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Comparison of the Effect of 810 nm Diode Laser and Transcranial Direct Current Stimulation on Relieving Symptoms of Patients With Temporomandibular Joint Disorders

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Abstract

Introduction: The high prevalence of temporomandibular joint disorder (TMD) and the side effects of drug treatments, as well as invasive surgical methods, highlight the importance of less invasive and less complicated methods. This study aimed to compare the effectiveness of an 810 nm diode laser and transcranial direct current stimulation (TDCS) in the treatment of patients with TMD.

Methods: The design of the study was a randomized controlled trial in which 34 patients with TMD were included and randomly treated with 810 nm diode laser or TDCS. In the laser group, 9 sessions of laser therapy were performed during 3 weeks. In the TDCS group, treatment was accomplished in 5 sessions within 5 consecutive days after sample selection. Before the first and after the last treatment session in both groups, the outcomes including the TMJ spontaneous pain score, facial muscle tenderness, maximum range of pain-free opening of the mouth and presence of jaw sounds were evaluated. The patient's satisfaction score was evaluated immediately after treatment, as well as one month later. The data were entered into SPSS statistical software version 17 and statistically analyzed by independent and paired t-tests. A significance level of less than 5% was considered.

Results: The average TMJ spontaneous pain score and muscle tenderness score in temporal, TMJ, and gonial regions decreased significantly in both groups ($P<0.001$), also the mean maximum mouth opening increased significantly in both groups ($P<0.05$), but there was no significant difference between the two groups. The average score of patient satisfaction with the treatment immediately and one month after the treatment in the laser group was significantly higher than that of TDCS.

Conclusion: 810 nm diode laser and TDCS were effective in reducing the symptoms of TMD patients. The level of satisfaction with the treatment in the laser group was significantly higher than that in the TDCS method.

Keywords: Low-level laser; Diode laser; Temporomandibular joint disorders; TMD; TDCS.

Introduction

The term temporomandibular joint disorder (TMD) includes a number of clinical problems that involve the masticatory muscle system, the temporomandibular joint (TMJ), or both.[1] It is the second most common cause of orofacial pain in adults.[2] TMD occurs more often in women between the ages of 20-40. The lower prevalence of TMD symptoms in the elderly probably indicates that most cases are self-limiting.[3]

Although most of the causes of TMD are unknown, some of the factors proposed in the etiology of the disease are: (1) Parafunctional habits, (2) Abnormal function or excessive contraction of masticatory muscles, (3) Intra-articular disorders (displacement of the disc with or without reduction), and (4) Degenerative joint diseases (such as erosion and flattened condyle).[4]

Clinical manifestations of TMD include facial pain in the areas related to the TMJ or masticatory muscles, tenderness of the TMJ or masticatory muscles, limitation or deviation in the range of movements of the lower jaw, TMJ sounds during joint activity, difficulty and discomfort in chewing, ear pain, and tinnitus.[1,4] Common imaging such as panoramic radiography still cannot accurately diagnose TMD due to superimposition and

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two-dimensionality. CT scan and MRI are not indicated for all patients. The best way to evaluate patients is to take history and physical examination.[5]

TMD treatment options are divided into reversible or primary and irreversible or surgical treatments.[6] Reversible treatment solutions include the recommendation of using a soft diet and reducing jaw movements, pharmacotherapy, physiotherapy, intraoral devices (such as splints, night guards, etc), behavioral treatments, and relaxation techniques. These approaches are mostly effective, but in the long term, they may lead to the return of symptoms and may not have long-term effects.[7] On the other hand, the surgical method is considered quite invasive, so providing a method with less complication, as well as less invasiveness and longer efficacy, is the request of many researchers who work in this field.[8]

The use of lasers for TMJ pain is a method with negligible side effects and less invasiveness compared to the surgical approach.[9] The diode laser (GaAlAs) uses a combination of aluminum, gallium and arsenide to convert electrical energy into light energy and is considered a type of low-level laser. The reason for the acceptance of diode laser devices is their small size, relatively low price, and easy use.[10]

Transcranial direct current stimulation (TDCS) and "neurofeedback" are non-invasive brain stimulation techniques that are capable of modulating neural flexibility in humans and are used in neuro-psychiatric disorders to reduce symptoms and increase rehabilitation. TDCS is a non-invasive, painless, and inexpensive method that directly injects a mild electric current (maximum 7 mA) into the brain.[11]

Few studies compared these two approaches for the treatment of TMD patients.[12,13] Considering the beneficial effects of low-level laser and TDCS on reducing pain and inflammation and biostimulating properties, at the same time, there are contradictions regarding the effectiveness of low-level laser and TDCS as a TMD management approach in different studies.[14,15] This study aimed to compare the effectiveness of an 810 nm diode laser and TDCS in the treatment of patients with TMD.

Methods

This randomized clinical trial with a before-after design has been registered in the Iranian Registry of Clinical Trials with the code IRCT20210321050751N3. Also, this study has been approved by the "Research Ethics Committee of Shahid Sadougi University of Medical Sciences, Yazd" under the number IR.SSU.REC.1401.014.

The sample size was calculated using Cochran's formula based on Oliveira's study,[14] and 34 patients (17 in each group) were considered. The studied samples included patients with TMD symptoms who were selected by the convenience sampling method and based on the study inclusion criteria. The patients were randomly assigned to either the "laser" group or the "TDCS" group.

The study inclusion criteria consisted of patients aged 18-40 years who had at least one of the following symptoms: pain in the TMJ for at least 2 months (score 4 or higher on the VAS scale), tenderness of masticatory muscles, and lower jaw restriction in opening. It also included completion of informed consent, no history of jaw trauma, no history of joint diseases or rheumatoid arthritis, and no current TMD treatment.

The exclusion criteria included the occurrence of any disease or trauma that affects TMD symptoms after the start of the study, the use of drugs such as cartilage regeneration medicine and NSAIDs, non-cooperation until the end of the treatment sessions, and contraindications for lasers or TDCS. The distribution of patients in two groups ("laser" and "TDCS") was based on a random number table.

Laser Group

The mechanism of low-power lasers includes the induction of analgesia, stimulation of tissue healing and remodeling, modulation of pro-inflammatory chemical mediators, induction of muscle relaxation, and dissolution of trigger points. Additionally, it may increase muscle metabolic activity and decrease fatigue. Thus, it can improve the motor activity of the stomatognathic system, reduce pain, and enhance joint health in chronic disorders.[16]

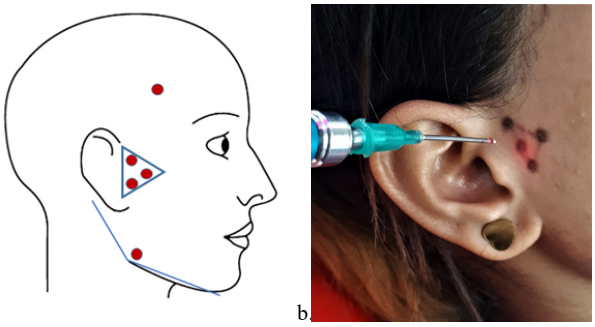
A diode laser device with a wavelength of 810 nm (Cheese, Wuhan Gigga Optronics Technology CO, LTD, China) was used in this study. The patients included in the study underwent laser therapy three times a week, every other day, for three weeks (9 sessions in total). The laser with an output power of 100 Mw was irradiated in continuous mode with a probe diameter (spot size) of 300 μ (Figure 1).

The points where the laser was irradiated included three points in the TM joint area, one point in the temporalis muscle area, and one point in the gonial angle (a total of 5 points) (Figure 2). In the area of the TM joint, exactly in front of the tragus of the ear, three points with a distance of about 4 mm were determined in the form of a triangle. In the temporal region, the patients were asked to swallow until the temporalis muscle was defined as a point above the eyebrow[16], and the last point was about 1 cm above the gonial angle, which was determined by touch. The probe of the device was placed at a 90 degree angle with a distance of about 4-5 mm from the skin, and the laser was irradiated at each point for 30 seconds (Figure 2).

TDCS Group

The mechanism of TDCS includes the modification of the cortical activity pattern and the restoration of the normal activation of the pain processing centers.[13] Two electrodes, one positive pole and one negative pole, were placed on the head through a sponge pad moistened with

Figure 1. Diode Laser Device



a. b.

Figure 2. Points of Laser Diode Radiation. a. Schematic view, b. View of the patient's face

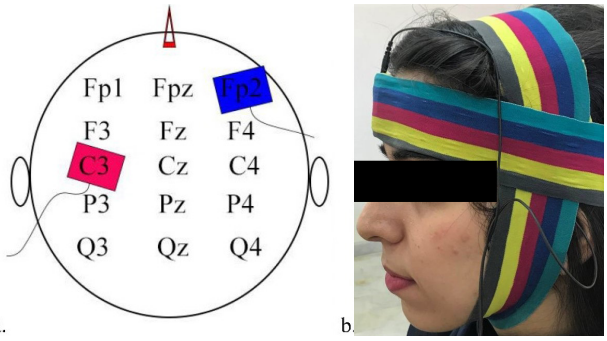
a conductive solution such as washing serum (normal saline). Passing a weak current of 2 milliamps to the brain between two electrodes, where the current enters the brain from the anode, passes through the tissue and exits from the cathode, causes changes in the brain (Figure 3).

In this group, TDCS treatment was applied in five sessions within five consecutive days[14,17] after sample selection. The TDCS device consists of two electrodes, anode and cathode, which are connected to an energy source that produces a direct current (DC). In this research, the anode was placed in C3 or C4 (parietal bone region) and the cathode was placed in Fp1 or Fp2 (frontal region) above the eyebrow (Figure 4). The duration of the stimulation was 20 minutes, and then the device turned off automatically.

Evaluation of Outcomes

Before the first and after the last treatment session in both groups, the outcomes including the TMJ spontaneous pain score, facial muscle tenderness (by the VAS scale (Visual Analogue Scale)), maximum range of pain-free opening of the mouth (by gauge in mm) and presence of jaw sounds were evaluated. The patient's satisfaction

Figure 3. TDCS Device With Two Electrodes, Sponge Pad, Holding Strips and Normal Saline



a. b.

Figure 4. Location of Placement of Electrodes on the Head; a. Schematic view, b. View of the patient

score in both groups was evaluated after the completion of the treatment sessions, as well as one month later. Six questions were included in a satisfaction survey that focused on reducing jaw pain and sound, enhancing the function of chewing, opening the mouth, and sleeping. Data collection was performed by a blinded examiner (not aware of the grouping and treatments received).

The data were entered into SPSS statistical software version 17 and statistically analyzed by independent and paired *t* tests. A significance level of less than 5% was considered.

Results

In this study, out of 34 patients (17 patients in each group), 6 (17.6%) were male and 28 (82.4%) were female. The age range of the patients was 18 to 40 years with a mean age of 24.71 ± 6.00 years.

Spontaneous pain in the TM joint or masticatory muscles was observed in 26 patients (76.5%; 12 for TDCS and 14 for laser) before the intervention and in 9 patients (26.5%; 4 for TDCS and 5 for laser) after the intervention. Also, joint sounds were reported in 16 patients (47.1%) before the treatment (8 in each group) and 8 patients (23.5%) after the treatment (6 in the TDCS group and 2 in the laser group).

Before the treatment, the maximum mouth opening range was from 22 to 38 mm with an average of 34.09 ± 3.59 mm. After the treatment, its range was from 30 to 47 mm

with an average of 38.68 ± 3.40 mm. In general, there was a positive and significant correlation between the data before and after the treatment ($P < 0.05$). The satisfaction score of the treatment according to the 6-question survey had a minimum score of 6 and a maximum score of 30. The mean satisfaction score was 25.05 ± 2.72 immediately after the treatment and 23.35 ± 3.41 one month after the treatment.

The mean spontaneous pain score (VAS) in the TDCS and laser groups decreased by 1.94 and 2.33, respectively, and 2.08 in all patients during the treatment, which was significant in both groups ($P < 0.001$). Although the reduction of the mean score of spontaneous pain (VAS) was higher in the laser group, the difference between the two groups was not significant ($P = 0.591$) (Figure 5).

The average total tenderness score (VAS) of the temporal, TMJ, and gonial regions in the TDCS and laser groups decreased by 1.55 and 2.20, respectively, and in all patients by 1.87 after the treatment, which was significant in both groups ($P < 0.001$). Although the decrease in the average tenderness score was higher in the laser group, the difference between the two groups was not significant (P-0.320) (Figure 6).

The mean tenderness score (VAS) in the temporal region and in the TMJ area was significantly reduced in the TDCS and laser groups after the treatment. Furthermore, the average tenderness score (VAS) in the gonial region was reduced in the TDCS and laser groups after the treatment. This reduction was not significant in the TDCS group, but it was significant in the laser group (Table 1).

The mean maximum mouth opening, in the TDCS and laser groups, increased significantly by 4.35 mm (P value = 0.004) and 4.82 mm (P value = 0.006), respectively, following the intervention (Figure 7).

The average score of patient satisfaction immediately and one month after the treatment in the TDCS group was 23.00 and 20.71, respectively, and in the diode laser group, it was 27.12 and 26.00, respectively. It shows that the level of satisfaction with the 810 nm diode laser was significantly higher both immediately and one month after the treatment compared to the TDSC group (P value < 0.001). In both groups, the level of satisfaction was higher immediately after the treatment compared to one month later (Table 2).

Discussion

The high prevalence of TMD, especially among young people, and the side effects of drug treatments such as NSAIDs, as well as invasive surgical methods for joint reconstruction or disc release, highlight the importance of less invasive and less complicated methods such as the use of lasers or TDCS devices.

In past studies, there were contradictions regarding the effectiveness of treating TMD patients with a low-level laser (such as a diode) and TDCS device.[14,15] Therefore, this study was conducted to compare the effectiveness of diode laser and TDCS as a minimally invasive treatment

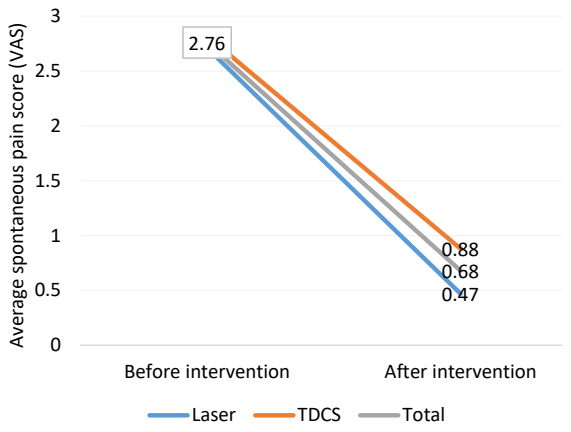


Figure 5. Average Spontaneous Pain Score (VAS) Before and After Treatment in Two Groups

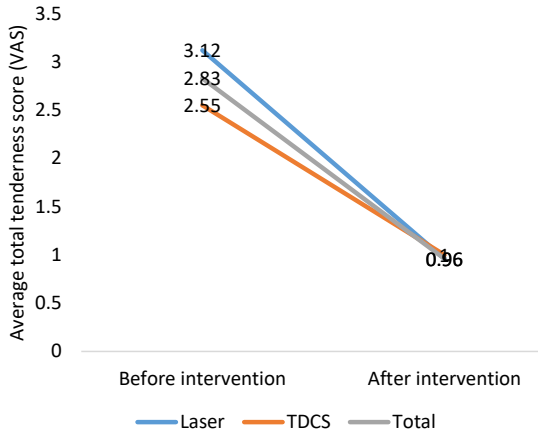


Figure 6. Average Total Tenderness Score (VAS) for the Temporal, TMJ, and Gonial Regions Before and After the Intervention in the Two Study Groups.

Table 1. Average Tenderness Score (VAS) in the Temporal, TMJ and Gonial Regions Separately Before and After the Treatment in the Two Investigated Groups

Area of Pain	Groups	Before Intervention		After Intervention		Difference		*P* Value[a]
		Mean	SD	Mean	SD	Mean	SD	
Temporal	TDCS	1.53	1.70	0.41	0.79	1.12	1.27	0.002
	Laser	1.71	1.86	0.23	0.56	1.48	1.42	<0.001
TMJ	TDCS	5.00	1.66	2.29	1.40	2.71	1.49	0.026
	Laser	4.88	2.29	1.82	1.42	3.06	1.30	<0.001
Gonial	TDCS	1.12	1.50	0.29	0.69	0.83	1.38	0.121

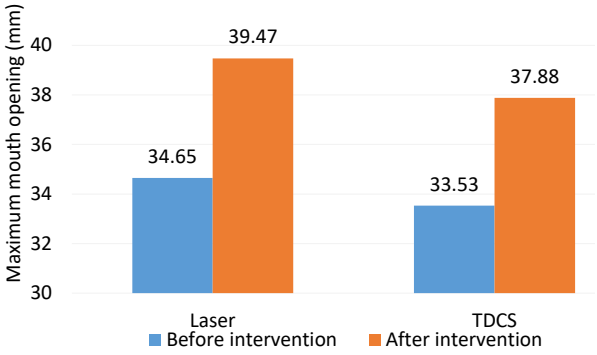


Figure 7. Average Maximum Mouth Opening Before and After Treatment in the Two Studied Groups

option in patients with TMD.

One of the challenging issues of this study was finding the right number of samples. However, we tried to increase the number of samples compared to similar studies that compared two treatment approaches in the management of TMD. Therefore, in the current study, 34 patients were examined, and this number was higher than those in the studies of Hassanien et al[18] (20 samples), Thiemi et al[19] (18 samples) and Kogawa et al [20](19 samples).

In terms of epidemiology, Greenberg et al. [21] suggest a higher prevalence of TMD in women aged 20-40 years. Pedroni et al.[22] also noted a fourfold higher prevalence of TMD in women. In the present study, 28 of the 34 patients under treatment (82.4%) were women, and the average age of the patients was 24.71 ± 6.00 years, which shows that most of the patients were young people, especially students.

In this study, standard management of TMD (including stretching exercises, a soft diet, cold and heat packs, correction of neck position, and elimination of parafunctional habits) was not performed for any of the groups.

Before the intervention, 16 (47.1%) of the patients had joint noise (click or crepitus) in addition to spontaneous pain or tenderness. At the same time, other patients (52.9%) did not have joint sounds. This suggests that pain and joint noise in the TMJ do not necessarily always occur together. After the treatment, 8 patients (23.5%) had joint noise. This shows that the intervention of the two groups improved the joint noise in half of the patients, most of whom were in the laser group. In the study of Nabeel Sayed et al. [23], treatment with a 904 nm laser improved joint sound, which is consistent with the present study.

The results of the present study showed that the average score of spontaneous pain evaluated with the VAS in the TDCS and laser groups was significantly reduced by 1.94 and 2.33 after the treatment. As a result, both treatments were significantly effective in reducing spontaneous pain. Although the laser was a more effective method in reducing the spontaneous pain score, the difference between the two groups was not significant. In the study

Table 2. The Average Score of Satisfaction Immediately and One Month After the Treatment in the Two Studied Groups

Group	No.	Immediately Post-intervention		One-Month Post-intervention	
		Mean	SD	Mean	SD
TDCS	17	23.00	2.03	20.71	2.47
Laser	17	27.12	1.50	26.00	1.73
P Value[a]		<0.001		<0.001	

[a] Independent *t* test.

of Kogawa et al.[20], low-level laser therapy (LLLT) with a wavelength of 830 to 904 nm and neurofeedback therapy through Micro electric Neuro stimulation)MENS) were compared on 19 patients with TMD. The results of their study showed that the average spontaneous pain score in the laser group decreased from 66.1 mm to 4.4 mm and in the MENS group from 44 mm to 6 mm, and in the laser group, this decrease was significantly higher. Therefore, it was consistent with the results of the present study.

In Oliveira et al.'s study [14], 32 patients with TMD were placed in two treatment groups: TDCS Sham and active TDCS along with physical therapy exercises for 4 weeks. TDCS stimulation was applied through sponge electrodes with an amplitude of 2 Ma for 20 minutes daily during the first 5 days of the study. The results of their study showed that the average pain intensity did not decrease significantly by adding TDCS to physical therapy exercises. These results were not consistent with the findings of the present study.

The average tenderness score was evaluated by the VAS scale in three areas including TMJ, temporal and gonial areas. The average tenderness score of the TMJ region was higher than the other two regions before and after the treatment, and the greatest decrease in tenderness was also related to the TMJ region. This finding shows that the cause of painful muscle touch in TMD patients is mostly related to the TMJ joint. The results of the present study showed that the average score of total tenderness (average of temporal, TMJ, gonial regions) in the TDCS and laser groups decreased by 1.55 and 2.20 respectively after the treatment, which was positive and significant in both groups. Although the laser was a more effective method in reducing the tenderness pain score, the difference between the two groups was not significant. As a result, both treatments were significantly effective in reducing tenderness in all three temporal, TMJ and gonial regions.

On the basis of their study, Thiemi et al. [19] reported that masseter and anterior temporalis muscle tenderness significantly decreased following therapeutic intervention in both Transcutaneous electrical nerve stimulation (TENS) and LLLT groups, which is consistent with the present study. In the study of Kogawa et al,[20] like the present study, both laser and MENS methods were significantly effective in reducing muscle tenderness, but no significant difference was observed between the two groups.

According to Dworkin and LeResche, the maximum amount of mouth opening ability less than 40 mm is considered a limitation.[24] In the present study, the limitation of mouth opening was one of the patients' complaints. The average maximum mouth opening in the TDCS and laser groups increased by 4.35 mm and 4.82 mm after the interventions, which was statistically significant. Although in the laser group, this increase was slightly higher (about 0.5 mm), the difference was not significant. In the study by Thiemi et al,[19] the maximum amount of mouth opening in both TENS and laser groups increased from 42.5 mm to 47.4 mm (4.9 mm improved) and as in the present study, there was no significant difference between the two groups. In the study of Kogawa et al,[20] although limitation in the maximum amount of mouth opening was not the main complaint of the patients, its value increased from 44.65 mm to 48.5 in both laser and MENS groups (3.85 mm improved), and the difference between the two groups was not significant.

The average score of patient satisfaction with the treatment regarding the improvement of function, sleep, joint sound, and ability to open the mouth immediately and one month after the treatment in the 810 nm diode laser treatment method was significantly higher compared to the TDSC group. In both groups, the level of satisfaction immediately after the treatment was higher than the one-month follow-up, which can be concluded that there is a possibility of recurrence of TMD symptoms after treatment with these approaches.

Unlike the present study, Chamani et al[15] concluded in their study that low-level laser therapy is not considered an adjunctive treatment in addition to standard TMD management (including stretching exercises, soft diet, cold and heat packs, as well as correcting neck posture and eliminating parafunctional habits) and cannot be considered a substitute for standard treatment. They reported that physical therapy as the main treatment in TMD patients significantly reduces pain and improves patients' function.

Since these two treatment methods are less invasive and less expensive than surgical methods, they can replace medical and surgical treatments. However, in the short-term follow-up of one month, the level of satisfaction with these two treatment methods was still high, although it was not comparable to immediately after the treatment. Most of the patients who expressed less satisfaction with the treatment in the follow-up were those who were placed in stressful situations and some of their symptoms had recurred. It can be concluded that along with these treatments, it is necessary to follow simple tips such as reducing and controlling stress and avoiding eating hard foods, opening the mouth suddenly, and yawning to a large extent.

While this study yields valuable findings, it is important to acknowledge its inherent limitations. The restricted sample size restricts the generalizability of the results and hinders the attainment of representative findings. Moreover, the study primarily focuses on subjective measurements, neglecting objective assessments such as paraclinical and radiographic examinations. Additionally, the absence of an evaluation of long-term outcomes can be regarded as a drawback.

Conclusion

In general, both 810 nm diode laser and TDCS approaches were effective in reducing the symptoms of TMD patients, including reducing spontaneous pain, reducing tenderness and painful touch of the masticatory muscles, increasing the amount of mouth opening, and even reducing jaw sounds. The results were more favorable in the laser group, although the difference was not significant. The level of satisfaction with the treatment was significantly higher in the laser group compared to the TDCS method.

Suggestions

According to the searches conducted in databases such as PubMed and Google Scholar, no study had compared 810 nm laser and TDCS, which was done in the present study. Therefore, more studies on the effectiveness of these two methods on a wider scale with a larger sample size and with a longer follow-up are suggested in the future.

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Authors' Contribution

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Project administration: Parisa Mosenzade.
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Software: Parisa Mosenzade.
Supervision: Soghra Yassaei, Parisa Mohsenzade, MohammadHassan Akhavan Karbassi, Zahra Fazaelipour.
Validation: Soghra Yassaei, Parisa Mosenzade.
Visualization: Soghra Yassaei, Parisa Mosenzade.
Writing–original draft: Parisa Mosenzade.
Writing–review & editing: Parisa Mosenzade.

Competing Interests

The authors declared no conflict of interest.

Ethical Approval

This study has been approved by the "Research Ethics Committee of Shahid Sadougi University of Medical Sciences, Yazd" under the number IR.SSU.REC.1401.014. This clinical trial with a before & after design has been registered in the Iranian Registry of Clinical Trials with the code IRCT20210321050751N3.

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