Effects of Different Therapeutic Modalities on the Clicking Sound and Quantitative Assessment of the Vertical and Lateral Mandibular Movements of Patients with Internal Derangements of the Temporomandibular Joint

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Purpose: To compare the efficacy of low-dose laser therapy to that of conservative treatment using two different occlusal splints (stabilization and anterior repositioning splints) in patients with internal derangements of the temporomandibular joint (TMJ). ***Materials and Methods:*** The study population consisted of patients with disc displacement with reduction diagnosed according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) Axis I and Axis II. In addition, disc displacement with reduction was confirmed in all patients using TMJ ultrasonography. These tests were conducted for 6 months with an interim control in the third month. The "clicking" sound from the joint on opening and closing the mouth and the extent to which the mouth opened vertically and laterally were assessed. In all, 20 patients received low-dose laser therapy, 20 were treated with a stabilization splint, and 20 were treated with an anterior repositioning splint. In addition, 10 untreated patients were included as a patient control group, and a further 10 healthy subjects were included as a healthy control group. Changes in the condition were assessed based on the results of the RDC/TMD Axis II and with the use of an algometer. ***Results:*** The anterior repositioning splint group showed improvement in the "clicking" sound during mouth opening. Lateral movement improved significantly in patients who received laser therapy. In the patient control group, the click disappeared during mouth opening, the algometrically determined pain improved, and the lateral movement increased. There were no statistically significant differences between groups in the improvement of vertical mouth movement or in the clicking sound during mouth closing. ***Conclusion:*** Each treatment modality applied in this study separately produced positive results for the clicking sound, restrictions in vertical and lateral movements, and reduction of the pressure pain threshold observed in cases of TMJ irregularity. In conclusion, the decision regarding which treatment modality should be employed can be made based on the patient's symptoms. However, this study also indicates that TMJ derangements can resolve spontaneously when left untreated. *Int J Prosthodont 2021;34:1–X. doi: 10.11607/ijp.6836*

Internal derangement of the temporomandibular joint (TMJ) is defined as an abnormal relationship of the disc with the condyle and glenoid fossa. This condition causes pain in the head and ear around the joint, leads to difficulties with speech and mastication, and restricts mouth opening and lateral movements, among other issues.[1,2] Several therapeutic modalities are used to treat complaints related to TMJ derangements, including splint therapy, low-dose laser therapy, physiotherapy, and many other methods.

Of the conservative approaches, occlusal splints are the most common.[3–5] Of the several different types of splint available, occlusal stabilization splints and anterior repositioning splints are used most frequently in patients with TMJ derangements,

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Table 1 Comparison of Sex and Age Between Treatment Groups

Variables	Groups						
	Anterior repositioning splint (n = 20)	Stabilization splint (n = 20)	Laser therapy (n = 20)	Patient control (n = 10)	Healthy control (n = 10)	Total (n = 80)	*P*
Sex, n (%)							
Male	4 (20.0)	4 (20.0)	4 (20.0)	2 (20.0)	3 (30.0)	17 (21.25)	.979
Female	16 (80.0)	16 (80.0)	16 (80.0)	8 (80.0)	7 (70.0)	63 (78.75)	
Mean ± SD age, y	28.30 ± 9.92	30.25 ± 14.34	24.15 ± 9.47	23.10 ± 5.70	26.70 ± 3.20	26.90 ± 10.33	.265

particularly when treating disc displacement with reduction.[6–9]

Lately, laser treatment methods have increasingly been adopted. Low-dose laser systems, which have biostimulative, regenerative, analgesic, and anti-inflammatory effects, activate immune and hematologic systems. Positive results have been reported for laser treatment.[10]

Although the primary factor in internal derangement of the TMJ is thought to be disc displacement, recent studies have shown that more complicated events, such as occlusion-related factors, the influence of oral habits, and TMJ anatomy, also play a role in the internal derangement of the TMJ.[11–13] In fact, internal derangements can occur due to changes in various biochemical substances due to the effects of the forces acting on the disc, synovial fluid, and joint. The aim of treatment is to enable the patient to recover normal mandibular mobility by eliminating inflammation and excess pressure on the joint rather than by repositioning the disc.

In the present study, the efficacies of low-dose laser therapy and conservative treatment using two different occlusal splints (stabilization and anterior repositioning splints) in patients with TMJ derangements were assessed. Healthy control and patient control groups received no treatment and were not informed about their TMJ derangement or clinical course.

The null hypothesis was: there would be no differences between the groups in terms of the clicking sound or the vertical and lateral mandibular movements of the patients with internal derangements of the TMJ.

MATERIALS AND METHODS

This study was performed with a total sample of 80 patients (17 men and 63 women) treated at the Prosthetic Dental Treatment Department of the Faculty of Dentistry, Erciyes University, Kayseri, Turkey, for complaints of TMJ ache, limited mandibular mobility, and articulatory sounds. The patients ranged from 18 to 60 years of age, with a mean age of 26.90 ± 10.33 years (Table 1). This study was approved by the Erciyes University Clinical Research Ethics Committee Chairmanship (decision no: 2016/04). The participants provided written informed consent prior to inclusion in the study. The patients included in the study had TMJ derangements according to Axis I and a Group IIa diagnosis of disc displacement with reduction according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD).

The 80 individuals were split into five groups: three treatment groups and two control groups (anterior repositioning splint, stabilization splint, and laser treatment groups: n = 20 each; healthy control: n = 10; untreated patient control: n = 10). The treatment groups and untreated control groups were determined randomly. An interim assessment was performed after data collection. When the primary hypothesis of the study (absence or presence of intergroup differences in articulatory sounds) was assessed, the α was calculated to be .05 and the power was calculated as 0.956 using SigmaStat 3.5 (SYSTAT) for the sample sizes in the groups (20, 20, 20, 10, and 10, respectively). As this value was above 80%, no additional patients were included.

RDC/TMD Axis I and II forms were completed for all patients before treatment (baseline), after 3 months of treatment, and after 6 months of treatment. The healthy and patient control groups were included to accurately evaluate the positive effects of treatment on the findings.

Clinical Examination Forms

Research Diagnostic Criteria for Temporomandibular Disorders

The diagnosis algorithm presented in Fig 1 was used to select patients.[14] The RDC/TMD consists of two parts. The first part, Axis I, is made up of a clinical examination form used for diagnosis of TMJ derangements. The second is a questionnaire used to evaluate correlations between TMJ derangement and psychosocial status.

In the present study, the Turkish translations of the RDC/TMD forms provided by the International RDC/

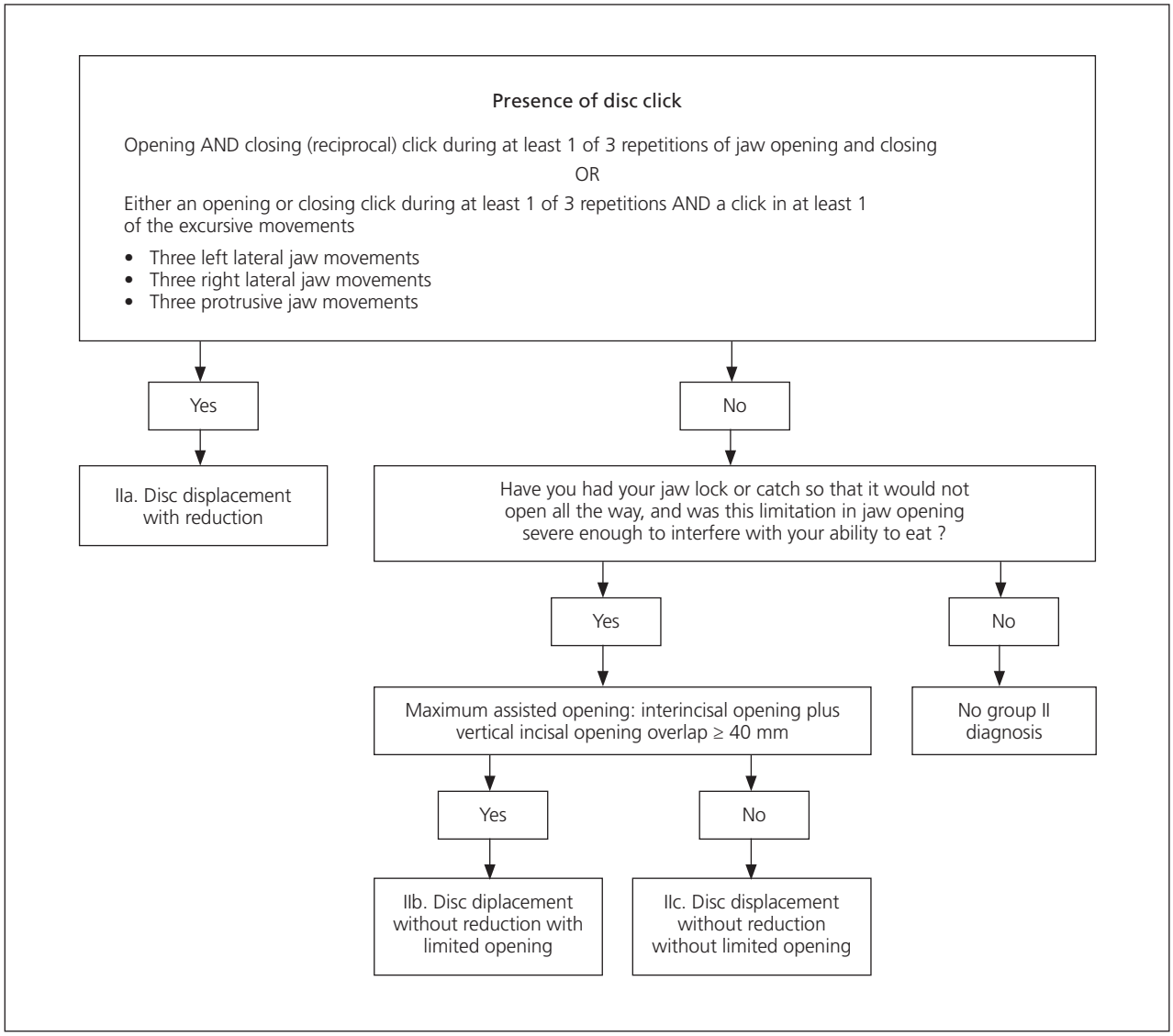


Fig 1 Revised Group II disc displacements diagnostic algorithm. Reprinted with permission from Schiffman et al.[14]

TMD–based Research Consortium were used.[15] In addition to these forms, measurements were noted in a table. General guidance regarding completion of the forms and clinical examinations was taken into consideration. The data obtained were assessed as described by Dworkin and LeResche.[16]

Clinical examinations were performed by one physician in accordance with the guidelines regarding application of RDC/TMD forms (E.R.).

Algometric Measurements

The sensitivity of trigger points may not be measured accurately by manual palpation alone. The algometer developed by Fischer[17] enables objective evaluation of sensitive points and provides measurements in units of kgf/cm^2 or N/cm^2. The efficacies of different treatment modalities were compared by measuring the minimum force that caused pain in areas of local sensitivity. An FPX 25 digital algometer (Wagner Instruments) was used.

Ultrasound Examination

In addition to the RDC/TMD form, ultrasound images were obtained from all patients to confirm the findings of anterior disc displacement with reduction. Ultrasound joint imaging of patients in the treatment groups was performed in the Dental and Maxillofacial Radiology Department of the Faculty of Dentistry, Erciyes University. Simultaneous measurements were obtained using

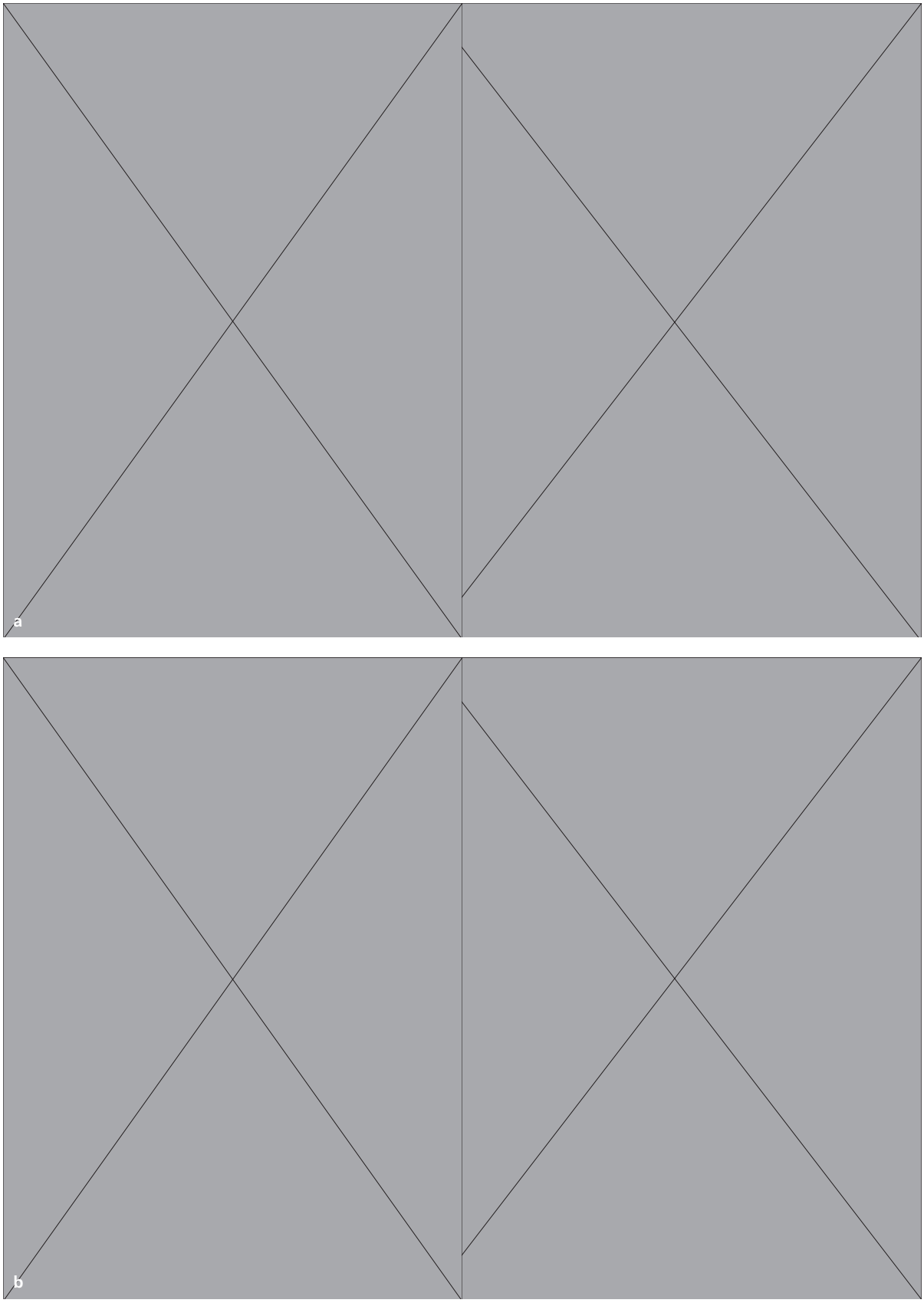


Fig 2 B-mode ultrasound images of the obliquely positioned area in the linear probe right TMJ section at the *(a)* start and *(b)* end of treatment. K = mouth closed, A = mouth open.

both B-mode and the high-frequency linear scanning probe (14-7.2 MHz, PLT-1204 BT) of the ultrasound device (Aplio 500, Toshiba Medical Systems) (Fig 2).

Laser Therapy

Low-dose laser therapy was performed with a diode laser (Epic 10 Diode Laser InGaAsp, 940 ± 10 nm; Biolase). Treatment was applied with the laser 2 mm from the skin of the TMJ and to the painful trigger points with an energy intensity of 18 J/cm^2 and an output of 0.3 W for 60 seconds. Treatment was applied in 10 sessions with 3 sessions per week for 3.5 weeks.

Splint Therapy

Preparation of anterior repositioning splint

For patients in the anterior repositioning splint group, recordings were taken by covering the mandible with silicone recording material with the teeth positioned head to head. Each patient's maxillary model was transferred in spatial position to the articulator with a facebow transfer. The mandibular model was connected by record index to the articulator with the mandible in the anterior position.

An occlusal splint was prepared for each patient by pressing hard a Essix splint (Dispodent) after the maxilla was isolated and the undercut areas were concealed with modeling wax. Transparent autopolymerizing acrylic resin (Imicryl Dental) was prepared according to the manufacturer's directions and attached to the maxillary part of the occlusal splint, after which the articular was carefully closed. After hardening, excess acrylic resin was removed with a drill. Taking the lateral and protrusive movements into consideration, premature contacts were eliminated on the semi-adjustable articulator using articulation paper.

The patients used anterior repositioning splints for 3 months. After 3 months, the patients stopped using the anterior repositioning splint. Stabilization splints were subsequently prepared and were used by the patients for a further 3 months.[18]

Preparation of stabilization splint

The positions of the occlusal splints were determined using silicone bite planes, and lateral and protrusive movements were recorded using silicone bite registration material. Each patient's facebow transfer and maxillary models were transferred spatially to the articulator. Subsequently, the mandibular model was taken to the articulator, taking lateral and protrusive movements into consideration.

An occlusal splint was prepared for each patient by pressing dual laminate plastic onto the maxilla, and the undercut areas were concealed with modeling wax. For patients who were to receive a stabilization splint, transparent autopolymerizing acrylic resin was prepared in accordance with the manufacturer's instructions and added to the splint, and the articulator was closed. Then, lateral and protrusive movements were considered, and finishing with a diamond bur was performed where necessary to complete the splint. The patients were called back for follow-up at 3 and 6 months.

All such procedures were performed by a single prosthodontist at the Erciyes University Faculty of Dentistry Department of Prosthodontics (E.R.).

Both types of splint were worn for 24 hours a day except during eating and brushing the teeth.

Patients in the patient control group were not informed of the cause or course of their disease and did not receive any treatment. They completed the RDC/TMD Axis I and II forms three times: before undergoing any therapy (baseline), after 3 months, and after 6 months. Healthy controls also did not receive treatment and completed the same forms at the same three time points.

Statistical Analyses

The data were analyzed for a normal distribution using histograms, quantile-quantile (QQ) graphics, and Shapiro-Wilk test. Relationships between qualitative variables were assessed via Pearson chi-square analyses. Friedman test was used for comparisons between measurements, and analysis of variance (ANOVA) was used for repeated measures. In intergroup comparisons, one-way ANOVA and Kruskal-Wallis test were used for quantitative variables. Multiple comparisons were performed with Tukey and Dunn-Bonferroni tests. Data were analyzed using Turcosa Cloud statistical software. In all analyses, $P < .05$ indicated statistical significance.

RESULTS

There were significant differences in clicking sounds during mouth opening on the right side between the treatment groups at each time point ($P < .05$), but no significant differences in intragroup comparisons between time points, except for in the untreated patient control group. The results were the same for clicking sounds during mouth opening on the left side, except for a significant difference within the anterior repositioning splint group ($P < .05$) (Table 2).

The clicking sounds during mouth closing on the right side did not differ between groups at baseline or 6 months after treatment, but did differ after 3 months. There were no differences in intragroup comparisons. The results were the same for clicking during mouth closing on the left side (Table 2).

Algometric values for the lateral pole of the condyle region were not significantly different between groups at any time point, but differed within the anterior repositioning splint, stabilization splint, and laser therapy

Table 2 Comparison of the Level of Clicking Sound When Opening and Closing the Mouth Between Treatment Groups and According to Time Point

Variables	Groups					$P^{\dagger}$
	Anterior repositioning splint (n = 20)	Stabilization splint (n = 20)	Laser therapy (n = 20)	Patient control (n = 10)	Healthy control (n = 10)	
Opening the mouth (right)						
Baseline	1.00 (0.25–1.00)^{a}	1.00 (0.00–1.00)^{a}	0.50 (0.00–1.00)^{ab}	1.00 (0.00–1.00)^{A,a}	0.00 (0.00–0.00)^{b}	.001
3 mo	0.50 (0.00–1.00)^{ab}	1.00 (0.00–1.00)^{a}	0.00 (0.00–1.00)^{ab}	0.50 (0.00–1.00)^{AB,ab}	0.00 (0.00–0.00)^{b}	.019
6 mo	1.00 (0.00–1.00)^{a}	0.50 (0.00–1.00)^{ab}	0.00 (0.00–1.00)^{ab}	0.00 (0.00–0.25)^{B,ab}	0.00 (0.00–0.00)^{b}	.027
$P^{\ddagger}$	.072	.074	.513	.022	.999	
Opening the mouth (left)						
Baseline	1.00 (0.25–1.00)^{A,a}	1.00 (0.25–1.00)^{a}	0.50 (0.00–1.00)^{ab}	1.00 (0.00–1.00)^{ab}	0.00 (0.00–0.00)^{b}	.001
3 mo	1.00 (0.00–1.00)^{B,a}	1.00 (0.00–1.00)^{a}	0.00 (0.00–1.00)^{ab}	1.00 (0.00–1.00)^{ab}	0.00 (0.00–0.00)^{b}	.008
6 mo	1.00 (0.00–1.00)^{B,a}	1.00 (0.00–1.00)^{a}	0.00 (0.00–1.00)^{ab}	0.00 (0.00–1.00)^{ab}	0.00 (0.00–0.00)^{b}	.015
$P^{\ddagger}$	.041	.247	.074	.135	.999	
Closing the mouth (right)						
Baseline	0.00 (0.00–1.00)	0.00 (0.00–0.75)	0.00 (0.00–1.00)	0.50 (0.00–1.00)	0.00 (0.00–0.00)	.084
3 mo	0.50 (0.00–1.00)^{a}	0.00 (0.00–0.00)^{b}	0.00 (0.00–1.00)^{b}	0.50 (0.00–1.00)^{a}	0.00 (0.00–0.00)^{b}	.018
6 mo	0.00 (0.00–0.75)	0.00 (0.00–0.00)	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.00 (0.00–0.00)	.226
$P^{\ddagger}$	.097	.513	.779	.368	.999	
Closing the mouth (left)						
Baseline	0.00 (0.00–1.00)^{a}	0.00 (0.00–0.00)^{a}	0.00 (0.00–1.00)^{a}	0.50 (0.00–1.00)^{b}	0.00 (0.00–0.00)^{a}	.020
3 mo	0.00 (0.00–1.00)^{a}	0.00 (0.00–0.00)^{a}	0.00 (0.00–1.00)^{a}	0.50 (0.00–1.00)^{b}	0.00 (0.00–0.00)^{a}	.014
6 mo	0.00 (0.00–0.75)	0.00 (0.00–0.00)	0.00 (0.00–1.00)	0.00 (0.00–1.00)	0.00 (0.00–0.00)	.084
$P^{\ddagger}$	.169	.717	.135	.717	.999	

Data are expressed as median (first quartile–third quartile). Median and quartile values have been calculated according to subcategory coding. Different lowercase superscript letters in the same row indicate a significant difference ($P < .05$) between treatment groups. Different uppercase superscript letters in the same column denote a significant intragroup difference between time points.
†Kruskal-Wallis test *P* values for the comparison between treatment groups.
‡Friedman test *P* values for intragroup time point comparisons.

groups (Table 3). There were no inter- or intragroup differences in the rate of painless mouth opening, unaided maximum mouth opening, or aided maximum mouth opening at any time point (Table 4).

Lateral movement on the right side did not differ between groups at any time point; within groups, it differed only in the laser therapy group ($P < .05$). The results were the same for the left side, except for a significant difference in the untreated patient control group (Table 5).

DISCUSSION

The anterior repositioning splint group showed improvement in the clicking sound during mouth opening. Lateral movement improved significantly in patients who had received laser therapy. In the patient control group, the click disappeared during mouth opening, the algometrically determined pain improved, and the lateral movement increased. There were no statistically significant differences between groups in the improvement of vertical mouth movement or in the clicking sound during mouth closing.

Axis I of the RDC/TMD is a well established and reliable diagnostic protocol.[15,16] The RDC/TMD was employed rather than the DC/TMD,[19] as the DC/TMD was introduced after this study commenced. Dynamic high-resolution ultrasonography was used to confirm the diagnoses, as it is the preferred imaging method.[20–27] Apart

Table 3 Intergroup and Intragroup Time Point Comparisons of Algometric Values of the Lateral Pole of the Condyle

Algometry (lateral)	Groups					$P^{\dagger}$
	Anterior repositioning splint (n = 20)	Stabilization splint (n = 20)	Laser therapy (n = 20)	Patient control (n = 10)	Healthy control (n = 10)	
Baseline	9.35 ± 3.35	10.30 ± 3.20	10.29 ± 4.36	7.58 ± 1.96^{A}	11.88 ± 4.75^{A}	.109
3 mo	8.97 ± 2.68	9.34 ± 2.89	9.74 ± 4.31	9.67 ± 2.57^{B}	9.01 ± 4.07^{B}	.950
6 mo	10.52 ± 3.44	10.24 ± 3.07	11.13 ± 4.28	9.86 ± 1.89^{B}	9.91 ± 3.08^{AB}	.839
$P^{\ddagger}$	.109	.262	.211	.010	.047	

Data are presented as mean ± SD. Different uppercase superscript letters in the same column denote a significant intragroup difference between time points.
†One-way analysis of variance (ANOVA) test for comparisons between the treatment groups.
‡Repeated-measures ANOVA for intragroup time point comparisons.

Table 4 Comparison of Mouth Opening (mm) Between Treatment Groups and Time Points

Variables	Groups					$P^{\dagger}$
	Anterior repositioning splint (n = 20)	Stabilization splint (n = 20)	Laser therapy (n = 20)	Patient control (n = 10)	Healthy control (n = 10)	
Unaided, painless mouth opening						
Baseline	35.55 ± 6.96	34.01 ± 8.50	32.89 ± 9.60	32.27 ± 7.96	31.55 ± 4.61	.676
3 mo	33.07 ± 5.40	30.81 ± 5.36	31.66 ± 8.33	32.80 ± 6.74	31.70 ± 8.36	.858
6 mo	34.67 ± 6.28	30.73 ± 5.77	32.53 ± 6.26	32.0 ± 4.95	31.89 ± 6.90	.363
$P^{\ddagger}$	.359	.085	.791	.950	.989	
Maximum unaided mouth opening						
Baseline	46.00 ± 4.41	42.45 ± 6.08	43.42 ± 7.08	43.06 ± 6.67	44.53 ± 4.61	.389
3 mo	45.27 ± 5.93	41.41 ± 5.50	42.34 ± 5.19	43.82 ± 7.75	45.04 ± 4.66	.210
6 mo	46.38 ± 5.75	41.58 ± 5.05	43.84 ± 5.57	42.33 ± 5.95	44.32 ± 4.87	.083
$P^{\ddagger}$	.394	.427	.135	.315	.757	
Maximum aided mouth opening						
Baseline	48.23 ± 4.24	44.83 ± 5.56	45.47 ± 6.20	44.38 ± 6.45	47.40 ± 4.36	.207
3 mo	48.01 ± 6.01	44.51 ± 4.88	44.84 ± 4.74	45.28 ± 7.43	46.70 ± 4.23	.259
6 mo	48.55 ± 5.57	44.29 ± 5.20	45.70 ± 6.02	45.55 ± 8.03	42.96 ± 14.47	.308
$P^{\ddagger}$	.673	.584	.277	.273	.333	

Data are presented as mean ± SD.
†One-way analysis of variance (ANOVA) test for comparisons between treatment groups.
‡Repeated-measures ANOVA for intragroup time point comparisons.

from cost and availability, 12.5-MHz ultrasound provides more reliable identification of disc displacements.[28–31]

In the clicking sound analyses, significant differences were found only for mouth opening clicks on both sides of the face between treatment groups at each time point, on the right side within untreated patient controls, and on the left side within the anterior repositioning splint group. MC clicks on both sides differed between groups only after 3 months. Bertolucci and Grey[32] found that, compared to controls, TMJ patients who received low-dose laser therapy reported lower pain and clicking sounds, but the differences were not significant. They suggested that the minor differences observed were due to improvements in secondary muscular inhibition by hyperactive intra-articular sensory receptors induced by laser therapy. Kulekçioğlu et al[33] also suggested that laser treatment has no beneficial effect on joint sounds and reported that none of the conservative choices affect mechanical problems of the joint. In line with these previous studies, it was found that low-dose laser therapy did not have significant effects on joint sounds.

Occlusal splints are generally used to treat joint sounds, relieve pain, and eliminate excessive jaw mobility.[34] A previous study suggested that a stabilization splint should be used to treat TMJ and joint sounds.[34] In the present study, although the stabilization splint resulted in a reduction of clicking sounds in vertical movements, the effect was not significant.

Alvarez-Arenal et al[36] reported reductions in levels of opening and closing sounds in groups treated with

Table 5 Comparison of Lateral Movement (mm) Between Treatment Groups and Time Points

Variables	Groups					$p^{\dagger}$
	Anterior repositioning splint (n = 20)	Stabilization splint (n = 20)	Laser therapy (n = 20)	Patient control (n = 10)	Healthy control (n = 10)	
Quantity of lateral movement (right)						
Baseline	7.61 ± 2.60	7.30 ± 2.50	7.09 ± 2.37^{AB}	7.08 ± 2.55	7.28 ± 1.88	.968
3 mo	6.93 ± 2.25	7.73 ± 2.54	6.39 ± 1.88^{A}	7.46 ± 2.46	6.31 ± 1.33	.277
6 mo	7.21 ± 2.54	8.20 ± 2.55	7.44 ± 1.75^{B}	7.93 ± 2.14	7.23 ± 1.69	.621
$P^{\ddagger}$	.477	.124	.019	.097	.249	
Quantity of lateral movement (left)						
Baseline	8.16 ± 2.56	7.98 ± 1.43	7.02 ± 2.95	6.73 ± 2.53^{A}	8.45 ± 1.24	.238
3 mo	7.21 ± 2.28	8.09 ± 1.72	7.45 ± 2.12	7.70 ± 2.52^{AB}	7.23 ± 1.33	.684
6 mo	7.10 ± 2.16	8.17 ± 1.83	8.26 ± 1.80	8.16 ± 2.72^{B}	7.16 ± 3.00	.340
$P^{\ddagger}$	.132	.874	.096	.020	.136	

Data are reported as mean ± SD. Different uppercase superscript letters in the same column indicate a significant intragroup difference between time points.
†One-way analysis of variance (ANOVA) test for comparisons between treatment groups.
‡Repeated-measures ANOVA for intragroup time point comparisons. The same capital letters in the same column (A, B, C) denote the similarity in intra-group temporal comparisons, and the different small letters denote the dissimilarity between the treatment groups in intra-group comparisons.

stabilization splints and transcutaneous electrical nerve stimulation (TENS), but the differences were not significant. Wassell et al[37] compared stabilization splint and control splint groups and reported that clicking sounds were reduced in both groups following the initial treatment. The clicks returned by the end of the first year in controls, but not in the stabilization splint group. The present results are in line with these findings.

Truelove et al[38] compared behavioral therapy (ie, self-care therapy) to rigid acrylic resin and soft splint therapies and reported that the presence of clicking sounds dropped from 66% to 37% in treatments that used rigid splints, from 53% to 43% in soft splints, and from 65% to 46% in behavioral therapy. These findings are similar to the present findings in that there was a decrease in the level of sounds, although the extent of the decrease was not significant.

In the present study, quantification of the pressure pain threshold of the lateral pole of the condyle based on algometric measurements indicated a positive effect only in controls. Komiyama and De Laat reported that mean thresholds in the masseter muscle were 2.14 kgf/cm^2 in men and 1.49 kgf/cm^2 in women.[39] Patients with myofascial pain tend to have lower pain thresholds than those with pain symptoms,[40,41] which may explain why the mean pretreatment threshold was higher in controls in the present study. These results are also in line with Öz et al,[42] who reported reductions in muscular sensitivity in both laser-treated and splint (occlusal) groups, although the differences were not significant. Hansdottir and Bakke[43] reported significant differences between patients with pain disorders and healthy controls. Their findings corroborate the results of acute pain experiments and confirm that the clinical presence of long-lasting TMJ pain is related to marked functional impairment. This impairment can be the result of reflex adaptation of mandibular muscles and their long-lasting hypoactivity and may explain why the mean pretreatment pressure pain thresholds in the lateral pole of the condyle were greater in controls than in the other groups in the present study.[43]

In terms of the degree of painless aided or unaided mouth opening, positive results were obtained only in the stabilization splint group for unaided mouth opening, although the results were not statistically significant (despite long treatment periods), which is in line with previous work.[42,44] However, a nonsignificant increase in the degree of maximum mouth opening was also found in all groups, in line with Okeson et al,[45] who compared a stabilization splint to cathartic therapy. By contrast, Winocur et al[46] reported the opposite results. Sato et al[47] reported an increase of 10.3 mm in a study with a 1-year follow-up, while another study reported an increase of 13.3 mm with a follow-up period of 27 months.[48] These differences from the present study may be attributable to the long follow-up periods in the previous studies, suggesting that the condition improves over time due to its self-limiting nature.

In terms of lateral movements, these were similar within treatment groups, and therefore there were no

significant differences between treatments. However, the laser group showed a significant difference in right lateral movement at 6 months. A significant difference in left side lateral movement was found in the untreated patient control group also at 6 months.

Few studies have compared conservative therapy choices for the TMJ in terms of eccentric mandibular movements, but these results are in line with Çetiner et al,[49] who found a significant change in right lateral movement after low-dose laser treatment. However, the changes observed in the present study were not significantly different between treatment groups. Another study reported values of 1.11 mm for right lateral movement, 0.88 mm for left lateral movement, and 0.3 mm for protrusion.[50] In comparison, the present values are somewhat low for right lateral movement but higher for left lateral movement. Kulekçioğlu et al[33] applied a 15-session gallium arsenide treatment in 35 patients with TMJ disorders and reported significant increases in right and left lateral movements immediately after treatment and at 1 month after treatment. The present findings are in line with these findings; however, their values were much higher than the present ones, which may be attributable to differences in the number of treatment sessions and characteristics of the laser used. Considering the studies evaluating the effect of the use of stabilization splints on the degree of lateral movement, the results were found to be compatible with the results of the present study.[51,52]

Finally, these results are similar to those of Yamaner,[53] who reported that neither laser nor ozone therapy produced significant changes in mandibular mouth opening or lateral movements. However, in the present study, patients with TMJ derangements of both myalgic and arthralgic origins were assessed together. The changes in movement were not significant in most of the treatment groups.

There were no differences between groups in terms of the clicking sound or the vertical and lateral mandibular movements of the patients; thus, the null hypothesis of this study was rejected. **[AU: Since the null hypothesis was stated to be there would be no differences, should this say the null hypothesis was accepted?]**

It should be noted that this study was limited in that the follow-up period was only 6 months. Future studies with longer follow-up periods will provide additional insight into the efficacies of different types of therapy, the course of the disease, and its self-limiting nature.

CONCLUSIONS

A statistically significant increase in lateral movement was found in patients who received laser treatment. Anterior repositioning splint treatment resulted in a significant reduction in mouth opening. These modalities may be used as alternatives in the treatment of TMJ derangement. In addition, stabilization splint treatment improved painless unaided mouth opening, although the effects were not statistically significant. Untreated controls showed a significant improvement in clicking during mouth opening on the right side, algometry, and lateral movement on the left side. These observations indicate the self-limiting nature of TMJ derangement. Finally, there were no significant intergroup differences in vertical mouth-opening movements or mouth-closing clicking sounds.

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