

Association of Malocclusion, Parafunctional Habits and Quality of Life in Patients with Temporomandibular Joint Disorder

Temporomandibular Eklem Bozukluğu Olan Hastalarda Maloklüzyon, Parafonksiyonel Alışkanlıklar ve Yaşam Kalitesi ile İlişkisi

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ABSTRACT Objective: The aim of this study is to investigate the relationship between malocclusion, parafunctional habits and quality of life in patients with the temporomandibular joint disorder (TMD). **Material and Methods:** This cross-sectional study included 482 TMD patients who sought treatment at the oral and maxillofacial surgery clinic of a faculty of dentistry. While the malocclusion status of participants was evaluated with The Dental Aesthetic Index, bruxism, chewing side preference and parafunctional habits were evaluated with Oral Behavior Checklist. Quality of life was assessed by Oral Health-Related Quality of Life-United Kingdom (OHRQoL-UK). The data were analyzed with the SPSS 20 program. **Results:** The mean OHRQoL-UK score of the participants was 46.46±11.64. There was a significant difference in both OHRQoL-UK total scores and OHRQoL-UK domain scores between those with and without bruxism ($p<0.005$). The total quality of life scores of those without bruxism (49.29±10.629) were found significantly higher than those with bruxism (45.54±11.82). There was no significant difference between OHRQoL-UK total scores and OHRQoL-UK domain scores between those with and without malocclusion ($p=0.254$). Similarly, there was no significant difference in OHRQoL of TMD patients in terms of parafunctional habits and chewing side preference ($p=0.300$, $p=0.548$ respectively). **Conclusion:** In the present study, OHRQoL in TMD patients with bruxism was significantly lower than in TMD patients without bruxism. Malocclusion, chewing side preference, and parafunctional habits did not have a significant effect on OHRQoL in TMD patients.

ÖZET Amaç: Bu çalışmanın amacı, temporomandibular eklem bozukluğu [temporomandibular joint disorder (TMD)] olan hastalarda maloklüzyon, parafonksiyonel alışkanlıklar ve yaşam kalitesi ile ilişkisini araştırmaktır. **Gereç ve Yöntemler:** Bu kesitsel çalışmaya, bir diş hekimliği fakültesinin oral ve maksillofasial cerrahi kliniğinde tedavi görmek isteyen 482 TMD hastası dâhil edildi. Katılımcıların maloklüzyon durumları Dental Estetik İndeksi ile değerlendirilirken, brüksizm, çiğneme tarafı tercihi ve parafonksiyonel alışkanlıklar Oral Davranış Kontrol Listesi ile değerlendirildi. Yaşam kalitesi, Ağız Sağlığıyla İlgili Yaşam Kalitesi-Birleşik Krallık [Oral Health-Related Quality of Life-United Kingdom (OHRQoL-UK)] ölçeği ile değerlendirildi. Veriler, SPSS 20 programı ile analiz edildi. **Bulgular:** Katılımcıların ortalama OHRQoL-UK skoru 46,46±11,64 idi. Brüksizmi olan ve olmayanlar arasında, hem OHRQoL-UK toplam puanları hem de OHRQoL-UK alan puanları açısından anlamlı fark vardı ($p<0,005$). Brüksizmi olmayanların toplam yaşam kalitesi puanları (49,29±10,629), brüksizmi olanlara göre (45,54±11,82) anlamlı olarak daha yüksek bulundu. Maloklüzyonu olanlar ve olmayanlar arasında OHRQoL-UK toplam puanları ile OHRQoL-UK alan puanları arasında anlamlı bir fark yoktu ($p=0,254$). Benzer şekilde, TMD hastalarının ağız sağlığı ile ilgili yaşam kalitelerinde parafonksiyonel alışkanlıklar ve çiğneme tarafı tercihi açısından anlamlı bir farklılık yoktu (sırasıyla $p=0,300$, $p=0,548$). **Sonuç:** Bu çalışmada, brüksizmi olan TMD hastalarında ağız sağlığı ile ilişkili yaşam kalitesi, brüksizmi olmayan TMD hastalarına göre anlamlı derecede düşüktü. TMD hastalarında maloklüzyon, çiğneme tarafı tercihi ve parafonksiyonel alışkanlıklar ağız sağlığı ile ilgili yaşam kalitesi üzerinde anlamlı bir etkiye sahip değildi.

Keywords: Malocclusion; parafunctional habit; bruxism; temporomandibular disorder; quality of life

Anahtar Kelimeler: Maloklüzyon; parafonksiyonel alışkanlık; brüksizm; temporomandibular bozukluk; yaşam kalitesi

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Temporomandibular disorders (TMDs) consist of a group of disorders affecting the temporomandibular joint (TMJ), the masticatory muscles, or both.¹ The most common signs and symptoms of TMD are chronic pain, jaw muscle aches, restricted range of jaw movement, and temporomandibular joint noise.² Pain is the most common symptom among patients with TMD and also the principal reason for seeking treatment.³ TMD is more prevalent in individuals between the ages of 20 and 40 years and in females. Temporomandibular disorders are a major public health problem affecting a significant part of the population.⁴

TMD has a multifactorial etiology, with anatomy, craniofacial morphology, trauma, occlusion, stress, and psychological factors as a potential risk or contributing factors, and the role of occlusion in TMD etiology is still under discussion.⁵⁻⁸ Occlusal features were found by Pullinger and Seligman as co-factor for only a small proportion of TMD patients.⁹ However, research has shown that there is a higher incidence of facial pain and TMD in subjects with malocclusion and dental deformities than in subjects with normal occlusion. Temporomandibular disorders are linked to types of malocclusion, such as anterior open bite, unilateral crossbite, and serious overjet. In addition, angle class II/III occlusions and deep bite are also discussed to be risk factors for TMD.¹⁰ Parafunctional habits, like bruxism, were also associated with increased risk of developing TMD.¹¹ Bruxism is described as repetitive jaw-muscle activity characterized by clenching or grinding.¹² When the habit of clenching or grinding teeth is repeated, it may lead to dental damage, symptoms of TMD, headache, toothache, and periodontal problems.¹³

Quality of life (QoL) refers to individuals' subjective perception of their position in life, in the context of values and culture in which they live, and with regard to their objectives, expectations, and concerns. Patients with chronic pain, like TMD, frequently experience major QoL changes.¹⁴ This is highly clinically important, as the daily activities of such patients, which involve basic functions such as chewing, speaking, swallowing and even social activities, may be impaired by pain and/or movement limita-

tions.¹⁵ Patients with severe malocclusion can also show a number of oral health-related effects that lower their QoL in many ways.¹⁶ Sleep bruxism (SB) and chewing-side preference (CSP) also decrease Oral Health-Related Quality of Life (OHRQoL) as they can cause muscle and joint pain around TMJ regions, and these behaviors can be correlated with psychological causes.¹⁷ However, a recent study shows that there is still a great deal of debate about the impact of malocclusion on QoL.¹⁸ Nonetheless, the impacts of malocclusion and parafunctional habits on OHRQoL are very poorly studied in patients with TMJ disorders. Hence, the aim of this study was to examine the relationship between malocclusion, parafunctional habits, and OHRQoL in patients with TMJ disorder.

MATERIAL AND METHODS

This cross-sectional study involved 482 patients who sought treatment at the Department of Oral and Maxillofacial Surgery, Afyonkarahisar Health Sciences University Faculty of Dentistry, in 2020. The study protocol was approved by the Ethics Committee of the Faculty of Medicine at Afyonkarahisar Health Sciences University (2020/ 357, 21.8.2020). The research was performed in full compliance with the Declaration of Helsinki of the World Medical Association. Informed consent was obtained from the adult patients and from the parents of the pediatric patients.

The appropriate sample size was determined as 105 in the power analysis with the G*power 3.1 program (alpha error probability=0.05) for this study. Four hundred and eighty two patients diagnosed with TMD according to the Turkish version of the Diagnostic Criteria for TMDs (DC/TMD) were included in the study. The exclusion criteria included the history of TMJ trauma or TMJ-related surgery, neuromuscular disorders, malignancy, and pregnancy. Both face-to-face interviews and clinical tests were used to gather data. The patients and their parents were notified of the research, and approval was obtained as necessary. All clinical examinations were performed by a single experienced oral and maxillofacial surgeon.

ASSESSMENT OF MALOCCLUSION

The Dental Aesthetic Index (DAI) is a numerical index that evaluates occlusal features that may cause psychosocial disability. It includes 10 parameters of dentofacial anomalies: Number of impacted teeth; anterior crowding; anterior spacing; midline diastema; open bite, maxillary anterior misalignment; maxillary anterior horizontal overlap; mandibular anterior horizontal overlap; anteroposterior molar relationship, and posterior crossbite. According to the DAI score, the patients were classified as having malocclusion ($DAI > 25$) or no malocclusion ($DAI \leq 25$).

ASSESSMENT OF SELF-REPORTED BRUXISM, CHEWING-SIDE PREFERENCE AND OTHER PARAFUNCTIONAL HABITS

SB can be diagnosed through patient reports and clinical interviews, clinical examinations, intraoral appliances, or muscle activity recordings. According to the last international consensus, the diagnosis of bruxism made by self-report is classified as potential bruxism.¹² According to the American Academy of Sleep Medicine, bruxism is diagnosed when a person reports teeth grinding or clenching during sleep. According to the Oral Behavior Checklist (OBC), patients were asked to answer questions about bruxism, chewing side preference, and parafunctional habits. Answers to “never” were recorded as “no”, otherwise as “yes”.¹⁹

ASSESSMENT OF QUALITY OF LIFE

QoL was assessed by OHRQoL-United Kingdom (OHRQoL-UK). OHRQoL-UK instrument which was created in 2000 by McGrath and Bedi in England, shows the effects of oral health on QoL in positive and negative areas.²⁰ It consists of 16 questions in four different categories. These categories are; symptom (2 questions), physical condition (5 questions), psychological state (5 questions), social status (4 questions).²¹ In the OHRQoL-UK questionnaire, questions scored according to the Likert scale are valued between 1-5. When the scores of a total of 16 questions are added together, there is a value between 16-80. The low score obtained on the OHRQoL-UK scale indicates that the QoL associated with oral health is low.

STATISTICAL ANALYSIS

While evaluating the findings obtained in the study, SPSS (Statistical Package for Social Sciences) for Windows 20.0 program was used for statistical analyses. In presenting the descriptive analyses, mean and standard deviation values were used. The compatibility of variables with normal distribution was reviewed by Kolmogorov-Smirnov tests. t-test and one-way ANOVA analysis was used. Results were evaluated in a 95% confidence interval, at $p < 0.05$ significance levels.

RESULTS

Sociodemographic characteristics of the participants were given in [Table 1](#). Of the participants, 83.4% were female and 16.6% were male. Most participants were in the 20-29 age range. Almost half of the participants (49.4%) were married. High school graduates were in the majority. Only 53.1% of the participants were at a normal weight. Most of the others were overweight (30.7%) and obese (59.5%). The unemployed (32.4%) and housewives (23.9%) were the highest in the occupational group, respectively.

The change of OHRQoL-UK scale scores according to the socio-demographic characteristics of the participants was given in [Table 1](#). The mean OHRQoL-UK score of the participants was 46.46 ± 11.64 . There was no substantial difference between the QoL points of the female and male participants. There was no significant difference between age groups. The QoL scores of the divorced participants (41.42 ± 15.17) was significantly lower than those of married and single ($p < 0.005$). When the QoL scores were examined in terms of educational status, primary school graduates had the highest QoL scores (51.00 ± 15.20). The QoL scores of the underweight (52.62 ± 9.79) and the QoL scores of the overweight (49.48 ± 10.82) were significantly higher than those of normal weight and obese ($p < 0.001$). QoL scores of officers (52.52 ± 16.04) and QoL scores of self employments (52.33 ± 7.15) were significantly higher than students and housewives. In addition, the QoL scores of officers was higher than unemployed people ($p < 0.005$).

TABLE 1: Socio-demographic characteristics and quality of life of the participants.

Demographic data	n	%	OHRQoL-UK Mean±SD	p value	Post hoc p value
Gender					
Female	402	83.4	49.85±10.95	p=0.004	
Male	80	16.6	45.79±11.67		
Age					
<20 years old	108	22.4	48.59±12.21	p=0.100	
20-29 years old	140	29	45.54±9.12		
30-39 years old	128	26.6	46.87±11.60		
40 and over	106	22	45.03±13.70		
Marital status					
Married	238	49.4	47.28±11.73	p=0.038*	1-2; p=0.012
Single	216	44.8	46.22±10.88		2-3; p=0.040
Divorced	28	5.8	41.42±15.17		
Education status					
Primary school	119	24.7	51.00±15.20	p=0.000**	1-2; p=0.001
Secondary school	144	29.9	45.66±9.83		1-3; p=0.000
High school	163	33.8	44.22±9.64		1-4; p=0.014
Faculty and graduate	56	11.6	45.42±10.05		
BMI					
<18.5 kg/m ² (Weak)	32	6.6	52.62±9.79	p=0.000**	1-2; p=0.001
18.5-24.9 kg/m ² (normal)	256	53.1	44.35±10.50		1-4; p=0.007
25-29.9 kg/m ² (overweight)	148	30.7	49.48±10.82		2-3; p=0.000
>30 kg/m ² (obese)	46	9.5	44.21±16.95		3-4; p=0.031
Occupation					
Student	76	15.8	44.89±8.22	p=0.037*	1-4; p=0.006
Housewife	115	23.9	44.95±11.25		1-5; p=0.039
Worker	68	14.1	47.11±13.58		2-4; p=0.004
Officer	23	4.8	52.52±16.04		2-5; p=0.036
Self-employment	12	2.5	52.33±7.15		4-7; p=0.018
Retired	32	6.6	48.00±13.39		
Unemployed	156	32.4	46.41±11.28		
Total	482	100	46.46±11.64		

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; BMI: Body mass index; n: Number; SD: Standard deviation; p value was estimated using t-test or one-way ANOVA.

*In each line, different superscripts indicate statistically significant difference between groups (p<0.005).

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Malocclusion was seen in 61.20% of the participants. The comparison of the QoL scores of the participants according to their malocclusion status was given in Table 2. There was no significant difference between OHRQoL-UK total scores and OHRQoL-UK domain scores between those with and without malocclusion. The main types of malocclusion seen in the participants are shown in Table 3. Overbite (n=72), underbite (n=60), open bite (n=44) and cross-bite (n=43) are the most common types of malocclusion, respectively. There was no significant difference between OHRQoL-UK scores of the participants according to the malocclusion types.

Parafunctional habits were observed in 13.27% of the participants: Nail biting (n=36), finger biting (n=12), nail- biting and finger biting (n=8), lip biting (n=4), pencil-eraser biting (n=4). The comparison of the QoL scores of the participants according to their parafunctional habits was given in Table 4. There was no significant difference between OHRQoL-UK total scores and OHRQoL-UK domain scores between those with and without parafunctional habits.

Of the participants, 75.31% stated that they had SB or awake bruxism. The comparison of the QoL scores of the participants according to their bruxism

TABLE 2: Comparison of OHRQoL-UK scores according to malocclusion status of participants.

OHRQoL-UK	Total (n=482)	No malocclusion (n=187)	Malocclusion (n=295)	p values
	Mean±SD	Mean±SD	Mean±SD	
1. Symptoms	5.19±1.74	5.26±1.63	5.14±1.81	0.477
2. Physical state	14.30±4.14	14.61±4.60	14.11±3.81	0.214
3. Psychological status	14.91±4.09	15.38±4.59	14.61±3.72	0.055
4. Social situation	12.09±3.36	12.25±3.58	12.00±3.21	0.415
Total score	46.46±11.64	47.26±12.94	45.96±10.73	0.254

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; n: Number; SD: Standard deviation; p value was estimated using t-test.

TABLE 3: Comparison of OHRQoL-UK sum scores of malocclusion types.

Malocclusion types	n	%	OHRQoL-UK		p value
			Mean	SD	
Open-bite	44	14.91	47.36	7.803	0.121
Over-bite	72	24.40	46.83	9.845	
Cross-bite	43	14.57	45.11	14.167	
Protrusion	16	5.42	43.75	11.601	
Under-bite	60	20.33	47.80	10.673	
Diastema	24	8.13	46.66	15.136	
Crowded teeth	36	12.20	41.00	4.000	
Total	295	100	46.46	11.642	

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; n: Number; SD: Standard deviation.

TABLE 4: Comparison of OHRQoL-UK scores according to parafunctional habitual status of participants.

OHRQoL-UK	Total (n=482)	No parafunctional habits (n=418)	Parafunctional habits (n=64)	p values
	Mean±SD	Mean±SD	Mean±SD	
1. Symptoms	5.19±1.74	5.19±1.78	5.18±1.47	0.985
2. Physical state	14.30±4.14	14.25±4.15	14.62±4.12	0.510
3. Psychological status	14.91±4.09	14.87±4.11	15.18±4.00	0.565
4. Social situation	12.09±3.36	11.98±3.47	12.87±2.41	0.051
Total score	46.46±11.64	46.25±11.73	47.87±11.01	0.300

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; n: Number; SD: Standard deviation; p value was estimated using t-test.

status is given in [Table 5](#). There was a significant difference in both OHRQoL-UK total scores and OHRQoL-UK domain scores between those with and without bruxism ($p<0.005$). The total QoL scores of those without bruxism (49.29 ± 10.629) were found significantly higher than those with bruxism (45.54 ± 11.82).

Of the participants, 65.97% were chewing unilaterally. The comparison of the QoL scores of the participants according to the preference of the chewing side is given in [Table 6](#). There was no significant difference in both the OHRQoL-UK total scores and the OHRQoL-UK domain scores between those who chew bilaterally and those who chew unilaterally.

TABLE 5: Comparison of OHRQoL-UK scores according to sleep bruxism of participants.

OHRQoL-UK	Total (n=482) Mean±SD	No bruxism (n=119) Mean±SD	Bruxism (n=363) Mean±SD	p values
1. Symptoms	5.19±1.74	5.37±1.91	5.12±1.68	0.001*
2. Physical state	14.30±4.14	15.03±3.80	14.06±4.22	0.027*
3. Psychological status	14.91±4.09	16.04±4.24	14.54±3.98	0.001*
4. Social situation	12.09±3.36	13.17±2.99	11.74±3.40	0.000*
Total score	46.46±11.64	49.29±10.62	45.54±11.82	0.002*

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; n: Number; SD: Standard deviation; p value was estimated using t-test.

*In each line, different superscripts indicate statistically significant difference between groups (p<0.005).

TABLE 6: Comparison of OHRQoL-UK scores according to chewing-side preference of participants.

OHRQoL-UK	Total (n=482) Mean±SD	Bilateral (n=164) Mean±SD	Unilateral (n=318) Mean±SD	p values
1. Symptoms	5.19±1.74	4.97±1.91	5.30±1.68	0.052
2. Physical state	14.30±4.14	13.97±3.80	14.47±4.22	0.180
3. Psychological status	14.91±4.09	15.02±4.24	14.85±3.98	0.668
4. Social situation	12.09±3.36	12.04±2.99	12.12±3.40	0.812
Total score	46.46±11.64	46.02±10.62	46.69±11.82	0.548

OHRQoL-UK: Oral Health Related Quality of Life-United Kingdom; n: Number; SD: Standard deviation; p value was estimated using t-test.

DISCUSSION

TMDs may have a negative effect on the QoL and, in particular, on the QoL associated with oral health, a multi-dimensional term that encompasses the subjective evaluation of the physical, psychological, and social dimensions of oral health perceived.²² Malocclusions may be related to several functional problems such as TMDs and facial pain, not just with esthetic deficiency. Malocclusion's self-perceived effect can vary between individuals and is associated with impaired OHRQoL.^{23,24} In this study, the variation in OHRQoL and sociodemographic characteristics were investigated in patients with TMD. On the other hand, the effect of malocclusion and parafunctional habits on QoL in patients with TMD was examined. To our knowledge, this study is the first literature study investigating the effect of malocclusion and parafunctional habits on QoL in patients with TMD using the OHRQoL-UK scale.

Malocclusions are very common in society and can impair the physical, social and psychological func-

tions of people. A previous study reported that more severe malocclusion had a greater impact on people's QoL.²⁵ de Oliveira and Sheiham stated that malocclusions could impair OHRQoL in TMD patients.²⁶ Contrary to their study findings, in the current study, there was no statistically significant difference in OHRQoL-UK scores between TMD patient groups with and without malocclusion. Furthermore, there was no significant difference in OHRQoL-UK scores between different malocclusion types. The source of this difference may be that the patients in the previous study were patients who received orthodontic treatment and may think that malocclusion impairs facial appearance. TMD patients in this study did not have severe malocclusions and therefore their impact on the QoL of the patients, especially in social and psychological dimensions, may have been minimal. Araki et al., similar to the results of this report, found that the existence of malocclusion per se is not importantly linked to OHRQoL.²⁷ Sardenberg et al. reported that anterior overjet and anterior crossbite were importantly linked to OHRQoL in school children in Brazil.²⁸ Su et al. suggested that either the total OHIP-

14 score or any OHIP-14 domain score was not substantially correlated with malocclusion.²⁹

There can be a wide range of causes of temporomandibular disorders, the most common of which are: parafunctional behaviors, occlusal disharmony, trauma and microtrauma, imbalance of posture, stress, anxiety, and abnormal physiological conditions.³⁰ Some studies have found positive associations between parafunctional habits and temporomandibular disorders, while others have not.³¹ Michelotti et al. stated that there is an association between temporomandibular disorder and parafunctional habits.³² According to the study of van der Meulen et al., no significant correlations could be found between oral parafunctional behaviors and facial pain in TMD patients.³³ Antoun et al. reported that there was no significant difference in OBC scores of hyperdivergent and normodivergent individuals.³⁴ In this study, there was no statistically significant difference in OHRQoL-UK scores between TMD patient groups with and without parafunctional habit.

Bruxism has two circular manifestations that can occur during sleep (called SB) or wakefulness (called awake bruxism).¹² Bruxism and chewing side preference are believed to play a role in the etiology of TMDs, as muscle tension can increase the burden of TMJ. However, the relationship between bruxism and chewing side preference with the symptoms of TMD is controversial.²⁹ In the present study, CSP was not related to the OHRQoL in TMD patients. Contrary to the findings of this study, it was reported that the frequency of CSP increased significantly in patients with unilateral TMJ pain in a previous study. Su et al. found that CSP was related to both the OHIP-14 total score and the psychological and social dimensions of OHIP-14 in TMD patients.²⁹ These differences may be due to the fact that the studies were conducted in different populations and different measurement tools were used.

SB and CSP, which may occur in relation to psychological reasons, may cause muscle and joint pain in the temporal region.¹⁸ It is noteworthy that in a previous similar study, AB was closely related to all OHIP-14 dimensions while SB was not associated with physical pain dimension.²⁹ AB was found to be associated with craniofacial pain in a large-scale study of Swedish subjects.³⁵ In this study, consistent with the literature, both the OHRQoL-UK total scores and all OHRQoL-UK

domain scores of TMD patients with bruxism were significantly lower than those of TMD patients without bruxism. The findings of this study confirm previous data that bruxism is related to the physical, psychological, and social dimensions of OHRQoL.

This study has some limitations. The study included TMD patients and the results do not represent the general population. Participants' habits such as bruxism, parafunctional habits and chewing side preference were entirely based on their own self-reports. The diagnosis of bruxism was made by a professional clinician on the basis of clinical diagnostic criteria for SB, as defined by the American Academy of Sleep Medicine.¹² Sleep laboratory evaluation is needed to establish a definitive diagnosis of SB, but it is costly and inaccessible for large samples. The strengths of our study are that it was conducted in the large TMD sample group and it was the diagnosis TMD after the DC/TMD diagnostic criteria, which are accepted as the gold standard. In addition, the diagnosis of malocclusion was done using an international standard, i.e., the DAI.

CONCLUSION

According to the findings of this study, while bruxism was associated with OHRQoL in TMD patients, malocclusion, chewing side preference and parafunctional habits were not found to be associated. More longitudinal cohort studies are required on the effects of malocclusion and parafunctional habits in terms of their physical, social and psychological

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

This study is entirely author's own work and no other author contribution.

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