Relationship between malocclusion and craniomandibular dysfunction in children and adolescents: a review

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Abstract

Review of the literature on the relationship between malocclusion and craniomandibular dysfunction is presented. The results were interpreted by applying the epidemiologic approach of "necessary and sufficient," which implies that there must be a one-to-one relationship between a factor and a disease. If the correlation between malocclusion and craniomandibular dysfunction were a one-to-one relationship, one would expect to see significant correlations reported consistently. Some of the studies found such significant correlations, however most of the correlations were weak. The lack of consistency and strength of the reported correlations does not support causality. On the basis of the evidence provided by the reviewed studies, malocclusion cannot be considered a necessary and/or sufficient etiologic factor of craniomandibular dysfunction. Therefore, early treatment of occlusal conditions to prevent the development of craniomandibular dysfunction is not justified scientifically. (Pediatr Dent 15:317–22, 1993)

Introduction

Malocclusion has been considered one of the etiologic factors of craniomandibular dysfunction (CMD).[1,2] However, there are varying opinions regarding the contribution of occlusal conditions to the development of signs and symptoms of CMD. It would be beneficial, therefore, to know whether the relationship between malocclusion and CMD is strong enough to prevent the development of signs and symptoms of CMD by early treatment of occlusal conditions.

We review the literature regarding the relationship between malocclusion and signs and symptoms of CMD and apply the epidemiologic approaches to interpret their causal relationship.

Literature review

Studies published in English are included in this review. Most of the relevant information provided by each study is reported in the tables. Four of the studies[3–6] were longitudinal while the others were cross-sectional. The relationship between morphologic malocclusion and CMD was investigated in thirteen studies[3,5–16] while the relationship between functional malocclusion and CMD was investigated in ten.[4, 5, 8–11, 13–15, 17] In one study[18] the type of malocclusion was not reported. Another study[15] was conducted in children with unilateral cleft lip and cleft lip and palate, while the others included noncleft children and adolescents.

The investigations by Egermark-Eriksson,[8] Gunn et al.,[14] and Vanderas[15] were carried out by one examiner. Gianniri et al.,[16] and Egermark-Eriksson et al.[6] did not report the number of examiners, while two or more examiners participated in the rest of the studies. The investigations by Gazit et al.,[11] Egermark-Eriksson,[8] Egermark-Eriksson et al.,[4,6] Gunn et al.,[14] and Kritsineli et al.[16] collected the information by clinical examination and questionnaire. Nesbitt et al.[3] used dental casts, cephalograms, and a mailed questionnaire, while Lieberman et al.,[12] Gianniri et al.,[17] and DeBoever et al.[5] used a clinical examination. Also, Gianniri et al.[17] applied a photocclusion technique for the quantitative and qualitative analysis of the occlusal tooth contacts. Nilner,[9,10] Brandt,[13] and Vanderas[15] collected the information by a clinical examination and an interview.

Reliability tests were reported by DeBoever et al.,[5] Egermark-Eriksson,[8] Brandt,[13] Nilner,[9, 10] Egermark-Eriksson et al.,[4] and Vanderas.[15] The studies by de Boever et al.,[5] Egermark-Eriksson,[8] and Vanderas[15] found that the inter- or intraexaminer reliability was high, while the others reported acceptable interexaminer variability. In four studies,[9, 10, 13, 15] the examiners had trained on patients before the investigation.

CMD was defined in all studies by the presence or absence of one or more signs or symptoms recorded in each investigation. Although the criteria used to identify CMD signs were similar in the reviewed studies, differences in the examination technique as well as in opinion concerning positive and negative findings were unavoidable. The diagnosis of temporomandibular joint (TMJ) sounds was performed in some studies by a stethoscope,[5, 9, 10, 15, 16] but audibly in the others. Hardison and Okeson[19] reported that different techniques for recording joint sounds reveal different findings even in the same patient.

Regarding the CMD symptoms, only three studies[4, 8, 15] tested the reproducibility of the questionnaire used. Riolo et al.[20] questioned the validity of the reported symptoms because of the low value of sensitivity and high false-positive rates in the correspondence between signs and symptoms. In their study, however, the patients were interviewed by three teams and no reproducibility of the

Table 1. Studies on the relationship between morphologic malocclusion and signs and symptoms of craniomandibular dysfunction

Investigator	*Sample Size* M	F	*Age (Years)*	*Correlations* *Type of Malocclusion*	*Signs/Symptoms*	*P-value*
Egermark-Eriksson 1982	136		7			
	131		11	Crossbite	Muscle tenderness	$.01 < P < .05$
	135		15			
Nilner 1983a	222	218	7–14	NC		> .05
Nilner 1983b	147	162	15–18	NC		> .05
Gazit et al. 1984	188	181	10–18	Malocclusion	Muscle tenderness	.033
Lieberman et al. 1985	188	181	10–18	Deep bite	Signs of CMD	.01
Brandt 1985	673	669	6–17	Posterior crossbite	Clicking	.002
				Open bite	Muscle tenderness	.04
				Deep bite	Limited maximal opening	.001
Nesbitt et al. 1985	38	43	5–16	NC		> .05
deBoever et al. 1987	33	42	8–11	NC		> .05
Gunn et al. 1988	67	84	6–18	NC		> .05
Vanderas 1989	22	8	6–10	Anterior crossbite	Definitional symptoms of CMD	.05
				Crossbite		
				Inversion of incisor	TMJ tenderness	.31*
	36	30	11	Lateral open bite		
Egermark-Eriksson	25	28	15			
et al. 1990	55	64	20	Unilateral crossbite	Subjective symptoms	$.01 < P < .05$
				Unilateral crossbite	TMJ function	$.001 < P < .01$
				Unilateral crossbite	Pain on movement	$.001 < P < .01$
				Extreme overjet	Clinical index	$.01 < P < .05$
Kritsineli et al. 1992	48	32	Primary & mixed dentition patients	Overjet Overbite Crossbite Frontal open bite	Clicking Condylar displacement	NR

The study by Williamson is not included in the table since it reports the results in percentages.
NC = No correlation; NR = Not reported; TMJ = Temporomandibular joint; * Indicates the value of R^2.

questionnaire or interrater reliability was reported.

The correlations between malocclusion and CMD were carried out between each sign/symptom and each type of malocclusion,[3-6, 8-16] the definitional symptoms of CMD and each type of malocclusion,[15] and finally between each type of malocclusion and the Helkimo's[21] dysfunction index.[4, 6, 8-10] Kritsineli et al.[16] did not report the significance level while the 95% probability was used in all other studies.

Table 1 shows the correlations between signs or symptoms of CMD and morphologic malocclusion. The types of morphologic malocclusion recorded in all studies were anterior and posterior crossbites, open bite, overjet, and deep bite. Of the 12 studies that investigated the relationship between CMD and morphologic malocclusion, Egermark-Eriksson[8] in a cross-sectional study found statistically significant correlations between crossbite in the molar region and muscle tenderness, while the longitudinal study[6] conducted on the same sample found significant correlations between unilateral crossbite and subjective symptoms, TMJ function, pain on movement of the mandible, and extreme overjet and clinical dysfunction index. In the multiple stepwise regression analysis performed in the longitudinal study,[6] an association was found between TMJ tenderness and the variables crossbite, inversion of incisor, and lateral open bite. Gazit et al.[11] reported statistically significant correlation between malocclusion and muscle tenderness, while Lieberman et al.[12] found statistically significant correlation between deep bite and signs of CMD. Brandt[13] reported statistically significant associations between clicking and posterior crossbite, muscle tenderness and open bite, as well as between limited mouth opening and deep bite, while another study conducted by Vanderas[15] in children with clefts, found correlations between anterior crossbite and the definitional symptoms of CMD. Kritsineli et al.[16] reported sig-

nificant correlations between overjet, overbite, crossbite, frontal open bite, and clicking and/or condylar displacement in primary and mixed dentition patients. In these studies, the relationship between morphologic malocclusion and clinical signs or symptoms of CMD was investigated in a different way. Thus, Egermark-Eriksson et al.[6, 8] investigated the relationship between each type of malocclusion and each sign or symptom or Helkimo's[21] dysfunction index. Gazit et al.[11] investigated the relationship between each sign of CMD and malocclusion, while Lieberman et al.[12] classified the clinical signs in a scale from 0 to 4, and then the relationship was studied with the different types of malocclusion. Brandt[13] and Kritsineli et al.[16] investigated the relationship between each sign or symptom and each type of morphologic malocclusion, while in the other study by Vanderas[15] the statistically significant correlation was found when the definitional symptoms of CMD were aggregated.

Table 2 reveals the correlations between signs and symptoms and functional malocclusion, while Table 3 shows the types of functional malocclusion recorded in each study. Of the 10 studies that investigated the relationship between functional malocclusion and CMD, four[4, 8, 10, 17] reported statistically significant correlations between these variables (Table 2). However, in only two studies by Egermark-Eriksson[4] and Nilner[10] the same type of malocclusion was correlated with the same sign. One of these studies was cross-sectional,[10] while the other was longitudinal.[4] Also, the longitudinal study failed to reassure the correlations found in the cross-sectional study[8] conducted on the same subjects by the same investigator.

Among the review studies[22–24] published on malocclusion and CMD in pediatric populations, one by Morawa et al.[22] reported that several structural factors such as Class II and Class III malocclusions, crossbites, deep bites, and open bites often are associated with functional problems and occlusal interferences that are major factors in the development of TMJ disorders. Another study by Okeson[23] pointed out the multifactorial etiology of CMD. Based on the results of the studies, the investigator reported that malocclusion and CMD cannot have a simple cause-and-effect relationship. Also, according to Okeson, certain occlusal conditions such as unilateral crossbite created by a lateral functional shift may represent predisposing factors for certain signs of CMD. The conclusion of this study was that early correction of malocclusion cannot prevent development of CMD. The review conducted by Tallents et al.[24] reported that signs and symptoms of CMD do not have a strong relationship with morphologic malocclusion. The investigators concluded that if a pediatric population has signs and symptoms of CMD, a small segment of this population may be at risk for further development of symptoms, regardless of presence or absence of initiating factors.

Discussion

The reviewed epidemiologic studies investigated the causal relationships between different types of malocclusion and signs and symptoms of CMD. One should keep in mind however, that the clinical examination techniques are generally subject to error. The majority of the reviewed studies did not report a reliability test, while those that performed one, reported inter- or intraexaminer variabil-

Table 2. Studies on the relationship between functional malocclusion and signs and symptoms of craniomandibular dysfunction

Investigator	*Correlations* *Type of Functional Malocclusion*	*Signs/Symptoms*	*P-value*
Egermark-Eriksson 1982	Unilateral contact	Dysfunction index	< .05
	Unilateral contact	Muscle tenderness	< .05
	Anterior posterior distance between retruded and intercuspal positions	Dysfunction index	< .05
Nilner 1983a	NC		> .05
Nilner 1983b	Interferences in the terminal hinge movement	Clicking	< .01
		TMJ/muscle tenderness	< .05
Brandt 1985	NC		> .05
Gazit et al. 1984	NC		> .05
Egermark-Eriksson et al. 1987	Lateral deviation	Clicking	< .05
	Unilateral contact	Clicking	< .05
deBoever et al. 1987	NC		> .05
Gunn et al. 1988	NC		> .05
Vanderas 1989	NC		> .05
Gianniri et al.* 1991	Statistically significant differences between adolescents with and without signs of CMD in the number and intensity of occlusal contacts		< .001

TMJ = Temporomandibular joint; NC = No correlation.

* The sample size was 28 subjects in each group, 8 males and 20 females aged 16–17 years.

Note: Sample size and age of subjects as indicated in Table 1.

Table 3. Types of functional malocclusion recorded in each study

Investigator	*Type of Functional Malocclusion*
Egermark-Eriksson 1982, 1987	Unilateral contact in retruded position Lateral deviation Large anterior-posterior distance between retruded and intercuspal positions Functional nonworking side interference Nonworking side interference
Nilner 1983a, 1983b	Interferences in the terminal hinge movement Mediotrusion interferences Cuspid rise
Brandt 1985 Gunn et al. 1988	Functional shift of the mandible
deBoever et al. 1987	Working side contacts Centric slide with an anterior and/or lateral component of 2 and 1 mm respectively
Gazit et al. 1984	Nonworking and/or protrusive interferences Unilateral contact in retruded position
Vanderas 1989	Anterior-posterior distance between retruded and intercuspal positions Lateral deviation Interferences in the terminal hinge movement
Gianniri et al. 1991	Number and intensity of occlusal contacts

ity. To interpret their results we apply the epidemiologic approaches concerning the meaning of "cause" of a disease.[25]

One of the approaches is the logician's definition of "cause," which states that a factor must be both "necessary and sufficient" for the occurrence of a disease before it can be considered the cause of that disease. Necessary indicates that the factor must be present for the disease to occur, while sufficient indicates that if the factor is present, the disease can occur (but the factor's presence does not always result in the disease). The concept of necessary and sufficient implies that there must be a one-to-one relationship between the factor and the disease; that is, whenever the factor is present, the disease must occur, and whenever the disease occurs, the factor must be present.

Some of the reviewed studies showed that certain occlusal conditions are correlated significantly with certain signs and symptoms of CMD. Still other studies reveal no significant correlation. If the correlation between malocclusion and CMD were a one-to-one relationship, one would expect to see significant correlations reported consistently. However, this is not the case. On the basis of the evidence provided by the reviewed studies, therefore, malocclusion cannot be considered a necessary etiologic factor for the development of CMD. It is also unlikely to be a sufficient factor, since signs and symptoms of CMD can be developed in patients without any type of malocclusion.

The multifactorial etiologic approach of CMD has been noted by some investigators.[4, 8, 10, 23, 26] In this context, two cases of causal relationship are mentioned by the epidemiology. The first one purports that each of the multiple etiologic factors acts independently and produces a change at the cell level, which becomes the necessary precondition of the disease. This view, however, implies that whenever malocclusion is present and acts independently, the correlation between this variable and CMD must be a one-to-one relationship. As mentioned earlier, the results of the reviewed studies do not support this relationship. Furthermore, the central question is how much each of the multiple etiologic factors contributes to the development of signs and symptoms of CMD. An approach to this problem is to study the prevalence of signs and symptoms of CMD separately for patients subject to different etiologic factors. One study[27] followed this approach and found statistically significant differences in the prevalence of muscle and TMJ tenderness in children with and without emotional states.

According to the second case of causal relationship, each of the multiple factors is necessary, but no single one is sufficient. It is also possible that each of several causative factors acts independently, but when an individual is exposed to two or more, there is a synergistic effect. However, no studies have been carried out in children and adolescents to investigate the synergistic effect of malocclusion and other known etiologic factors. In the framework of multifactorial etiology of CMD, it is reasonable to adopt the following conditions regarding the concept of causality:

1. A causal relationship would exist whenever evidence indicates that the factors form part of the complex of circumstances that increases the probability of the occurrence of CMD.
2. Diminution of one or more of these factors decreases the frequency of signs and symptoms of CMD.

As mentioned earlier, a one-to-one relationship between malocclusion and CMD is not supported scientifically. Also, most of the correlations that show the relative importance of occlusal factors in producing CMD reported

by the reviewed studies[4,8,10,12,15,28] were weak. The lack of consistency and strength of the reported correlations does not support causality. Therefore, it is reasonable to assume that malocclusion cannot increase the probability of the occurrence of CMD.

With respect to the second condition, well-controlled studies to support the need or effectiveness of occlusal treatment have yet to be published. Ingerslev[29] reported that 94% of 366 patients aged six to 16 years, with various signs and symptoms of CMD were treated effectively with conservative treatment modalities but the diagnosis of CMD was not well defined. On the other hand, several studies[30-35] investigated the effect of orthodontic treatment on the initiation of CMD and found no significant differences between treated and untreated groups or between before and after treatment. Based on these findings, Tallents et al.,[24] in a literature review, concluded that orthodontic treatment neither hinders nor accelerates CMD development. In addition, although the frequency of signs and symptoms of CMD is high in children and adolescents,[36] only a small percentage needs treatment.[23] Longitudinal studies[37,38] have shown that signs and symptoms of CMD as well as occlusal interferences are inconsistent. These findings show that the initial impairment of the masticatory system can improve or not develop into a severe dysfunction. On the basis of the evidence provided by the reviewed studies, malocclusion cannot be considered as a necessary and/or sufficient factor for CMD development.

This study does not support the suggestions of Morawa et al.[21] that certain occlusal conditions seem to predispose the occurrence of CMD. This study, however, agrees with the conclusions of the other two reviews by Okeson[22] and Tallents et al.,[23] but differs from them in the epidemiologic approach of "necessary and sufficient" etiologic factors applied to interpret the results.

Conclusion

Based on the reviewed studies it can be concluded that early treatment of occlusal conditions to prevent development of CMD is not justified scientifically since no strong relationship between malocclusion and dysfunction of the masticatory system has been established.

Since the reason for determining etiologic factors of CMD is to apply this knowledge to prevent its development, it is advisable to investigate—in children and adolescents—how much malocclusion contributes to the development of CMD, as well as its synergistic effect with other known etiologic factors such as trauma, emotional states, and oral parafunctions.

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Work-related adolescent injuries a substantial problem

Study says occupational injuries in working adolescents are preventable

Work injuries among teenagers are a significant factor in the annual number of total injuries among adolescents, according to a study published in the *Journal of the American Medical Association.*

Renate Belville, MA, and colleagues from the Department of Community Medicine, Mount Sinai School of Medicine, New York, analyzed New York State Workers' Compensation award data from 1980 to 1987, to determine occupational injury trends among 14- to 17-year-olds.

The researchers found that between 1980 and 1987, a total of 9,656 work-related injury awards were made to adolescents aged 14–17 in New York State. That translates into an annual compensated occupational injury award rate of 28.2 per 10,000 working adolescents. The injuries include an average of one death per year for 14- and 15-year-old workers and three deaths per year for 16- and 17-year-old workers. During the study period, 31 adolescents died of work-related injuries and 43.5% of those compensated (4,201) suffered permanent disability.

Occupational injury awards were higher in males than in females, and ranged from 8.2 per 10,000 in 14-year-old male workers to 46.8 per 10,000 in 17-year-old male workers.

Highest rates by industry were in manufacturing (49 per 10,000) and agriculture (46.2 per 10,000). Unskilled labor was the most dangerous occupation, with a rate of 52.3 injuries per 10,000.

The researchers conclude: "These data confirm the results of other studies documenting that work makes an important, but under-recognized contribution to the continuing epidemic of adolescent injury in the United States. The estimated number of 15- to 19-year-olds killed each year at work (110) is comparable to the number killed in falls (103), in fires (126), on bicycles (129), by poisoning (191), and by unintentional firearm injuries (266)."

They also say: "Because occupational injuries in children and adolescents are entirely the consequence of human economic activity, they ought, in theory, to be preventable."

The researchers propose a number of prevention methods, including development of better systems for monitoring the working patterns of adolescents; better job, health, and safety training, and supervision of employed adolescents; and better enforcement of existing child labor laws.