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Original Article

Pulsed ND:YAG laser combined with progressive pressure release in the treatment of cervical myofascial pain syndrome: a randomized control trial

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Abstract. [Purpose] To investigate the effect of pulsed Nd:YAG laser combined with the progressive pressure release technique (PPRT) and exercises in the treatment of myofascial trigger points (MTrPs) in patients with myofascial pain syndrome (MPS). [Participants and Methods] A total of 50 patients with MTrPs in the upper trapezius muscle participated in the study. The patients were randomly assigned to two groups and treated with laser plus PPRT (Laser + PPRT group) or placebo laser and exercises (PL + PPRT group). The laser was applied for eight MTrPs with a 50 J/point. PPRT was applied for 30 seconds for each point. Exercises included strengthening and stretching exercises applied three times per week for four weeks. A visual analogue scale (VAS) and pressure pain threshold (PPT) were used to measure pain and pain threshold, respectively. A cervical range of motion device (CROM) was used to measure the cervical range of motion. [Results] Both treatment groups showed significant improvement in CROM, PPT, and VAS post-treatment with a more significant effect in the Laser + PPRT group compared to the PL + PPRT group. [Conclusion] PPRT and exercises alone or that in combination with laser therapy were effective in the treatment of active MTrPs in patients with MPS.

Key words: Myofascial pain syndrome, Progressive pressure release, Pulsed Nd:YAG laser

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INTRODUCTION

Myofascial pain syndrome (MPS) is a common clinical syndrome characterized by hypersensitive areas of pain in the muscle and fascia caused by myofascial trigger points (MTrPs)[1)]. MTrPs are recognized as focal, discrete, stiff, and hyperirritable spots of tender points, represented as small swelling nodules during palpation of the affected muscle. On compression, it can inflict pain, tenderness, and motor dysfunction[2)], which is believed to be the result of hyper-contracture of the sarcomere in this area[3)]. MPS treatment is accomplished by inactivating the MTrPs and restoring normal body biomechanics to the greatest possible extent[4)]. Manual techniques are currently used to treat MTrPs, including an acupressure type massage as well as using physical therapy modalities such as ultrasound[5)] and laser[6, 7)].

The recent use of pulsed neodymium-doped yttrium aluminum garnet (Nd:YAG) laser therapy for musculoskeletal disorders proved its efficacy in reducing inflammation[8, 9)] and pain[6, 7, 10)]. The Nd:YAG laser provides high power (3,000 W) at a 1,064 nm wavelength that penetrates deeper than low-level lasers, and it is postulated that it has a photothermal, photochemical, and photomechanical effects[11–13)].

The progressive pressure release technique (PPRT) is believed to normalize the length of the sarcomere to MTrPs, soften-

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ing the felt knot and inactivating the MTrPs that cause taut bands and pain, causing ischemia followed by reactive hyperemia in the MTrPs[14]. Application of the Nd:YAG laser to this taut band may relieve pain and increase the efficiency of the PPRT. Therefore, the present study aimed to investigate the effect of Nd:YAG laser combined with the progressive pressure release technique (PPRT) and exercises in the treatment of MTrPs in the upper trapezius muscle in MPS.

PARTICIPANTS AND METHODS

The University's Ethics Research Committee approved a randomized controlled trial with a local registry number (27-MED-1437). The study was performed according to the 1964 Declaration of Helsinki and subsequent amendments or comparable ethical standards. To calculate the sample size, the program G-power 3.1 for Windows was used to perform the power analysis. The program used a power of 0.80, an effect size d=0.85, α error probability=0.05, and Allocation ratio=1 with independent t-tests to determine the variance between two groups in the pain level measured by the visual analogue scale (VAS). The effect size was based on the results of prior studies[6, 7]. The estimated sample size was 23 patients for each group. To account for possible withdrawal of patients from the study, the overall number of recruited patients was set to 50.

A careful examination was performed for all subjects with active MTrPs in the upper trapezius muscle according to the criteria reported by Travell et al[2]. The inclusion criteria were; active MTrPs with pain distributed in the ipsilateral, posterolateral cervical, paraspinal area, mastoid process, or temporal area with perceptible or apparent local twitch responses on snapping palpation at the most sensitive spot in the taut band. Patients with symptoms of fibromyalgia, having myofascial trigger injection or receiving physical therapy modalities within one year before this study were excluded. Patients exposed to acute trauma or having a history of inflammatory joint or muscle disease, infection or malignancy, diagnosis of cervical radiculopathy, or any evidence of neurological deficit were also excluded from the study.

A total of 50 participants were randomly assigned to two equal groups of 25 in each group. Randomization was performed using serial identification numbers by the online GraphPad software. Group I was treated with laser and PPRT for the upper trapezius muscle (Laser + PPRT group), while Group II was treated with PPRT and placebo laser (PL + PPRT group) and served as the control group. Both treatment groups received exercises with instructions to repeat these exercises at home. All the participants and therapists were blinded to the patient's allocation or treatment schedule. All patients signed a written informed consent form, including their acceptance to participate in the study and publish their results.

The pulsed Nd:YAG laser used in the treatment was a HIRO 3 device (ASA, Arcugnano, Vicenza, Italy). HIRO-3 device provides 3,000 W peak power, 10.5 W average power, at a 1,064 nm wavelength, 100 µs pulse duration, 15 Hz frequency, 0.1% duty cycle, and spot size 0.2 cm^2. Patients in Laser + PPRT received pulsed Nd:YAG laser three times per week for four weeks. The laser probe was applied perpendicularly to the predetermined trigger points in four phases. For each point, in the first, second, third and fourth phases, the patients received an energy density of 510,610,710,810 mJ/cm^2 in a time of 7,7,6, and 6 seconds to deliver 10,12.5,12.5 and 15 J, respectively. The treatment was applied for at least 8 trigger points[15]. Between each phase, the therapist palpated the trigger point and feedback was taken from every patient for possible local temperature increases. The total amount of energy received for each point was 50 J/point in the four phases. The laser was calibrated by the manufacturer to maintain the average power constant throughout the study. A placebo laser was applied to patients in the PL + PPRT group at the same sequence and time interval, except that there was no active laser radiation.

All patients received PL + PPRT and exercises. Pressure was applied by the thumbs, knuckles, or four fingers of one or both hands. Steady pressure was applied moving inward towards the center of the hand. On feeling tissue resistance, the pressure was seized until the resistance dissipated. When the therapist felt a slow-release or a "melting away" sensation of the tissue under treating fingers, a further steady inward pressure towards the center was applied. This cycle was repeated several times. The muscle was placed in stretched and relaxed positions and constant feedback was provided by the patient. The pressure was applied for at least 30 seconds, and the total duration for each point was two minutes. PPRT was applied after laser treatment three times per week for four weeks of treatment.

Patients in both treatment groups received stretching and strengthening exercises for the upper fibers of the trapezius muscle[15]. Patients performed 10 sets of stretching for the upper fibers of the trapezius muscles for 30 seconds with a five-second rest in between[16]. The patient was asked to conduct self-stretching at home with the same number of sets. Isometric neck exercises were performed in the first session. The isometric exercises performed were extension, flexion, and side bending. The same therapist performed a program of exercise therapy for all patients three times per week for four weeks with advice to all patients to repeat the exercises at home.

The VAS was used to measure pain levels. The VAS is a 10-cm line divided into 10 equal sections, with 10 expressing "unbearable pain" and 0 indicating "no pain"[17]. Each patient was asked to point on this line to their level of neck pain. The pressure pain threshold (PPT) was evaluated using a pressure algometer (Force one gauge-model FDI, Wagner Instruments, Greenwich, CT, USA). The probe was placed on the MTrPs to measure local tenderness. Using their finger, the patient pointed out the area of the most tender spot. The algometer tip was applied over the tender spot at a right angle to the examined muscle. The pressure was constantly increased at a rate of 1 kg/s, and the displayed number was obtained. After pressure release, the algometer tip was removed and the PPT was recorded.

Cervical flexion, extension, bending, and rotation were measured using a cervical range of motion device (CROM). The CROM is a plastic device with three well-positioned inclinometers strapped on the patient's forehead by a Velcro strap just above the nose bridge. Each patient was instructed to move the head within the pain-free range. The angular displacement in the lateral inclinometer reflects the flexion and extension range. The in-front inclinometer measured the lateral bending to the right and/or left. The CROM can measure rotation to both sides of the neck in the horizontal plane by the above-head inclinometer[18] with the magnet strapped around the patient's shoulder[19]. The CROM device is considered a valid and reliable measuring tool for cervical range of motion[18, 19]. The VAS, PPT, and CROM were evaluated before and after 4 weeks of treatment.

The analysis was performed using Statistical Package for the Social Sciences (SPSS) for Windows, version 16 (SPSS Inc., Chicago, IL, USA). A paired t-test analyzed patient demographic data, VAS, PPT, and CROM. An independent t-test performed Pre-Post treatment comparison in each treatment group. For multiple comparisons, Bonferroni correction was performed for the p-value for each t-test. The corrected p-value is shown in Tables 2, 3. Values of $p<0.05$ were deemed significant.

RESULTS

A total of 50 patients volunteered to participate in this study. Their mean age, weight, height, and duration of illness were: 28.08 (4.8) years, 72.28 (8.7) kg, 170.55 (3.9) cm, 24.69 (3.2) kg/m^2, and 4.38 (1.04) months, respectively. To test the homogeneity of variance, the Kolmogoro-Smirnov normality test was performed, which revealed non-significant differences in baseline mean values ($p>0.01$). There were no significant differences in the patients' mean age, weight, height, BMI, and duration of illness between both treatment groups (Table 1). The baseline values of CROM, VAS, and PPT showed non-significant differences between the two treatment groups. Both treatment groups showed significant improvement in CROM and PPT, with a significant reduction in VAS score post-treatment as compared to baseline values, with a more significant effect in the Laser + PPRT group as compared to the PL + PPRT group (Tables 2, 3).

Table 1. Patients demographic data

	LASER + PPRT group	PL + PPRT group
Age (years)	28.47 ± 5.07	27.70 ± 4.56
Weight (kg)	70.17 ± 10.73	74.40 ± 5.39
Height (cm)	170.20 ± 3.91	170.90 ± 4.10
BMI (kg/cm^2)	24.27 ± 4.00	25.13 ± 2.21
Duration of illness (months)	4.43 ± 1.14	4.33 ± 0.96
Female to male ratio	18/12	16/14

PPR: Progressive pressure release technique; BMI: body mass index.
Independent t-test; $p<0.05$.

Table 2. Changes in CROM in both treatment groups

		Laser + PPRT group	PL + PPRT group
Flexion	Pre-treatment	47.83 ± 2.94	46.53 ± 3.8
	Post treatment	59.46 ± 3.17*	52.56 ± 2.19*†
Extension	Pre-treatment	46.73 ± 3.54	48.1 ± 3.25
	Post treatment	61.0 ± 4.1*	52.46 ± 1.79*†
Rt bending	Pre-treatment	30.6 ± 2.35	31.56 ± 2.45
	Post treatment	41.5 ± 1.59*	38.20 ± 2.78*†
Lt bending	Pre-treatment	31.96 ± 2.17	32.96 ± 2.26
	Post treatment	42.76 ± 2.92*	37.63 ± 3.09*†
Rt rotation	Pre-treatment	48.93 ± 3.08	48.56 ± 2.95
	Post treatment	64.36 ± 2.17*	55.10 ± 2.75*†
Lt rotation	Pre-treatment	49.66 ± 2.97	48.03 ± 3.59
	Post treatment	64.03 ± 1.99*	55.26 ± 4.40*†

PPRT: Progressive pressure release technique; PL: placebo laser; Rt: right; Lt: left.
*Significant paired t-test ($p<0.05$), †Significant independent t-test; ($p<0.05$).

Table 3. Changes in VAS and PPT in both treatment groups

		Laser + PPRT group	PL + PPRT group
VAS	Pre-treatment	8.03 ± 0.72	7.90 ± 0.71
	Post treatment	1.43 ± 0.773*	3.60 ± 0.674*†
PPT (kg/cm^2)	Pre-treatment	1.61 ± 0.37	1.67 ± 0.35
	Post treatment	2.85 ± 0.49*	1.9 ± 0.32*†

Data was expressed as means ± standard deviation. PPRT: Progressive pressure release technique; PL: placebo laser. *Significant paired t-test ($p<0.05$), †Significant independent t-test; ($p<0.05$).

DISCUSSION

The present study showed that pulsed Nd:YAG laser combined with PPRT significantly decreased the VAS score and significantly increased the CROM and PPT in MTrPs of the upper trapezius muscle. This combination proved to be more effective in the treatment of MTrPs in patients with MPS than in PPRT plus exercises.

Pulsed Nd:YAG laser was effective in decreasing musculoskeletal pain[8, 9, 20, 21] and spinal pain[6, 7, 10, 22]. Nd:YAG lasers has 1,064 nm wavelength, which lies in the infrared band of the electromagnetic spectrum and works in a therapeutic window in which there is no adequate concentration of the absorbing material in the superficial layers and is therefore considered a deep penetrating modality[11–13]. In addition to wavelength, the high power used allows high energy density (50 J/ point) to be delivered to tissues in a brief time (26 s).

The laser reduces pain by direct neural stimulation[23], which alters pain signal transmission by inhibiting Aδ- and C-fibers and the release of endorphins and enkephalins, which are endogenous pain-relieving chemicals[24, 25]. The infrared laser can reduce pain indirectly by modulating the inflammatory process by reducing the concentration of pro-inflammatory cytokines[26] and increasing the levels of anti-inflammatory cytokines[27]. The infrared laser stimulates nociceptors and leads to an increased pain threshold[28]. MTrPs are characterized by muscle fiber shortening, which results in impaired local circulation, leading to poor oxygen and nutrient supply[29]. The near-infrared laser changes cell metabolism by increasing blood flow and vascular permeability and subsequently decreasing muscular tension[30]. Moreover, the laser stimulates cytochrome c-oxidase and nitric oxide release in the mitochondria and increases the production of adenosine triphosphate (ATP), RNA, and DNA[31]. Using a high peak power of 3,000 W with high energy density delivered to human tissues it may lead to a photothermal effect[32, 33]. Short duty cycles with a brief pulse duration do not permit any thermal accumulation inside tissues, which in turn reflects the safety and comfort of using pulsed Nd:YAG laser to tissues, although there is a need to measure this effect in tissues[34].

PPRT has been reported to be the most effective method for increasing the pain threshold, compared to other modalities such as transcutaneous electrical nerve stimulation and stretching[35]. The mechanism of pain reduction and softening of the taut band by manual therapy remains hypothetical[4]. PPRT restored the uniform sarcomere length in the affected muscle fibers. Lengthening sarcomeres can reduce muscle tension and consequently reduce energy depletion, which releases noxious substances. The release of contraction knots is necessary to cut off the pain cycle that generates the ischemic contractions[36]. Pain reduction following PPRT may be caused by local area hyperemia due to a counter-irritant effect. In addition, it may be due to a spinal reflex mechanism that may induce reflex relaxation of the involved muscle[14]. A previous study investigated the effect of manual pressure on the relief of upper trapezius MTrPs. The authors found that 60 seconds of pressure release induced an immediate significant decline in the MTrPs sensitivity and an increase in CROM[36].

Studies have recently compared the effect of a once-weekly comprehensive treatment including manual pressure, manual stretching, and intermittent cold application to MTrPs. A statistically as well as clinically significant difference was observed with a decrease in the active MTrPs of shoulder muscles in the intervention group compared to the control group. This result reinforces the presupposed biomedical mechanisms underlying MTrPs therapy[37]. More recently, Ganesh et al.[38] showed a significant increase in CROM and decrease in pressure pain sensitivity after cervical mobilization and ischemic compression therapy in patients with latent trigger points[38].

The present study showed improvement in CROM as well as PPT, with a reduction of VAS score post-treatment as compared to pretreatment mean values. Despite the exercise type, exercise therapy plays a substantial role in improving the psychological status of the patient by moving responsibility for welfare to the patient[39].

Many clinical trials have reported the beneficial effects of several types of exercises in the treatment of neck pain[40, 41]. Stretching exercises to the cervical and shoulder muscles were effective in relieving neck pain among office workers with neck pain. Stretching exercises relieved pain and improved neck function as well as quality of life[42]. Stretching exercises plus acupuncture proved to reduce pain and improve range of motion in patients with cervical MPS[43]. Resisted exercises to the neck extensors are important procedures in the treatment of patients with cervical pain during the session or as a home routine[44, 45]. The same program of exercises was repeated at home, and a report of exercise compliance was obtained from them. Although no deficiency was reported, which the authors deemed as a limiting factor. In conclusion, PPRT and exercises alone or combined with laser therapy were effective in the treatment of active MTrPs in patients with MPS.

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Conflict of interest

None.

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