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Original article

COMPARATIVE STUDY ON THE EVALUATION OF TEMPOROMANDIBULAR JOINT AND NECK STRUCTURES IN HEALTHY VOLUNTEERS AND IDIOPATHIC SCOLIOSIS PATIENTS

Benli Merve,[1] Gokcen-Rohlig Bilge,[1] Akgül Turgut,[2] Evlioglu [illegible]nser

[1] Department of prosthodontics, Faculty of dentistry, Istanbul University, Ista[illegible] Tur[illegible]
[2] Department of orthopaedics and traumatology, Istanbul Faculty of medicine, Ista[illegible]anbul, Turkey

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Abstract: **Objective:** The aim of this study was to investigate the correlation of temporomandibular joint disorders (TMD) and neck structure changes in adolescents with idiopathic scoliosis (IS) by clinical examination. **Material and Methods:** The study included 51 patients affected by IS (24 males, 27 females; mean age: 13.5 ± 2.1 years) selected using simple random sampling, and a healthy control group of 50 subjec[illegible] (23 males, 27 females; mean age: 14.5 ± 2.3 [illegible]rs). The Diagnostic Criteria for Temporomandibu[illegible] Di[illegible]orders: Clinical Protocol and Assessment [illegible]stru[illegible]s (DC/TMD) form was utilized to assess[illegible]igns a[illegible] symptoms of TMD in the subjects. For the e[illegible]ation of neck structures, masseter and [illegible]mporalis mu[illegible]es, pressure pain threshold (PPT) va[illegible] wer[illegible]easured with a hand-held pressure [illegible]ometer. Obt[illegible]ed data were analyzed statistically a[illegible]y Mann Whitney U test, Wilcoxon, and chi-square[illegible] a significance level of 0.05. **Re[illegible]ts** [illegible]ccor[illegible]g to the DC/TMD form, the following [illegible] showed statistically significant diff[illegible]ices b[illegible]en the groups ($p \leq 0.001$): presence of [illegible] mpora[illegible]eadache, midline deviation, and [illegible]t and le[illegible]teral movements. The PPT values we[illegible]igh[illegible] in the control group compared with the study g[illegible]p (p [illegible]0.001). Additionally, the type of p[illegible]-re[illegible]ed T[illegible]identified in the subjects was myalgi[illegible]lgia was significantly ($p < 0.001$) higher in the [illegible]dy group (68.6%) than in the control group (22%). **Conclusion:** This study concluded that spinal diseases which cause postural changes, like IS, in the head and shoulder region are associated with muscle adaptation and alterations in the temporomandibular joint area.

Key words: Temporomandibular disorders, scoliosis, headache, pain, myalgia.

INTRO[illegible]TIO[illegible]

The influe[illegible] of [illegible]nal deformities on temporomandi[illegible]joint [illegible]rders (TMD) is a current topic with no [illegible]ns[illegible]as of yet. Temporomandibular disorders (TM[illegible] have a multifactorial etiology, and the [illegible]idelines o[illegible]e American Academy of Orofacial Pain ha[illegible]roposed a link between cervical spine disorders [illegible]d [illegible]D. Recent literature investigates the etiologic fa[illegible]s of TMD and the link between different postural [illegible]nomalies and spinal diseases. Since idiopathic scoliosis (IS) is a common cervical spinal disease, the possible association between disease-induced postural changes and TMD poses a question in the minds of researchers.

The symptoms of TMD are headache, joint sounds, pain, alterations in functional dynamics, limitation of mandibular movements and other changes in muscle tonus (1). Although pain and restriction of the mandibular opening are the main complaints of TMD, these may be accompanied by muscle tiredness, deviation in the spine axis and consequently, postural problems (2). Postural problems contributing to the development of dentofacial anomalies may lead to a chronic influence on head posture over the long term (3, 4). A study by Kondo et al. demonstrated that changes in head posture can cause structural deformities in TMJ or TMD (5). These findings, which are also present in scoliosis, raise the question of whether this disease is related to TMD or not. However, there is not sufficient data in the literature.

The most well-known type of IS is right convex dorsal scoliosis, which belongs to the non-balanced types and causes a left-inclined head position with postural changes. The literature notes that bad posture influ-

ences the muscles and tendons and affects mandibular position, concluding that alterations in the TMJ region may be associated with joint dysfunction. Some studies in the literature have indicated that postural alterations of the head and cervical spine function over burden the TMJ and are treated as a causal agent of TMD, while others did not demonstrate any relevance, therefore highlighting the need for further studies on this issue (6-9).

AIM

In the above-mentioned contradictory situations, it seems that current studies in the literature has not evaluated the possible relationship between IS and TMD. Therefore, the present study aims to answer this question and collect data for further studies related to this topic. The null hypothesis is that IS is associated with the presence of TMD and changes in neighboring structures.

MATERIAL AND METHODS

Study sample

The Ethics Committee of the Istanbul University Faculty of Dentistry approved this research under protocol number 2017/49 and the research was conducted in accordance with the Helsinki Declaration of 1975. Subjects attending the study received detailed formal information about the procedures, and their caregivers provided written informed consent for participation. Based on a preliminary pilot study, a power analysis was performed using G*Power (v3.1.7) to determine the essential sample size required to achieve a minimum 80% power with an alpha error probability of 5%, this generated a sample size of at least 26 participants. Authors decided to increase the number of participants as it was not difficult to reach a large number of patients and healthy controls in the institution where the study was conducted. Accordingly, initial sample size was increased to 50 per group so the authenticity and results of the study could be improved. Power calculations were performed based on the new sample size. A simple random sampling from a list which included more subjects was used to recruit participants for the study.

Protocol

The present study was conducted in the Department of Orthodontics, Faculty of Dentistry, Istanbul University, Istanbul. The total sample size consisted of 101 subjects between the age of 10–17 years. Included in the study were 51 patients affected by IS (24 males, 27 females; mean age: 13.5 ± 2.1 years) and a healthy control group of 50 subjects (23 males, 27 females; mean age: 14.5 ± 2.3 years).

All the subjects had to meet the following inclusion criteria: diagnosis of IS (for the experimental group), under 18 years of age, absence of pregnancy, absence of spontaneous pain (myogenous pain at rest or without preciseconditions), good general health based on medical history, absence of trauma which could affect postural position, absence of distinct postural problems, absence of dentofacial deformity, absence of ongoing orthodontic treatment or former orthodontic treatment in the past 3 years, and the absence of neurological disorders. Subjects with congenital or acquired skeletal abnormalities, earache or headache, temporomandibular disorders, were undertaking any physiotherapy for postural alteration or had back surgery were excluded from the study due to possible impact on the results.

In the study group, 28 patients with diagnosed IS were referred by the Department of Orthopaedics and Traumatology, Istanbul Faculty of Medicine, Istanbul University. Seven of the patients were excluded from the study, as two of them had ongoing orthodontic treatment and five had back surgery for scoliosis treatment. The remaining patients (mean age: 13.5 ± 2.1 years) and the control group underwent a TMD clinical diagnosis according to Diagnostic Criteria for Temporomandibular Disorders: Clinical Protocol and Assessment Instruments (DC/TMD) with a focus on the criteria of axis I. For the evaluation of muscles, upper trapezius muscle and SCM (sternocleidomastoid muscle) were added to the clinical examination during examination as ažsupplemental muscle group' upon complaints of the subjects. Using these criteria, individual records of each subject examined were created and data records obtained to investigate the effect of clinical status on the possible relationship of IS and TMD.

In addition to the DC/TMD protocols, pain of the head and neck muscles during clinical examination was assessed by obtaining pressure pain threshold (PPT) measurements taken from the points listed in Table 1 with a hand-held algometer (Force Dial model FDK 40 Push Pull Force Gage; Wagner Instruments, Riverside, CT, USA). The PPT was bilaterally assessed by applying pressure to the lateral pole and around the lateral pole of TMJ and the following four muscles for three consecutive series in a random sequence: masseter, temporalis,

Table 1. *Anatomical sites of PPT (pressure pain threshold) assessment of evaluated muscles*

Evaluated muscle	Segments
Masseter	Origin, body, and insertion
Temporalis	Anterior, middle, and posterior
SCM†	Upper, middle, and lower
Upper trapezius	Midpoint between C7 and acromion

SCM†: sternocleidomastoid muscle

SCM, and upper trapezius. During muscle evaluation, the most sensitive points in those areas were measured and average values were used for analysis. The blinded examiner was trained to apply a steady pressure of 1 kg/cm^2/s with optimal positioning of the algometer vertically to the evaluated surfaces. A 90.8% specificity value was used to determine the appropriate PPT cut off values for all muscles studied. The examination of the above mentioned muscles was applied extraorally by the same examiner and the interval rate between the examination of the right and left sides was five seconds (10). A digital metronome was used in all evaluations to supply an audio feedback and standardize testing speed for the examination. Participants were informed that the aim of the study was to define the pain threshold and they were asked to report when they first felt pain. All participants were trained formally on the the nar area of the right hand with a first assessment at the beginning of the study.

All the data obtained from the tests were collected and separate files were prepared for each subject.

Statistical tests

The IBM SPSS V23 software package (IBM Corp., Armonk, NY, USA) was used for data analysis. Data normality was confirmed by the Shapiro-Wilk test. The Mann-Whitney U test and Wilcoxon tests were used fo comparison of data with non-normal distributions. To evaluate the qualitative variables, the chi-squared test was performed. Quantitative data that do not correspond to normal distribution are presented as median (min-max) and qualitative data are shown as frequency (percent). Significancelevels were set at $p < 0.05$.

RESULTS

Resulting PPT values were higher in e control group compared with the study group, as fie y the statistically significant difference between t vo g ups ($p < 0.001$).When the right and ft mean v of the groups were analyzed for intragr eval ation, a statistically significant differe e as not tempo-ralis muscle (right-left: 3.6 k /cm^2 [kg/f/cm^2– 4.1 kg/f/cm^2] - 3.1 kg/f/cm^2 9 k m^2 3.6 kg/f/cm^2] and TMJ (right-left: 7 kg m^2 [2.9 kg/f/cm^2 – 4.2 kg/f/cm^2] - 2.9 kg/f [2.1 kg n^2– 3.3 kg/f/cm^2]) in the control group ($p < 0.$) (Table 2).

Protrusi vement, ain-free opening, maximum unassi and incisal overjet and overbite sh ed no istically significant difference between t and ontrol groups ($p > 0.05$). However, midl ion was slightly higher in subjects with IS (2 [1 mm – 3 mm]), and the IS group had r right-left lateral movement values (5 mm [2 mm

Table 2. *PPT (pressure pain threshold) val es ato al structures assessedwithan algometer*

	Co ol Medi (Mi um aximum) (kg/f/cm^2)	Study Median (Minimum-Maximum) (kg/f/cm^2)	p*
Right temporalis	(2.1–4.1)	1.2 (1–1.3)	< 0.001
Left temporalis	3.1 (2.9–3.6)	1.2 (1–1.3)	< 0.001
p**	< 0.001	0.083	
Right masseter	3.2 (0.7–4)	1.2 (1–1.3)	< 0.001
Left masseter	3.3 (2.3–4)	1.2 (0.6–1.5)	< 0.001
p**	0.051	0.797	
Right TMJ‡	3.7 (2.9–4.2)	1.2 (0.7–1.5)	< 0.001
Left TMJ‡	2.9 (2.1–3.3)	1.2 (0.8–1.2)	< 0.001
p**	< 0.001	0.476	
Right t apezius	3.7 (2.5–4.1)	1.2 (0.6–1.5)	< 0.001
L per s	3.7 (2.8–4.1)	1.1 (0.8–1.3)	< 0.001
p**	0.730	0.960	
Rig CM†	3.1 (2.5–3.9)	1.1 (0.5–1.3)	< 0.001
Left SCM†	3.1 (2.–3.9)	1.1 (0.5–1.3)	< 0.001
p**	0.355	0.959	

SCM†: sternocleidomastoid muscle
TMJ‡: Lateral pole and around lateral pole of temporomandibular joint
* Mann-Whitney U test
**Wilcoxon test

Table 3. *Descriptive statistics of study measurement values*

	Control Median (Minimum-Maximum) (mm)	**Study** Median (Minimum-Maximum) (mm)	p*
Incisal overjet	2 (1–10)	2 (1–5)	0.716
Incisal overbite	2 (0–4)	3 (0–5)	0.590
Midline deviation	0 (0–3)	2 (1–3)	< 0.001
Right lateral movement	7 (4–8)	5 (2–8)	0.001
Left lateral movement	7 (2–8)	5 (3–8)	0.00
Protrusive movement	5 (2–6)	4 (3–7)	0.
Pain-free opening	45 (40–58)	45 (32–	.911
Maximum unassisted opening	45 (40–58)	45 (34–)	0.563

* Mann-Whitney U test

Table 4. *Comparison of t qualitative data (Frequency-%)*

	Control	**Study**	p*
Pain disorders			
None	39 (78)	16 (31.4)	< 0.001
Myalgia	11 (22)	35 (68.6)	
Location of headache			
None	41 (82)	32 (62.8)	< 0.001
Temporal	9 (18)	19 (37.2)	

* Chi-squared test

– 8 mm], 5 mm [3 mm – 8 mm]) than the healthy control group (7 mm [4 mm – 8 mm] [illegible] mm [2 mm – 8 mm]) by a significant difference (p < 0.001) (Table 3).

The type of pain-related TMD identified in the groups was myalgia. The myalgia was significantly higher in the IS group (68.6%) than the control group (22%) (p < 0.001) (Table 4).

Temporal headache results were higher in the IS group (37.2%) compared with the control group (18%), as confirmed by the statistically significant difference between the two groups (p < 0.001) (Table 4).

DISCUSSION

The study was performed to gain a deeper insight into the effects of characteristic features of IS on TMD, and to contribute to the scarce amount of data about this topic. The findings obtained in the current study are original,as no specific study has been conducted on patients with idiopathic scoliosis regarding TMD.

According to the DC/TMD examination form of axis I assessment, statistically significant differences were found between the values of the study and control groups for the following parameters: presence of TMD (pain disorders), PPT values, temporal headache, midline deviation, and right lateral movements. Findings show these changes in idiopathic scoliosis patients may play a predisposing role in TMD and in changes to incorporated structures, thus, the null hypothesis can be accepted. Whether measurements of incisal overjet and overbite, protrusive movements, mandibular opening pattern, and right and left TMJ disorders were approximately equal, and there were no statistically significant differences. When examining the values of midline deviation, lateral movements, incisal overjet and overbite, it was discovered that the obtained numerical values in the study group were in accordance with a previous study in literature (11). Pain-free opening 45mm (32 mm – 55 mm) and maximum unassisted opening 45 mm (34 mm – 55 mm) values were in the normal range for the study group and showed no signiWcant differences between groups (12). These parameters, investigated in the current study, can be used during routine TMJ examination in clinics and are practical in terms of early diagnosis and the need for early treatment options for TMD.

In the literature, a variety of results have been reported regarding body posture-TMD correlation. Some studies found a correlation between body posture and TMD, while others did not state any kind of relationship (9, 13-17). In this respect, some researchers support the theory that the forward-inclined head position and the dislocated center of gravity could be a risk factor in TMD development; others report that a laterally inclined head position loads the joint area asymmetrically and this situation leads to mandibular deviation (4, 5). The same variational situation is also described in reports of pediatric patients and postural changes (18). This group of patients with IS were chosen to perform this study because they have precise postural changes on the frontal plane. According to the present study, the obtained values of midline deviation, asymmetrical characterization of lateral movement ranges, PPT values, and temporal headache

parameters seem to support the null hypothesis regarding the relationship between IS and the presence of TMD and changes in neighboring structures. This data suggests the possibility of development of unilateral dentofacial deformities or TMD in this patient group.

The data obtained in the study indicates patients with IS are more likely to have muscular disorders than any other TMD type. While 68.6% of the subjects in the study group had pain-related TMD, this was 22% in the control group ($p < 0.001$) (Table 4). PPT values for the examined muscles showed a statistically significant difference between groups ($p < 0.001$) (Table 2). The results of the present study show lower PPT values for the study group; this suggests that the patient group is more prone to have pain in the evaluated muscles than the control group. Another supporting finding is that 37.2% of the IS group had temporal headaches, as opposed to 18% of the control group ($p < 0.001$) (Table 4). These can be attributed to idiopathic scoliosis-related postural changes or resulting reactions from the adaptation of the surrounding tissues. Thus, the involvement of muscles in IS isan important factor in terms of TMD and postural changes and indicates the importance of muscle examination for both orthopedists and dentists during clinical examinations in daily practice.

The findings of the present study can be supported by the recent study from Nota et al.,demonstrating the role of muscles in the appearance of TMD (19). Another literature in agreement with the present studyis that of al.,which includes the evaluation of scoliosis patients and shows 21.42% of the scoliosis group pathological symptoms of TMJ, in comparison to another study group with Scheuermann's disease that research did not mention the type of TMD or any symptoms (11). Furthermore, the results of the present study support the hypothesis of Deriu et al. that the presence of oligosynaptic and polysynaptic relations between the vestibular labyrinth and masticatory muscles (named vestibulo-masticatory) can be considered a potential relationship between myogenous and postural disorders, rather than arthrogenous ones (20). However, this hypothesis is thought to be speculative and could not be proven due to the limited findings.

Based on previous studies, opinions differ in terms of correlation between postural alterations and TMD. If this correlation exists, the relationship between postural alterations and TMD is still not clearly explained. This theory is inconsistent with the study by Rocha et al., as they found no significant differences in posture-TMD correlation between subjects with and without unilateral disc displacement of joints by explaining these findings as habitual daily postures or functional adaptations like compensatory cervical extensions (9). However, they admit that the uncoordinated actions of forces can contribute to a change in the center of mass and cause imbalance in the musculoskeletal system. IS leads to changes in the center of mass on the frontal plane by the characteristic right/left tilted head position and resulting postural balance problems, which may also take place in TMJ, as this change occurs in the whole body. From this point of view, the findings of the present study are in accordance with the literature and indicate postural changes caused by idiopathic scoliosis (IS) may play a role in increasing the risk of TMD by affecting TMJ and incorporated structures (9, 19). However, available information is insufficient to achieve a clear conclusion in this regard, and the topic needs further clinical long-term study.

Limitations of the study

As a suggestion for future researchers, we recommend taking into consideration the type of TMD in evaluating possible postural effects due to the multifactorial etiology and variety of clinical conditions. For this purpose, MRI assessment which is one of the limitations of this study can be utilized to detect the stage of TMJ and the type of TMD. This type of assessment would also be helpful in excluding false positives that occuras clinically asymptomatic TMD during the workflow. Another limitation of this study is that only the superior body quadrant was considered in the evaluation of posture-TMD correlation. Appraising whole body posture is recommended to reveal all possible effects of postural stability on the musculoskeletal system and TMD. Such an approach may be beneficial for both improving knowledge of the physiology of the postural change-TMD relationship and carrying out robust comparisons among studies in the literature, providing standardization in the methodology.

CONCLUSION

Within the limitations of the study, it may be concluded that a relationship can be found between craniocervical posture in the frontal plane and the presence of muscular TMD in IS patients. An original finding of the current study was that the spinal alterations may be a risk factor for pain disorders of TMJ. Therefore, patients with IS should be routinely monitored in terms of TMD and neck structure changes, and early measures should be taken to reduce the need for further treatment. In this regard, it becomes essential to improve rehabilitation and orientation programs for this group of adolescents with the aim of hindering possible future complications of TMD, improving quality of lifeand providing psychosocial and financial advantages. There is a need for further studies with a larger sample in order to reveal the relevance of this important factor in TMD diagnosis and to develop relevant scientific knowledge on this topic.

DECLARATION OF INTEREST

The authors declare that there are no conflicts of interest.

ABBREVIATIONS

DC/TMD — Diagnostic Criteria for Temporomandibular Disorders: Clinical Protocol and Assessment Instruments

IS — Idiopathic scoliosis
PTT — Pressure pain threshold
SCM — sternocleidomastoid muscle
TMD — Temporomandibular joint disorders
TMJ — Temporomandibular joint

Sažetak

KOMPARATIVNA STUDIJA PROCENE TEMPOROMANDIBULARNOG ZGLOBA I STRUKTURA U VRATU KOD ZDRAVIH VOLONTERA I KOD PACIJENATA KOJI BOLUJU OD IDIOPATSKE SKOLIOZE

Benli Merve,[1] Gokcen-Rohlig Bilge,[1] Akgül Turgut,[2] Evlioglu Gulumser[1]

[1] Department of prosthodontics, Faculty of dentistry, Istanbul University, Istanbul, Turkey
[2] Department of orthopaedics and traumatology, Istanbul Faculty of medicine, Istanbul University, Istanbul, Turkey

Cilj: Cilj ove studije bio je da se ispita povezanost poremećaja temporomandibularnog zgloba (TMD) i promena struktura u vratu kod adolescenata sa idiopatskom skoliozom (IS) kliničkim ispitivanjima. **Materijal i metode:** U studiju je uključen 51 pacijent oboleo od IS (24 muškarca i 27 žena; prosečne starosti: 13,5 ± 2,1 godina) koji su selektovani primenom jednostavne nasumične metode i zdrave osobe koje su činile kontrolnu grupu, koja se brojala 51 ispitanika (23 muškarca; 27 žena, prosečne starosti: 14, 2,3 godine). Dijagnostički kriterijumi za procenu temporomandibularnog zgloba: klinički protokoli procena instrumenata (DC/TMD) su korišćeni radi procene znakova i simptoma TMD kod ispitanika. Za procenu struktura vrata, inklinometar i digitalni miš su bili korišćeni. Merenje osetljivosti na pritisak (PPT) korišćenjem algometra. Dobijeni rezultati analizirani korišćenjem statističkog Mann-Whitney U testa sa vrednostima Hi kvadrat testa sa nivoom značajnosti $p < 0,05$. **Rezultati:** Prema DC/TMD formulari procenjeni parametri su pokazali statističku značajnu razliku između grupa ($p \leq 0,001$): prisustvo TMD, temporalne glavobolje, devijacije u odnosu na srednju liniju, levi i desni pokreti u stranu. PPT vrednosti su bile više u kontrolnoj grupi u poređenju sa grupom obolelih ($p < 0,001$). Štaviše, vrsta bolno-zavisnog TMD utvrđena je u pacijenata sa mijalgijom. Mijalgija je bila statistički značajno viša u grupi obolelih (68,6%) nego u kontrolnoj grupi (22%). **Zaključak:** U ovoj studiji je zaključeno da spinalni poremećaji koji uzrokuju posturalne promene, kao što su idiopatska skleroza, u regionu vrata i ramena su povezani sa mišićnom adaptacijom i promenama u regiji temporomandibularnog zgloba.

Ključne reči: temporomandibularni poremećaji, skolioza, glavobolja, bol, mijalgija.

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Correspondence to/Autor za korespondenciju
Dr. MerveBenli
İstanbul Üniversitesi Diş Hekimliği Fakültesi
Topkapı Mahallesi, Turgut Özal Millet Cd, 34093 Fatih/İstanbul
Phone: 0090 212 414 20 20/30362
Fax: 0090 212 531 22 30
E-Mail: benlimerve@hotmail.com