ORIGINAL ARTICLE

Malocclusion as a risk factor in the etiology of headaches in children and adolescents

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Introduction: The purpose of this study was to determine the importance of occlusal factors in recurrent headaches in children and adolescents without other signs or symptoms of temporomandibular disorders or related craniomandibular disorders. **Methods:** A sample of 50 children and adolescents, ages 8 to16, who reported headaches was obtained from the University at Buffalo Orthodontic Clinic records; a control group of 50 children and adolescents, matched for age and sex, was also obtained. Plaster models, made during the routine collection of orthodontic records, were used to obtain the following occlusal trait measurements: Angle classification, overjet, anterior and posterior crossbite, scissors-bite, overbite, open bite, dental midline discrepancy, crowding, spacing, and dental development stage. **Results:** Overbite, overjet, and posterior crossbite showed statistically significant associations (chi-square) with increased risk for headaches. Logistic regression analysis demonstrated that overjet was a significant factor only because of its correlation with overbite and posterior crossbite. Overjet was not significant after adjusting for the other 2 variables, whereas overbite and posterior crossbite were associated with significantly increased risk (>3:1) of headache. The combination of 2 or more of these 3 occlusal factors increased the risk of headache even more (8.5:1). **Conclusions:** Posterior crossbite and overbite ≥5 mm were associated with significantly increased risk of headache in children and adolescents. (Am J Orthod Dentofacial Orthop 2007;132:754-61)

It is well accepted in the dental community that the etiology of temporomandibular disorders (TMD) is multifactorial. There has been much debate about which factors are and are not important in the development of TMD. Malocclusion has often been cited as a contributory factor in the development of TMD, but current literature shows contradictory results. In a review of the literature, we concluded that occlusion cannot be considered a unique or dominant factor in the development of TMD. The overall research shows a relatively low association between occlusal factors and TMD, and most dentists and specialists greatly overrate the influence of occlusion on TMD.[1,2]

The ideal occlusion described by orthodontists today—the criteria on which orthodontic case outcomes are judged—is derived from the studies of Angle[3] and Andrews.[4] These criteria focus on the specific anatomic relationships of the teeth and dental arches. A common belief among orthodontists is that the ideal static occlusion is compatible with an ideal functional occlusion.[3,4] This belief has led clinicians to suggest that occlusal discrepancies are a major etiological factor in the multifactorial origin of TMD and recurrent tension-type headaches.

The assumed strong association between TMD and occlusion has been a major reason that the diagnosis and treatment of these disorders fall within the scope of dentistry. Many TMD and headache therapies are based on this presumed connection, and dentists and specialists have used this connection to justify many treatment modalities, including occlusal appliance therapy, anterior repositioning appliances, occlusal adjustment, restorative procedures, and orthodontic/orthognathic treatment.[2]

Headaches are frequently the most reported symptoms of TMD in children and adolescents.[7,8] The correlation between recurrent tension-type headaches, TMD, and tenderness to palpation of the masticatory muscles has been well established.[9,10] This supports the theory that recurrent headache disorders in children and adolescents are most often of the muscle tension/contraction type. The relationship between tension-type headaches and TMD signs and symptoms might be because both conditions share the same pathophysiologic mechanisms that affect the trigeminal pain pathways to the central nervous system.[11-13]

Much like the data on TMD and malocclusion, specific occlusal factors have been identified as influencing the development of headaches. The occlusal

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factors found to have a statistically significant relationship to headache are similar to those for TMD.[1,2,14-16] These are unilateral posterior crossbite, anterior open bite, unilateral retruded cuspal position interference, lateral forced bite/balancing-side interference, Class II occlusion, and overjet greater than 6 mm. Headaches have also been strongly correlated to oral parafunctional habits such as clenching, grinding, nail biting, and lip or cheek biting.[16,17]

The relative importance of occlusion in relation to TMD and recurrent headaches is still questioned and debated, even though this area has been extensively studied in the orthodontic literature. The conclusions of these studies[1,2,14-16] indicate, in general, that occlusal factors are of minor etiological importance for pain and functional disorders in the masticatory system. However, these conclusions were all made in the context of research and patient populations centered on TMD signs and symptoms. Few studies have addressed malocclusion and headaches outside the TMD arena.

The purposes of this study were to evaluate and describe the relationship between malocclusion and headache in children and adolescents without signs and symptoms of TMD or other craniomandibular disorders to facilitate evidence-based therapies for the treatment of their headaches.

MATERIALS AND METHODS

The sample consisted of 2 groups, each containing 50 children and adolescents ages 8 to 16 taken from the patient records of the Orthodontic Graduate Program, State University of New York at Buffalo. The headache group and the control group each had 35 girls and 15 boys. The groups were well matched for age (average and range) and Angle classification (Table I).

The headache group was selected by reviewing the medical histories of all patients of the currently active and retention patients in the Department of Orthodontics of the University at Buffalo. A total of 1428 charts were examined; 1107 of the patients were 18 years of age or less. Patients with documented frequent headaches in their medical history were selected. Exclusion criteria included age over 18 years, dental stage (DS) 1, incomplete medical history, treatment for TMD, previous orthodontic treatment, history of prescription medication for headaches, diagnosed with or treated for migraine headaches by physician, history of neurological or craniofacial disorder, and head or neck trauma or surgery.

Thus, 54 patients were left in our headache group; 4 were later excluded because of incomplete orthodontic records. The final group included 50 patients (35 female, 15 male).

Table I. Descriptive statistics of study groups

	Headache group	*Control group*
Age		
Average	12 y 6 mo	12 y 9 mo
Range	8 y 6 mo-16 y 5 mo	9 y 0 m-16 y 7 mo
Dental classification		
Class I	10	14
Class II	32	32
Class III	8	4

The control group was selected from the same group of 1,428 patients. The sample was controlled to match sex with the headache group. Patients were selected if they had no history (previous or current) of headache. The same exclusion criteria were applied to the control group as to the headache group. The final control group was 50 patients, equally matched to the headache group for sex and closely matched for age and Angle classification.

Plaster models taken during orthodontic initial records collection for each patient were used to calculate Angle dental classification, maxillary overjet, mandibular overjet (reverse overjet), anterior crossbite, posterior crossbite, scissors-bite, overbite, open bite, dental midline discrepancy, crowding, spacing, and dental stage.

All mesiodistal tooth and arch-length measurements were made by 1 operator (C.L.) using a digital caliper accurate to 0.01 mm. The absolute measurements of each tooth and each arch-length segment were summed and reported to the nearest 0.5 mm. Overjet, overbite, and open bite were measured with a periodontal probe with 1-mm markings and calculated at the greatest point of discrepancy. These measurements were also reported to the nearest 0.5 mm. Midline discrepancy was measured with a millimeter ruler from the maxillary dental midline to the mandibular dental midline; no relationship to skeletal or facial midline was measured.

Crowding and spacing were calculated by measuring the space required for the teeth as the sum of the mesiodistal width of all teeth, measured from contact point to contact point.[18] The space available was calculated by dividing the dental arch into 4 straight-line segments, measuring each segment individually, and adding them together.[18] The space required was then subtracted from the total arch length (space available) to determine tooth size-arch length discrepancies.

In mixed dentition patients, the Tanaka and Johnston[19] prediction value equation was used to estimate the width of the permanent teeth still needing to erupt. The Tanaka and Johnston method uses the width of the 4 mandibular incisors to predict the size of the unerupted canines and premolars. This method is convenient because it requires no reference tables or radiographs.[18]

The Angle classification was determined by using the permanent first molars as the reference point. Anterior crossbite was defined as at least 1 maxillary incisor occluding lingually to the mandibular incisors. Posterior crossbite was defined when any mandibular posterior (including canine) buccal cusp occluded buccally to the maxillary buccal cusp. Scissors-bite was defined as a maxillary posterior tooth completely displaced to the buccal aspect, either not occluding with its mandibular antagonist tooth, or contact was made between the lingual surface of the maxillary lingual cusp and the buccal surface of the mandibular buccal cusp. All crossbite measurements were recorded as unilateral or bilateral.

The DS was classified according to the stage of dental development described by Bjork et al[20] using tooth eruption markers. The stages are defined as follows: DS1 (early mixed dentition) is when the incisors are erupting; DS2 (intermediate mixed dentition) is when the incisors have fully erupted; DS3 (late mixed dentition) is when the canines or the premolars are erupting; and DS4 (adolescent permanent dentition) is when the canines and the premolars have fully erupted.

After initial measurements were made on all 100 plaster models, 20 models (10 from each group) were selected again at random. All criteria were measured again and recorded for reproducibility tests to be performed.

Statistical analysis

Statistical analyses consisted of chi-square contingency table analysis for determination of associations between occlusal trait measurements and subject group. Univariate odds ratios (OR) are reported for comparison with the logistic regression analyses. Logistic regression enables the assessment of increased risk while adjusting for other potential risk factors. A significance level of $\alpha = 0.05$ (5%) was used for all tests. The assessments of reproducibility were made by using percent agreement for categorical variables. For continuous variables, the mean difference between replicate measurements and the Dahlberg standard deviation are reported.

RESULTS

Replicate assessments were made on 20 subjects, 10 from each group. All 20 subjects were judged to have the same Angle classification at each assessment, whereas 15 (75%) received the same DS identification.

Table II. Assessment of reproducibility for continuous measurements

Measurement	*Mean (mm)*	*SD*	*Dahlberg*
Overjet	−0.08	0.406	0.285
Overbite	−0.15	0.366	0.274
Midline	0	0.397	0.274
Mandibular crowding	−0.05	0.484	0.335
Maxillary crowding	−0.33	0.654	0.506
Mandibular spacing	0.15	0.671	0.474
Maxillary spacing	0	0.795	0.548

Mean, Mean of differences between replicate measurements, first – second; *SD,* sample SD, adjusted for sample mean; *Dahlberg,* SD unadjusted for sample mean.

For the continuous measurements, the Dahlberg standard deviation was calculated, and the results are included in Table II. along with the mean difference and the ordinary standard deviation.

The reproducibility of the measurements in this study was generally good. For overjet, overbite, and midline assessments, the Dahlberg standard deviation was less than 0.3 mm, indicating that most (within 3 SD) of the replicate measurements were within 1 mm of each other. The slightly higher values for crowding and spacing indicate that replicate measurements would be within 2 mm of each other.

An initial assessment was performed to determine whether DS or Angle classification was associated with the headache group. No association was found for either variable (DS: chi-square = 0.194, df = 2, P = .9076; Angle classification: chi-square = 2.000, df = 2, P = .3626).

The occlusal trait measurements were categorized into 2 groups: problem and no problem. The criteria for when a patient was considered to have an occlusal trait problem were identified by past research and reviews.[7-12] The values used in this study to identify problem traits were as follows: maxillary overjet ≥5 mm, mandibular overjet ≥0 mm, overbite ≥5 mm, open bite ≥0 mm, dental midline discrepancy ≥2 mm, crowding ≥2 mm, and spacing ≥2 mm.

For statistical purposes, patients with maxillary overjet ≥5 mm or mandibular overjet ≥0 mm were initially classified into 1 group as having an overjet problem. Similarly, patients with overbite ≥5 mm or open bite ≥0 mm were classified into 1 group as having an overbite problem. Every other occlusal trait was also reported individually as having a problem or no problem.

The assessment of an association between the problem and the occurrence of headaches was determined by contingency table analysis (Table III). All assessments, except crowding in the maxillary arch,

Table III. Results of the chi-square contingency table analyses

Problem	*Prevalence*		*Chi-square*	P *value*	*OR*
	Control group %	*Headache group %*			
Overjet	36	60	5.769	.0163	2.67
Overbite	34	60	6.784	.0092	2.91
Midline	26	36	1.169	.2797	1.60
Crowding					
Mandibular	44	56	1.440	.2301	1.62
Maxillary	52	52	0	1	1
Spacing					
Mandibular	14	20	0.638	.4245	1.54
Maxillary	12	14	0.088	.7662	1.19
Agenesis	8	16	1.515	.2184	2.19
Anterior crossbite	20	36	3.175	.0748	2.25
Posterior crossbite	18	38	4.960	.0259	2.79
Scissors-bite	2	6	0.260*	.6098	3.13

All tables are 2 by 2 resulting in 1 df, and there are 50 subjects in each group.
*Continuity correction factor used due to extremely low prevalence.

Table IV. Results of the chi-square contingency table analyses for separated conditions

Problem	*Prevalence*		*Chi-square*	P *value*	*OR*
	Control group %	*Headache group %*			
Overjet					
Maxillary	44 (21/48)	68 (28/41)	5.383	.0203	2.77
Mandibular	6 (2/29)	31 (9/22)	6.697*	.0097	9.35
Overbite					
Deep	30 (14/47)	56 (25/45)	6.251	.0124	2.95
Open	8 (3/36)	20 (5/25)	0.899*	.3430	2.75

All tables are 2 by 2 resulting in 1 df, but the number of subjects in each group depends on subjects with the opposite condition.
*Continuity correction factor used due to extremely low prevalence.

showed higher prevalence for headache in the sample group than in the control group. This was also seen in the ORs, which are all greater than or equal to 1.

Increased risks of headache were seen for overjet (chi-square = 5.769, df = 2, P = .0163, OR = 2.67), overbite (chi-square = 6.784, df = 2, P = .0092, OR = 2.91), and posterior crossbite (chi-square = 4.960, df = 2, P = .0259, OR = 2.79).

Because the initial definitions of overjet and overbite combined 2 conditions (maxillary and mandibular for overjet, open and deep for overbite) that might have individual relationships to the prevalence of headaches, separate analyses were done for each condition. In these cases, only those having a particular problem were compared with those with no problem, and, as a result, the group sizes were less than 50 subjects. The results are summarized in Table IV.

As shown in Table IV, the prevalence of the problem was higher in the headache group than in the control group for each condition. For overjet, the sample group had significantly increased risk of headaches (maxillary: chi-square = 5.383, df = 1, P = .0203; mandibular: chi-square = 6.697, df = 1, P = .0097) compared with the control group, even though a problem in the mandible is relatively infrequent. For overbite, the increased risk for the sample group was statistically significant for deepbite only (chi-square = 6.251, df = 1, P = .0124).

For the final analyses, we used logistic regression to investigate combinations of problems that were significantly associated with increased risk on an individual basis. These were overjet, overbite, and posterior crossbite. The combinations of these 3 problems are shown in Table V.

Because few subjects had all 3 problems, groups 2 and 3 were combined for this logistic regression analysis. The results of this analysis are presented in Table VI.

As shown in Table VI, there is a highly significant increased risk for headaches for those with 2 or more problems compared with the control group (OR = 8.571, P = .0009) but not for those with only 1 problem

Table V. Frequency of combinations of 3 problems

Overjet	*Overbite*	*Posterior crossbite*	*n*	*n #*
No	No	No	21	21, group 0
No	No	Yes	15	48, group 1
No	Yes	No	12	
Yes	No	No	21	
No	Yes	Yes	3	25, group 2
Yes	No	Yes	4	
Yes	Yes	No	18	
Yes	Yes	Yes	6	6, group 3

Due to the low number of subjects with all 3 problems, groups 2 and 3 were combined for this logistic regression analysis. *n,* Number of subjects; *#,* number of problems. The results of this analysis are given in Table VI.

(OR = 1.786, $P > .05$), but the confidence intervals are larger.

The next logistic regression model estimated the adjusted association of each of the 3 variables. The results are given in Table VII.

As shown in Table VII, overbite and posterior crossbite were associated with significantly increased risk of headache (OR = 2.768, $P = .0248$ and OR = 3.887, $P = .0086$, respectively) when compared with the control group. Overjet was not statistically significant (OR = 1.926, $P > .05$) after adjusting for the other 2 variables.

As a result of the previous model, a new model that included only overbite and posterior crossbite was evaluated. The results are given in Table VIII.

As shown in Table VIII, both problems were statistically significant ($P = .0131$ for overbite and $P = .0147$ for posterior crossbite) after adjusting for each other. Both problems had similar risks for headache (OR = 3.013 for overbite and OR = 3.322 for posterior crossbite). In addition, confidence bands were slightly narrower.

DISCUSSION

Our aim in this study was to evaluate the association between malocclusion factors and headaches in children and adolescents. Our approach differed from most studies on this subject by evaluating the association between malocclusion and headache in children and adolescents outside the context of TMD. Our samples were carefully selected to specifically exclude patients with a history or treatment of signs and symptoms of TMD. Several occlusal traits were studied, and the reliability of the measurements was high, since all measurements except spacing and crowding were reproducible within ± 0.5 mm (Table II).

Specifically, the recurrent, tension-type headache was targeted in children and adolescents. Because of the retrospective nature of our research, we could not classify the headaches according to the guidelines of the International Headache Society,[21] but we excluded patients with known migraine headaches (diagnosed), neurological disorders, trauma-related conditions, and other possible disorders related to the head and neck region based on complete medical history information.

The tension type of headache is the most common, and it has the most damaging socioeconomic effect on the general population of any health disorder.[22] Tension-type headache also has a profound impact on the quality of life for children and adolescents.[23] The effects of tension headaches on children and adolescents have been documented,[24-26] and the etiological factors need to be determined and controlled.

The underlying pain mechanisms in tension-type headache are highly dynamic, and the outcomes of these mechanisms seem to be varied in frequency and intensity among patients and even in the same patient over time. The initiating stimulus can be mental stress, anxiety, motor stress, a local myofascial release of noxious stimuli, or the accumulation of endogenous substances. The underlying pain mechanism might therefore be an effect of temporal or spatial summation of peripheral stimuli that lead to an altered central nervous system response and possibly to central sensitization. Central sensitization is probably the most important key to understanding the etiology of tension-type headache.[27]

Two extensive reviews by Pullinger et al[2] and McNamara et al[1] established 5 occlusal risk factors for TMD and headache. They cited skeletal open bite, overjet >6 mm, discrepancies from centric occlusion to centric relation >4 mm, unilateral posterior crossbite, and the absence of 5 or more posterior teeth. Pullinger et al[2] concluded that occlusion plays a minor role in TMD, and its importance must not be overemphasized. In accord with these previous reports of low and inconsistent association between malocclusion and TMD is the recent report of Gesch et al.[28] Although occlusion cannot be considered the most important factor in the development of TMD,[1,2] the above occlusal risk factors have been associated with TMD. This association does not necessarily demonstrate cause and effect.

In this study, we used many of the same criteria to assess the relationship between headache and malocclusion while excluding any patient with a history of TMD. Nonexclusion of a TMD patient, though possible, is unlikely to occur because the medical history,

Table VI. Results of the logistic regression analysis for number of problems

Problems (n)	*Coefficient*	*Chi-square*	P *value*	*OR*	*95% CI*
1	.580	1.054	.3046	1.786	(0.590, 5.403)
2 or 3	2.148	11.046	.0009	8.571	(2.414, 30.433)

Table VII. Results of the logistic regression analysis for individual problems

Problem	*Coefficient*	*Chi-square*	P *value*	*OR*	*95% CI*
Overjet	.656	2.150	.1426	1.926	(0.802, 4.628)
Overbite	1.018	5.038	.0248	2.768	(1.138, 6.736)
Posterior crossbite	1.356	6.905	.0086	3.887	(1.412, 10.700)

Table VIII. Results of the logistic regression analysis for individual problems identified in previous model

Problem	*Coefficient*	*Chi-square*	P *value*	*OR*	*95% CI*
Overbite	1.103	6.158	.0131	3.013	(1.261, 7.202)
Posterior crossbite	1.201	5.951	.0147	3.322	(1.266, 8.717)

patient questionnaire, and clinical and radiographic examinations were completed for all patients before their acceptance in the Department of Orthodontics at the University at Buffalo.

Many occlusal traits previously thought to be problematic contributed little to the change in risk in the multiple-factor chi-square analysis (Table III and IV). Although the relative odds were high for many occlusal factors, only overjet, overbite, and posterior crossbite were statistically significant.

For a clinically perceptible influence to be achieved, it is hypothesized that an occlusal trait would need to have at least a 2:1 mean OR of disease.[2] Eight occlusal factors reached this threshold (Table II and III). These factors were maxillary overjet ≥5 mm, mandibular overjet ≥0 mm, deepbite ≥5 mm, anterior open bite, posterior crossbite, anterior crossbite, and scissors-bite.

Although the OR for anterior crossbite was 2.25, the difference in prevalence between the 2 groups was not sufficient to achieve statistical significance. However, further study is warranted for anterior crossbite to determine whether there is a connection to the prevalence of headaches.

For the overbite group, the increased risk for the sample group was statistically significant for deepbite only. Even though the OR for anterior open bite was greater than 2, the *P* value was not significant, and a relationship might not exist or might be undetectable because of the infrequent occurrence of these problems in the study population (the same explanation can be applied to scissors-bite: OR >2, but *P* value not significant). Thus, the overall significance of the overbite problem is most likely due to the strength of the deepbite variable (Table IV).

The occlusal traits with an OR greater than 2 and a statistically significant *P* value were overjet problems (≥0 mm and ≥5 mm), deepbite (≥5 mm), and posterior crossbite. Logistic regression analysis was used to determine whether combinations of these problems increased the risk of a patient having frequent headaches (Tables IV and V). Patients who had 2 or all 3 problems (overjet, overbite, and posterior crossbite) had a highly significant increased risk (8.5:1) for headaches compared with the control group. Patients with only 1 problem did not have a significantly increased risk for headache. However, there was much variability in this study as indicated by the large confidence intervals. For logistic regression to produce stable results, a much larger sample is required.

Logistic regression analysis of specific problems (Table VI) shows that only overbite and posterior crossbite were associated with significantly increased risk of headache when compared with the control group. Overjet was not statistically significant after adjusting for the other 2 variables. A possible explanation is that, although an overjet problem is relatively frequent (49 subjects), it was the sole problem in only 21 subjects and was combined with the other 2 problems in 28 subjects. Thus, a relationship between deepbite and posterior crossbite with headaches might be indicated when all 49 subjects are included in the univariate analysis. This seems to make clinical sense, because many patients with excessive overjet also have corresponding vertical or transverse dental or skeletal discrepancy. One factor related to the development of deepbite is excessive overjet.[29,30] It was shown that as there is a significant positive correlation between ANB angle and overbite in Class II females[31] and that there is a posterior crossbite tendency in Class II patients.[32,33]

Thus, with overjet not being statistically significant, we developed a new model for logistic regression analysis of only deepbite and posterior crossbite (Table VII). Both problems have similar risks for headache (>3:1); this further indicates that the overjet problem found in the univariate analysis was confounded with these 2 problems. In addition, the ORs are somewhat more stable as indicated by the slightly narrower confidence bands.

Other findings include a relatively low risk associated with the other selected occlusal variables and headaches in children and adolescents. Thus, the determination of the need for occlusal therapy based on these isolated occlusal factors might not be justified. Careful diagnosis must be undertaken so as not to neglect the many other causes of headache and orofacial pain in a biologically multifactorial system.

CONCLUSIONS

1. Posterior crossbite is associated with increased risk of headache in children and adolescents.
2. Overbite $\geq$5 mm is associated with increased risk of headache in children and adolescents.
3. The combination of these 2 problems greatly encreases the risk of headache in children and adolescents.
4. Other occlusal factors have low associations with increased risk of headache in children and adolescents, and treatment modalities based on these occlusal factors should be reassessed, so as not to neglect other possible biological, chemical, or environmental causes.

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