Original Article

Occlusal Risk Factors for Temporomandibular Disorders

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ABSTRACT

Objective: To determine the role of occlusal variables (overbite; overjet; number of anterior and posterior teeth; bilateral canine guidance on lateral and protrusive movements; anterior centric slide; Angle Classes I, II, and III malocclusion) as risk indicators for the development of temporomandibular disorders (TMDs).

Materials and Methods: Seventy-two TMD patients with myofascial pain, with or without limited opening and arthralgia, as well as 30 age- and gender-matched pain-free concurrent controls were included. The association (critical odds ratio [OR] = 2.0) between the significant occlusal variables and TMD was calculated. Confounders were controlled in the inclusion-exclusion criteria as well as in the analysis stage (unconditional logistic regression) by variation in the OR (15%).

Results: Angle Class II malocclusion (crude OR = 8.0, confidence interval [CI] = 2.2 to 29.3) and the absence of bilateral canine guidance on lateral excursion (crude OR = 3.9, CI = 1.6 to 9.7) were statistically more common in patients than in controls. Spontaneous pain as well as pain on palpation (Class II or higher) were also statistically worse in TMD patients. Significant confounders (ie, employment, age, cigarette and alcohol consumption) acted as effect modifiers not changing the critical OR (adjusted OR Angle Class II and bilateral canine guidance = 8.3 to 12.4 and 2.2 to 4.1, respectively).

Conclusions: Absence of bilateral canine guidance on lateral excursion and particularly Angle Class II malocclusion were considered important risk indicators for the development of TMD in this investigation, even when some sociodemographic factors were considered as effect modifiers.

KEY WORDS: Angle Class II; Occlusion; Temporomandibular disorders; Orofacial pain; Case-control study; Risk factors

INTRODUCTION

Some analytical studies have shown the role of occlusal factors as risk indicators for the development of temporomandibular disorder (TMD).[1,2] Kirveskari et al[3] and Kirveskari[4] in a double-blind intervention study concluded that the elimination of occlusal interferences reduced the risk of developing signs and symptoms. These studies have preserved the traditional view of the biomedical model for treatment of TMD, which tries to identify only local (occlusal) causes rather than centrally mediated pain mechanisms and reactions.[5,6]

Notwithstanding, the multifactorial etiology of TMD and the complete examination of all physical, emotional, and behavioral factors involved in the disease were also emphasized supporting the biopsychosocial model for chronic TMDs.[7] Some studies have shown that depression and somatization have been heavily implicated in chronic pain, including TMD.[8–10] Indeed, in one longitudinal treatment outcome study, sleep disorders and depression were implicated as perpetuating factors in nonresponding TMD patients.[11] In other studies, the etiologic role of occlusion has been challenged in studies applying multiple logistic regression to calculate the odds ratios (ORs) (relative risk) for several occlusal features.[12,13] This disagreement dem-

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onstrates that there is the need of studies evaluating occlusal factors as part of the multifactorial etiology of TMD.[11,14]

Therefore, the objective of this study is to clarify the issue of 10 significant occlusal factors controlling for sociodemographic factors in the etiology of TMDs in an analytical (case-control) study.

MATERIALS AND METHODS

Population and Inclusion and Exclusion Criteria

Newly diagnosed patients were selected from the Pain Clinic at the Pontifical Catholic University of Rio Grande do Sul (PUCRS) Dental School, Brazil. Patients were included who had been diagnosed with myofascial pain, with or without limited opening and arthralgia. In addition, only women between the ages of 15 and 60 years old were selected in order to control age and eliminate gender as confounders in the design stage.[14–16]

According to their medical histories, patients were excluded if they had a history of muscle spasm, myositis, contracture, polyarthritis, acute traumatic injury, metabolic diseases, neurologic disorders, vascular disease, neoplasia, psychiatric disorders, drug abuse, or motor vehicle accidents or presented with medical-dental emergencies as well as with visual, auditory, and motor impairments. In addition, patients currently receiving medication, particularly those affecting the central nervous system, were also excluded.[11,17–19]

A concurrent control group was recruited for comparison. The volunteers needed to have no pain (acute or chronic) complaints and sought the Faculty of Dentistry for restorative procedures.[20] The exclusion criteria were the same as described for the TMD group in addition to not having previous treatment for chronic pain conditions. This study was approved by the Institutional Review Board, and all volunteers signed a written consent form.

Signs and Symptoms of TMD and Clinical Examination (Occlusal Variables)

Social and demographic information and the pain symptom questionnaire were self-recorded by each patient under supervision of two clinical researchers. Pain intensity at rest and pain on chewing were assessed with 100-mm visual analogue scales (VAS). Anchors to both scales were labeled as ''no pain'' and ''extremely severe pain.''[21] The measurement validity and reliability have been described elsewhere.[22,23]

To assess the occlusion and the clinical signs of TMD (clinical examination form), a third orofacial pain specialist was chosen, who did not participate in the neuropsychologic testing and pain symptom questionnaire and was blinded to both TMD and control groups.[21] The occlusal assessment was made for some occlusal variables that have been shown to be associated with TMD[1–4] (ie, overbite, overjet, number of anterior teeth, number of posterior teeth, Angle malocclusion classification, bilateral canine guidance on lateral excursion, bilateral canine guidance of protrusion, and anterior centric [CR-CO] slide). Overbite, overjet, and CR-CO slide were assessed with a digital caliper (Mitutoyo Digimatic Caliper, Tokyo, Japan), whereas the presence of working and balancing side interferences when the patient was in lateral excursion was assessed with a thin double-sided articulating paper (Accu Film II, Parker, Farmingdale, NY). The classification of Angle malocclusion (Classes I and II) was described elsewhere[1]; Class III included cases with bilateral or unilateral mesial displacement of the lower first molar and canine of at least half a cusp.

The examination for signs and symptoms of TMD was based on the standardized RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders).[15] Intraoral examination, besides the occlusal variables previously described, included evaluation of (1) maximum unassisted mandibular opening, (2) percussion sensitivity, and (3) presence of dental caries to exclude pain from dentoalveolar etiology.

Confounders, Sample Size, and Data Analysis

Sociodemographic confounders such as age, gender, language, chemical dependency, history of trauma, neurologic disorders, and psychologic status were controlled for in the design stage by restriction in the inclusion-exclusion criteria. Educational level, employment, income, race, marital status, number of children, physical activity, coffee, and cigarette and alcohol consumption—not controlled for in the design stage—were adjusted in the analysis stage. Circadian factors were controlled by standardization of the day time (10:00 AM and 4:00 PM) and site (same clinic) where the history and clinical examination were performed.[11,24]

The formula for calculating sample size for two independent means is described in a previous publication.[11,25] To disclose a percent difference of 40% (two-sided test at the .05 level with a power of 80%) for all occlusal variables, it was estimated that 27 patients must be screened in each group, which was increased to 30 to compensate for dropouts.[17] Considering that a patient-to-control ratio of 2:1 is considered good, 60 patients and 30 controls were selected.[20]

The role of confounders was calculated by variation in ORs (15% or greater in both directions) by using unconditional logistic regression and dichotomized variables to allow direct comparison based on the literature.[11,12,20] The TMD patients comprised group 1

Table 1. Traditional signs and symptoms in temporomandibular disorder (TMD) group (group 1) vs nonpain (group 2) group[a]

Dependent variables (unit or category)	TMD group (n=72)	Nonpain group (n=30)	OR (95% CI)[b]	Significance
TMJ–lateral pole, %				
0 through I = 0	44.4	96.7	NA	.0000 *** (chi-square test)
II through III = 1	55.6	3.3		
Masseter, %				
0 through I = 0	33.3	76.7	NA	.0000 *** (chi-square test)
II through III = 1	66.7	23.3		
Temporalis, %				
0 through I = 0	45.8	96.7	NA	.000 *** (chi-square test)
II through III = 1	54.2	3.3		
Sternocleidomastoid, %				
0 though I = 0	61.1	93.3	NA	.001 ** (chi-square test)
II through III = 1	38.9	6.7		
Percussion sensitivity, %				
Negative = 0	76.4	100.0	NA	.003 ** (chi-square test)
Positive = 1	23.6	0.0		
Exacerbation after examination, %				
Negative = 0	61.1	100.0	NA	.0000 *** (chi-square test)
Positive = 1	38.9	0.0		
Pain at rest, 100-mm VAS				
Mean (SD)	33.8 (27.7)	0.0 (0.0)	NA	.0000 *** (Mann-Whitney *U*-test)
Pain on chewing, 100-mm VAS)				
Mean (SD)	39.1 (29.9)	0.0 (0.0)	NA	.0000 *** (Mann-Whitney *U*-test)
Caries, %				
Negative = 0	88.9	100.0	NA	.1 NS (chi-square test)
Positive = 1	11.1	0.0		
Maximum mouth opening, mm				
Mean (SD)	50.2 (9.5)	47.8 (6.3)	NA	.09 NS (Mann-Whitney *U*-test)

[a] OR indicates odds ratio; CI, confidence interval; TMJ, temporomandibular joint; NA, nonavailable (not risk indicators; VAS, visual analogue scales; SD, standard deviation; and NS, nonsignificant.

[b] Critical OR = 2.0.

* $P < .05$; ** $P < .01$; *** $P < .001$.

and the controls comprised group 2. All analyses were performed by SPSS version 11.5 for Windows (SPSS Inc, Chicago, IL, USA).

RESULTS

Signs and Symptoms of TMD and Clinical Examination (Occlusal Variables)

Some clinical variables did not show statistically significant differences between the experimental and control groups (Table 1). Maximum unassisted mandibular opening, overbite, and overjet all were similar between TMD patients and nonpain subjects. The mean numbers of anterior teeth and posterior teeth were also very close between groups. Class III malocclusion was present in 7.9% of the TMD patients vs 7.4% of controls, and this difference was not significant. CR-CO slide was also not significant. However, only 11.3% of TMD patients had a CR-CO slide greater than 2 mm vs none in the control group. Conversely, the presence of bilateral canine guidance on protrusion was unusual (TMD patients 1.4% vs nonpain subjects 6.7%), but this was also not significant. Additionally, neither group had evidence of carious lesions detectable with a probe (Table 2).

Other clinical variables did show highly statistically significant differences between the TMD patients and nonpain subjects. The masseter, temporalis, and sternocleidomastoid muscles as well as the temporomandibular joint (TMJ)–lateral pole palpation, following the RDC/TMD scores II to III, were proportionately more sensitive in TMD patients than in controls. Also, the TMD patients had a mild intensity pain level compared with no pain in the control group with respect to pain intensity at rest and on chewing, and this was a highly statistically significant difference. In addition, 38.9% of the TMD patients and none of the controls had exacerbation of joint and muscle pain after examination. In addition, percussion sensitivity was also more commonly found in TMD patients (23.6%) than in nonpain subjects (0%) (Table 1).

Regarding the significant occlusal variables, TMD patients were more likely to have absence of bilateral canine guidance on lateral movements when com-

Table 2. Occlusal variables in temporomandibular disorder (TMD) group (group 1) vs nonpain (group 2) group[a]

Dependent variables (unit or category)	TMD group (n = 72)	Nonpain group (n = 30)	OR (94% CI)[b]	Significance
Overbite, mm				
Mean (SD)	2.9 (1.5)	2.8 (1.9)	NA	.39 NS (Mann-Whitney *U*-test)
Overjet, mm				
Mean (SD)	2.9 (1.6)	2.4 (1.6)	NA	.25 NS (Mann-Whitney *U*-test)
Number of anterior teeth				
Mean (SD)	11.6 (1.1)	11.3 (2.2)	NA	.17 NS (Mann-Whitney *U*-test)
Number of posterior teeth				
Mean (SD)	15.2 (3.1)	13.5 (5.2)	NA	.27 NS (Mann-Whitney *U*-test)
Canine guidance on lateral excursion, %				
Present bilaterally = 0	22.5	53.3	3.9	.002 ** (chi-square test)
Absent bilaterally = 1	77.5	46.7	(1.6–9.7)	
Canine guidance on protrusive movement, %				
Present bilaterally = 0	1.4	6.7	5.0	.2 NS (Fisher exact test)
Absent bilaterally = 1	98.6	93.3	(0.4–57.3)	
Angle malocclusion, %				
Class I = 0	50.7	89.3	8.0	.0004 *** (chi-square test)
Class II = 1	49.3	10.7	(2.2–29.3)	
	(n = 69)	(n = 28)		
Angle malocclusion, %				
Class I = 0	92.1	92.6	1.0	1.0 NS (Fisher exact test)
Class III = 1	7.9	7.4	(0.1–6.8)	
	(n = 38)	(n = 27)		

[a] OR indicates odds ratio; CI, confidence interval; SD, standard deviation; NA, nonavailable (not risk indicators); and NS, nonsignificant.
[b] Critical OR = 2.0.
* $P < .05$; ** $P < .01$; *** $P < .001$.

pared with nonpain subjects, with an increase of 3.9 times the risk (OR) of being a TMD patient. Class II malocclusion was also more common in the TMD group when compared with controls, with an increased risk (OR = 8.0) of developing TMD (Table 2).

Assessment of Confounders and Selection of Best-Risk Indicators

Unemployment, age, and cigarette and alcohol consumption did show statistically significant differences between TMD patients and nonpain subjects. The role of these confounders (Table 3) in the association between Class II and bilateral canine guidance on lateral excursion vs TMD was calculated by variation in the ORs (15% or greater in both directions) by using unconditional logistic regression.[11,12,20] The OR for Class II did not change substantially when controlled for age and alcohol consumption. On the other hand, employment and cigarette consumption acted as effect modifiers by increasing the OR to 10.1 and 12.4, respectively. Therefore, they did not reduce the effect of the Class II. Similarly, canine guidance on lateral excursion (OR = 3.9) was not changed by employment and age, but cigarette and alcohol consumption decreased its effect to 2.7 and 2.2. Nevertheless, they neither were statistically significant nor reached our critical level (OR = 2.0).

DISCUSSION

In this investigation, we separated TMD patients (predominantly muscle disorders) from controls assessing traditional signs and symptoms of TMD as well as selected occlusal variables. A case-control design was selected because it is the most adequate analysis to study cases where the latency period of the disease is long or the incidence is low.[14,20] Our TMD sample size allowed the use of logistic regression and was similar to previous studies.[1,2,26,27] The primary diagnosis of myofascial pain, with or without limited opening, and arthralgia was chosen.[15] This was done because patients diagnosed with myofascial pain and arthralgia have been shown to have significantly higher levels of depression and somatization than those with only disk displacements.[10] In addition, TMD pain is predominantly of muscular origin (52.9%), which in combination grants clinical relevance and external validity.[16]

In parallel, this is in agreement with a current trend in the TMD literature to study well-defined populations in order to increase the internal validity and reproducibility of the results.[1–3,10,11,18,26,27] Indeed, studies have shown that different TMD subgroups have different risk factors and etiologies.[18,28,29] Our frequencies of Angle malocclusion and canine guidance were also similar to previous studies.[12,13,19]

Among the occlusal variables, overbite, overjet, ca-

Table 3. Confounders in temporomandibular disorder (TMD) group (group 1) vs nonpain (group 2) group[a]

Dependent variables (unit or category)	TMD group (n = 72)	Nonpain group (n = 30)	OR (95% CI)[b]	Significance
Education level, %				
Postsecondary diploma/certificate or higher = 0	15.9	24	1.7	.37 (NS, Fisher exact test)
Some education after high school or less = 1	84.1	76	(0.5–5.1)	
Employment, %				
Employed = 0	35.2	70	4.3	.001 ** (chi-square test)
Unemployed = 1	64.8	30	(1.7–10.8)	
Income, %	38	26.7	0.6	.27 (NS, chi-square test)
$5 minimum wages or more = 0	62	73.3	(0.2–1.5)	
$ up to 5 minimum wages = 1				
Age, y				
Mean (SD)	32.4 (12.1)	38.7 (13.4)		.03 * (Mann-Whitney *U*-test)
Maritial status, %				
Single = 9	40.8	33.3	0.7	.47 (NS, chi-square test)
Married, separated, divorced, widowed = 1	59.2	66.7	(0.3–1.8)	
Number of children				
Mean (SD)	1.9 (1.0)	1.9 (1.1)	NA	.7 (NS, Mann-Whitney *U*-test)
Physical activity, %				
Moderate or regular = 0	33.3	30	0.8	.77 (NS, chi-square test)
Little or none = 1	66.7	70	(0.3–2.5)	
Social activity, %				
Moderate or regular = 0	63.6	60	0.9	.77 (NS, chi-square test)
Little or none = 1	36.4	40	(0.3–2.4)	
Coffee consumption, %				
Up to two cups a day = 0	84.8	90	1.6	.77 (NS, Fisher exact test)
More than two cups = 1	15.2	10	(0.3–7.4)	
Cigarette consumption, %				
None or occasionally = 0	93.9	70	0.1	.01 * (chi-square test)
One pack a day or more = 1	6.1	30	(0.03–0.8)	
Alcohol consumption, %				
None = 0	45.5	10	0.1	.001 ** (chi-square test)
Occasionally = 1	54.5	90	(0.03–0.53)	

[a] OR indicates odds ratio; CI, confidence interval; NS, nonsignificant; SD, standard deviation; NA, nonavailable; SAQ, the Sleep Assessment Questionnaire; and BDI, the Beck Depression Inventory (Brazilian-Portugese Version).
[b] Critical OR = 2.0.
* $P < .05$; ** $P < .01$; *** $P < .001$.

nine guidance on protrusive movement, Class III malocclusion, number of anterior and posterior teeth, and CR-CO slide did not yield significant results between TMD and nonpain groups. Nevertheless, bilateral canine guidance on lateral excursion and Class II malocclusion were significant (Table 2). Other studies also found that some occlusal factors, particularly Class II malocclusion,[1] are important risk factors for the development of TMD.[1–4,6]

Regarding signs and symptoms of TMD, palpation of TMJ (lateral pole) and masseter, temporalis, and sternocleidomastoid muscles disclosed significant differences (Table 1), confirming the separation between the two groups. Previous studies[18,30] also found very sensitive muscles in TMD patients, particularly nonresponding and posttraumatic TMD patients. However, signs and symptoms of TMD, including muscle and joint palpation, do not have a good reproducibility and were not considered good predictors of treatment outcome.[11,21,31] In addition, it has been shown that dysfunctional (nonresponding) TMD patients usually present positive responses to placebo sites.[32] Maximum unassisted mandibular opening was neither significant nor relevant between the two groups, and only 6% of our TMD patients and none of our controls had incisal openings less than 35 mm, which agrees with previous literature where the range has been reported from 0% to 5%.[11,18,30] Percussion sensitivity was also significantly more common in patients than in controls, and this clinical variable has been associated with bruxism.[7]

The pain level at rest (100-mm VAS) for the TMD group in this investigation was of medium intensity and comparable with previous studies (35 to 64 mm).[11,17,33] The pain on chewing in our study was gently higher, and this aggravation of pain during function was also reported by Grossi et al[11] and Dao et al.[17] The former found it a good predictor of TMD treatment outcome.

All TMD patients in this study were women in order

Table 4. Crude and adjusted odds ratio (critial OR = 2.0) and 95% confidence interval (CI) for the association between temporomandibular disorder (TMD) and two occlusal variables controlled by six weighted dichotomous confounders (alone and in combination)

	Occlusal variables	
Confounders	Class II (n = 97) OR (95% CI)	Canine guidance (n = 102) OR (95% CI)
Group Nonpain = 0 TMD = 1	8.0* (2.2–29.3)[a]	3.9* (1.6–9.7)[a]
Employment Employed = 0 Unemployed = 1	10.1* (2.5–39.7)[b, c]	3.8* (1.4–10.0)[b]
Age 46 to 60 = 0 14 to 45 = 1	8.3* (2.2–30.4)[b]	4.1 (1.6–10.4)[b]
Cigarette consumption None or occasionally = 0 One pack a day or more = 1	12.4* (2.4–63.5)[b, c]	2.7 (0.9–8.2)[b, c]
Alcohol consumption None = 0 Occasionally = 1	8.7* (2.0–38.0)[b]	2.2 (0.7–6.7)[b, c]

[a] Crude OR.
[b] Adjusted OR.
[c] Variation (±) of OR greater than 15% when compared with crude OR.
* $P < 0.5$.

to increase the internal validity and to control an important confounder in the design stage.[20] Despite this, the gender distribution seems to be comparable with other studies (65% to 100%), also granting good external validity to the results.[1,26–28,34]

The majority of our TMD population did not have a postsecondary diploma certificate or higher education or high levels of unemployment, which differed from previous studies[11,26,34,35] (Table 3). Similar to our previous study (57.9%), this study's sample also had a predominantly low income level, but it contrasted (25.4%) with two other studies.[11,34] Unfortunately, not all studies reported employment and income level. The age of our TMD sample was similar to what is found in the literature (mean = 27.4 to 47 years, range = 5 to 61 years),[10,26,29,34] but it was significantly lower than our control group (Table 3). Cigarette and alcohol consumption did differ between TMD patients and controls by reducing the risk of developing TMD, which was unexpected. However, no comparison has been made because of its novel assessment. In general, our social and demographic variables seem to be comparable with similar studies.

The impact of significant confounders (Table 3) was controlled for in our multivariate analysis (Table 4). The OR for Class II and canine guidance on lateral excursion with TMD was mostly unchanged substantially in any direction and never reached our critical OR. Actually, only in Class II, the four confounders in Table 4 acted predominantly by increasing the association. The four confounders included in our logistic regression analysis did not influence the association between our two significant occlusal variables (Table 2). These findings are relevant, for most studies published in the literature report only crude ORs without controlling for other significant confounding variables.[3,4,12,13]

Despite controlling for confounders, the absence of canine guidance on lateral excursion, as well as percussion sensitivity found more commonly in TMD patients (Table 1), might be indicative of the presence of bruxism, and its association with TMD still needs further verification.[7,36,37] In addition, the rationale for the association between Class II and TMD is still debatable and also needs further longitudinal study.[1,14,38,39]

CONCLUSIONS

- The results confirm that some occlusal factors, such as Class II malocclusion and the absence of canine guidance on lateral excursions, can be considered risk indicators for TMD, even controlling for sociodemographic confounding variables (employment, age, cigarette and alcohol consumption).

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