. Treatment comprised of 12 sessions, three times a week (28 days).

2.4 Treatment Evaluation

The treatment evaluation was performed by assessing the parameters: quality-of-life using the Health Assessment Questionnaire (HAQ; 15 questions) [10], pain intensity by the visual analog scale (VAS) that classifies the pain on a scale from 0 to 10, being 10 the maximum pain, and muscle strength that was evaluated through a protocol in which the patient performs two specific movements of the shoulder joint (abduction and flexion), using a weight of up to 50 N. Other evaluation parameter was the range of motion, which was measured in degrees with a goniometer. This last parameter was subdivided

into six aspects to evaluate every movement separately: flexion, extension, abduction, adduction, medial rotation, and lateral rotation. Each parameter was measured before and at the 28th day of treatment. The treatment performance was evaluated by using the evolution score index, which is defined as:

$$\text{evolution score} = (\text{score post} - \text{treatment} - \text{score pre} - \text{treatment}) \quad (1)$$

Evolution scores positives for muscle strength and shoulder motion indicate that the patient shows improvement in the corresponding parameter. On the contrary, negative values for pain and HAQ means improvements.

2.5 Statistical Analysis

A one-way ANOVA test followed by Tukey post-hoc test was used for the statistical intragroup analysis of the scores of each parameter before and after treatment. The intergroup analysis was performed by applying a parametric, unpaired, and two-tailed Student t-test to compare the evolution scores of the TUS group with the CP group. The GraphPad Prism 8® software (GraphPad Software Inc., La Jolla, CA, USA) was used for intragroup and intergroups statistical analysis, with a significance level of 5% ($p < 0.05$). Results are expressed as Mean ± SEM.

3 Results and Discussion

Table 1 shows the scores of the 10 parameters that were evaluated in the groups TUS and the phonophoresis CP, as well as the intragroup statistical analysis. The data in Table 1 indicate that both treatments induce an improvement of the patients in all parameters, although at different intensity, being the increase statistically significant for 8 parameters in the CP group, and only 5 parameters of the TUS group.

Evolution scores of the parameters for both groups are depicted in Table 2. The improvement in shoulder tendinitis by both therapies is manifested in the values of the positive evolution scores for muscle intensity and shoulder movement, and negative for pain reduction and the HAQ test. Table 2 also contain the results of the intergroup statistical analysis, which are described as follows:

Evaluation of pain intensity and quality of life. The CP group using the phonophoresis technique induces a statistically significant reduction of pain when compared to the TUS group. On the contrary, in the quality-of-life parameter using the HAQ test the CP group shows a smaller increase than for the TUS group, a result that could be explained by the very subjective characteristic of the HAQ test.

Evaluation of muscle strength. The parameter that evaluates muscle strength was divided into two components, i.e., abduction and flexion movements, to facilitate the understanding and implementation of the assessment. The treatment using phonophoresis presents a significant increase in strength when compared with the ultrasound therapy for both components of the parameter.

Evaluation of range of motion. The assessed shoulder motion parameter comprised six angular movements: flexion, extension, abduction, adduction and, medial and lateral

Table 1. Parameter scores and intragroup statistical analysis for TUS and CP groups: Mean (SEM)

Parameter	Group TUS			Group CP		
	Pre-treatment	Post-treatment	p	Pre-treatment	Post-treatment	p
Pain	6.0 (0.5)	2.4 (0.5)	***	6.8 (0.5)	1.1 (0.3)	***
HAQ	10.3 (1.7)	1,2 (0.3)	***	6.2 (1.3)	2.7 (0.8)	ns
Muscle strength (N)						
Abduction	5.9 (1.8)	10.9 (2.4)	ns	4.6 (1.2)	16.8 (0.9)	***
Flexion	3.5 (0.6)	8.6 (1.1)	ns	7.4 (1.5)	15.5 (1.7)	***
Shoulder motion (°)						
Flexion	135.5 (11.3)	157.5 (8.9)	ns	118.7 (8.5)	178.0 (2.0)	***
Extension	36.4 (1.3)	43.0 (0.8)	***	32.9 (0.8)	45.0 (0.1)	***
Abduction	138.0 (7.1)	164.0 (7.3)	*	162.0 (3.2)	176.5 (3.5)	ns
Adduction	33.5 (1.7)	39.0 (0.7)	ns	28.7 (2.0)	40.0 (0.1)	***
Medial rotation	68.5 (4.7)	83.5 (3.2)	*	62.5 (3.3)	89.0 (0.7)	***
Lateral rotation	75.0 (3.6)	87.0 (2.1)	ns	64.0 (4.6)	88.0 (1.3)	***

A one-way ANOVA test followed by Tukey post-hoc test was used for the statistical intragroup analysis of the scores of each parameter before and after treatment. Statistical analysis with a significance level of 5% ($p < 0.05$).
Parameter units: (N) Newton, (°) degree. TUS: therapeutic ultrasound. CP: Copaiba oil. SEM: standard error of the median. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, ns-not significant.

rotations. It can be observed from the intergroup analysis data shown in Table 2 that the phonophoresis with Copaiba gel induces a statistically significant increase, in relation to therapeutic ultrasound, in the angulation of shoulder movements flexion, extension, adduction, medial and lateral rotations, with statistical uncertainty values of $p < 0.05$ to $p < 0.01$, depending on the parameter studied. On the contrary, although the TUS and CP groups increased angulation in the abduction movement after treatment, the increase was lower for the CP group.

Briefly, the results of this study show that the insertion of 10% Copaiba oil to the gel used in the treatment with therapeutic ultrasound enhances the effect of the ultrasound in the treatment of shoulder tendinitis, in eight of the ten evaluated parameters.

The aim of the present study was to assess the reduction of the painful process in the chronic phase of shoulder tendinitis using two therapies: conventional ultrasound and ultrasound with coupler gel containing the herbal substance Copaiba. In this sense, a reduction in the painful process in the chronic phase was observed in our study for both proposed therapies.

The ultrasound parameters used in the present study optimized the therapeutic effects of the ultrasound on shoulder tendinitis, allowing deeper penetration into the tissue, providing maximum rate tissue regeneration, and avoiding thermal effects in the stratum corneum [23].

Table 2. Intergroup statistical analysis of the evolution scores for TUS and CP groups: mean (SEM)

Parameter	Group TUS	Group CP	p
Pain	−3.6 (0.4)	−5.7 (0.6)	**
HAQ	−9.1 (1.6)	−3.5 (0.8)	**
Muscle strength (N)			
Abduction	5.0 (1.1)	12.2 (1.0)	***
Flexion	5.1 (0.8)	8.1 (1.2)	*
Shoulder motion (°)			
Flexion	22.0 (5.1))	59.2 (8.5)	**
Extension	6.6 (1.3)	12.1 (1.8)	*
Abduction	26.0 (2.2)	14.5 (2.3)	**
Adduction	5.5 (1.4)	11.3 (2.0)	*
Medial rotation	15.0 (3.3)	26.5 (2.8)	**
Lateral rotation	12 (3.1)	24 (3.6)	*

The intergroup analysis was performed by applying a parametric, unpaired, and two-tailed Student t-test to compare the evolution scores of the TUS group with the CP group. The GraphPad Prism 8® software (GraphPad Software Inc., La Jolla, CA, USA) was used for intragroup for statistical analysis, with a significance level of 5% ($p<0.05$). Parameter units: (N) Newton, (°) degree. TUS: therapeutic ultrasound. CP: Copaiba oil. SEM: standard error of the median. *$p<0.05$, **$p<0.01$, ***$p<0.001$.

The choice of the right medium to be used as an ultrasound coupler is important to obtain the maximum transfer of acoustic power to the tissue. Casarotto et al. [24] reported that gel used with ultrasound presented the highest transmission, an attenuation coefficient and acoustic impedance close to that of the skin, as compared with other materials such as mineral oil, white petrolatum, and degassed water. Based on those findings, we chose to employ the gel as the ultrasound coupler in the present study, alone or combined with Copaiba oil.

Therapeutic ultrasound combined with anti-inflammatory drugs has been widely employed in recent decades. For instance, Jun et al. [25] compared the effect of phonophoresis using Chinese medicinal herbs or sodium diclofenac on the treatment of knee osteoarthritis observing that the two therapies were efficient and no statistically significant difference was found between both drugs.

In a recent work, Altan et al. [17] reported a study on the therapy of acute low back pain using phonophoresis (diclofenac plus thiocolchioside gel) or therapeutic ultrasound. They assessed the parameters Visual numeric scale (VNS), Oswestry Disability Index (ODI), and Shober test. Comparing the two therapies was found that phonophoresis presented a significantly improvement in VNS and ODI parameters.

Our results agree with findings reported in the literature that phonophoresis enhances the effect of the therapeutic ultrasound regarding pain reduction and improvement in functional capacity [15–17, 25].

Several parameters were analyzed in our study for the treatment of shoulder tendinitis. It was found that phonophoresis using the Copaiba oil gel (at 10% concentration) presented statistically significant differences when compared with conventional ultrasound for eight out of the ten studied parameters: pain relief, increased muscle strength (abduction and flexion) and articular movement of the shoulder (flexion, extension, adduction and, medial end lateral rotation). These results indicate that the phonophoresis process enhanced the permeation of drugs when they are included into the gel.

Moreover, Copaiba oil has anti-inflammatory and analgesic activity due to the presence of sesquiterpenes such as β-caryophyllene (main component of the oil). Tung et al. [21], Chavan et al. [22], and Ghelardini et al. [26] highlighted the medicinal activity of β-caryophyllene, due to its anti-inflammatory and analgesic properties.

In this way, the gel with Copaiba oil seems to be effective for the treatment of chronic shoulder tendinitis, improving pain relief and functional capacity; therefore, improving the quality-of-life of the patients.

However, even though these results are promising for shoulder tendinitis treatment, further studies are needed with an augment of the cohort size to corroborate these findings. Likewise, longitudinal studies as the rehabilitation of patients with kinesiotherapy, to strengthen the rotator cuff muscles that were affected by the lesion, and follow up of patients' recovery after therapy are convenient.

Phonophoresis using gel with Copaiba oil seems to be a valuable candidate for a low-cost alternative treatment for shoulder tendinitis.

4 Conclusion

It can be concluded that treatment of shoulder tendinitis with ultrasound using gel containing Copaiba oil (10% concentration) was more efficient than the conventional ultrasound with water-based gel, suggesting that phonophoresis enhances the anti-inflammatory and analgesic activities of ultrasound.

Acknowledgments. JPSM thanks the Coordination for the Improvement of Higher Education Personnel (CAPES) for the PhD scholarship. ABF, RAL-Z, LPA, ABV, and CJL thank the Anima Institute (Brazil) for the grating of their Research Scholarships.

Conflict of Interest. The authors declare that they have no conflict of interest.

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