

# Orthodontics as risk factor for temporomandibular disorders: a systematic review

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## Abstract

**Aim:** The interrelationship between Orthodontics and Temporomandibular Disorders (TMD) has attracted an increasing interest in Dentistry in the last years, becoming subject of discussion and controversy. In a recent past, occlusion was considered the main etiological factor of TMD and orthodontic treatment a primary therapeutical measure for a physiological reestablishment of the stomatognathic system. Thus, the role of Orthodontics in the prevention, development and treatment of TMD started to be investigated. With the accomplishment of scientific studies with more rigorous and precise methodology, the relationship between orthodontic treatment and TMD could be evaluated and questioned in a context based on scientific evidences. This study, through a systematic literature review had the purpose of analyzing the interrelationship between Orthodontics and TMD, verifying if the orthodontic treatment is a contributing factor for TMD development. **Methods:** Survey in research bases: MEDLINE, Cochrane, EMBASE, Pubmed, Lilacs and BBO, between the years of 1966 and 2009, with focus in randomized clinical trials, longitudinal prospective nonrandomized studies, systematic reviews and meta-analysis. **Results:** After application of the inclusion criteria 18 articles was used, 12 of which were longitudinal prospective nonrandomized studies, four systematic reviews, one randomized clinical trial and one meta-analysis, which evaluated the relationship between orthodontic treatment and TMD. **Conclusions:** According to the literature, the data concludes that orthodontic treatment cannot be considered a contributing factor for the development of Temporomandibular Disorders.

**Keywords:** Temporomandibular Joint Dysfunction Syndrome. Temporomandibular Joint Disorders. Craniomandibular Disorders. Temporomandibular Joint. Orthodontics. Dental Occlusion.

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## INTRODUCTION

Recent years have seen a considerable increase in the prevalence of signs and symptoms of Temporomandibular Disorders (TMD).<sup>44</sup> Several theories have been proposed to determine the etiology of TMD, but a single and specific factor was not detected.<sup>44,47</sup> The etiology of TMD has a multifactorial nature and is associated with muscle hyperactivity, trauma, emotional stress, malocclusion and other predisposing, precipitating or perpetuating factors of this condition.<sup>47</sup> Due to the etiological complexity and variety of signs and symptoms that may, generally, also represent other conditions, recognition and differentiation of Temporomandibular Disorders can present in a not very clear way to the professional.<sup>5</sup>

Epidemiological studies show that the signs and symptoms of TMD are commonly found in children and adults,<sup>9,32</sup> may reaching up to 31% of the population<sup>42</sup> and affects more than 10 million people in the U.S.A.<sup>41</sup>. Usually the signs and symptoms are milder in childhood and increases in adolescence both in prevalence and severity.<sup>49</sup>

Some studies have attempted to evaluate the possible effect of occlusal factors on the development of TMD. The results of these studies indicate that occlusal factors have small etiological importance in relation to pain and to the functional alterations of the stomatognathic system, but the role of occlusion in the etiology of TMD is still a subject of discussion.<sup>17</sup>

Thus, the role of Orthodontics in the development, prevention and treatment of TMD remains controversial. This study aimed, through a systematic review of literature, to analyze the inter-relationship between orthodontic treatment and TMD and specifically verify if orthodontic treatment is a contributing factor to the development of TMD.

## MATERIAL AND METHODS

We performed a computerized search in

MEDLINE, Cochrane, EMBASE, PubMed, Lilacs and BBO in the period from 1966 through January 2009. The research descriptors used were “orthodontics”, “orthodontic treatment”, “temporomandibular disorder,” “temporomandibular joint”, “craniomandibular disorder”, “TMD”, “TMJ”, “malocclusion” and “dental occlusion”, which were crossed in search engines. The initial list of articles was submitted to review by two reviewers, who applied inclusion criteria to determine the final sample of articles, which were assessed by their title and abstract. If there was any disagreement between the results of the reviewers, a third reviewer would be consulted by reading the full version of the article.

Inclusion criteria for the selecting articles were:

- Studies that evaluated Orthodontics in relation to its role in the development of TMD and in which orthodontic treatment is already finished in the samples;

- Randomized clinical trials (RCTs), longitudinal prospective nonrandomized studies, systematic reviews and meta-analysis. Clinical trials should present control group;

- Clinical trials in which was performed clinical examination in patients and at least one clinical evaluation was realized after the final of orthodontic treatment. Studies based only on nuclear magnetic resonance imaging (MRI), computed tomography (CT), electromyography, cephalometry and conventional radiographs were excluded;

- Studies written in English, Spanish and Portuguese and published between 1966 and January 2009.

Thus, we excluded cross-sectional studies, clinical case reports, case series, simple reviews and opinions papers, as well as studies in which orthodontic treatment has not yet been completed and studies based only on imaging tests.

## RESULTS

After applying the inclusion criteria was reached 18 articles: 12 longitudinal prospective nonrandomized studies, 4 systematic reviews, 1 randomized clinical trial and 1 meta-analysis, as shown in Figure 1.

The final sample of selected articles was divided into two groups: 1) clinical trials, in which were performed clinical evaluations and 2) sys-

tematic reviews and meta-analysis, and is presented in Tables 1, 2 e 3.

FIGURE 1 - Design of included studies

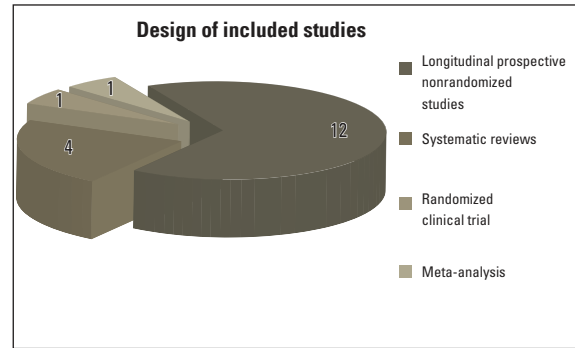


TABLE 1 - Design of clinical trials.

Authors	Year of publication	Design	Sample size	Orthodontic appliances used
Sadowsky et al <sup>52</sup>	1991	P, L	160 tt 90 no tt	F
Hirata et al <sup>24</sup>	1992	P, L	102 tt 41 no tt	F
Egermark e Thilander <sup>13</sup>	1992	P, L	402 mixed	F, AF
O'Reilly et al <sup>46</sup>	1993	P, L	60 tt 60 no tt	F
Egermark e Ronnerman <sup>12</sup>	1995	P, L	50 tt 135 no tt	F, AF
Keeling et al <sup>26</sup>	1995	RCT	60 tt Bionator 71 tt headgear 60 não tt	AF
Henrikson e Nilner <sup>21</sup>	2000	P, L	65 tt 58 no tt (class II) 60 no tt (normal)	F
Henrikson et al <sup>22</sup>	2000	P, L	65 tt 58 no tt (class II) 60 no tt (normal)	F
Imai et al <sup>25</sup>	2000	P, L	18 tt (after splint) 27 tt (without splint) 13 no tt (after splint)	F
Egermark et al <sup>11</sup>	2003	P, L	320 mixed	F, AF
Henrikson e Nilner <sup>23</sup>	2003	P, L	65 tt 58 no tt (class II) 60 no tt (normal)	F
Mohlin et al <sup>40</sup>	2004	P, L, CC	72 without DTM 62 with DTM	F, AF
Egermark et al <sup>10</sup>	2005	P, L	40 tt 135 no tt	F, AF

P: prospective, L: longitudinal RCT: randomized clinical trial; CC: case-control; tt: treatment, F: fixed appliances; FA: functional appliances.

TABLE 2 - Results of clinical trials.

Authors	Time of assessment	Diagnostic criteria for TMD	Relationship between extractions and TMD	Relationship between Orthodontics and TMD
Sadowsky et al <sup>52</sup>	After tt	TMJ sounds	No	No
Hirata et al <sup>24</sup>	1.2 years during tt	Questionnaire, mmO, TMJ sounds, deviations	NA	No
Egermark e Thilander <sup>13</sup>	10 years	Questionnaire, Helkimo index	NA	Improvement
O'Reilly et al <sup>46</sup>	During, just after tt	Lateral movement, TMJ sounds, tenderness	No	No
Egermark e Ronnerman <sup>12</sup>	Before, during and after tt	Questionnaire, Helkimo index	No	Improvement
Keeling et al <sup>26</sup>	Follow-up of 2 years	TMJ sound, TMJ pain, muscle pain	NA	No
Henrikson e Nilner <sup>21</sup>	2 years after 1st evaluation	Symptoms (headache, TMJ sounds, pain)	NA	Improvement
Henrikson et al <sup>22</sup>	2 years after 1st evaluation	Signs (MM, pain, TMJ sounds)	NA	Improvement
Imai et al. <sup>25</sup>	Initial, after splint, after tt, 1 year after tt	TMJ sounds, pain, restriction	NA	No
Egermark et al <sup>11</sup>	20 years after 1st evaluation	Questionnaire, Helkimo index	NA	No
Henrikson e Nilner <sup>23</sup>	Beginning, after 1 and 2 years of tt and 1 year after the end of tt	Signs and symptoms	No	No
Mohlin et al <sup>40</sup>	Performed at 19 and 30 years old	Questionnaire, clinical assessment, psychological status	No	No
Egermark et al <sup>10</sup>	Before, during, after tt and 15-18 years after the end of tt	Questionnaire, Helkimo index	NA	No

tt: treatment; mmO: maximum mouth opening; mm: mandibular movement; NA: not analyzed.

TABLE 3 - Systematic reviews and meta-analysis.

Authors	Year of publication	Design	Number of included studies	Orthodontic appliances used	Relationship between Orthodontics and TMD
Mcnamara & Turp <sup>37</sup>	1997	RS	21	F, AF	No
Kim et al <sup>27</sup>	2002	MA	31	F, AF	No
Popowich et al <sup>50</sup>	2003	RS	5	Aparelho de Herbst	Insufficient evidences
Mohlin et al <sup>39</sup>	2007	RS	30	F, AF	No
Abrahamsson et al <sup>1</sup>	2007	RS	3	CO	Insufficient evidences

SR: systematic review; MA: meta-analysis, F: fixed appliances; FA: functional appliances; OS: orthognathic surgery.

## DISCUSSION

Considerations about the subject should always be performed through a critical reading of the methodology used by different authors. The use of the basic research principles allows to the researchers to try to control as best as possible the biases of the study generating higher levels of evidence. Thus, becomes important the sample size calculation, so that the sample presents representativity and the results can be extrapolated to the studied population. Moreover, the calibration intra and inter-examiners should be performed to assure the reliability of diagnostic criteria, as well as adoption of randomization and blinding criteria. Likewise, careful matching for age and sex between the test and control groups should also be observed.<sup>53</sup>

Within this context of an evidence-based Dentistry, it appears that the most common types of studies published in Brazilian journals correspond to studies of low potential for direct clinical applications: *in vitro* studies (25%), narrative reviews (24%) and case reports (20%). The low number of studies with greater strength of evidence shows the necessity to expand the knowledge of evidence-based methods among Brazilian researchers.<sup>45</sup>

The supposed relationship between Orthodontics and Temporomandibular Disorders has attracted the interest of orthodontic class in last years. Despite significant advances in diagnostic capability due to advanced techniques such as nuclear magnetic resonance imaging, 3D computed tomography, volumetric cone-beam tomography and application of more sophisticated clinical procedures, this possible relationship remains unclear. A reflection of this controversy is the way that orthodontic treatment is considered in several publications. If for some authors, orthodontic correction may be the cure for TMJ dysfunction, for others it may predispose patients to pain and dysfunction of the stomatognathic system.<sup>5</sup>

For the establishment of a risk factor, it must perform several methodological criteria to qualify as a true risk factor. Thus, the factor should be identified with the outcome in longitudinal studies, must be present before the establishment of the disease and shows a biological plausibility with the disease. Moreover, the factor remains associated after controlled for other risk factors, there must be a dose-response relationship, that is, higher the factor, higher the outcome and this factor must be identified in different populations.<sup>2</sup>

Cross-sectional or retrospective studies allow the study of associations that identify risk indicators and generate hypotheses. Subsequently, these hypotheses need to be tested in longitudinal studies to identify true risk factors, because only longitudinal studies can be used as generators of cause and effect evidence due to its temporal component.<sup>54</sup> Therefore, the clinical trials included in this systematic review show longitudinal design, whereas in this point of view is that must consider the interrelationship Orthodontics and TMD.

There is a difference in the quality of the designs of clinical studies before and during the 80s decade, and the most recent.<sup>35</sup> Studies of cross sectional and observational nature, methodological errors - such as lack of information about randomization, blinding, sample size calculation, calibration and control of factors - and inadequate quality of study designs compromised the power generation of scientific evidence. Furthermore, the heterogeneity of results in published studies difficult realization of an adequate meta-analysis. Added to this the lack of a standardized classification system for TMD diagnosis. Thus, you can always find a scientific article to prove a point of view.<sup>27</sup>

Another important factor, as previously mentioned, when evaluating studies involving the interrelation of Orthodontics and TMD, are the diagnostic criteria adopted by the authors. Due

to the lack of a universal classification system and validated for TMD, can be found in this systematic review various diagnostic methods used by the authors of the included studies: Helkimo index,<sup>18,19</sup> Craniomandibular index,<sup>15,16</sup> as well as adaptations of these or other questionnaires. This fact complicates the comparison and analysis of results obtained in the studies evaluated in this systematic review.

In order to standardize the diagnostic criteria and facilitate future clinical trials, was formulated the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), which examined jointly the physical and psychosocial aspects of TMD, in the axis I and II, respectively.<sup>8</sup> This diagnostic method has been translated, culturally adapted and validated in Brazil.<sup>31,48</sup> Thus, future clinical studies may use a standardized and universal index, which will facilitate comparison of study results. It is important to be noted that none of the studies evaluated in this systematic review used the RDC/TMD as a diagnostic criteria.

Studies also analyzed the relationship between TMJ sounds and its morphology. Sounds can be associated with various pathologies and the presence of clicks and crackles does not necessarily indicate a TMJ with abnormal morphology<sup>14</sup>. It becomes important the knowledge in situations of disk displacement with and without reduction, as well as the presence of crackles as indicative of osteoarthritis. It is important accentuate that the absence of TMJ sounds, not necessarily characterized a situation of normality.<sup>14,52</sup>

There are many factors that may cause or aggravate TMD. A review of the literature did not find a positive association between orthodontic treatment in children and adolescents and future risk of TMD developing. In addition, orthodontic mechanotherapy performs gradual changes in a system that has a great capacity of adaptation.<sup>51</sup> Similar results were obtained in

other studies, and that there was not observed worsening of signs and symptoms of TMD pre-treatment.<sup>20</sup>

In a critical review of the literature, there was noted a low association between occlusal factors that characterize TMD. Moreover, orthodontic treatment performed during adolescence usually do not increases or decreases the probability of developing TMD in the future. Some occlusal factors, such as skeletal anterior open bite, overjet greater than 6-7 mm, retruded cuspal position/intercuspal position slides greater than 4 mm, unilateral posterior crossbite and absence of 5 or more posterior teeth may be associated with specific diagnosis of TMD.<sup>36</sup>

In another critical review, it was found that the signs and symptoms of TMD can occur in healthy individuals, increasing with age, particularly during adolescence, until menopause, and that the TMD that begin during orthodontic treatment may not be related to the treatment. Moreover, there is no risk for TMD associated with any type of orthodontic mechanics and there is no evidence that a stable occlusion, as ideal objective of orthodontic treatment, prevents signs and symptoms of TMD. Still, the extraction of teeth as part of orthodontic treatment plan does not increase the risk for development of TMD.<sup>35</sup>

Current studies, within a context of an evidence-based Dentistry, such as randomized clinical trials, longitudinal prospective nonrandomized studies, systematic reviews and meta-analysis, through the use of more rigorous methodological criteria and adequate designs, evaluated more precisely the interaction between orthodontic treatment and Temporomandibular Disorders.

Significant current scientific evidences, such as longitudinal and experimental-interventionist studies, point to a tendency of not association of the relationship between orthodontic treatment and TMD,<sup>10,11,21,22,23,25,26,40</sup> and the presence or

absence of extractions during orthodontic treatment did not increase the prevalence or worsened signs and symptoms related to TMD.<sup>11,23</sup> Randomized clinical trials<sup>26</sup> and longitudinal prospective nonrandomized studies,<sup>10,11,21,23,25</sup> well as meta-analysis<sup>27</sup> and systematic review,<sup>39</sup> besides present more rigorous methodologies, generate a greater power of scientific evidence. Moreover, the correct occlusal relationship between the teeth did not cause a change in the physiological position of the condyles and articular discs in TMJ when examined MRIs and CT.<sup>3,28,29</sup>

Reviewing the literature in search of randomized clinical trials - studies that generate a high level of scientific evidence - about the interrelation of orthodontic treatment and TMD, there is only one study in the evaluated period in this systematic review.<sup>26</sup> This fact occurs due to difficulties in the accomplishment of randomized clinical trials evaluating orthodontic treatment and TMD, due to ethical and practices reasons.<sup>27</sup> Difficulties those are also present when assessing other forms of irreversible therapies such as TMD treatment protocols. An example of this situation is the occlusal adjustment, where from 1966 to 2002, only 6 RCTs evaluating the occlusal adjustment as treatment and prevention option for TMD in a systematic review published in Cochrane Library.<sup>30</sup>

Regarding to the role of orthognathic surgery and orthodontic treatment with the Herbst appliance in relation to TMD, the literature analysis shows that there is a necessity for a higher number of longitudinal studies, controlled and randomized, to obtain more precise conclusions about the role of those therapeutics in relation to TMD. Systematic reviews that attempted to assess both therapeutics and their relationship with signs and symptoms of TMD were inconclusive, due to small number of significant scientific evidences.<sup>1,50</sup> In relation to the role of therapy with Bionator<sup>26</sup> and headgear,<sup>26</sup> it ap-

pears that they have no association with the development of TMD. It is important to be noted that the use of chin cup<sup>4,6,7</sup> and facial mask<sup>43</sup> shows weak or nonexistent associations in relation to TMD, but studies with this conclusions were not included by the methodological criteria of this systematic review.

Before the beginning of orthodontic treatment should be performed by the Orthodontist, in asymptomatic patients, a full history and physical examination on signs and symptoms of TMD.<sup>34</sup> Studies evaluating the attitude of Orthodontists front to the TMD show that this interrelationship is viewed differently as the possibility of orthodontic treatment increase the probability of developing of TMD.<sup>33,34</sup>

Assessing the attitudes and beliefs of Orthodontists regarding to TMD, in a cross-sectional study, the authors obtained results as the majority of respondents did not feel secure about the diagnosis, therapeutic decision and assessment of treatment outcomes of TMD. The vast majority of respondents reported believing that orthodontic treatment does not carry to a higher incidence of TMD and Orofacial Pain (OP), but believe that it can be a form of prevention and treatment of these disorders. It is important to be noted that most participants reported obtained knowledge at a basic level or no knowledge about TMD and Orofacial Pain during their postgraduate course in Orthodontics.<sup>38</sup>

Already the results of a research examining the attitudes of Chinese Orthodontists, regarding orthodontic treatment and TMD, through a questionnaire, showed that most Orthodontists think that an inadequate orthodontic treatment could increase the development of TMD and an adequate orthodontic treatment that could prevent it.<sup>33</sup>

In the presence of signs and symptoms of TMD, the primary treatment protocol should be minimally invasive and with reversible nature. Therapies that change the occlusal pattern

irreversibly, such as orthodontic treatment and occlusal adjustment, should be indicated in a conscious and precise way. Furthermore, this decision should be based on significant scientific evidences.

## CONCLUSIONS

- Many of the available studies in literature have limitations in their designs and methodologies, as well as heterogeneity of results, which reduces the power of evidence generated. Current studies, with rigorous methodological criteria and adequate designs, present more precise evidences of the interrelationship of the orthodontic treatment and TMD.

- The systematic review of literature shows that there is not an increased in prevalence of TMD due to traditional orthodontic treatment, either with protocols for extractions or not, with

significant scientific evidences, such as longitudinal controlled randomized and nonrandomized trials, systematic reviews and meta-analysis, concluding for a tendency to not association. However, it is necessary to perform further randomized clinical trials, with standardized diagnostic criteria for TMD to the determination of more accurate causal associations.

- It is important to perform, during the diagnostic phase of the pre-orthodontic patients, a full assessment of the presence or absence of signs and symptoms of TMD and Orofacial Pain, making use of complementary examinations for a correct diagnosis. In the presence of TMD, becomes important an integration with the Temporomandibular Disorders and Orofacial Pain specialty to an appropriate treatment decision, due to the high prevalence of TMD in the general population.



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