A literature review on the causal relationship between Occlusal Factors (OF) and Temporomandibular Disorders (TMD) IV: experimental studies on occlusal adjustment by occlusal carving as a preventive or therapeutic intervention

Una revisión de la literatura sobre la relación causal entre los factores oclusales (FO) y los desórdenes temporomandibulares (DTM) IV: estudios experimentales del ajuste oclusal por tallado selectivo como intervención preventiva o terapéutica

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ABSTRACT

Introduction: *this is the fourth article in a series that have as purpose to present a literature review about the causal relationship between the occlusal factors (OF) and temporomandibular disorders (TMD).* ***Methods:*** *this article presented and analyzed experimental studies in which researchers used occlusal adjustment (OA) as a therapeutic means for TMDs and other associated disorders.* ***Results and conclusions:*** *the analysis of the studies presented in this literature review shows that the actual evidence does not support the use of OA as a primary therapeutic method. This is especially true when one considers the fact that it is an irreversible treatment, with secondary effects (tooth sensitivity) and that is limited to certain occlusal schemes.*

Keywords: *occlusion, temporomandibular disorders, etiology, occlusal factors, temporomandibular joint, experimental studies, occlusal adjustment, selective tooth grinding.*

RESUMEN

Introducción: *este es el cuarto de una serie de artículos que tienen como propósito presentar una revisión de la literatura sobre la relación causal entre los factores oclusales (FO) y los desórdenes temporomandibulares (DTM).* ***Métodos:*** *en este artículo se presentaron y analizaron los estudios experimentales en los que se usó el ajuste oclusal (AO) como medio terapéutico para DTM y otros desórdenes asociados. Para el análisis se usaron los parámetros recomendados por Mohl.* ***Resultados y conclusiones:*** *el análisis de los estudios presentados en esta revisión de la literatura muestra que la evidencia actual no soporta al uso del AO como medio terapéutico de primera línea. Esto es en especial cierto cuando se considera el hecho de que es un tratamiento irreversible, con efectos secundarios (sensibilidad dental) y que es limitado a ciertos esquemas oclusales.*

Palabras clave: *oclusión, desórdenes temporomandibulares, etiología, factores oclusales, articulación temporomandibular, estudios experimentales, ajuste oclusal, tallado dental selectivo.*

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INTRODUCTION

This is the fourth of this series of articles [1-3] aiming to review different epidemiological studies and their validity, in order to evaluate the current scientific evidence that supports the possible relationship between temporomandibular disorders (TMD) and occlusal factors (OF). Occlusal adjustment (OA) is the selective removal of dental tissue with the purpose of achieving harmonious occlusion of the upper and lower teeth in the intercuspal position, as well as the elimination of interferences in mandibular movements. OA is a therapeutic method that changes the occlusal scheme and has traditionally been used for the management of patients with TMD. This article will present and analyze experimental epidemiological studies about occlusal adjustment (OA) by occlusal carving as a therapeutic intervention to eliminate occlusal interference that could possibly induce the development of a TMD. In this article we will review the literature concerning the OA use as a treatment method for DTM and other associated conditions.

METHODS

The literature review was performed using different sources of information:

1. The standard medical information Medline database, specifically using the MedlineOVID library (from 1966 to 2008). The abstracts of the articles in English and whose title suggested the study of OA use for TMD were reviewed. In order to narrow the search, keywords like occlusal adjustment, occlusal carving, occlusal therapy were cross-referenced with the relevant terms under the TDM (temporomandibular disorders) header and TMJ dysfunction (temporomandibular joint).

2. The bibliography of the articles initially found in the MedlineOVID database search.

3. The bibliography of different books on the TMD (or TMJ dysfunction) and occlusion domain.

4. The bibliography of several literature reviews on the subject matter from the MedlineOVID database.

The validity of the studies was evaluated following the parameters recommended by Mohl.[4] These parameters were described in detail in three previous articles [1-3] and are shown in Table 1 (Appendix 1).

Table 1. Parameters for assessing the validity of scientific studies

Definition of the gold standard
Establishment of an acceptable system of diagnostic classification
Use of clearly defined measures
Intra- and inter-examinators acceptable reliability
Use of suitable samples

Data collection by "blind" examiners
Study replicability
Consideration of alternative hypotheses
Using matched groups
Random assignment of patients and subjects to the control group

Source: by the authors

RESULTS

Among the reports that used OA as a preventive or therapeutic option, a total of twenty-eight studies with clinical design of experimental type were found. OA was used in eight studies as a preventive measure for TMD signs and symptoms in asymptomatic subjects (Table 2)[5-12] and in twenty studies as a therapeutic measure, applied to different types of conditions of orofacial disorders related to the masticatory system. Eight studies specifically addressed only TMDs (Table 3),[13-20] seven evaluated headaches and TMDs (Table 4),[21-27] five evaluated other disorders such as bruxism (three articles), one evaluated shoulder/neck pain and one "globus" syndrome (globus pharyngis) (Table 5).[28-32]

Analysis of the factors guaranteeing the validity of the collected experimental studies:

1. Definition of the gold standard. In order to determine the presence or absence of TMDs, most studies used clinical evaluation as the gold standard, and although inclusion and exclusion criteria were presented in many of the studies,[21, 22, 23, 25, 27, 32] some studies provided vague or incomplete information,[13, 14, 15, 18- 20, 24, 26, 31] or simply lacked that information.[16, 17, 28-30] In addition, data collection was not homogeneous among the studies, and none reported having considered the reliability and validity of the clinical aspects included in the clinical evaluation. Information about symptoms was obtained with different types of questionnaires or interviews. Likewise, the physical examination was conducted in different ways and few studies used other diagnostic aids (EMG, kinesiography).[5, 13, 17, 19, 26, 28, 29, 32] In the studied conditions, aspects related to the signs and symptoms' chronicity or persistence and psychosocial aspects were not considered in the diagnostic criteria for the selection of the participants.

2. Diagnostic classification system. In the reviewed studies, no systematic diagnostic classification was used to allow the differential diagnosis of TMDs; however, taking into account the description of the clinical criteria, the participants appeared to be more associated with muscular than articular disorders. In any case, the diagnostic impressions were confusing, vague and impossible to validate. Even in a study that provided a specific diagnosis such as myofascial pain, the diagnostic process was questionable since the clinical evaluation was incomplete as it only used the patient's subjective information but not the physical examination.[20] In most studies that included patients with headaches, these had a medical evaluation using a diagnostic classification[33] that allowed a differential diagnosis (tension

headaches, migraines or other headaches). However, in other studies headaches were considered a symptom and no differential diagnosis was reported.[24-27] The diagnosis of other disorders such as bruxism was not different. Although all studies claimed to have bruxism patients —even severe bruxism—, it is not possible to know if they used common clinical criteria such as tooth wear or if they were subjective criteria such as jaw pain or fatigue in the mornings, during the day or tooth clenching at night.[28-30]

3. Use of clearly defined measures. The criteria used to evaluate the masticatory system were similar, although the methods varied between questionnaires (with yes/no answers, multiple-choice answers, or visual analogue scale —VAS), [8, 12, 15, 16, 18-24, 32] interviews[9, 11, 25-27] and different physical evaluation methods.[10, 11] Some of these physical evaluation methods had previously been used in other reports,[5, 11, 15]; however, their diagnostic validity or reliability was considered in few of the studies.[25] Many reports [5, 6, 15, 16, 18, 19] used the Helkimo index,[34] while others simply used evaluation systems that were "standard" for them.[12, 15, 16, 21, 22, 24,26, 27, 31, 32] Likewise, something similar was found among the treatment regimens. Previously published therapeutic procedures [35-39] were used to perform the OA in many of the reports, while in others the type of OA method used was not clarified. These also varied significantly and in the studies where time was reported, sessions could last between 10 to 30 minutes,[21] up to the thorough elimination of interference that included four sessions that lasted 60 minutes each.[24] Others included electromyographic (EMG) reports as a primary part for OA completion [27, 28, 29] Additionally, many aspects of both the clinical evaluation [13, 14, 17, 20, 28, 32] and of the way of carrying out the OA were not described in detail. [5, 6, 17, 18, 19, 31, 32]

4. Intra- and inter-examinators acceptable reliability. Only a few studies reported data related to the reliability of the examiners. Two studies reported the reliability of aspects related to the evaluation of the occlusal variables [6, 25] while only one also took into account the clinical evaluation of the masticatory system.[27] In other reports, although they did consider the examiners previous training before clinical measurements were performed, the reliability of these was not reported.[11, 12] On the other hand, in many of the studies the number of examiners was not clear and apparently varied between one, two or more.

5. Use of suitable samples. In studies evaluating the effect of occlusal adjustment in asymptomatic individuals, participants were individuals from the general population,[7, 9, 10, 12] dental patients [6, 10, 11] or dentistry students [5, 8] chosen in a non-random way. In most studies, patients with TMDs or other associated disorders belonged to university clinics specializing in TMDs [13-16, 18, 19, 24-32] or neurology. [21-23] Other studies included students or patients from dental schools with TMD.[17, 20] The samples varied widely in the number of subjects, although a good number of the reports included more than thirty participants. Samples also varied in age ranges and some of the studies included young people under 30 years of age, while others included

patients over 50 years of age. The severity of patient's symptoms was generally not determined by factors such as intensity, duration or frequency of the subjects' signs and symptoms. None of the studies attempted to analyze possible contributing etiological factors. Therefore, the samples included patients in whom other factors (such as anxiety, depression or sleep disorders) were possibly primarily responsible for the development of TMDs and therefore would clearly diminish any chance of success that the OA might have in the management of patients' symptoms.

6. Data collection by "blind" examiners. Thirteen of the studies used single [9, 11, 25, 26, 32] or double [7, 8, 12, 18, 19, 21-23]"blind", while the rest were open-label studies. However, the procedure for keeping the "blind" design in the studies was not clarified in many of the reports and the difficulty of achieving this was mentioned by some authors.[8, 9, 20]

7. Study replicability. Studies that reported similar conclusions do not necessarily reflect replicability of patient responses to the therapeutic regimens used in the different studies. This is due to the heterogeneity of the designs and other methodological shortcomings that have been mentioned in the points analyzed above. Similarly, although different occlusal adjustment methods were used between studies, many of the reports used similar methods. However, no reports compared the efficacy of two or more occlusal adjustment methods.

8. Using matched control groups. Only a few studies handled potential confounding variables using subject matching. In one of the reports, the subjects were matched by age and sex before randomizing the participants.[32]

9. Random assignment of patients and subjects to the control group. A good number of studies [7-9, 11, 12, 15, 18, 19, 21-27, 31, 32] used random distribution; however, only some of them described the process.[9, 12, 21, 22] In others the random distribution produced unbalanced study groups [18, 19, 21] while in others it was not possible to know if this occurred,[7, 8, 11, 15, 23, 25, 31] nor did any of them report having considered this aspect.

10. Consideration of alternative hypotheses. Although there is not complete agreement between the results of the evaluated studies, the general trend was disapproval of the use of occlusal adjustment as a therapeutic intervention. However, alternatively one might ask: Could the use of homogeneous samples and therapeutic methods better clarify the effectiveness of the results reported in the different studies? Is the reported improvement of patients in some of the studies due to the placebo effect or to the cyclicality of the symptoms of the disorders studied? Is there an OA method that has better results, and if no method is better than another, then perhaps what matters is the sensory change that occurs when making an OA, but not the OA (or the change in the occlusal scheme caused by the OA) itself? If aspects such as the chronicity of the disorders studied were considered, would the results change?

Table 2. Population of asymptomatic subjects

First author & year	Sample (F/M) and description of the study groups	Clinical evaluation and diagnosis	Type of intervention	Follow-up time	Results	Conclusion
Ingervall, 1982	27 asymptomatic dentistry students with and without non-working interferences	EMG records	EG: 13 (7/6) people received OA eliminating the non-working interferences and premature contacts CG: it received NTr	3, 21 and 114 days in average	No significant differences were reported between the two groups	Absence of a noticeable influence of interferences on the EMG pattern of asymptomatic subjects.
Ettala-Ylitalo, 1986	59 dental patients previously treated with fixed prosthesis	Interview, questionnaire and examination*^	EG: 22 (13/9) people received OA CG: 37 (21/16) received NTr	1 year	Significant improvement in EG in Di improvement 2. There were no differences in Ai	The dysfunction and occlusal index improved as a result of occlusal adjustment. OA prior prosthetic rehabilitations is important to minimize future TMD signs and symptoms.
Kirveskari, 1989	99 (NR) asymptomatic children and adolescents from the general population	Questionnaire and examination©	EG: 53 (NR) people received OA CG: 46 (NR) received POA	3 years	Although in the first two years no significant differences were seen, in the third evaluation less TMD signs and symptoms were observed in EG	OA may have a prophylactic effect for TMD
Kirveskari, 1989	65 asymptomatic dentistry students®	Interview, questionnaire and examination©	GE: 33 (22/11) people received OA GC: 32 (24/8) received POA	2 years	Increase in symptoms in both groups but 25% more in the CG. AN improvement in the CG and increase of tenderness on palpation	OA reduces the occurrence of subjective symptoms and possibly also the occurrence of TMD clinical signs
Kirveskari, 1992	128 (61/67) 5-year-old children and 109 (54/55) 10-year-old children for a total of 244 (115/129) ®	Questionnaire and examination	EG: NR, received OA CG: NR, received POA	5 years	Significant association between interference number and TMD signs	OA reduces TMD signs
Kirveskari, 1995	178 asymptomatic subjects	Interview, questionnaire and examination©	GE: 89 (22/11) people received OA GC: 89 (24/8) received POA	5 years	No relationship could be established due to the absence of interferences in the EG.	No correlation could be established between occlusal interference and muscular tenderness on palpation
Karjalainen, 1997	138 (88/35) asymptomatic subjects after orthodontic treatment ®	Interview, questionnaire and examination©	EG: 63 (NR) people received OA CG: 60 (NR) received POA	3 years	Further reduction of muscle tenderness on palpation in EG.	OA could serve as a preventive measure for TMD development
Kirveskari, 1998	146 asymptomatic subjects ®	Questionnaire and examination©	EG: 74 (52/22) received OA CG: 72 (51/21) received POA	4 years	More CG subjects (9/67) required TMD treatment in comparison to EG (1/60)	Subjects who received OA showed a lower risk of developing TMDs compared to the group that received POA

® Random assignment of participating subjects. © Use of "blind" examiners. * Application of the Helkimo index (HI). ^ Reported examiners reliability; Helkimo amnestic index (Ai); Helkimo dysfunction index (Di). NC, no correlation NR, not reported F, female. M, male. DDwoR, disc displacement without reduction MRI, magnetic resonance imaging. TMD, temporomandibular disorders. TMJ, temporomandibular joint AN, articular noises OA, occlusal adjustment POA, placebo occlusal adjustment, no treatment (NTr). EG, experimental group. CG, group control.

Table 3. Population of TMD patients

First author & year	Sample (F/M) and description of the study groups	Clinical evaluation and diagnosis	Type of intervention	Follow-up time	Results	Conclusion
Ramfjord, 1961	32 (12/20) TMD patients	Interview, examination and EMG measurements	OA	3 years	Improvement of TMD symptoms and harmonious, more synchronized EMG records	OA eliminates TMD symptoms and improves muscle contraction patterns measured with EMG.
Goodman, 1976	25 (NR) TMD patients of MM	Interview and examination BS	POA	3 weeks	64% reported marked improvement	The placebo effect is pronounced in the management of these patients.
Kopp, 1979	30 patients with TMD clinical signs	Questionnaire and examination*	All received counseling. EG: 15 people received OA, 8 of which used interocclusal orthosis CG: 12 received NTr	6 weeks	40-60% reported significant symptom improvement in both groups; improvement in Di with OA	Counseling reduces subjective symptoms; OA reduces signs, but with considerable variation among individuals and it is influenced by other factors. Poor correlation between clinical and subjective dysfunction
Kopp, 1981	18 new patients with TMD and 15 patients refractory to traditional TMD management (palliative care, occlusal plates and jaw exercises)	Questionnaire and examination Subgroup: TMJ with local pain and tenderness on palpation	EG: 9 people received OA, and other interventions CG: 15 received intra-articular injections	2 years	There was no significant difference in symptom improvement between the two groups. Significant improvement of general signs in the CG.	Both treatments provide long-term palliative effect. Treatment with intra-articular injections has a stronger effect on the signs and symptoms improvement.
Sheikho-lesman, 1982	37 TMD patients and 37 dentistry students	Interview, examination, and EMG measurements	EG: 37 people received OA, and other interventions CG: 37 received NTr	2, 6 and 24 months	Reduced EMG postural values and signs and symptoms in the TMD group.	OA (combined with other TMD treatments) influences postural EMG values but not on maximum tightening. It also reduces the TMD signs and symptoms
Tsolka, 1992	51 (NR) TMD patients®	Questionnaire and examination ©	EG: 28 people received OA CG: 23 received POA	1-6 months	Significant differences in the reduction of TMD symptoms and signs were reported in both groups. Similar for both groups.	No significant differences were shown in the OA or POA effect on TMD signs or symptoms.
Tsolka, 1993	51 (NR) TMD patients®	Kinesiography and electromyography©	EG: 28 people received OA CG: 23 received POA	1-6 months	Changes in electromyographic and kinesiographic measurements were reported in both groups. Similar for both groups.	No significant differences were shown in the OA or POA effect in electromyographic and kinesiographic measurements.
Kerstein, 1997	25 (NR) students with symptoms similar to patients with myofascial pain	Interview	EG: 10 people received OA CG: 8 received POA and 7 received NTr	6 months	Symptom improvement was significant in the treatment group. There were no changes in the control or no-treatment groups.	Occlusal changes achieved with OA can induce remission of muscular symptoms.

Table 4. Population of TMD and headaches patients

First author/year	Sample (F/M) and description of the study groups	Clinical evaluation and diagnosis	Type of intervention	Follow-up time	Results	Conclusion
Forsell, 1985	96 patients with headaches (tension, migraine and mixed ones) ®	Questionnaire and examination©	EG: 48 people received OA (some received occlusal plates) CG: 43 received POA	5-20 months	Improvement in headaches of 60% in EG and 49% in CG	Headaches (especially tension and mixed ones) appear to respond to TDM treatment
Forsell, 1986	96 patients with headaches (tension, migraine and mixed ones) ®	Questionnaire and examination©	EG: 48 people received OA (some received occlusal plates) CG: 43 received POA	5-20 months	No difference in symptoms Minor signs in EG	OA has a significant effect on signs but not on symptoms
Forsell, 1987	19 patients with headaches (tension, migraine, and mixed ones)	Questionnaire and examination©	19 received OA (14 also received occlusal plates)	5-7 months	Significant differences in the reduction of TMD symptoms and signs	Occlusal treatment (OA and occlusal plates) is superior to POA
Wenneberg, 1988	30 (NR) TMD and headache patients ®	Questionnaire and examination	EG: 15 people received OA CG: 15 received occlusal plates, mandibular exercises and 4 received minor OA	2 months	Significant differences in the reduction of TMD symptoms and signs were reported in both groups. Major in the CG	Combination therapy (occlusal plates, mandibular exercises, minor OA) is superior to OA treatment.
Vallon, 1991	50 (44/6) TMD and headache patients®	Interview and examination^©	EG: 25 people received OA, palliative care and patient education CG: 25 received patient education and counseling	1 month	Significant improvement of general signs in the EG. There was no difference in VAS measurements for pain or headache frequency. Significant improvement of some signs in the EG.	OA is superior to POA to provide overall subjective improvement
Vallon, 1995	50 (44/6) TMD and headache patients ®	Interview, examination and EMG measurements^©	EG: 25 people received OA, palliative care and patient education CG: 25 received patient education and counseling	3 and 6 months	Some participants received other treatments during the follow-up period in both groups. Participants receiving no treatment showed deterioration in symptomatology.	OA (aided with palliative care and patient education) is superior to no treatment at 3- and 6-month follow-up. Although the differences with the CG were not so noticeable after 6 months
Vallon, 1997	50 (44/6) TMD and headache patients®	Interview, examination and EMG measurements ^BS	EG: 25 people received OA, palliative care and patient education CG: 25 received patient education and counseling	2 years	Many participants received other treatments during the follow-up period in both groups. Participants receiving no treatment did not show significant differences in signs or symptoms	OA (aided with palliative care and patient education) is superior to no treatment.

Table 5. Population of patients with other disorders possibly associated with TMD

First author/year	Sample (F/M) and description of the study groups	Clinical evaluation and diagnosis	Type of intervention	Follow-up time	Results	Conclusion
Ramfjord, 1961	34 (12/22) TMD patients	Interview, examination and EMG measurements	All of them received OA: CR = MI, no balance, smooth displacement in working position, minimal in protrusive maxillary anterior	3 years	Improvement of TMD symptoms and harmonious, more synchronized EMG records	OA eliminates TMD symptoms and improves muscle contraction patterns measured with EMG.
Kardachi, 1978	20 (8/12) subjects: 16 with bruxism	Interview, examination and EMG measurements	EG: 4 (3/1) people received OA: 4 (2/2) received biofeedback GC: 4 (1/3) received POA, 4 received control biofeedback. The EMG activity of 4 people without bruxism was measured	3 months	In the EG there was great variation in the values of unilateral portable masseter and temporary EMG, while in the CG there was a slight decrease	OA effect on bruxism management is unpredictable
Bailey, 1980	9 (NR) patients with bruxism seeking treatment	Nightly unilateral EMG records before, during, and after	All of them received OA in two sessions, one week apart	Less than 1 month	There were no consistent effects or responses on unilateral masseter muscle EMG measures in 8 subjects	The relief of bruxism-associated clinical symptoms after OA does not come from an improvement on bruxism itself
Puhakka,1988	22 (18/4) patients with globus pharyngis ®	Interview and examination	EG: 13 people received OA CG: 9 received POA	3 months	EG reported a significant reduction in symptoms	The use of OA is successful in globus pharyngis management
Karppinen, 1999	40 (30/10) patients with chronic neck pain, shoulder pain and/or headache®	Interview, examination and EMG measurements®	EG: 20 people received OA CG: 20 received POA Both groups received home exercises and physical therapy	6 weeks, 12 and 60 months	There were significant differences in the reduction of TMD symptoms and signs in both groups. In the three follow-ups	OA is superior to POA

CR, centric relation; MI, maximum intercuspation

DISCUSSION

The etiology of TMDs and other disorders related to them is controversial, especially when the etiological factors to consider are OFs. Certainly, this controversy also applies to the role that occlusal therapy, specifically occlusal adjustment by selective carving, could have in TMD management.[40-48] This article analyzed experimental clinical investigations where OA was used as a preventive measure for the development of TMDs by implementing it in asymptomatic subjects (Table 2)[5-12] or as a therapeutic measure, implementing it in TMD patients (Table 3)[13-20] or patients of other TMD-associated disorders such as headaches (Table 4),[21-27] bruxism, globus pallidus and cervicogenic pain (Table 5).[28-32]

When the eight studies [5-12] presented in Table 2 were reviewed, six publications showed positive results regarding the use of OA as a prophylactic method able to prevent or decrease the future

risk of the presence of TMD signs and symptoms.[6-9, 11, 12] However, although signs and symptoms decreased significantly in the follow-up period in the subjects who received OA, these signs and symptoms do not necessarily represent an actual TMD unless patients require treatment. Only one study reported a higher incidence in the need for treatment in subjects who had not received OA at the beginning of the study.[12] The authors concluded that removing the presumed structural risks of dental occlusion appears to reduce the TMD incidence in a select group of young subjects. However, the same authors commented that the widespread prophylactic use of OA was not justified without clarifying the cost/benefit relationship and the identification of risk groups. These studies are generally well-designed, controlled, randomly distributed, and their results should be seriously considered.[7-10, 12] However, the use of young subjects (<20 years) jeopardizes the applicability of the results to older patients, which represent a large portion of what is considered the population at greatest risk (15 to 40 years) of developing a TMD.[49] In addition, these results have not been replicated by other groups of researchers and therefore this lack of replicability hinders the validity and generalizability of the results.

The eight studies [13-20] that evaluated OA in TMDs are presented in Table 3. Two of these studies [13, 14] were uncontrolled and investigated the response of TMD patients before and after OA; three were controlled without the use of randomizations [16, 17, 20] and three were controlled with the use of random distribution.[15, 18, 19] Only three studies yielded positive results regarding the use of OA [13, 17, 20] and five reported no significant differences in OA use compared to placebo use. [14, 15, 16, 18,19] Among the three studies that reported positive results, Ramfjord[13] concluded that OA eliminated TMD symptoms and improved muscle contraction patterns measured with EMG. In this study they did not use "blind" examiners, the inclusion and exclusion criteria were not clearly presented, the participating patients had already received previous occlusal treatments and it is not possible to know if the improvement in the patients' condition is real or due to the placebo effect since the study was not controlled. All these factors make the validity of their results questionable. Sheikholesman[17] concluded that OA (combined with other TMD treatments) had an impact on postural EMG values and also reduced TMD signs and symptoms. Although this study was controlled, it was done inadequately. Asymptomatic dentistry students who did not receive any type of treatment were used as control subjects; therefore, the placebo effect could not be controlled.

Besides this, OA was not the only treatment used in the experimental group, thus it is impossible to compare the effect of OA with respect to signs and symptoms between patients and the control group. Additionally, no “blind” examiners were used in this study, the inclusion and exclusion criteria were not clearly presented, and random distribution was not used. Once more, these factors call into question the validity of its conclusions. Finally, Kerstein20 reported that there was a significant improvement in symptoms in the OA treatment group and that there were no changes in the control group, which did not receive OA. The overall design shortcoming of this study was that random distribution was not used and an inadequate control group was chosen they used dental students (who know the treatment being studied), which made it difficult to keep the study "blind". Therefore, the placebo effect could not be

controlled. This sample selection bias was evident when the investigators admitted the difficulty of keeping patients "blinded" to the type of treatment (real OA or placebo). In addition, pretreatment conditions were different between the groups compared, and although both the frequency and intensity of pain were higher in the treatment group than in the control group students, this was never considered in this report. Likewise, these methodological failures make the validity of the results questionable. Among the studies not reporting a positive response to the use of OA as a TMD treatment, there were also methodological problems. After using placebo OA in twenty-five TMD patients, Goodman[14] concluded that the placebo effect in these patients was significant. Although this was a study in which patients were "blinded" to the use of placebo OA (but not the examiners), there was actually no active treatment, and the results were subjective based on the percentage of improvement reported by patients after receiving placebo OA. Additionally, it is not possible to know if the improvement in the condition of the patients was significant since there was no data prior to the use of the placebo OA. These factors make the validity of these results weak. Kopp[15] conducted the first randomized clinical study and reported no significant differences between two groups with TMD who were treated with real OA and placebo OA. However, inclusion and exclusion criteria were not clearly presented; no "blind" examiners were used, nor was their reliability reported. Additionally, other therapies were used in the patients during the study, and it was not clear whether the participating patients had already received previous occlusal treatments. These factors call into question the validity of their results. Kopp (1981)[16] also reported no significant differences in symptom improvement between two TMD groups who were treated with OA (combined with other TMD therapies) and intra-articular injections into the TMJ. Although inclusion and exclusion criteria were not clearly presented, the study was limited to patients with pain located in the TMJ and who had not previously responded to other conservative therapies (palliative care, occlusal adjustment, occlusal plates, among others). In this study, random distribution was not used, no "blinds" were used, nor was the reliability of these reported. These factors cause the results to be questionable as to their validity. Finally, Tsolka[18, 19] reported no significant differences in symptom improvement, EMG records, or kinesiographic records between two groups of TMD patients who were treated with OA or placebo OA. In this randomized, double-blind clinical study, inclusion and exclusion criteria were not clearly presented, nor was the reliability of the examiners reported, and they mentioned facing difficulties to keep the participants "blind". All these factors cause the validity of their results to be questioned.

All the studies that questioned the OA efficacy in the management of headaches (Table 4)[21-27] used random distribution and "blind" designs, except for three reports: two were not "blind"[24, 26] and in the other it was not clear whether it was "blind".[25] Forsell[21-23] studied the effects of occlusal therapies on headaches and TMD in a group of patients referred to a neurology clinic specialized in headache management. In its first report, Forsell[21] reported significant improvement in headache frequency and intensity both in the experimental group (EG) and the control group (CG). However, this improvement was significantly greater in the EG, which leads to the conclusion that headaches (especially tension and mixed ones) seem to respond to TMD treatment. In the second article of the same research study, Forsell[22] reported a significant

impact of occlusal treatment on the TMD signs, but not on TMD symptoms. Several aspects must be taken into account to evaluate the results of these two research studies[21,22]. Apparently, no consideration was given to whether the participating patients had received previous treatment for headaches or TMD. During the study, the EG received other rescue treatments (occlusal plates) in addition to OA and both the average number of visits and the time spent per treatment session were much higher in the EG. It was also unclear how changes in patient symptomatology were assessed and no training or reliability values for examiners were reported. The randomization process produced EG with more TMD symptomatology and higher frequency of headaches. Later in a third report, Forsell[23] reported the effects of OA (combined with occlusal plates) in patients in whom placebo OA (nineteen control group patients) had had no significant effect on the management of their orofacial conditions. After using occlusal therapy in these patients, significant differences were found in the reduction of symptoms and signs of TMDs and headaches. It was concluded that occlusal treatment (combined with occlusal plates) is superior to OA placebo. However, due to all the factors mentioned above that concern these reports, and although OA was the main treatment evaluated in this research, it is not possible to know if the positive effects reported for headache and TMD management are specifically due to OA or to the combination with other therapies (occlusal plates). Therefore, the validity of its results is questioned. Using a random, but not "blind" design, Wenneberg[24] reported significant differences in the reduction of symptoms and signs of TMD and headaches. Both in the EG (who received only OA) and in the CG there were differences. However, differences were bigger in the CG, which had received combined occlusal treatment (occlusal plates, mandibular exercises, minor OA). It appears that no consideration was given to whether the participating patients had received previous treatment for headaches or TMD, and during the study the CG received other rescue treatments (occlusal plates) in addition to OA (minor OA). Both the average number of visits and the time spent per treatment session were different between the groups. No training or reliability values for examiners were reported, and the randomization process produced EG with higher TMD symptomatology and headache frequency. Therefore, the validity of its results is questioned. Using a randomized, "blind" design, Vallon[25-27] reported short- and long-term OA results, compared to the use of palliative care. Although inclusion and exclusion criteria were not clearly presented, especially for the type of headaches, it can be assumed that patients had mainly muscular type TMD. Although not clearly reported, examiner reliability was apparently considered at least in the occlusal evaluation. The time used for each treatment was not reported, nor was the CG's adherence to palliative care instructions monitored. Additionally, it was not reported whether patients had received prior treatment; therefore, their perception of the therapeutic modalities used in the study could be different. Although in the initial evaluation the severity of symptoms was made only with a visual analogous scale (VAS), in the final evaluation a different system with multiple selection categories was used. In the one-month follow-up report[25], significant improvement in general symptoms and some of the signs was found in the EG. However, there was no difference regarding the frequency of headaches, facial pain or pain in jaw movements. It was concluded that OA was an alternative treatment for TMD that provided improvement in the general subjective TMD symptoms. This

conclusion was reached even though results reported no significant differences in VAS values within and between groups. In the second report[26] of three- and six-month follow-up, improvement in overall symptoms was shown in EG, but was only significant at the three-month follow-up and only a significant difference between groups was reported at the six-month follow-up with respect to facial pain. However, the overall dropout (loss of patients) from the sample during the follow-up period, plus the intentional elimination from the analysis of patients who required occlusal plates in their treatment, hinders the validity of the results. In the third report, [27] no significant difference was found between the study groups in regard to subjective symptoms or clinical signs. These results can be seriously questioned because only a small number of patients remained in the study and therefore it cannot be decided whether the results are real or respond to the decreased sample size.

Table 5 presents the studies in which the OA was used in other conditions associated with the masticatory system: three in bruxism,[28-30], one in globus pallidus[31] and one in cervicogenic pain.[32] Ramfjord[28] reported that the use of OA in patients with "severe" bruxism eliminated bruxism, improved TMD symptoms, and resulted in more harmonious and synchronized EMG records. The main flaws of this study were previously described when the first report of this author was analyzed[13] and are equally valid to question the conclusions of these reports. It should only be noted that it is impossible to know how they diagnosed the severity of bruxism of patients. Kardachi[29] reported that there was great variation in the EMG values in the EG, while in the CG there was a slight decrease; thus, concluding that the OA effects on bruxism management are unpredictable. In this non-randomized controlled study with a small sample, they did not use "blind" examiners, inclusion and exclusion criteria to determine bruxism and its level of severity were not clearly presented. In addition, the therapeutic regimens for the groups varied in the number and duration of sessions. These factors call into question the validity of their results. Baiyle[30] monitored the masseter muscle unilateral EMG records of nine patients in an uncontrolled study and reported no effects or responses consistent with EMG measures of masseter muscle after OA use. He concluded that relief of habit-associated clinical symptoms after OA does not come from a reduction in bruxism per se. Given that it was only the abstract, little can be evaluated of the study methodology. Another studied condition is globus sensation (globus pharyngis),[31] which is described as the sensation of having a floating ball or organ moving freely in the throat. Using a randomized, "blinded" design, Puhakka[31] evaluated the short- and long-term effects of OA in patients with globus sensation and reported reduced globus sensation symptoms after AO treatment. The characteristics of the groups after random distribution were not reported, nor were the inclusion and exclusion criteria for the condition diagnosis clearly presented. The reliability of the examiners was also not considered, and the number of sessions and the time used for each treatment session was different in the EG. It was not reported whether patients had received prior treatment and thus their perception of the therapeutic modalities used in the study could be different. These and other factors raise questions about the validity of their results. Using a randomized, controlled, double-blind design with matched subjects (by age, sex, and type of dental occlusion), Karppinen[32] reported the short- and long-term results of placebo OA and OA in patients with chronic cervicogenic pain and headaches.

In this last study it was concluded that the OA produced long-term improvement in the symptoms and signs of cervicogenic disorders. Although overall a well-designed study, they did not report examiner reliability values and the statistical differences reported are not necessarily relevant in clinical practice. Both at[12]- and 60-months follow-up the difference between EG (OA) and CG (placebo OA) regarding subjective pain was 5 points (from 35 for EG and 0 for CG) on a scale of 0 to 100. Therefore, the validity of these results can be questioned.

CONCLUSIONS

The analysis of the studies presented in this literature review shows that methodological problems were several and evident in all reports, regardless of whether the results were positive or negative in relation to the use of OA in TMD and other associated disorders. However, it was also evident that there was a tendency for the worst performing designs to be those studies in which a positive response to the use of OA was reported. Therefore, one could argue that until there is better designed research with a high level on the scale of scientific evidence, it is not advisable to approve or disapprove the use of OA as a preventive or therapeutic intervention in masticatory system disorders. It is also important to consider that this dilemma is partly due to the fact that there are many factors contributing to TMD development and none of the reports clarified which were the main factors associated with the patients. OA would only have effect in cases where OFs were playing a primary role in the etiology in the patients managed in these studies. If on the contrary other recognized contributing factors such as anxiety, depression or sleep disorders were the primary ethological factors in the investigated patients, the probability that OA would have any effect on them would become much lower. Perhaps if there was a clear individualized clinical evaluation of patients allowing to establish more clearly when OFs are actually primarily involved in the etiologic development of TMDs, then perhaps OA could be beneficial for those patients. This would also help to make the results of the research reports less vague, confusing and thus clarify the possible benefit of the use of AO in TMDs. Overall, however, it must be concluded that the current evidence does not support the use of OA as a first-line preventive or therapeutic measure in the management of TMD or other associated disorders. This is particularly true when considering that it is an irreversible treatment, with side effects (tooth sensitivity) and limited to certain occlusal schemes. Perhaps it might be fair to consider that, in a limited number of cases, OA could be used as part of a comprehensive treatment that individually weighs the clinical benefits to the patient and clearly establishes that the occlusal changes that will be generated will improve the patient's condition.

CONFLICT OF INTEREST

The authors state that they have no conflict of interest.

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