

Relationship between temporomandibular disorders and orthodontic treatment: A literature review

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Objective: The objective of this study was to review the most recent studies from the last 15 years, in search of clinical studies that report the relationship between TMD and orthodontic treatment and/or malocclusion. Our intention was to determine whether orthodontic treatment would increase the incidence of signs and symptoms of TMD, and whether orthodontic treatment would be recommended for treating or preventing signs and symptoms of TMD.

Methods: Literature reviews, editorials, letters to the editor, experimental studies in animals and short communications were excluded from this review. Were included only prospective, longitudinal, case-control or retrospective studies with a large sample and significant statistical analysis. Studies that dealt with craniofacial deformities and syndromes or orthognathic surgery treatment were also excluded, as well as those that reported only the association between malocclusion and TMD.

Results: There were 20 articles relating orthodontics to TMD according to the inclusion criteria. The studies that associated signs and symptoms of TMD to orthodontic treatment showed discrepant results. Some have found positive effects of orthodontic treatment on signs and symptoms of TMD, however, none showed a statistically significant difference.

Conclusions: All studies cited in this literature review reported that orthodontic treatment did not provide risk to the development of signs and symptoms of TMD, regardless of the technique used for treatment, the extraction or non-extraction of premolars and the type of malocclusion previously presented by the patient. Some studies with long-term follow-up concluded that orthodontic treatment would not be preventive or a treatment option for TMD.

Keywords: Orthodontics. Temporomandibular joint disorders. Dental occlusion.

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INTRODUCTION

The problems associated with the diagnosis and management of temporomandibular disorders (TMD) have aroused interest to the orthodontist. The attention to signs and symptoms associated with TMD have modified the clinical management before and during orthodontic treatment.¹

According to the American Academy of Orofacial Pain, the term temporomandibular disorder refers to a set of clinical problems that involve the masticatory musculature, the temporomandibular joint (TMJ) and associated structures, or both, being identified as the leading cause of non-dental pain in the orofacial region and is considered a subclass of musculoskeletal disorders.²

The signs and symptoms that indicate any abnormality of the TMJ are: Alteration of the mandibular movement, limitation of mouth opening, joint pain with mandibular function, constraint function, joint noises, asymptomatic radiographic changes of the TMJ and jaw locking with open mouth and closed mouth.³

The most common symptom associated with TMD is pain, usually located in the masticatory muscles, pre-auricular area and / or temporomandibular joint (TMJ). The pain is often aggravated by chewing or other functional activities. Limitation of mouth opening and movement, and the presence of joint noises are other common complaints in patients with TMD.²

There are several classification schemes that assist in the clinical diagnosis of TMD, e.g. schemes of the American Academy of Orofacial Pain. Almost all divide the TMD in subgroups: Muscular, articular and mixed.⁴ The role of malocclusion in the etiology of TMD has been reported as controversial in recent years. McNamara Jr., Seligman and Okeson⁵ published an extensive systematic review which concluded that there is a significant association between the presence of some occlusal factors (skeletal open bite, unilateral crossbite, absence of five or more teeth, deep overbite and severe overjet) and the presence of TMD signs and symptoms. Recently, a study in Brazil showed that the absence of bilateral canine guidance on lateral excursion and the presence of Class II malocclusion are important risk indicators for TMD development.⁶

Pellizoni et al⁷ based on the hypothesis raised by epidemiological studies, that there is an association between unilateral posterior crossbite (UPC) and disc displacement in TMJ, proposed a prospective

study that evaluated the articular disc position and its configuration in children with functional UPC and individuals with normal occlusion using magnetic resonance imaging. All participants showed no clinical signs and symptoms of TMD.

Only an individual with articular TMD (disk displacement without reduction) was found. This one belonged to the study group and the crossbite was ipsilateral to the side of the disc displacement. These results suggest that internal disturbances of TMJ and UPC occur independently, or the magnitude of these disorders can not be identified by magnetic resonance imaging in this age group (6 to 13 years).⁷ Another explanation for UPC not implying in the TMJ disk displacement is the compensatory potential of the asymmetrical mandibular condyle growth or the remodeling of the articular fossa, which allows the articular disc to be in its normal position.

In the last decade, much effort has been placed to explain the supposed relationship between orthodontic treatment and TMD. Even with the availability of sophisticated and modern diagnostic tools such as magnetic resonance imaging, and scientific studies with long-term follow-up, it has not yet been possible to eliminate this existing controversy.⁸ Opinions differ between those who argue that orthodontic treatment increases the risk of onset of signs and symptoms of TMD and those who claim that this treatment would be a type of treatment for TMD, or at least to reduce the risk of the patient to develop it.⁹

The objective of this study was to review studies from the last 15 years, searching for clinical studies that report the relationship between TMD and orthodontic treatment and/or malocclusion, with the objective of determining if:

1. Orthodontic treatment would increase the incidence of signs and symptoms of TMD.
2. Orthodontic treatment would be an option for treating or preventing TMD symptoms and signs.

MATERIAL AND METHODS

A search was performed in the databases of International Literature in Health Sciences (MedLine), Latin American Literature and Caribbean Health Sciences (Lilacs) and Brazilian Dentistry Bibliography (BBO) using the following keywords: Orthodontics and temporomandibular disorder, in Portuguese and

Table 1 - Studies on the association between orthodontic treatment and signs and symptoms of Temporomandibular Disorders.

Study	Study design	Population	Variables	Results
Krenemak et al ¹¹	CS, prospective, 2-year follow-up	65 patients orthodontically treated Group I: 26 non-extraction Group II: 25 four premolar extractions Group III: 14 extractions of two premolar	DI Before the treatment 0 to 12 months after treatment 12 to 24 months after treatment	(1) there was no statistically significant difference between group means, at all times. (2) a small reduction in signs and symptoms of TMD was found between the means of groups I and II
Krenemak et al ¹²	CS, prospective, 6-year follow-up	109 patients undergoing orthodontic treatment with fixed appliances	DI 6-year control Number of patients per year: 92, 56, 33, 19, 11 and 7	(1) 90% of patients maintained or improved the clinical picture 10% of patients had worsening (2) Orthodontic treatment was not an important etiological factor for signs and symptoms of TMD
Hirata et al ¹³	CC, prospective, 2-year follow-up	SG: 102 patients, mean age 15.3 years old CG: 41 patients, mean age 16.2 years old	DI Before the treatment 12 months after treatment 24 months after treatment	(1) no differences between groups (2) orthodontics did not represent increased risk for development of signs and symptoms of TMD
Egemark and Thailander ¹⁴	CS, prospective, 10-year follow-up	402 children divided in 3 age groups: 7, 11 and 15 years old	DI 293 questionnaires were answered After 10 years, 83 individuals examined, now 25 years-old	(1) individuals with a history of orthodontic treatment showed a low prevalence of TMD symptoms and lower DI (2) more evident differences in the older group
Wadwa Utreja and Tewari ¹⁵	CS	102 individuals, ages between 13 and 25 years old Group I: 30 individuals with normal occlusion Group II: 41 with malocclusion and without orthodontic treatment Group III: 31 with malocclusion and orthodontic treatment	DI	(1) no differences between groups (2) orthodontic treatment would not present risk or prevent the development of signs and symptoms of TMD
O'Reilly, Rinchuse and Close ¹⁶	CC, prospective	120 individuals SG: 60 patients, average age 15.3 years old, 48 with Class II, division 1 and 12 with Class I malocclusion CG: 60 individuals, average age 15.3 years, 38 with Class II, division 1 and 22 with Class I malocclusion	DI Before the treatment 8 to 10 months after 12 to 16 months after At the end of the treatment	(1) orthodontic mechanics applied has no effect or no significant effect on signs and symptoms of TMD
Beattie, Paquette and Johnston ¹⁷	CS, retrospective	63 patients with Class II malocclusion treated with and without premolar extractions	DI Evaluation 14 years after treatment end	(1) no differences between those who underwent premolar extractions or not. (2) premolar extraction would not be a risk factor for developing signs and symptoms of TMD
Egemark and Ronnerman ¹⁸	CS, prospective	50 patients underwent orthodontic treatment, average age of 12.9 years old	DI Before, during or immediately after treatment	(1) high prevalence of signs and symptoms of TMD before treatment (2) signs and symptoms decreased during treatment, except for joint noises (3) occlusal interferences during treatment did not influence the development of signs and symptoms of TMD
Lima ¹⁹	CS, prospective	100 individuals, Dental students, ages between 18 and 25 years	DI	(1) Individuals orthodontically treated or not showed similar tendency to present signs and symptoms of TMD
Katzberg et al ²⁰	CC, retrospective	178 individuals SG: 102 patients with symptomatic TMD CG: 76 asymptomatic volunteers	Questionnaire about previous orthodontic treatment and details of signs and symptoms of TMD, Magnetic Resonance Images	(1) TMD patients showed a higher percentage (77%) of TMJ disk displacement than the CG (33%) (2) There was no statistically significant association between previous orthodontic treatment (with or without extraction) and disc displacement
Lagerström, Egemark and Carlsson ²¹	CS, prospective	860 individuals 19 years after they underwent orthodontic treatment Group I: 520 treated by specialists in Orthodontics Group II: 340 treated by general practitioners	DI Test performed on 260 subjects (77%)	(1) There was no difference in the prevalence of signs and symptoms of TMD (2) Female individuals had higher prevalence of signs and symptoms of TMD (3) No association between occlusal contacts and signs and symptoms of TMD
Owen ²²	CS, retrospective	600 patients who underwent orthodontic or orthopedic treatment	DI During the treatment	(1) 16 patients (2.6%) developed signs and symptoms of TMD during treatment (2) female patients, with Class II and moderate to severe overbite or overjet, regardless of treatment technique used, were more likely to develop signs and symptoms of TMD
Henrikson, Nilner and Kuroi ²³	CC, prospective, with 2-year follow-up	183 adolescents Group I: 65 patients, Class II malocclusion orthodontically treated Group II: 58 individuals with Angle Class II, no orthodontic treatment Group III: 60 subjects with normal occlusion	DI Before orthodontic treatment, 2 years after treatment	(1) Group I showed a reduction of muscular signs after treatment (2) Small changes in Groups II and III after 2 years (3) joint noise increased in three groups, but less in Group III (4) individuals in Group III had the lowest prevalence of signs and symptoms of TMD (5) orthodontic treatment did not increase the risk for or worsen signs and symptoms of TMD

Henrikson and Nilner ²⁴	CC, prospective, 2-year follow-up	183 adolescents Group I: 65 patients, Class II malocclusion orthodontically treated Group II: 58 patients with Angle Class II, no orthodontic treatment Group III: 60 patients with normal occlusion	DI Before orthodontic treatment, 2 years after treatment	(1) TMD symptoms presented floating prevalence over the two years (2) orthodontic treatment did not increase the risk for developing signs and symptoms of TMD and headache
Valle ²⁵	CC, prospective	200 individuals Group I: 50 subjects with Class I malocclusion, no orthodontic treatment Group II: 50 subjects with Class II malocclusion, no orthodontic treatment Group III: 50 subjects with Class I malocclusions orthodontically treated Group IV: 50 subjects with Class II malocclusion orthodontically treated	Fonseca questionnaire Physical examination Occlusion examination	(1) No association between the severity of signs and symptoms of TMD and orthodontic treatment, regardless of the malocclusion type (2) The severity of signs and symptoms of TMD may only be associated with the absence of anterior guidance
Conti et al ⁸	CC, prospective	200 individuals Group I: 50 subjects with Class I malocclusion, no orthodontic treatment Group II: 50 subjects with Class II malocclusion, no orthodontic treatment Group III: 50 subjects with Class I malocclusions orthodontically treated Group IV: 50 subjects with Class II malocclusion orthodontically treated	Fonseca questionnaire Physical examination Before and after orthodontic treatment	(1) Presence and severity of TMD did not present any relation with the type of orthodontic treatment or extraction protocol applied
Egermark, Carlsson and Magnusson ⁹	CS, prospective, 20-year follow-up	402 children divided in 3 age groups: 7, 11 and 15	DI / Questionnaire about previous orthodontic treatment; 320 individuals answered the questionnaire; 100 subjects were examined, now 35 years-old	(1) no occlusal factor was important for the development of signs and symptoms of TMD, however, unilateral crossbite, and differences between CR and MHI tended to be risk factors. (2) Individuals who have undergone orthodontic treatment did not present higher or lower risk of developing signs and symptoms of TMD than those who did not undergo orthodontic treatment
Corotti-Valle ²⁶	CS, prospective	50 patients with Class III malocclusion Group I: 25 patients submitted to orthodontic treatment Group II: 25 patients submitted to orthodontic treatment and orthognathic surgery	Fonseca questionnaire Clinical examination Tests carried out on at least one year after the treatment end	(1) There was no statistically significant difference between the two groups regarding the prevalence of TMD symptoms. (2) Significant association was found between the presence of interferences on the non-working side and the index of TMD symptoms severity. (3) The Class III malocclusion treatment had no influence in determining TMD severity.
Mohlin et al ²⁷	CS, prospective, 19-year follow-up	1,018 11-year-old individuals	DI Morphology Calculation of the malocclusion index Questionnaire on orthodontic treatment Examination at age 11 791 re-examined at 15 years old, 456 at age 19 and 337 at age of 30	(1) No significant difference was found between the groups regarding the types of malocclusion, tooth contact pattern, previous orthodontic treatment or extractions (2) A quarter of individuals with signs and symptoms of TMD at age 19 showed complete remission at the age of 30 (3) Orthodontic treatment was not a preventive nor causative factor of TMD
Egermark, Carlsson and Magnusson ⁹	CS, prospective, 17-year follow-up	50 patients submitted to orthodontic treatment, mean age 12.9 years	DI 17 years after treatment end, 40 patients completed the questionnaire and 31 were clinically reexamined	(1) the incidence of TMD needing clinical care was of 1% per year (2) orthodontic treatment did not increase the risk of developing signs and symptoms of TMD.

Legend: CS = Case series, CC = case-control, SG = study group; CG = control group, M = male, F = female; DI = Helkimo dysfunction Index; CR = centric relation; MHI = maximum habitual intercuspation.

English, between January 1, 1992 to September 30, 2007. Articles like literature reviews, editorials, letters to the editor, experimental studies with animals and short communications were excluded from this review. Were included prospective, longitudinal, case-control or retrospective studies with larger samples and significant statistical analysis. These studies are the level B of evidence (moderate evidence).¹⁰

Studies that dealt with deformities and craniofacial syndromes or treatment by means of orthognathic surgery were also excluded, as well as those who reported only the association between malocclusion and TMD.

RESULTS

There were 20 articles found relating orthodontics to TMD according to the inclusion criteria. Table 1 presents a description of the studies found.

DISCUSSION

The restrictions imposed in this study in relation to databases and languages in the search of the literature relating to TMD and Orthodontics may have resulted in few studies. However, finding the best evidence, prioritizing the quality of the studies and the diagnosis of TMD and its division into subtypes could lead to clearer conclusions about this association.

One of the biggest problems found in the studies selected in this search for understanding the association between TMD and Orthodontics was the methodology they used to identify TMD. All studies, except that performed by Katzberget al,²⁰ use the same tool to identify the signs and symptoms of TMD: the Helkimo index, published in 1974. There were few case-control studies, making it difficult to compare our data with regard to the signs and symptoms of TMD.

Professor Helkimo pioneered the development of indices to measure the severity of TMD, as well as pain in TMJ. In an epidemiological study, he developed an index divided into anamnesis, clinical and occlusal dysfunction. Through this index, he tried to identify, individually and in the population, the prevalence and severity of TMD, pain and occlusal instability. The protocol for the determination of this index consists of ten parameters: Emotional stress, parafunctional habits, mouth opening, lateralization of the jaw, joint sounds,

TMJ tenderness, palpation of the posterior muscles of the neck, palpation of masticatory muscles, maxillomandibular relationship and headaches.²⁸

The Helkimo anamnesis index (AI) is based on a questionnaire where the individual reports the presence of symptoms of TMD. The results can generate three different levels of dysfunction: no symptoms; mild, moderate, or severe symptoms. The Helkimo clinical index (CI) considers the functional evaluation of the stomatognathic system. According to the presence and/or severity of clinical signs, individuals are assigned scores ranging from 0, 1 or 5 points. The following aspects are observed: Range of mouth opening and lateral movements of the jaw; restricted jaw function; pain on palpation of masticatory muscles, TMJ and neck posterior muscles. The signs are also classified as none, mild, moderate or severe. The third index is called Helkimo occlusal index (OI) and is obtained by analyzing the occlusion of the individual regarding the number of teeth, number of teeth in occlusion and occlusal interference between the RC and MHI positions. According to the data obtained for each item, scores 0, 1 or 5 are assigned once again. The sum of the three indices generates the Helkimo dysfunction index (DI) (Table 2).

However, this tool, although widely used, is not able to diagnose and classify TMD, it only shows its signs and symptoms. There are limitations in using the DI, first because it gives equal importance to all the symptoms, it does not separate the muscular TMD from articular TMD, its categorization by points does not promote a continuous variable, reducing its specificity. Some symptoms are ignored, such as the type of joint noises and when they occur, and some muscle regions. Even though this index is able to document the signs and symptoms of TMD in the population, the organization of data from these indices seems not to benefit other areas of Epidemiology, for example, in understanding TMD etiology.²⁹ As an example of how the index might be flawed, if a person has more than 15 episodes of headache per month, and she/he is very tense and present pain on palpation of the posterior muscles: He/she would be classified as presenting with moderate TMD, without even having a single peculiar sign or symptom of TMD — i.e., the person might not even present TMD.

Bevilaqua-Grossi et al²⁹ suggested that a way to identify patients who really need TMD treatment

Table 2 - Degree of temporomandibular disorder according to Helkimo dysfunction Index.

Helkimo index (scores)	Degree of Temporomandibular Disorders
0 to 20	No signs and symptoms of TMD
21 to 30	Mild signs and symptoms of TMD
31 to 40	Moderate signs and symptoms of TMD
41 or more	Severe signs and symptoms of TMD

would be to determine the frequency and intensity of signs and symptoms of TMD. The authors suggest using the questionnaire proposed by Fonseca³⁰ (Table 3) and a clinical examination assessing the range of mouth opening and the tenderness of masticatory muscles and TMJ to palpation. According to the authors, Fonseca questionnaire³⁰ is a simple questionnaire, without pretension to diagnose TMD, but it can be a useful tool in observing the symptoms reported by patients. Not only the frequency of symptoms should be checked, but also its severity, aiming to identify those patients that require treatment for TMD. Three studies conducted in Brazil and reviewed in the present article used the Fonseca anamnesis questionnaire in order to discriminate patients who would present TMD, followed by physical examination.

Since 1992, to facilitate the conduction of clinical research, researchers in epidemiological and clinical studies or aiming to determine samples in randomized and controlled trials, use a classification scheme called the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) which diagnoses the presence of TMD. The RDC/TMD is a tool for clinical diagnostic criteria, measurable and reproducible, that aims at identifying subgroups of patients with TMD. The RDC/TMD classifies the most common types of TMD into three subgroups: Disorders of the masticatory muscles (myofascial pain), TMJ internal derangement (disk displacement), and degenerative diseases of the TMJ (arthralgia, arthritis and osteoarthritis). The use of the RDC depends on anamnesis and physical examination data, making use of questionnaires, surveys and specifications.³¹ The study by Katzberg et al²⁰ used this tool to diagnose disk displacement with reduction in its sample.

Thus, none of the studies associating TMD and Orthodontics diagnosed TMD, they only observed the presence of signs and symptoms. Therefore, one cannot conclude from these studies whether the

TMD would be a condition that motivates individuals to seek treatment for their functional problems. There is a large disparity between the signs and symptoms of TMD (which can be present in up to 68% of the population)³² and TMD diagnosis (8-15% of women and 3-10% of men).³³

Another difficulty in analyzing the signs and symptoms of TMD in the cited studies is the episodic or floating character of the appearance of these symptoms observed in long-term studies. The prevalence varied among the analysis performed on different occasions. Krenemak et al¹² showed in their sample that 90% of patients who developed signs and symptoms of TMD,

Table 3 - Fonseca³⁰ questionnaire for anamnesis of temporomandibular disorder.

1	Do you have difficulty to open your mouth?
2	Do you feel difficulty to move your jaw sideways? To the right? To the left? To both sides?
3	Do you have muscle fatigue or pain when chewing?
4	Do you often have headaches?
5	Do you feel pain in the neck or torticollis?
6	Do you have ear ache or in the temporomandibular joints region (TMJ)?
7	Have you noticed if you have TMJ sounds when chewing or when you open your mouth?
8	Have you noticed if you have any habits like pushing and/or grinding teeth, chewing gum, biting lip or pencil, nail biting?
9	Do you feel that your teeth do not fit together well?
10	Do you consider yourself a tense or nervous person?

Anamnestic index to classify the categories of severity of symptoms of TMD.

Categories of severity of TMD symptoms	Ratings threshold to classify the categories
No signs and symptoms	0 to 15
Mild signs and symptoms	20 to 40
Moderate signs and symptoms	45 to 65
Severe signs and symptoms	70 to 100

after two years maintained or improved the situation, while 10% worsened. While Mohlin et al²⁷ showed that 25% of patients at the end of 19 years of follow-up, had complete remission of signs and symptoms of TMD. The signs and symptoms appear to improve with time, except for joint noises, which increased after 2 years of follow-up.²³ Still, Owen²² reported that 2.6% of the patients developed signs and symptoms of TMD during orthodontic treatment. Egermark, Carlsson and Magnusson⁹ in a 17 years follow-up study, showed that 1% of the sample required TMD clinical care per year.

The studies associating signs and symptoms of TMD with orthodontic treatment showed discrepant results. Some studies have found positive effects of orthodontic treatment on the signs and symptoms of TMD, however, none showed statistically significant results.^{9,11,12,14,23} All studies cited in this literature review reported that orthodontic treatment did not provide risk to the development of signs and symptoms of TMD, regardless of the technique used for treatment, whether or not the extraction of premolars was performed, and the type of malocclusion previously presented by the patient.^{8,9,11-25,27} Some long-term studies concluded that the orthodontic treatment would not be preventive or a treatment modality for TMD.^{9,15,27} Henrikson and Nilner²⁴ suggested that due to the fluctuating character of the signs and symptoms of TMD, and as orthodontic treatment is not effective in treating TMD, a conservative and reversible approach should be adopted in the treatment of TMD, which agrees with the guidelines of the American Academy of Orofacial Pain.²

Some articles also mentioned the relationship between malocclusion and signs and symptoms of TMD. There was no statistically significant association between malocclusions and signs and symptoms of TMD.^{18,21,25,27} However there was a trend that patients with Class II malocclusion with overbite or moderate to severe overjet,²² absence of anterior guidance,²⁵ unilateral crossbite and difference between CR and MHI⁹ could present a greater number of signs and symptoms of TMD. Still, Corotti-Valle²⁶ found in their sample a significant association between severity of symptoms of TMD and interference in the balance side.

CONCLUSIONS

From the studies found in the literature review, we concluded that the orthodontic treatment — regardless of the technique used and whether or not the extraction of premolars during treatment — does not increase the signs and symptoms of TMD and therefore it is not a risk factor for its development. The orthodontic treatment does not appear to be a valuable resource for treating or preventing the onset of signs and symptoms of TMD. There is the need to improve the methodology used in studies that seek to demonstrate the association between TMD and orthodontic treatment so they can be less contradictory. Features such as controlled trials, longitudinal studies and tools that can diagnose TMD and divide it into subtypes (such as muscular, articular and mixed), seem to be necessary for a better understanding of this association.

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