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New Methodology to Potentiate the Anti-Algic Effect on the Small Joints of the Hands in Patients Affected by Rheumatoid Arthritis

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Abstract

Rheumatoid Arthritis is an autoimmune disease characterized by presenting chronic synovitis mainly in the small joints of the hands and feet, leading to the onset of pain and limitation of movements, with a higher incidence in females and interfering with the performance of daily, work and social activities, which reduces the quality of life of patients with this pathology. Our work analyzed the application of the conjugated therapy of Laser and Ultrasound, in the antialgesic effect in the small joints of the fingers. Four study groups were assigned to receive application to both hands, 3 minutes per point, 8 treatment sessions. Laser Group (n=10): Laser, wavelength 808nm/660nm, continuous, 100mW power; Ultrasound group (n=10): frequency 1MHz, intensity of 0.5W/cm², pulsed 100Hz with duty cycle 50%, power 1.30W; conjugated group: with bowl (n=10) and without bowl (n=10), frequency 1 MHz, intensity of 0.5W/cm², pulsed 100Hz with 50% duty cycle, power 1.30 W and Laser with wavelength 808nm/ 660nm, continuous, 100mW power. The group combined with a tub was applied with the hand submerged in water. Pre and post treatment, McGill Pain Questionnaire and pressure pain threshold were evaluated through algometry. The combined treatment with a bowl was superior (49.7%) to the Laser treatments (36.8%), Ultrasound (5.09%) and combined without a bowl (36.2%) for pain reduction. In this way, the conjugated therapy applied with the tub (underwater and combined with Laser and Ultrasound) for the treatment of small joints of the hands, provides a new non-pharmacological and non-invasive treatment approach that contributes to a better quality of life for patients with this disease. chronic joint inflammation.

Keywords: Laser; Ultrasound; Rheumatoid arthritis

Introduction

Rheumatoid arthritis is a type of autoimmune, chronic and systemic inflammatory arthritis [1], characterized by inflammation of the synovial tissue, cartilage and bone, triggered by the response of the innate and adaptive immune system to an autoantigen [2]. The immunopathogenic mechanism involved in synovial inflammation in rheumatoid arthritis comprises the interaction of innate and adaptive immunity, coordinated by cytokines, chemokines, and reactive oxygen species, released by immune cells that invade the membrane and synovial fluid, leading to disease progression, joint destruction by the formation of Pannus [3]. Pannus consists of hypertrophied synovial tissue, composed of macrophages, osteoclasts and fibroblast-like synoviocytes, which promotes the destruction of cartilage and subchondral bone, perpetuating the painful condition in the course of the disease [4]. In addition, the inflammatory molecular mediators present in chronic synovitis sensitize the sensory nerves present in the joint capsule, ligaments, subchondral bone, tendon sheaths and muscles, causing pain in the affected region [5].

Rheumatoid arthritis is one of the most frequent autoimmune diseases worldwide, affecting 0.5-1.0% of adult individuals. It predominates in females, appearing between the fourth and sixth decade of life, but its prevalence increases with advancing age [6].

Chronic synovitis is symmetrically evident in several synovial joints, starting in the joints of the hands, causing pain and deficiency of joint constituents and consequent functional impairment, negatively impacting the performance of daily and work activities, reducing the quality of life of patients with this condition disease [7].

Although there is no cure, Rheumatoid Arthritis can be controlled with the use of immunosuppressive, analgesic and anti-inflammatory drugs and with the therapeutic resources used in Physiotherapy such as Acupuncture, TENS, Laser and Ultrasound [8]. In recent years, a group of researchers from the Physics Institute of the University of São Paulo in São Carlos, started studies using equipment that combines laser and ultrasound, which has generated positive results in the treatment of chronic diseases such as osteoarthritis in hands and knees [9,10]and Fibromyalgia [11].

In this context, Laser is a resource widely used in clinical practice to control pain and inflammation, due to its biological effects on nerves such as hyperpolarization, reduction of conduction velocity and action potential of the nerve fiber, in addition to inducing the level of algogenic substances such as prostaglandin, bradykinin, histamine and acetylcholine, increase the levels of β-endorphin [12], increase the microcirculation and increase the lymphatic flow, the latter contributing to the reduction of pain and edema [13]. Ultrasound, even in pulsed mode, can promote thermic effect, acting on pain, resulting in an increase in tissue metabolic rate, temporarily increasing the extensibility of collagen fibers such as tendons, ligaments and joint capsules, in addition to increasing circulation by removing tissue algogenic substances [14]. On the other hand, the mechanical action of ultrasound can change the structure, function and permeability of

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cell membranes for calcium and sodium ions, promoting an increase in protein synthesis, inducing physiological effects such as tissue repair, pain reduction and inflammation control [15]. In this context, conjugated therapy presents a better approach in anti-inflammatory and analgesic modulation compared to individual therapy, as the synergy of therapies enhances tissue stimulation, which translates into better therapeutic responses [9,16].

However, the objective of the study was to verify the effectiveness of the use of conjugated therapy of Laser and Ultrasound in the anti-algic treatment in the small joints of the hands and how it is possible to maximize the therapeutic result in these conditions.

Materials and methods

Approval and location of the study

The study was approved by the Research Ethics Committee of the Santa Casa de Misericórdia de São Carlos, São Paulo, under the number CAAE 48879821.1.0000.8148. It was developed at the Photodynamic Therapy Unit, Research Unit of the Physics Institute of São Carlos, University of São Paulo in São Carlos, located in Santa Casa Hospital, São Carlos, São Paulo, Brazil.

Patient Selection

We selected 40 female volunteers, aged between 40 and 80 years, without restriction of race, ethnicity, religion, profession or socio-economic-cultural level, with a medical diagnosis of Rheumatoid Arthritis, who had pain in the proximal and distal interphalangeal joints. of both hands.

The volunteers were divided into 4 groups: Laser treatment group, Ultrasound treatment group, Conjugate treatment group and Conjugate treatment group with tub.

The treatment was applied to the dorsal aspect of the proximal and distal interphalangeal joints of the fingers on both hands. Each group received a treatment resource and in the conjugated groups, one received the application of the treatment without a tub and the other with the tub to perform the underwater technique.

Laser Group (n=10): received laser treatment without the vat, using the following parameters: wavelength 808nm and 660nm, continuous emission mode, with a power of 100mW. To apply the treatment, the fingers remained adducted, gel was used as a contact interface between the application tip and the skin, and the application was carried out with circular, continuous, slow and smooth movements, 3 minutes at each point, totaling 12 minutes in each hand (Figure 1).

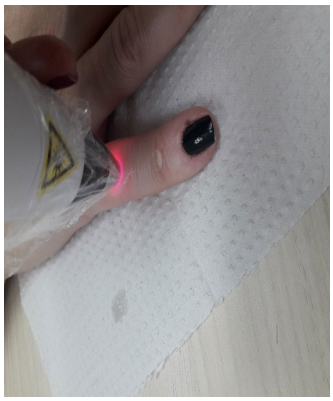

Figure 1: Laser application on the dorsal aspect of the proximal interphalangeal joint of the fifth finger.

Ultrasound Group (n=10): received ultrasound treatment, without the tub, with the following parameters: frequency 1 MHz, intensity of 0.5W/cm², pulsed 100Hz with 50% duty cycle, power 1.30W. With the fingers adducted, the transducer of effective radiation area (ERA) of 2.6cm² was placed in contact with the skin using gel as a contact medium. The application was performed with circular, continuous, slow and smooth movements, 3 minutes in each point, totaling 12 minutes in each hand (Figure 2).

Conjugated group without tub (n=10): received Conjugate treatment, without using the tub, with the following parameters: frequency 1MHz, intensity of 0.5W/cm², pulsed 100Hz with 50% duty cycle, power 1.30W in relation to the ultrasound and laser parameters: wavelength 808nm and 660nm, continuous emission mode, with power of 100mW. Gel was used as a contact interface between the ultrasound transducer and the skin, with the fingers adducted, the application was performed with circular, continuous, slow and smooth movements, 3 minutes at each point, totaling 12 minutes in each hand (Figure 3).

Group Conjugate with tub (n=10): received the Conjugate treatment, using the tub, with the following parameters programmed in the equipment: frequency 1MHz, intensity of 0.5W/cm², pulsed 100Hz with 50% duty cycle, power 1.30 W in relation to Ultrasound and laser parameters: wavelength 808nm and 660nm, continuous emission mode, with a power of 100mW. One of the hands was placed inside the bowl, so that the proximal and distal interphalangeal joints of the fingers were submerged. The acrylic portion of the handpiece was submerged and the transducer was placed in contact with the skin and the application was performed with circular, continuous, slow and smooth movements, for 3 minutes at each point, totaling 12 minutes in each hand (Figure 4).

Figure 2: Application of therapeutic ultrasound on the dorsal aspects of the proximal interphalangeal joints of the fingers.

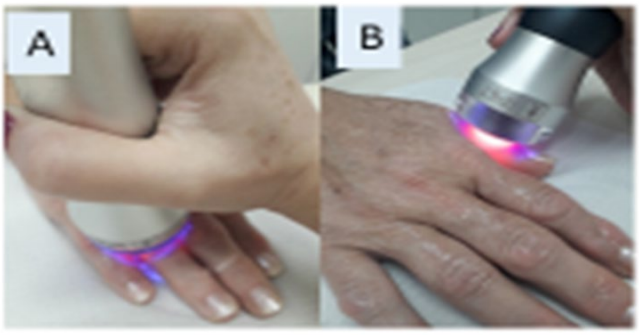

Figure 3: Application of combined laser and ultrasound therapy without the tub. In The application of conjugate therapy, in the dorsal aspects of the proximal interphalangeal joint of the fourth finger. In B application of conjugate therapy in the interphalangeal joint of the first finger.

Application Area

The four treatment application points are shown in Figure 5 below:

Equipment: The equipment was developed at the Technical Support Laboratory (LAT) of the Physics Institute of the University of São Paulo (USP) São Carlos and is produced and marketed by the company MMOptics São Carlos, São Paulo, Brazil, called Recupero®. The equipment promotes overlapping of therapeutic fields.

Evaluation: The McGill Pain Questionnaire and Algometry were used for pre- and post-treatment comparisons. The McGill Pain Questionnaire assesses the perception of pain that the patient experiences, indicated through descriptors whose sum gives us the pain index [17]. Algometry was used to assess the pressure pain threshold [9].

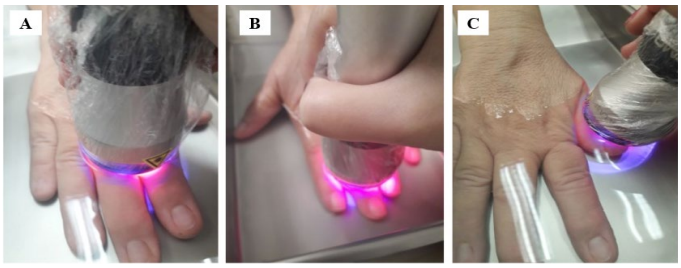

Figure 4: Application of the combined therapy Laser + Ultrasound with the metallic bowl. In The application of conjugate therapy in the proximal interphalangeal joints of the fingers. In B application of conjugate therapy in the distal interphalangeal joints of the fingers. In C application of conjugate therapy in the interphalangeal joint of the first finger.

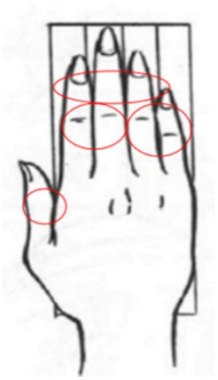

Figure 5: Points of application of therapy in the proximal and distal interphalangeal joints of the hand.

Statistic: Kolmogorov-Smirnov normality test was performed and subsequent Two-Way ANOVA analysis using Student Newman-Keuls "t" test for intragroup analysis for $p<0.05$. Instat 3.0 software for Windows was used.

Results

The present study produced several comparisons from the therapeutic resources Ultrasound, Laser, conjugated and conjugated with cuba, used to treat small joints of the fingers.

Figure 6 shows the pre- and post-treatment comparison for the therapeutic resources Ultrasound, Laser, conjugated and conjugated with a tub, using the pain index obtained with the McGill Pain Questionnaire. The lower the pain index, the greater the painful experience, in this sense, the Ultrasound showed a percentage of pain reduction of 5.09%, the Laser a percentage of 36.8% and the combined treatment showed a percentage of 36.2 % and the conjugate with cuba 49.7%.

Figure 7 illustrates the pre- and post-treatment comparison for the therapeutic resources Ultrasound, Laser, conjugated and conjugated with tub, using the values of pressure pain threshold in the proximal interphalangeal joints of the fingers of the right hand obtained with algometry. In algometry, the higher the pain threshold, the lower the painful experience, thus, in the Ultrasound, a statistically significant difference was observed $p<0.004$ while the Laser showed a statistically significant difference $p<0.0001$. In relation to the conjugated treatment, this presented a statistically significant difference $p<0.0001$ and the conjugated treatment with cuba a statistically significant difference $p<0.0001$. The comparison made between the groups Laser, conjugated and conjugated with vat show statistical similarity.

Figure 8 shows the pre- and post-treatment comparison for the therapeutic resources Ultrasound, Laser, conjugated and conjugated with tub, using the values of pressure pain threshold in the distal interphalangeal joints of the fingers of the right hand obtained with algometry. In algometry, the higher the pain threshold, the lower the

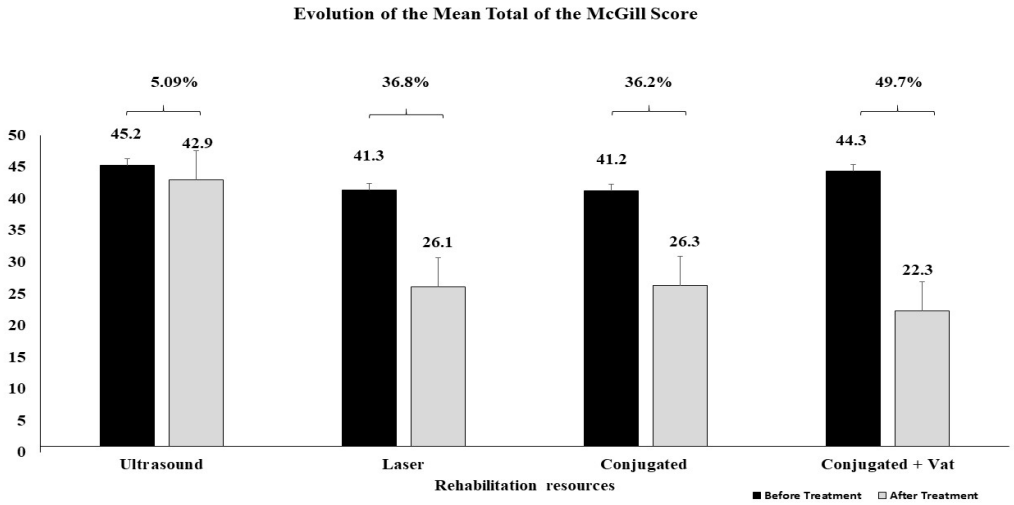

Figure 6: Evolution of the McGill Pain Questionnaire score, pre and post treatment in the treatment groups Ultrasound, Laser, conjugated and conjugated with tub.

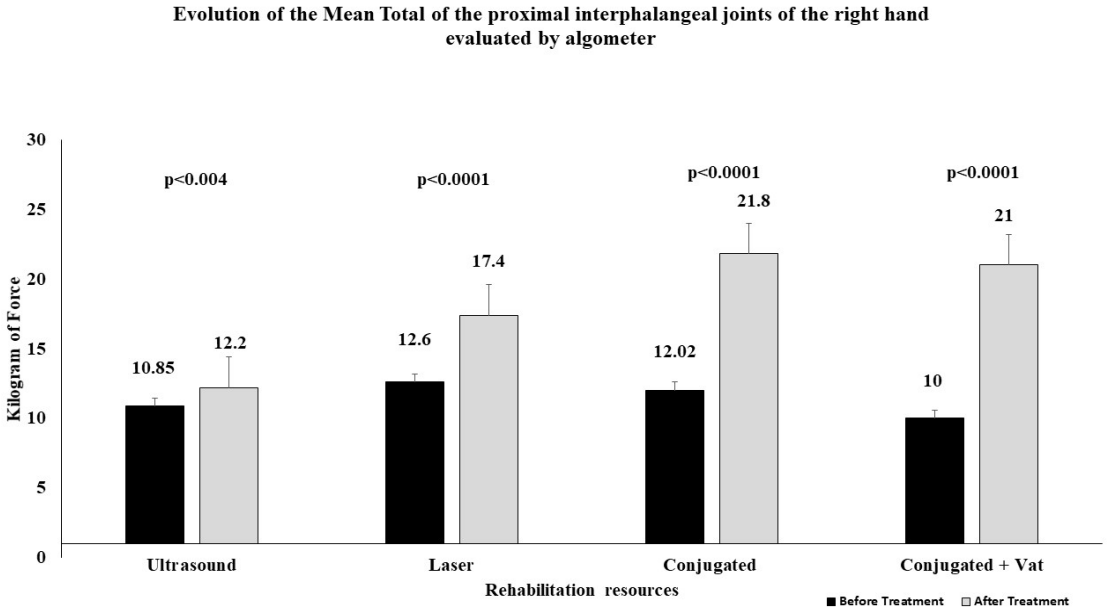

Figure 7: Evolution of pressure pain threshold in the proximal interphalangeal joints of the right hand, pre and post treatment in the Ultrasound, Laser, conjugated and conjugated tub groups.

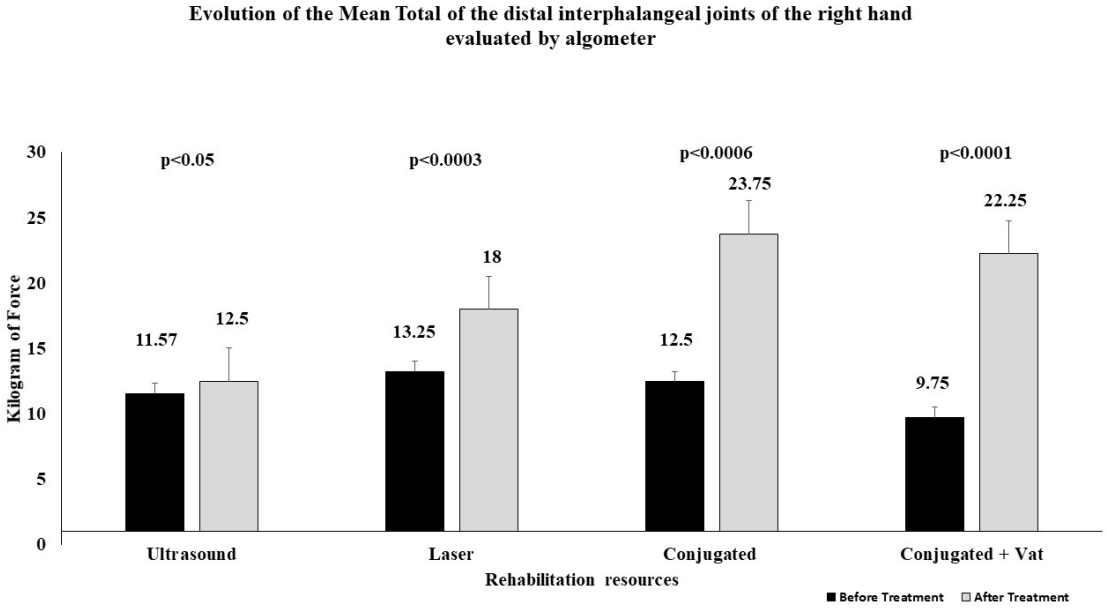

Figure 8: Evolution of pressure pain threshold in the distal interphalangeal joints of the right hand, pre and post treatment in the Ultrasound, Laser, conjugated and conjugated tub groups.

painful experience, thus, in the Ultrasound, a statistically significant difference was observed $p<0.05$ while the Laser showed a statistically significant difference $p<0.0003$. In relation to the conjugated treatment, this presented a statistically significant difference $p<0.0006$ and the conjugated treatment with cuba a statistically significant difference $p<0.0001$. In this way, the conjugated group versus the conjugated group with tub showed better results in relation to the others.

Figure 9 shows the pre- and post-treatment comparison for the therapeutic resources Ultrasound, Laser, conjugated and conjugated with tub, using the values of pressure pain threshold in the proximal interphalangeal joints of the fingers of the left hand obtained with algometry. In algometry, the higher the pain threshold, the lower the painful experience, thus, in the Ultrasound a statistically significant difference was observed $p<0.003$ while the Laser showed a statistically significant difference $p<0.0001$. In relation to the conjugated treatment, this presented a statistically significant difference $p<0.0003$ and the conjugated treatment with cuba a statistically significant difference $p<0.0001$. Statistical relevance shows the group combined with vat better than the others.

Figure 10 illustrates the pre- and post-treatment comparison for the therapeutic resources Ultrasound, Laser, conjugated and conjugated with tub, using the values of pressure pain threshold in

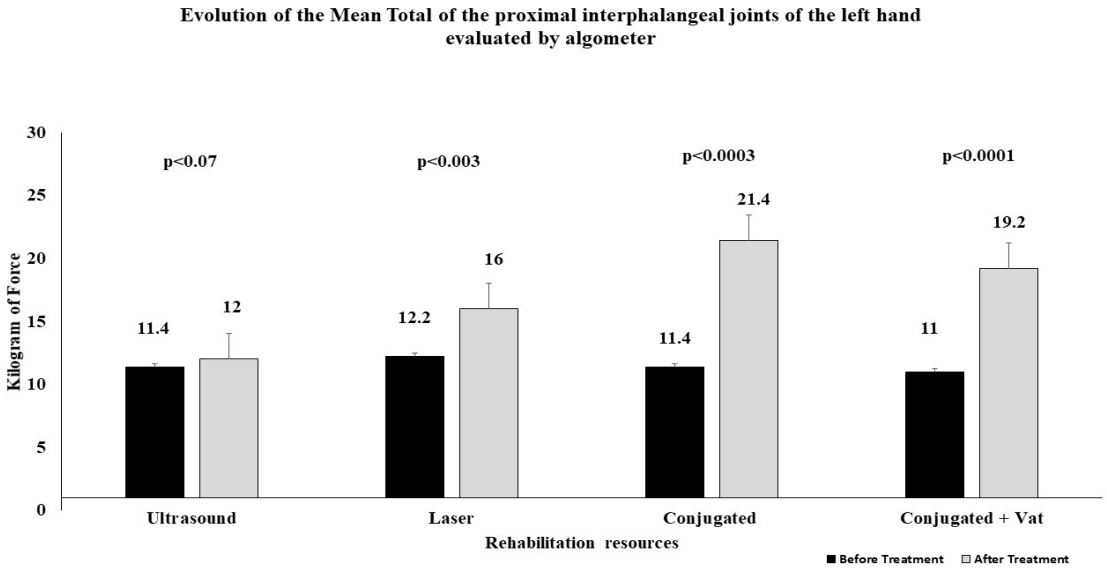

Figure 9: Evolution of pressure pain threshold in the proximal interphalangeal joints of the left hand, pre and post treatment in the Ultrasound, Laser, conjugated and conjugated tub groups.

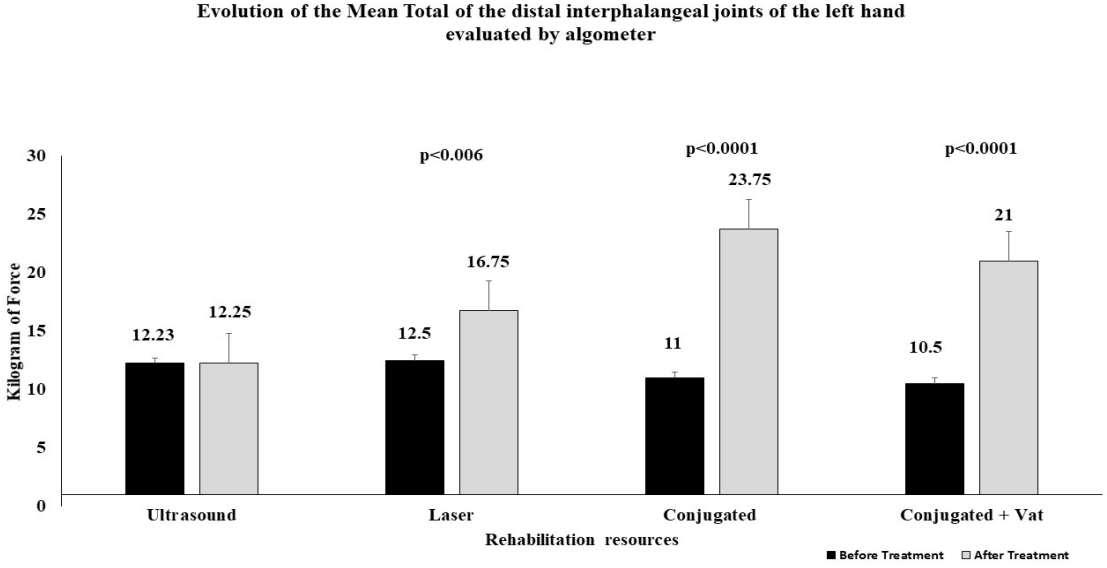

Figure 10: Evolution of pressure pain threshold in the distal interphalangeal joints of the left hand, pre and post treatment in the Ultrasound, Laser, combined and combined with tub groups.

the distal interphalangeal joints of the fingers of the left hand obtained with algometry. In algometry, the higher the pain threshold, the lower the painful experience, thus, in the Ultrasound there was no statistical difference while the Laser showed a statistically significant difference $p<0.006$. In relation to the conjugated treatment, this presented a statistically significant difference $p<0.0001$ and the conjugated treatment with cuba a statistically significant difference $p<0.0001$. In this case, the differences found in the conjugated group versus conjugated with cuba are shown to be similar.

Discussion

Rheumatoid Arthritis is an autoimmune, inflammatory, chronic and systemic disease that initially affects the joints of the hands, producing pain and limitation of movement. Such impairments affect the performance in carrying out daily, professional and recreational activities, reducing the quality of life of patients with this disease.

Although research generally focuses on large joints, the hands receive relatively little attention, resulting in a scarcity of more accurate methods of treatment that address the anatomical particularities of this region. In this context, the use of resources such as Laser and Ultrasound combined, proved to be efficient in the treatment of chronic degenerative diseases [9,10].

In the present research, we analyzed different resources of Laser, Ultrasound and conjugated treatment (Laser and Ultrasound) with and without the tub, regarding the anti-algic effect of these therapies on the small joints of the hands in Rheumatoid Arthritis. In view of the analysis of the before and after treatment results obtained through

the pain index and the pressure pain threshold, we observed that the combined therapy showed better results for pain reduction, when compared to the Ultrasound and Laser therapies applied in isolation for the treatment of the small joints of the hands. However, when comparing ultrasound and laser applied in isolation, the laser proved to be superior to ultrasound for analgesia of the small joints of the hands.

The anti-algesic effect of the Laser superior to the Ultrasound in this present study is probably due to the fact that the laser beam occupies the central region of the applicator source, allowing joint coverage, which favors the interaction of electromagnetic waves in the biological tissue. The analgesic action of Laser on biological tissue occurs through changes in neurotransmission [18], release of endogenous endorphins [19] and reduction of inflammatory mediators. As a result, the positive result of the Laser as an anti-algesic resource in the small joints of the hands obtained in this present study was also found in the studies by PALMGREN et al. (1989) [20] and EKIM & COLAK (2007) [21].

The fact that ultrasound has presented marginal results as an anti-algesic resource for the treatment of small joints of the hands, possibly due to the difficulty of coupling the transducer in these joints, due to the presence of bony prominences and anatomical reliefs, in addition to the transducer diameter being greater than the joint diameter, thus not allowing the full use of waves in the treatment. Cell activation by the mechanical waves of pulsed ultrasound induces anti-inflammatory and analgesic responses, modulating synovial inflammation [22]. However, for the ultrasonic waves to reach the target tissue beyond the contact medium, the therapy application technique is also important given the joint anatomical aspects of this region [23].

The results of the treatment with the combined therapy (Laser and Ultrasound) show that the group where the combined therapy was applied with the underwater technique using the tub, obtained superior results in terms of the anti-algesic effect, compared to the group that received the combined treatment. without the vat. From these results, we can infer that in the application of conjugated therapy without the tub, there is a partial use of the ultrasonic waves in the treatment of small joints, due to the possible losses due to the anatomical constitution and the transducer diameter being larger than the joint diameter.

However, even if the use of ultrasonic waves is partial when the treatment is not performed with the underwater technique, the superposition of the electromagnetic and mechanical fields allows the sum of the biological effects of each therapeutic resource, the laser acting through its photochemical effect and the Ultrasound through biochemical and mechanical effects on cells, resulting in inflammatory and pain control. The results obtained in this present research using conjugated therapy without the tub, corroborate the results of the study by PAOLILLO et al. (2015) [9] who also obtained pain reduction and improved hand functionality in women with osteoarthritis.

In the present research, using the tub to perform the underwater technique for the application of conjugated therapy in the small joints of the fingers, we observed that the anti-algesic effect was superior to that obtained with the conjugated treatment without a tub. We can also consider that as arthritis is an inflammatory pathology, which has the cardinal signs of edema, heat, redness, pain and loss of function, the effects were not only antalgic but also impacted on inflammatory modulation, leading to an improvement in the general clinical picture of this disease. This result suggests that the application of ultrasound with the underwater technique in the small joints of the hands, solves the problem of coupling because the water is a good conductor of the ultrasonic waves, its fluidity allows full coverage of the joint and, associated with that, the reflection of the waves in the The metallic surface of the tub makes the ultrasonic waves that did not reach the joint return to it, allowing its better use in the treatment.

In this context, the greater use of ultrasonic waves in the joint tissue translates into an amplification of the therapeutic effect in the treatment using the therapy combined with the tub, since the water does not interfere with the propagation of the Laser. Corroborating with the present study, positive results in analgesia were also found using therapeutic ultrasound with the underwater technique, in the short-term treatment of Rheumatoid Arthritis [24].

The innovation in the proposed treatment provided to maximize the antialgic therapeutic effects in the small joints of the hands, improving the quality of life of patients with rheumatoid arthritis.

Conclusion

Therefore, this new form of treatment of the small joints of the hands, where the potentiation of the combined and synergistic treatment of Laser and Ultrasound, allows to further improve the therapeutic potential of the treatment. Thus, adjuvant or not to pharmacological treatment, it allows the reduction of pain and early return to daily and work activities, improving the quality of life of the population affected by Rheumatoid Arthritis.

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Conflict of interest:

The authors declare no conflict of interest.

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