Original Article

The Association of Occlusal Factors with Masticatory Muscle Tenderness in 10- to 19-Year Old Turkish Subjects

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Abstract: The aims of this study were (1) to investigate the relationship between occlusal factors and masticatory muscle tenderness among 10- to 19-year-old (mean 14 years eight months) Turkish subjects and (2) to identify possible sex differences between them. The sample consisted of 716 individuals (355 male and 361 female subjects). Tenderness with palpation of masseter and temporalis muscles and functional manipulation of lateral and medial pterygoid muscles was registered. The examiners recorded the Angle classification bilaterally for molars, presence of anterior and posterior crossbites, excessive overjet, open and deep bites, functional shift, and severity of anterior crowding. Associations between the occlusal factors and muscle tenderness according to sex were evaluated with chi-square analysis. Statistically significant associations were found between masticatory muscle tenderness and all the investigated occlusal factors except posterior crossbite and functional shift. Masseter, medial, and lateral pterygoid muscle tenderness was higher in female subjects. Medial and lateral pterygoid muscle tenderness in Class I cases and masseter and medial pterygoid muscle tenderness in Class II, division 1 malocclusion cases were higher in female subjects ($P < .05$). In open-bite cases, medial pterygoid muscle tenderness ($P < .05$), in deep-bite cases, masseter ($P < .01$) and medial pterygoid ($P < .05$) muscle tenderness, and in excessive overjet cases, masseter muscle tenderness ($P < .05$) were also higher in female subjects. These results suggest that greater masticatory muscle tenderness in female subjects may contribute to the greater prevalence of temporomandibular disorders in them. (*Angle Orthod* 2004;75:40–46.)

Key Words: Muscle tenderness, Occlusal factors

INTRODUCTION

The etiology of intra- and extracapsular temporomandibular disorders (TMD) remains a subject of dispute, particularly with regard to the role of occlusion. Some studies on patient and nonpatient populations have found a significant correlation between malocclusions and signs and symptoms of TMD,[1–6] whereas others have not been able to substantiate these results.[7–10]

Several investigators have reported that the morphology of craniofacial skeletons correlates with forms of jaw muscles.[11,12] It has been shown that the chewing pattern is influenced by the presence of certain malocclusions, and that there is a relationship between facial shape and the electrical activity in the chewing muscles.[13] For example, activity in the masticatory muscles is generally higher in individuals with a rectangular face and lower in individuals with a large gonial angle, whereas hyperactivity in the middle and posterior temporalis muscle has been found on the affected side in patients with unilateral posterior crossbite.

The prevalence of occlusal factors in relation to TMD is common in the literature for various ethnic groups worldwide. However, only few studies have attempted to survey the occlusal factors in relation to masticatory muscle tenderness.[14,15]

According to the Pancherz,[16] children with Class II malocclusion exhibit an impaired muscle activity in comparison with children with normal occlusion. This is especially apparent with respect to the masseter muscle. Deep overbite and Class II, division 2 malocclusions are commonly cited factors in TMJ patient populations,[17,18] although the belief in their role is not accepted universally.[19] Deep bite is commonly said to be a cause of condylar displacement and masticatory muscle pain.[20–23] An increase in muscle tenderness has been reported associated with open bite in a study of children and young adults.[15] Riolo et al[15] indicated that

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Accepted: December 2003. Submitted: October 2003.

TABLE 1. Number of Female Subjects and Male Subjects by Age Group

	Age Groups (y)				
	10–12	13–15	16–19	Total	Mean Age
Female Subjects	129	144	88	361	14.6 ± 3.9
Male Subjects	125	106	124	355	15.0 ± 4.1
Total	254	250	212	716	14.8 ± 4.0

the relative frequency of muscle tenderness for cusp-to-cusp boy subjects was consistently greater than that for the Class I and Class II boy subjects for all ages. It has also been reported that the muscle coordination during functional movements is different in Class III malocclusion.[24]

With these considerations in mind, the aims of this study were to

- Investigate the relationship between occlusal factors (such as Angle classification of molars, anterior and posterior crossbites, excessive overjet, open and deep bites, functional shift, and anterior crowding) and masticatory muscle tenderness among 10- to 19-year-old Turkish subjects.
- Identify possible sex differences between female and male subjects.

MATERIALS AND METHODS

In the present study, 716 individuals (355 male and 361 female subjects) were selected randomly from four different schools in Konya, Turkey. The distribution of age for all participants is shown in Table 1. The following inclusion criteria were used for the selection of the sample: 10 years of age or older; all permanent first molars erupted; and Caucasian.

The examiners recorded the Angle classification bilaterally for molars, presence of anterior and posterior crossbites, excessive overjet, open and deep bites, functional shift, and severity of anterior crowding.

Anteroposterior molar relationship groups were established as (1) Class I, (2) Class II, division 1, (3) Class II, division 2, and (4) Class III on both sides. These classifications were mutually exclusive. The cases with the molars in one side being in Class I and on the other side in Class II or Class III relationship were excluded because of the difficulties of classification.

Crossbites were designated as either present or absent. Anterior and posterior crossbites were recorded as a single tooth or multiple teeth. No scissors bite was observed among all subjects. Overjet or the horizontal distance between the facial surface of the upper central incisors and the facial surface of the lower central incisors was recorded using a periodontal probe. Overjets exceeding six mm were recorded as extreme.

Similarly, overbites were established as (1) open bite (negative overbite), (2) deep bite (overbite greater than the lower incisor's crown height), and (3) overbite less than the total overlap of the lower incisor's crown.[15]

Functional shifts in the occlusion were recognized by deconditioning the subject's habitual biting pattern, thus making it possible to measure any functional shift of the mandible. In this way, any functional shift caused by an occlusal interference resulting in a reflex alteration in the movement pattern at the occlusal interface was detected. Deconditioning was accomplished using cotton rolls to separate posterior teeth for three minutes before any measurement of a functional shift was attempted. It was judged as a functional shift present or absent.

Crowding was estimated separately for the anterior segment of the maxillary and mandibular arches. Crowding was recorded as 0 = no crowding; 1 = mild (lack of space for less than half of the mesiodistal width of a tooth in a segment); 2 = moderate (lack of space for half or more of the width of one tooth but less than one tooth); and 3 = severe (lack of space for one tooth or more). Crowding was registered as being present if it was three mm and if it was at least one arch.

Symptoms of tenderness of the masticatory system were recorded on the basis of an anamnestic examination and a clinical examination. The tenderness with palpation of masseter and temporalis muscles and functional manipulation of lateral and medial pterygoid muscles was registered. Muscle tenderness of the anterior temporal, posterior temporal, and insertion of the temporal and superficial masseter was determined by palpation on both sides. Tenderness was graded as Score 0, if subject described no tenderness; Score 1, if the subject could feel the difference between the right and left sides or described little tenderness; Score 2, if described the palpation as painful; and Score 3, if pain gave rise to a palpebral reflex or guarding. Functional manipulation was carried out on the lateral and medial pterygoid muscle according to Okeson,[25] and the findings were graded in the same way as for the masseter and temporal muscles. During functional manipulation, all the information needed was obtained by having the patient open wide, protrude against resistance, clench the teeth together, and then bite on a separator. If a muscle was a true source of pain, functional manipulation is helpful in identifying this source.

The examinations were carried out by two trained investigators. The interobserver variability between two trained investigators was low, and the examination error seemed negligible.[26] Methods and criteria used in this study have been used as standard procedures in many other epidemiologic investigations and have been proved to be valid.[26]

All statistical analyses were performed using the SPSS software package (SPSS for Windows 98, version 10.0, SPSS Inc., Chicago, Ill). Differences in prevalence of masticatory muscle tenderness and occlusal factors and associations between masticatory muscle tenderness and occlusal factors were evaluated using the chi-square test (χ^2). Comparisons between the sexes were also performed. Val-

TABLE 2. Prevalence of Different Occlusal Factors Among 10- to 19-y-old Turkish Subjects

Occlusal Factors	Total (n)	%	Female Subject (n)	%	Male Subject (n)	%
Angle Class I	544	76	276	38.5	268	37.4
Angle Class II, division 1	112	15.6	53	7.4	59	8.2
Angle Class II, division 2	34	4.7	16	2.2	18	2.5
Angle Class III	26	3.7	16	2.2	10	1.4
Anterior crossbite	40	5.6	22	3.1	18	2.5
Posterior crossbite	70	9.8	36	5	34	4.7
Excessive overjet	126	17.6	63	8.8	63	8.8
Open bite	50	7	32	4.5	18	2.5
Deep bite	176	24.6	84	11.7	92	12.8
Functional shift	7	1	3	0.4	4	0.5
Anterior crowding	138	19.3	61	8.5	77	10.8

TABLE 3. Distribution of Masticatory Muscle Tenderness Among Different Occlusal Factors

	Muscles Tenderness (Score 1, Mild Tenderness)							
	Masseter		Medial Pterygoid		Lateral Pterygoid		Temporal	
Occlusal Factors	Female Subject (%)	Male Subject (%)	Female Subject (%)	Male Subject (%)	Female Subject (%)	Male Subject (%)	Female Subject (%)	Male Subject (%)
Angle Class I	22.21	19.69	7.68	4.61	11.87	8.94	8.52	8.38
Angle Class II, division 1	5.31	4.19	1.82	0.84	2.79	2.79	1.68	1.82
Angle Class II, division 2	1.40	1.26	0.42	0.42	0.98	0.56	0.28	0.56
Angle Class III	1.26	0.98	0.84	0.42	1.26	0.42	0.70	0.42
Anterior crossbite	1.96	1.54	0.98	0.84	1.12	0.98	1.26	0.84
Posterior crossbite	3.35	3.07	1.54	0.84	2.09	1.26	1.82	0.98
Excessive overjet	6.42	4.75	1.96	1.40	3.63	2.93	2.23	1.68
Open bite	2.79	1.26	1.68	0.28	1.96	0.84	1.68	0.56
Deep bite	8.52	6.42	2.51	1.40	4.61	4.05	2.23	2.51
Anterior crowding	5.45	5.87	1.96	1.40	3.63	3.35	2.37	3.21

ues of $P < .05$ were considered to indicate statistical significance.

RESULTS

The distribution of different occlusal factors in 10- to 19-year-old Turkish subjects is presented in Table 2. None of the subjects had severe masticatory muscle pain (Score 2, 3), whereas most of the scores were 1. The distributions of masticatory muscle tenderness according to the different occlusal factors are shown in Table 3.

The prevalence of masticatory muscle tenderness (Score 1, mild tenderness) was 56.25% among 10- to 19-year-old Turkish subjects. In general, 59.83% of female and 52.67% of male subjects had tenderness of the masticatory muscles. It appeared that the functional shift in this sample was quite rare (approximately 1% of the cases), therefore it was excluded from the statistical analyses.

There was an association between Angle Class I and lateral pterygoid muscle tenderness and Angle Class III malocclusion and medial pterygoid muscle tenderness ($P < .05$). Associations were also found between anterior crossbite with medial pterygoid and temporal muscle tenderness ($P < .05$); anterior crowding with lateral pterygoid and temporal muscle tenderness ($P < .05$); excessive overjet with masseter and lateral pterygoid muscle tenderness ($P < .05$); open bite with medial pterygoid muscle tenderness ($P < .05$); and deep bite with lateral muscle tenderness ($P < .05$) (Table 4). In general, medial pterygoid ($P < .01$), lateral pterygoid ($P < .05$), and masseter muscle tenderness ($P < .05$) were high in female subjects (Table 5).

Medial and lateral pterygoid muscle tenderness in Angle Class I cases and masseter and medial pterygoid muscle tenderness in Angle Class II, division 1 malocclusion cases were higher in female subjects ($P < .05$). In excessive overjet cases, masseter muscle tenderness ($P < .05$), in open-bite cases, medial pterygoid muscle tenderness ($P < .05$), and in deep-bite cases, masseter ($P < .01$) and medial pterygoid ($P < .05$) muscle tenderness were also higher in female subjects. Complete findings are presented in Table 6.

DISCUSSION

The prevalence of different occlusal factors or masticatory muscle tenderness has been noted in several reports.[1–10,12,14,15,27,35,37,38] Some of the prevalence studies exhibit methodological limitations and had a lack of specific diagnostic criteria, small or self-selected samples, and lack of developmental age-specific data. A study with standardized examination techniques, well-defined diagnostic crite-

TABLE 4. The Relationship Between Occlusal Factors and Masticatory Muscle Tenderness

	Muscles Tenderness (Score 1, Mild Tenderness)											
	Masseter			Med Pterygoid			Lat Pterygoid			Temporal		
Occlusal Factors	n	*P*	Significance	n	*P*	Significance	n	*P*	Significance	n	*P*	Significance
Angle Class I malocclusion	300	0.158	NS	88	0.164	NS	149	0.014	*	121	0.491	NS
Angle Class II, division 1 malocclusion	68	0.178	NS	19	0.553	NS	40	0.078	NS	25	0.553	NS
Angle Class II, division 2 malocclusion	19	0.548	NS	6	0.536	NS	11	0.425	NS	6	0.332	NS
Angle Class III malocclusion	16	0.367	NS	9	0.021	*	12	0.052	NS	8	0.205	NS
Anterior crossbite	25	0.259	NS	13	0.010	*	13	0.400	NS	15	0.019	*
Posterior crossbite	46	0.060	NS	17	0.067	NS	24	0.220	NS	20	0.123	NS
Excessive overjet	80	0.044	*	21	0.511	NS	47	0.025	*	28	0.538	NS
Open bite	29	0.460	NS	14	0.031	*	20	0.068	NS	16	0.068	NS
Deep bite	107	0.096	NS	28	0.370	NS	62	0.038	*	34	0.157	NS
Anterior crowding	81	0.295	NS	24	0.495	NS	50	0.038	*	40	0.026	*

NS indicates not significant; * $P < .05$

TABLE 5. The Relationship Between Sex and Masticatory Muscle Tenderness

	Muscles Tenderness (Score 1, Mild Tenderness)											
	Masseter			Medial Pterygoid			Lateral Pterygoid			Temporal		
	n	*P*	Significance	n	*P*	Significance	n	*P*	Significance	n	*P*	Significance
Female Subjects	216			77			121			80		
Male Subjects	187	.032	*	45	.001	**	91	.013	*	80	.488	NS[a]

[a] NS indicates not significant.
* $P < .05$; ** $P < .01$.

TABLE 6. The Relationship Among Occlusal Factors, Gender, and Masticatory Muscle Tenderness

		Muscles Tenderness (Score 1, Mild Tenderness)											
		Masseter			Medial Pterygoid			Lateral Pterygoid			Temporal		
Occlusal Factors		n	*P*	Significance	n	*P*	Significance	n	*P*	Significance	n	*P*	Significance
Angle Class I, malocclusion	Female Subject	159	0.139	NS[a]	55	0.011	*	85	0.043	*	61	0.509	NS
	Male Subject	141			33			64			60		
Angle Class II, division 1 malocclusion	Female Subject	38	0.019	*	13	0.038	*	20	0.410	NS	12	0.559	NS
	Male Subject	30			6			20			13		
Angle Class II, division 2 malocclusion	Female Subject	10	0.350	NS	3	0.611	NS	7	0.166	NS	2	0.389	NS
	Male Subject	9			3			4			4		
Angle Class III, malocclusion	Female Subject	9	0.391	NS	6	0.517	NS	9	0.184	NS	5	0.648	NS
	Male Subject	7			3			3			3		
Anterior crossbite	Female Subject	14	0.564	NS	7	0.592	NS	8	0.408	NS	9	0.436	NS
	Male Subject	11			6			5			6		
Posterior crossbite	Female Subject	24	0.531	NS	11	0.164	NS	15	0.139	NS	13	0.120	NS
	Male Subject	22			6			9			7		
Exessive overjet	Female Subject	46	0.021	*	14	0.075	NS	26	0.231	NS	16	0.260	NS
	Male Subject	34			7			21			12		
Open bite	Female Subject	20	0.287	NS	12	0.044	*	14	0.339	NS	12	0.215	NS
	Male Subject	9			2			6			4		
Deep bite	Female Subject	61	0.002	**	18	0.044	*	33	0.179	NS	16	0.542	NS
	Male Subject	46			10			29			18		
Anterior crowding	Female Subject	39	0.174	NS	14	0.096	NS	26	0.113	NS	17	0.474	NS
	Male Subject	42			10			24			23		

[a] NS indicates not significant, * $P < .05$; ** $P < .01$

ria, and a large representative sample would help to substantiate the prevalence of disorders in children.

In a study by Bush,[27] nearly 300 dental students were examined for muscle tenderness and various occlusal contacts, and he reported only mild masticatory muscle tenderness. In the present study, none of the subjects had severe masticatory muscle pain (Score 2, 3), whereas most of the scores were 1, in accordance with Bush's findings.

Children with Class II malocclusion tended to have more masticatory muscle tenderness.[28] In adults, an association has been demonstrated between muscle tenderness and Class II malocclusion.[1] No relationship between muscle tenderness and Angle classification was found in one study.[25] Another indicated that neither Class II nor cusp-to-cusp molar relationships were statistically associated with muscle tenderness, whereas a significant interaction was found between molar relation, sex, and age and the odds of having muscle tenderness.[15] An autopsy study of young adults[13] showed that Class III malocclusions were associated with deviation in the normal form of the temporomandibular joint components, and this was associated with masticatory muscle tenderness. Surprisingly, instead of Angle Class II malocclusion, we found an association between Angle Class I and lateral pterygoid muscle tenderness and Angle Class III with medial pterygoid muscle tenderness.

It has been suggested that undue forces are placed on the masticatory muscles as a consequence of an unfavorable incisor relationship.[29] Studies have suggested that factors such as increased overjet and overbite and anterior open bite are likely to be predisposing factors rather than initiating factors in the production of masticatory muscle symptoms.[29] However, Seligman et al[30] found that overjet was not related to symptoms of TMJ sounds or to masticatory muscle tenderness in a young adult nonpatient population. In the present study, statistically significant relationships were found between increased overjet and masseter and lateral pterygoid muscle tenderness. Our results are not in agreement with the findings of Seligman et al.[30] In our study, a statistically significant relationship was found between open bite and medial pterygoid muscle tenderness, in agreement with Riolo et al.[15]

Pullinger and Seligman[31] found no associations between deep bite (overbite of five mm or more) and masticatory muscle tenderness, and our findings are not in agreement.[31] We found a statistically significant relationships between deep bite and lateral pterygoid muscle tenderness.

According to Riolo et al,[15] the relative frequencies of muscle tenderness were significantly lower among subjects with a functional shift (17%) than in those without (8%). A relationship between a functional shift and masticatory muscle tenderness was also found for both sexes and across all age groups in the same study.[15] However, in the current study, no relationship was found between functional shift and masticatory muscle tenderness for both sexes.

Ahlgren and Posselt[32] and Shaw[13] have described an association between crossbite and occlusal interferences in children. Shaw[13] reported that hyperactivity in the middle and posterior temporalis muscle was found on the affected side in patients with unilateral posterior crossbite. Egermark-Eriksson et al[28] indicated that children with crossbite were found to have muscle tenderness more often than children without crossbite, and there does not seem to be any difference in risk between unilateral and bilateral crossbite or between crossbite in premolar and molar segments.[33] Results of Egermark-Eriksson and Ingervall[33] agree with findings in adults by Mohlin et al.[19] However, no relationship was found between posterior crossbite and masticatory muscle tenderness in the present study. We found a statistically significant relationship between anterior crossbite and medial pterygoid and temporal muscle tenderness.

Rantanen[34] found 24% of 2218 undergraduate students to have some type of TMD, or other disturbances of mandibular movements, with symptoms more common in girls (30%) than in boys (18%). Currently, it is widely understood that TMD is multifactorial in nature and is more prevalent in girls than in boys.[3,35–38] Studies on the development of pain and tenderness in muscles or jaws also revealed higher frequencies in girls than in boys.[38–40] Therefore, with respect to masticatory muscle tenderness, it is of a great importance to examine the sex differences in muscle tolerance in relation to the occlusal factors.

In general, our findings indicated that medial pterygoid muscle tenderness, lateral pterygoid muscle tenderness, and masseter muscle tenderness were higher in female than in male subjects. These results are in agreement with the previous epidemiologic studies' results.[3,36–38] According to Riolo et al,[15] the relative frequencies of muscle tenderness for cusp-to-cusp boy subjects were consistently greater than those for the Class I and Class II boy subjects for all ages. The girl molar classification groups showed no systematic relationship across age. In the present study, medial pterygoid muscle tenderness was higher in female subjects for both Angle Class I and Class II, division 1, and with open bite. Medial pterygoid muscle tenderness was found in subjects with excessive overjet, and masseter muscle tenderness was found in a higher ratio in female subjects. Masseter and medial pterygoid muscle tenderness was also higher in female subjects with deep bite. The highest prevalence of female subjects classified with some degree of muscle tenderness associated with different occlusal characteristics may be related to typical physiologic differences of the feminine sex, such as regular hormonal variations, muscular structure, and different characteristics of the conjunctive tissue. These matters need to be investigated fully.

CONCLUSIONS

The prevalence of masticatory muscle tenderness (Score 1, mild tenderness) was found in more than 50% of 10- to

19-year-old Turkish subjects. This percentage seemed to increase with age and become higher in the adult population.

Statistically significant relationships were found between masticatory muscle tenderness and all investigated occlusal factors except posterior crossbite and functional shift. It appears that short-term reversible therapy is adequate to resolve most muscle problems in most children. Certainly, studies are needed to confirm these findings. Studies that evaluate the effectiveness of treatments need to be controlled for each specific diagnosis (ie, masticatory muscle disorders vs disc interference disorders).

Statistically significant sex differences were found between different occlusal factors and masticatory muscle tenderness. Medial and lateral pterygoid muscle tenderness in Angle Class I cases and masseter and medial pterygoid muscle tenderness in Angle Class II, division 1 malocclusion cases were higher in female subjects. In excessive overjet cases, masseter muscle tenderness ($P < .05$), in open-bite cases, medial pterygoid muscle tenderness ($P < .05$), and in deep-bite cases, masseter ($P < .01$) and medial pterygoid ($P < .05$) muscle tenderness were also higher in female subjects. These results suggest that greater masticatory muscle tenderness in female subjects may contribute to the greater prevalence of TMD in them.

At this time, there is no scientific documentation that early correction of malocclusion will prevent masticatory muscle or temporomandibular joint disorders. Well-controlled longitudinal studies are needed in this area.

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