Orthodontics as risk factor for temporomandibular disorders: a systematic review

Eduardo Machado*, Patricia Machado**, Paulo Afonso Cunali***, Renésio Armindo Grehs****

Abstract

Introduction: 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. **Objective:** 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 were used, 12 of which were longitudinal prospective non-randomized 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.

* Specialist in Temporomandibular Disorders (TMD) and Orofacial Pain, Federal University of Paraná (UFPR). Dental Degree, Federal University of Santa Maria (UFSM).
** Specialist in Prosthetic Dentistry, Pontifical Catholic University of Rio Grande do Sul (PUCRS). Dental Degree, UFSM.
*** Ph.D. in Sciences ,Federal University of São Paulo (UNIFESP). Professor of Graduate and Post-graduate Course in Dentistry, Federal University of Paraná (UFPR). Coordinator of the Specialization Course in TMD and Orofacial Pain, UFPR.
**** PhD in Orthodontics, UNESP. Professor of Graduate and Post-graduate Course in Dentistry, UFSM.

INTRODUCTION

In recent years a considerable increase in the prevalence of signs and symptoms of temporomandibular disorders (TMD) has been observed.[44] Several theories have been proposed to determine the etiology of TMD, but a single and specific factor was not detected.[44,47] 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.[47] 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 itself in a very unclear way to the professional.[5]

Epidemiological studies show that the signs and symptoms of TMD are commonly found in children and adults,[9,32] and may reach up to 31% of the population[42] and it affects more than 10 million people in the USA.[41] Usually the signs and symptoms are milder in childhood and increases in adolescence both in prevalence and severity.[49]

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.[17]

Thus, the role of orthodontics in the development, prevention and treatment of TMD remains controversial. This study aimed to analyze by a systematic literature review 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

A computerized search in MEDLINE, Cochrane, EMBASE, PubMed, Lilacs and BBO was performed for 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 after reading the full version of the article.

Inclusion criteria for article selection 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 non-randomized studies, systematic reviews and meta-analysis. Clinical trials should present control group.

» Clinical trials in which clinical examination in patients were performed and at least one clinical evaluation was done after the end 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, cross-sectional studies, clinical case reports, case series, simple reviews and opinions papers were excluded, as well as studies in which orthodontic treatment had not yet been completed and studies based only on imaging tests.

RESULTS

After applying the inclusion criteria 18 articles were selected: 12 longitudinal prospective non-randomized 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 clinical evaluations were performed and 2) systematic reviews and meta-analysis, as presented in Tables 1, 2 and 3.

FIGURE 1 - Design of included studies.

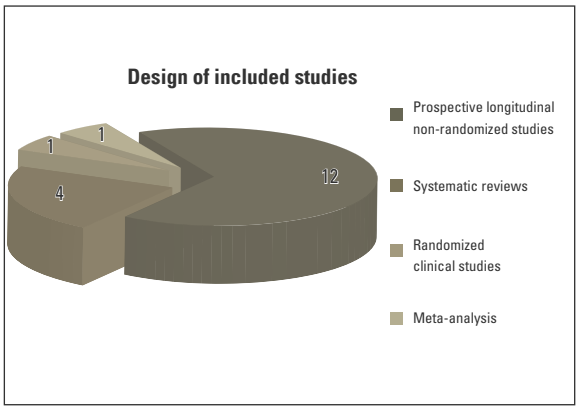

TABLE 1 - Design of clinical trials.

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

P: prospective; L: longitudinal; RCT: randomized clinical trial; CC: case-control; tt: treatment; F: fixed appliances; FA: functional appliances; NS: not specified.

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[52]	After tt	TMJ sounds	no	no
Hirata et al[24]	1.2 years during tt	Questionnaire, MMO, TMJ sounds, deviations	NE	no
Egermark and Thilander[13]	10 years	Questionnaire, Helkimo index	NE	Improvement
O'Reilly et al[46]	During, just after tt	Lateral movement, TMJ sounds, tenderness	no	no
Egermark and Ronnerman[12]	Before, during and after tt	Questionnaire, Helkimo index	no	Improvement
Keeling et al[26]	Follow-up of 2 years	TMJ sound, TMJ pain, muscle pain	NE	no
Henrikson and Nilner[21]	2 years after 1st evaluation	Symptoms (headache, TMJ sounds, pain)	NE	Improvement
Henrikson et al[22]	2 years after 1st evaluation	Signs (MM, pain, TMJ sounds)	NE	Improvement
Imai et al[25]	Initial, after splint, after tt, 1 year after tt	TMJ sounds, pain, restriction	NE	no
Egermark et al[11]	20 years after 1st evaluation	Questionnaire, Helkimo index	NE	no
Henrikson and Nilner[23]	Beginning, after 1 and 2 years of tt and 1 year after the end of tt	Signs and symptoms	no	no
Mohlin et al[40]	Performed at 19 and 30 years old	Questionnaire, clinical assessment, psychological status	no	no
Egermark et al[10]	Before, during, after tt and 15-18 years after the end of tt	Questionnaire, Helkimo index	NE	no

Tt: Treatment; MMO: Maximum mouth opening; MM: Mandibular movement; NE: not evaluated.

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 and Turp[37]	1997	SR	21	F, FA	no
Kim et al[27]	2002	MA	31	F, FA	no
Popowich et al[50]	2003	SR	5	Herbst appliance	Insufficient evidences
Mohlin et al[39]	2007	SR	30	F, FA	no
Abrahamsson et al[1]	2007	SR	3	OC	Insufficient evidences

SR: systematic review; MA: meta-analysis; F: fixed appliances; FA: functional appliances; OC: 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 the researchers to try to control as best as possible the biases of the study generating higher levels of evidence. Thus, the sample size calculation becomes important, so that the sample becomes representative 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.[53]

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.[45]

The supposed relationship between orthodontics and temporomandibular disorders has attracted the interest of the 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.[5]

For the establishment of a risk factor, it must fill out 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 show a biological plausibility with the disease. Moreover, the factor remains associated after being controlled for other risk factors, a dose-response relationship must exist, that is, the higher the risk factor, the higher the outcome and this factor must be identified in different populations.[2]

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.[54] Therefore, the clinical trials included in this systematic review show longitudinal design, whereas it should be in this point of view that the interrelationship between orthodontics and TMD must be considered.

There is a difference in the quality of the designs of clinical studies before and during the 80s, and the most recent ones.[35] 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 for generating scientific evidence. Furthermore, the heterogeneity of results in published studies makes an adequate meta-analysis more difficult to be obtained. Added to this, there is a lack of a standardized classification system for TMD diagnosis. Thus, you can always find a scientific article to prove a point of view.[27]

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, in this systematic review various diagnostic methods used by the authors of the included studies can be found: Helkimo index,[18,19] craniomandibular index,[15,16] 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, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) was formulated, which examined jointly the physical and psychosocial aspects of TMD, in the axis I and II, respectively.[8] This diagnostic method has been translated, culturally adapted and validated in Brazil.[31,48] 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.[14] It becomes important to acknowledge situations of disk displacement with and without reduction, as well as the presence of crackles as indicative of osteoarthritis. It is important to emphasize that the absence of TMJ sounds, not necessarily characterized a situation of normality.[14,52]

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 development. In addition, orthodontic mechanotherapy performs gradual changes in a system that has a great capacity of adaptation.[51] Similar results were obtained in other studies, and worsening of signs and symptoms of TMD pre-treatment were not observed.[20]

In a critical review of the literature, a low association between occlusal factors that characterize TMD was noted. Moreover, orthodontic treatment performed during adolescence usually does not increase or decrease 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 five or more posterior teeth may be associated with specific diagnosis of TMD.[36]

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.[35]

Current studies, within a context of an evidence-based Dentistry, such as randomized clinical trials, longitudinal prospective non-randomized 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 no association between orthodontic treatment and TMD,[10,11,21,22,23,25,26,40] and the presence

or absence of extractions during orthodontic treatment did not increase the prevalence or worsened signs and symptoms related to TMD.[11,23] Randomized clinical trials[26] and longitudinal prospective non-randomized studies,[10,11,21,23,25] as well as meta-analysis[27] and systematic review,[39] besides presenting 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.[3,28,29]

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.[26] This fact occurs due to difficulties in the accomplishment of randomized clinical trials evaluating orthodontic treatment and TMD, due to ethical and practices reasons.[27] Difficulties are also present when assessing other forms of irreversible therapies such as TMD treatment protocols. An example of this situation is the occlusal adjustment, from 1966 to 2002, there are only 6 RCTs evaluating the occlusal adjustment as treatment and prevention option for TMD in a systematic review published in Cochrane Library.[30]

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 these treatment modalities 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.[1,50] In relation to the role of therapy with Bionator[26] and headgear,[26] it appears that they have no association with the development of TMD. It is important to be noted that the use of chincup[4,6,7] and facial mask[43] shows weak or nonexistent associations in relation to TMD, but studies with this conclusions were not included due to the methodological criteria of this systematic review.

Before the beginning of orthodontic treatment, in asymptomatic patients, a full history and physical examination on signs and symptoms of TMD should be performed by the orthodontist.[34] Studies evaluating the attitude of orthodontists to TMD show that this interrelationship is viewed differently as the possibility of orthodontic treatment increase the probability of developing of TMD.[33,34]

Assessing the attitudes and beliefs of orthodontists regarding 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 lead to a higher incidence of TMD and orofacial pain, but believe that it can be a form of prevention and treatment of these disorders. It is important to noted that most participants reported knowledge at a basic level or no knowledge about TMD and orofacial pain during their postgraduate course in orthodontics.[38]

On the other hand, the results of a research examining the attitudes of Chinese orthodontists, regarding orthodontic treatment and TMD, using a questionnaire, showed that most orthodontists think that an inadequate orthodontic treatment could increase the development of TMD and an adequate orthodontic treatment could prevent it.[33]

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 literature review shows that there is no 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 non-randomized trials, systematic reviews and meta-analysis, concluding for a tendency of no association. However, it is necessary to perform further randomized clinical trials, with standardized diagnostic criteria for TMD for 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, an integration with the Temporomandibular Disorders and Orofacial Pain specialty becomes important for an appropriate treatment decision, due to the high prevalence of TMD in the general population.

REFERENCES

1. Abrahamsson C, Ekberg E, Henrikson T, Bondemark L. Alterations of temporomandibular disorders before and after orthognathic surgery: a systematic review. Angle Orthod. 2007 Jul;77(4):729-34.
2. Beck JD. Risk revisited. Community Dent Oral Epidemiol. 1998 Aug;26(4):220-5.
3. Carlton KL, Nanda RS. Prospective study of posttreatment changes in the temporomandibular joint. Am J Orthod Dentofacial Orthop. 2002 Nov;122(5):486-90.
4. Deguchi T, Uematsu S, Kawahara Y, Mimura H. Clinical evaluation of temporomandibular joint disorders (TMD) in patients treated with chin cup. Angle Orthod. 1998 Feb;68(1):91-4.
5. Delboni MEG, Abrão J. Estudo dos sinais de DTM em pacientes ortodônticos assintomáticos. Rev Dental Press Ortod Ortop Facial. 2005 jul-ago;10(4):88-96.
6. Dibbets JM, Van Der Weele LT. Extraction, orthodontic treatment, and craniomandibular dysfunction. Am J Orthod Dentofacial Orthop. 1991 Mar;99(3):210-9.
7. Dibbets JM, Van Der Weele LT. Long-term effects of orthodontic treatment, including extraction, on signs and symptoms attributed to CMD. Eur J Orthod. 1992 Feb;14(1):16-20.
8. Dworkin SF, Leresche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord. 1992 Fall;6(4):301-55.
9. Egermark-Eriksson I. Mandibular dysfunction in children and individuals with dual bite. Swed Dent J Suppl. 1982(10):1-45.
10. Egermark I, Carlsson GE, Magnusson T. A prospective long-term study of signs and symptoms of temporomandibular disorders in patients who received orthodontic treatment in childhood. Angle Orthod. 2005 Jul;75(4):645-50.
11. Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. Angle Orthod. 2003 Apr; 73(2):109-15.
12. Egermark I, Ronnerman A. Temporomandibular disorders in the active phase of orthodontic treatment. J Oral Rehabil. 1995 Aug; 22(8):613-8.
13. Egermark I, Thilander B. Craniomandibular disorders with special reference to orthodontic treatment: an evaluation from childhood to adulthood. Am J Orthod Dentofacial Orthop. 1992 Jan;101(1):28-34.
14. Eriksson L, Westesson PL, Rohlin M. Temporomandibular joint sounds in patients with disc displacement. Int J Oral Surg. 1985 Oct;14(5):428-36.
15. Fricton JR, Schiffman EL. The reliability of a craniomandibular index. J Dent Res. 1986 Nov;65(11):1359-64.
16. Fricton JR, Shiffman EL. The craniomandibular index: Validity. J Prosthet Dent. 1987 Aug;58(2):222-8.
17. Greene CS. The etiology of temporomandibular disorders: implications for treatment. J Orofac Pain. 2001 Spring;15(2):93-105.
18. Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. Sven Tandlak Tidskr. 1974 Mar;67(2):101-21.
19. Helkimo M. Studies on function and dysfunction of the masticatory system. III. Analyses of anamnestic and clinical recordings of dysfunction with the aid of indices. Sven Tandlak Tidskr. 1974 May;67(3):165-81.
20. Henrikson T. Temporomandibular disorders and mandibular function in relation to Class II malocclusion and orthodontic treatment. A controlled, prospective and longitudinal study. Swed Dent J. Suppl. 1999;134:44.
21. Henrikson T, Nilner M. Temporomandibular disorders and need of stomatognathic treatment in orthodontically treated and untreated girls. Eur J Orthod. 2000 Jun;22(3):283-92.
22. Henrikson T, Nilner M, Kurol, J. Signs of temporomandibular disorders in girls receiving orthodontic treatment. A prospective and longitudinal comparison with untreated Class II malocclusions and normal occlusion subjects. Eur J Orthod. 2000 Jun;22(3):271-81.
23. Henrikson T, Nilner M. Temporomandibular disorders, occlusion and orthodontic treatment. J Orthod. 2003 Jun;30(2):129-37.
24. Hirata HR, Heft MW, Hernandez B, King GT. Longitudinal study of signs of temporomandibular disorders (TMD) in orthodontically treated and non-treated groups. Am J Orthod Dentofacial Orthop. 1992 Jan;101(1):35-40.
25. Imai T, Okamoto T, Kaneko T, Umeda K, Yamamoto T, Nakamura S. Long-term follow-up of clinical symptoms in TMD patients who underwent occlusal reconstruction by orthodontic treatment. Eur J Orthod. 2000 Feb;22(1):61-7.
26. Keeling SD, Garvan CW, King GJ, Wheeler TT, McGorray S. Temporomandibular disorders after early Class II treatment with bionators and headgears: results from a randomized controlled trial. Semin Orthod. 1995 Sep;1(3):149-64.
27. Kim MR, Graber TM, Viana MA. Orthodontics and temporomandibular disorder: a meta-analysis. Am J Orthod Dentofacial Orthop. 2002 May;121(5):438-46.
28. Kinzinger G, Roth A, Gulden N, Bucker A, Diedrich P. Effects of orthodontic treatment with fixed functional orthopaedic appliances on the condyle-fossa relationship in the temporomandibular joint: a magnetic resonance imaging study (Part I). Dentomaxillofac Radiol. 2006 Sep;35(5):339-46.
29. Kinzinger G, Roth A, Gulden N, Bucker A, Diedrich P. Effects of orthodontic treatment with fixed functional orthopaedic appliances on the disc-condyle relationship in the temporomandibular joint: a magnetic resonance imaging study (Part II). Dentomaxillofac Radiol. 2006 Sep;35(5):347-56.
30. Koh H, Robinson PG. Occlusal adjustment for treating and preventing temporomandibular joint disorders (Cochrane Review). In: The Cochrane Library. Oxford: Update Software; 2008.
31. Kosminsky M, Lucena LBS, Siqueira JTT, Pereira Jr FJ, Góes PSA. Adaptação cultural do questionário "Research Diagnostic Criteria for Temporomandibular Disorders: Axis II" para o Português. J Bras Clín Odontol Integr. 2004 jan-fev; 8(43):51-61.
32. Luther F. Orthodontics and the temporomandibular joint: where are we now? Part 1. Angle Orthod. 1998 Aug;68(4):295-304.
33. Mao Y, Duan XH. Attitude of chinese orthodontists towards the between orthodontic treatment and temporomandibular disorders. Int Dent J. 2001 Aug;51(4):277-81.
34. Martins DR, Janson GRP, Touno JLA. Avaliação das disfunções temporomandibulares no exame ortodôntico inicial. Rev Dental Press Ortod Ortop Facial. 2000 jan-fev;5(1):12-6.
35. McNamara JA. Orthodontic treatment and temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1997 Jan;83(1):107-17.
36. McNamara JA Jr, Seligman DA, Okeson JP. Occlusion, orthodontic treatment, and temporomandibular disorders: a review. J Orofac Pain. 1995 Winter;9(1):73-90.
37. McNamara JA Jr, Türp JC. Orthodontic treatment and temporomandibular disorders: is there a relationship? Part 1: clinical studies. J Orofac Orthop. 1997;58(2):74-89.
38. Moana Filho EJ. Levantamento das atitudes e crenças dos ortodontistas com relação à disfunção temporomandibular e dor orofacial. Rev Dental Press Ortod Ortop Facial. 2005 jul-ago;10(4):60-75.
39. Mohlin B, Axelsson S, Paulin G, Pietilä T, Bondemark L, Brattström V, et al. TMD in relation to malocclusion and orthodontic treatment. Angle Orthod. 2007 May;77(3):542-8.

40. Mohlin BO, Derweduwen K, Pilley R, Kingdon A, Shaw WC, Kenealy P. Malocclusion and temporomandibular disorder: a comparison of adolescents with moderate to severe dysfunction with those without signs and symptoms of temporomandibular disorder and their further development to 30 years of age. Angle Orthod. 2004 Jun;74(3):319-27.
41. National Institute of Health. Management of temporomandibular disorders. NIH Technology Assessment Conference. Bethesda: NIH; 1996.
42. Nekora-Azak A, Evlioglu G, Ordulu M, Issever H. Prevalence of symptoms associated with temporomandibular disorders in a Turkish population. J Oral Rehabil. 2006 Feb;33(2):81-4.
43. Ngan PW, Yiu C, Hagg U, Wei SH, Bowley J. Masticatory muscle pain before, during, and after treatment with orthopedic protraction headgear: a pilot study. Angle Orthod. 1997;67(6):433-7.
44. Okeson JP. Orofacial pain. Guidelines for assessment. Diagnosis and management. Chicago: Quintessence;1996. p. 113-84.
45. Oliveira GJ, Oliveira ES, Leles CR. Tipos de delineamento de pesquisa de estudos publicados em periódicos odontológicos brasileiros. Rev Odonto Ciênc. 2007 jan-mar;22(55):42-7.
46. O'Reilly MT, Rinchuse DJ, Close J. Class II elastics and extractions and temporomandibular disorders: a longitudinal prospective study. Am J Orthod Dentofacial Orthop. 1993 May;103(5):459-63.
47. Parker MW. A dynamic model of etiology in temporomandibular disorders. J Am Dent Assoc. 1990 Mar;120(3):283-90.
48. Pereira Jr FJ, Favilla EE, Dworkin S, Huggins K. Critérios de diagnóstico para pesquisa das disfunções temporomandibulares. Tradução oficial para a língua portuguesa. J Bras Clín Odontol Integr. 2004 out-dez; 8(47):384-95.
49. Pilley JR, Mohlin B, Shaw WC, Kingdon A. A survey of craniomandibular disorders in 500 19-year-olds. Eur J Orthod. 1997 Feb;19(1):57-70.
50. Popowich K, Nebbe B, Major PW. Effect of Herbst treatment on temporomandibular joint morphology: a systematic literature review. Am J Orthod Dentofacial Orthop. 2003 Apr;123(4):388-94.
51. Sadowsky C. The risk of orthodontic treatment for producing temporomandibular mandibular disorders: a literature overview. Am J Orthod Dentofacial Orthop. 1992 Jan;101(1):79-83.
52. Sadowsky C, Theisen TA, Sakols EI. Orthodontic treatment and temporomandibular joint sounds - a longitudinal study. Am J Orthod Dentofacial Orthop. 1991 May;99(5):441-7.
53. Susin C, Rosing CK. Praticando odontologia baseada em evidências. 1ª ed. Canoas: Ulbra; 1999.
54. Susin C, Rosing CK. A importância do treinamento, reprodutibilidade e calibragem para a qualidade dos estudos. Rev Fac Odontol Porto Alegre. 2000 jul;41(1):3-7.

Submitted: February 2009
Revised and accepted: August 2009

Contact address
Eduardo Machado
Rua Francisco Trevisan, no. 20, Bairro Nossa Sra. de Lourdes
CEP: 97.050-230 - Santa Maria / RS
E-mail: machado.rs@bol.com.br