Occlusion

Are occlusal features associated with different temporomandibular disorder diagnoses in bruxers?

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Aims: The present study was designed to test the hypothesis that dental occlusion may have a role in mediating the effects of bruxism in temporomandibular disorders (TMD) patients. It aimed to answer the clinical research question: in a population of TMD patients with clinically diagnosed clenching-type bruxism, are the different TMD diagnoses associated with different occlusal features?

Materials and methods: A total of 294 TMD patients (73% females, mean age 38.3±9.2 years) who were positive for a clinical diagnosis of clenching-type bruxism underwent an assessment in accordance with the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) axis I, as well as a recording of nine occlusal features. Statistical analyses were performed to test the null hypotheses that: (1) no differences existed between the patients with or without the various occlusal features as for the prevalence of the various single and combined RDC/TMD group diagnoses (single variable analysis), and (2) having any specific occlusal feature makes no difference in distinguishing within the RDC/TMD diagnoses (multiple variable analysis).

Results: The distribution of the different combination of RDC/TMD axis I diagnoses was significantly different in patients with laterotrusive interferences with respect to those without such interferences (chi-square=15.209; P=0.033) as well as in patients with a slide from retruded contact position (RCP) to maximum intercuspation (MI) >2 mm with respect to those without such slide (chi-square=4.029; P=0.012) and in those with or without molar class asymmetry (chi-square=17.438; P=0.015). Multinomial regression analysis showed that the model including the various occlusal features account for 20.4% of the variance for RDC/TMD diagnoses (Nagelkerke R^2=0.204) and allowed the rejection of the null hypothesis that having such specific occlusal features makes no difference in distinguishing within the RDC/TMD diagnoses.

Conclusions: Within the limitations of this study, it can be suggested that in a population of patients with TMD and clinically-diagnosed clenching-type bruxism, the patterns of TMD diagnoses may be influenced, at least in part, by the presence of some features of dental occlusion, namely, slide RCP-MI, laterotrusive interferences, and molar asymmetry.

Keywords: Temporomandibular disorders, Bruxism, Occlusion, RDC/TMD, Clenching

Introduction

Bruxism is an oral motor condition that has been associated with a number of clinical consequences,[1] also representing a risk factor for tooth wear and teeth- or implant-supported restorations.[2] Despite the many issues that are yet to be clarified about bruxism's etiology,[3] differential diagnosis,[4] and physiopathology,[5] most clinicians agreed that such a phenomenon may be capable of jeopardizing the integrity of the stomatognathic system because it is a potential source of overload for the temporomandibular joints (TMJ) and the jaw muscles.

Temporomandibular disorders (TMD) are a heterogeneous group of musculoskeletal pathologies affecting the TMJ and/or the jaw muscles as well as the related structures.[6] They recognize a multifactorial etiology, with a number of factors interacting at the individual level to determine symptoms' onset.[7]

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Several works investigated the association between bruxism-related overload and the presence of TMD symptoms,[8,9] but reviews performed over the past two decades pointed out that several aspects have yet to be investigated before drawing any definite conclusions on the issue.[10–12]

In the attempt to gain a better insight into the issue, it is important to distinguish between the different forms of bruxism, namely, jaw clenching and tooth grinding, as well as to assess the effects of bruxism in patients with different facial morphology and occlusal features. In particular, it seems reasonable to hypothesize that clenching-type bruxism, which is associated with psychological factors[3] and is characterized by high-intensity isometric forces,[11] is likely more detrimental than grinding-like bruxism.[13]

Even if the role of dental occlusion as a risk factor for TMD has been progressively diminished over the years,[14] the possibility that one individual's occlusal features may condition the effects of bruxism by acting as a battleground through which bruxism loads are exerted on the stomatognathic structures, so representing a potential factor influencing the pattern of TMD symptoms in bruxers, cannot be underestimated. To this aim, it was recently suggested that in a population of TMD patients, those subjects with extreme occlusal abnormalities (i.e. large overjet and anterior open bite) and receiving a clinical diagnosis of jaw clenching may report more severe patterns of TMD diagnoses, namely, more multiple combined articular and muscular diagnoses, with respect to jaw clenchers with normal occlusion.[15] Considering that, it could be interesting to assess the different patterns of TMD diagnoses in clenching-type bruxers in relation to the different occlusal features.

Based on the above premises, the present study was designed to answer the clinical research question: in a population of TMD patients with clinically-diagnosed clenching-type bruxism, are the different temporomandibular disorder diagnoses associated with different occlusal features? The null hypotheses under assessment were that (1) no differences existed between the patients with or without the various occlusal features as for the prevalence of the various single and combined Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) group diagnoses (single variable analysis), and (2) having any specific occlusal feature makes no difference in distinguishing within the RDC/TMD diagnoses (multiple variable analysis).

Material and Methods

Study sample and design

The study sample consisted of consecutive first-visit patients attending the TMD Clinic, Department of Maxillofacial Surgery, University of Padova, Italy, seeking TMD advice during the years 2010 and 2011. The study design provided that all data gathered during TMD, bruxism, and occlusion assessments as part of the clinical activities of the Clinic were recorded in an Excel file to perform data mining, patients' selection for inclusion in the study, and statistical analyses. Participants were included independently by their positive/negative history of orthodontic treatment and the status of the dentition. All patients gave their informed consensus to the clinical and statistical procedures at the time of the clinical assessment, and approval was obtained by the local Institutional Review Board.

All patients were assessed in accordance with the Italian version of the RDC/TMD[16] by one of two trained operators with expertise in TMD clinical assessment and research methodology (D.M.; L.G.N.). The patients were given axis I physical diagnoses on the basis of the 1992 RDC/TMD classification guidelines: group I muscle disorders, group II disc displacements, group III arthralgia/osteoarthritis/osteoarthrosis. The RDC/TMD classification system allows multiple diagnoses, so that eight possible axis I diagnostic combinations ranging from the absence of any diagnoses to all the possible single and combined group diagnoses were determined to categorize patients (i.e. no diagnoses, RDC/TMD group I, RDC/TMD II, RDC/TMD III, I+II, I+III, II+III, I+II+III).

The following occlusal features were also accurately recorded for each patient, in accordance with protocols already adopted in a previous study:[17] retruded contact position (RCP) to maximum intercuspation (MI) slide length (normal value <2 mm) calculated in the three spatial axes after manual mandibular distraction; deep vertical overlap, namely, deep bite (>4 mm); large horizontal overlap, namely, large overjet (>5 mm); posterior reverse articulation, namely, posterior cross-bite; anterior open occlusal relationship, namely, anterior open bite; mediotrusive and laterotrusive interferences within the first millimeters of the lateral excursions identified by 40 μm thick articulating paper (Baush Dental KG, Köln Germany); symmetrical molar and canine relationships between the two dental arches.

The patients were also clinically assessed for the presence of clenching-type bruxism, in accordance to an adapted version of the clinical and anamnestic criteria that were recently used to assess the agreement between self-reported and clinically diagnosed bruxism.[18] In the absence of validated criteria for the diagnosis of clenching-type bruxism,[1] the approach here adopted provided that diagnosis of

clenching-type bruxism was based on patients' report of jaw and/or tooth clenching during wake- or sleep-time (i.e. anamnestic criterion) and exhibition of at least two of the following signs and symptoms (i.e. clinical criteria): observation of tooth wear or shiny spots on restorations; report of morning masticatory muscle fatigue or pain; pain in masseter muscles evoked with palpation; masseter hypertrophy upon digital palpation; tongue indentations; linea alba or indentations on the cheek mucosa. Patients who were positive for the so-diagnosed clenching-type bruxism were included in the data analysis.

Statistical analysis

The prevalence of the different combinations of RDC/TMD group diagnoses in patients with and without the various occlusal features under investigation was compared by means of chi-square test. The null hypothesis was that no differences existed between the patients with or without the various occlusal features as for the prevalence of the various single and combined RDC/TMD group diagnoses.

Then, a multiple variable analysis was performed by taking into account only selected variables. The occlusal variables that were significant at $P<0.10$ in the single variable analysis were entered a multinomial logistic regression analysis to assess their association with RDC/TMD diagnoses. The RDC/TMD axis I diagnosis was adopted as the dependent variable with the eight possible modalities, while the occlusal features were entered in the regression model as categorical covariates. The absence of any RDC/TMD axis I diagnoses was used as the reference category. Significance value to distinguish any RDC/TMD combination of diagnoses from the reference category was assessed for each of the occlusal features that were entered in the analysis; the null hypothesis was that having any specific occlusal feature makes no difference in distinguishing within the RDC/TMD diagnoses. Odds ratios (and their 95% confidence intervals [CI]) for RDC/TMD diagnoses were also assessed for each occlusal feature, while simultaneously controlling for the other occlusal variables. Nagelkerke's R-square (R^2) was obtained as an estimation of the total variance explained by the occlusal factors included in the model.

The level of significance was set at $P<0.05$. All statistical procedures were performed with the Statistical Package for the Social Sciences 19.0 (IBM Italia S.p.A, Segrate, MI, Italy).

Results

A total of 294 patients (73% females, mean age 38.3±9.2 years) satisfied inclusion criteria, namely, positivity for clenching-type bruxism, and were entered in the analysis. The prevalence of the different occlusal features ranged between 6.8% for the anterior open bite and 49.3% for a RCP-MI slide >2 mm. As for the RDC/TMD axis I diagnoses, group I muscle disorders were diagnosed in 40.4% of the patients, group II disc displacements in 62.1%, and group III arthralgia/arthritis/arthrosis in 61.1%. Multiple group diagnoses were assigned in 55% of the patients.

The distribution of the different combination of RDC/TMD axis I diagnoses was significantly different in patients with laterotrusive interferences with respect to those without such interferences (chi-square=15.209; $P=0.033$) as well as in patients with a slide from RCP to MI >2 mm with respect to those without such slide (chi-square=4.029; $P=0.012$) and in those with or without molar class asymmetry (chi-square=17.438; $P=0.015$). Thus, the null hypothesis that no differences existed between the patients with or without laterotrusive interferences, between patients with or without a slide RCP-MI >2 mm, and between patients with or without asymmetry of molar relationship as for the prevalence of the various single and combined RDC/TMD group diagnoses was rejected. For all the other occlusal features under investigation, the distribution of RDC/TMD diagnoses was not significantly different between patients with or without each specific feature (Table 1).

Multinomial regression analysis including those variables that showed P values lower than 0.10 in the single variable analysis showed that the model accounts for 20.4% of the variance for RDC/TMD diagnoses (Nagelkerke $R^2=0.204$). Molar asymmetry was shown to be a risk factor for group III arthralgia/arthritis/arthrosis alone ($P=0.007$; OR=0.14) as well as for group II disc displacements alone ($P=0.016$; OR=0.19). Laterotrusive interferences were a risk factor for group I muscle disorders alone ($P=0.002$; OR=0.10). Slide RCP-MI was positively associated with group II disc displacements alone ($P=0.008$; OR=0.27), with combined group II and group III disorders ($P=0.23$; OR=0.34) as well as with combined group I, II, and III diagnoses ($P=0.003$; OR=0.23). The above associations allowed the rejection of the null hypothesis that having such specific occlusal features makes no difference in distinguishing within the RDC/TMD diagnoses (Table 2).

Discussion

The etiology of temporomandibular disorders has always been a subject of debate, as suggested by

Table 1 Prevalence of the different single and combined RDC/TMD axis I group diagnoses in the study sample and in patients with or without each occlusal feature

RDC/TMD axis I diagnoses	Prevalence in the study sample (%)	Cross bite		Open bite		Deep bite		Large overjet		Canine asymmetry		Molar asymmetry		Laterotrusive interferences		Mediotrusive interferences		Slide RCP-MI	
		N (n=220)	Y (n=74)	N (n=274)	Y (n=20)	N (n=230)	Y (n=64)	N (n=260)	Y (n=34)	N (n=216)	Y (n=78)	N (n=228)	Y (n=66)	N (n=200)	Y (n=94)	N (n=152)	Y (n=142)	N (n=149)	Y (n=145)
No diagnoses	11.2	11.8	9.5	11.3	10	10.4	14.1	12.3	2.9	12	9	13.2	4.5	13	7.4	13.2	9.2	16.1	6.2
I	5.1	3.6	9.5	5.1	5	5.7	3.1	5.8	0	6	2.6	6.1	1.5	2	11.7	3.9	6.3	8.1	2.1
II	17.3	17.7	16.2	17.9	10	18.3	14.1	17.3	17.6	18.5	14.1	14.5	27.3	18.5	14.9	15.8	19	14.1	20.7
III	11.2	13.6	4.1	11.3	10	12.2	7.8	10.4	17.6	9.3	16.7	8.8	19.7	11.5	10.6	10.5	12	12.1	10.3
I+II	5.1	4.5	6.8	5.5	0	5.2	4.7	5	5.9	6	2.6	4.8	6.1	6	3.2	6.6	3.5	4.7	5.5
I+III	12.1	13.6	8.1	12	15	11.7	14.1	11.9	14.7	9.7	19.2	12.7	10.6	12	12.8	12.5	12	13.4	11
II+III	5.1	13.6	8.1	18.2	40	20	18.8	19.2	23.5	20.4	17.9	21.1	15.2	19.5	20.2	20.4	19	18.1	21.4
I+II+III	18	17.3	20.3	18.6	10	16.5	23.4	18.1	17.6	18.1	17.9	18.9	15.2	17.5	19.1	17.1	19	13.4	22.8
Sig.		0.085		0.409		0.758		0.511		0.138		0.015*		0.033*		0.776		0.012*	

Note: *Differences in the distribution of diagnoses in patients with or without the occlusal feature are significant at $P<0.05$.

Table 2 Multinomial regression analysis including those occlusal features that were significant at $P<0.10$ in the single variable analysis. Association of the occlusal features with the different combinations of RDC/TMD diagnoses and odds ratios (95% confidence intervals) for distinguishing each diagnosis with respect to the reference category (i.e. absence of any RDC/TMD diagnoses)

Occlusal features	RDC/TMD I		RDC/TMD II		RDC/TMD III		RDC/TMD I+II		RDC/TMD I+III		RDC/TMD II+III		RDC/TMD I+II+III	
	Sig.	OR (95%CI)	Sig.	OR (95%CI)	Sig.	OR (95%CI)	Sig.	OR (95%CI)	Sig.	OR (95%CI)	Sig.	OR (95%CI)	Sig.	OR (95%CI)
Cross bite	0.112	0.32 (0.08–1.29)	0.726	1.21 (0.4–3.61)	0.078	3.83 (0.85–17.1)	0.556	0.65 (0.16–2.64)	0.446	1.61 (0.47–5.55)	0.415	0.65 (0.23–1.8)	0.766	0.85 (0.29–2.46)
Molar asymmetry	0.503	2.28 (0.20–25.6)	0.016*	0.19 (0.05–0.7)	0.007**	0.14 (0.03–0.58)	0.556	0.65 (0.16–2.64)	0.251	0.42 (0.09–1.83)	0.429	0.57 (0.14–2.29)	0.329	0.49 (0.12–2.0)
Laterotrusive interferences	0.002**	0.10 (0.02–4.21)	0.687	0.80 (0.27–2.33)	0.492	0.66 (0.21–2.1)	0.798	1.22 (0.26–5.69)	0.293	0.55 (0.18–1.66)	0.305	0.58 (0.21–1.62)	0.262	0.55 (0.19–1.55)
Slide RCP-MI	0.557	1.57 (0.34–7.22)	0.008**	0.27 (0.10–0.7)	0.138	0.46 (0.16–1.28)	0.107	0.34 (0.09–1.25)	0.138	0.46 (0.16–1.28)	0.023*	0.34 (0.13–0.86)	0.003**	0.23 (0.09–0.6)

Note: *sig. at $P<0.05$; **sig. at $P<0.01$.

the evolving theories on TMD physiopathology abandoning occlusally-focused concepts to embrace patient-centered biopsychosocial approaches.[19] According to such views, the role of purported abnormalities of dental occlusion as an etiological factor for TMD has diminished[20] in favor of the need to delve deeper into the triangle of bruxism, pain, and psychosocial factors.[21] Notwithstanding that, it can also be hypothesized that dental occlusion may have a role as the battleground through which the forces are transferred to the different structures of the stomatognathic system, thus representing a mediator enhancing the potential negative influence of bruxism forces on the jaw muscles and temporomandibular joints. In particular, clenching-type bruxism may be viewed as the most detrimental motor activity among those included in the bruxism definition, since it features no degrees of freedom for the joint under constant load and an isometric, fatigue-inducing contraction of the jaw closing muscles. The literature on the relationship between the different bruxism activities and temporomandibular disorders has not been conclusive so far, likely due to the very poor specificity of many studies for both bruxism activities and TMD symptoms.[11,12] Also, the hypothesis that subjects with different anatomical features may react differently to clenching-related muscle and joint loads must be taken into account as a main confounding factor for the available literature.

Based on these premises, the present investigation was performed to test the hypothesis that the effects of clenching-type bruxism in temporomandibular disorder patients may be different in relation to the presence of certain occlusal features.

The difficulties in designing a study which provides reliable information on such an issue lies in the impossibility of performing longitudinal studies on healthy subjects, who should probably be monitored for years to assess the possible relationship between the different bruxism activities and their effects on subjects with different dental occlusion. Therefore, as a compromise solution, the study was performed on subjects belonging to a population of attendees of the authors' clinic already showing TMD symptoms. The patterns of TMD diagnoses in a population of patients seeking TMD advice and receiving a clinically-based diagnosis of clenching-type bruxism were assessed and compared between patients with and without the nine occlusal features. The working hypothesis was that the pattern of TMD diagnoses might be influenced by the different occlusal features.

This study has some other methodological shortcomings, mainly related to the method here adopted to diagnose clenching. However, despite obvious limits due to the lack of definite measurements of bruxism activities, the combined anamnestic and clinical approach can be viewed as the best available strategy to detect a probable clenching.[1] In any case, further studies providing a quantitative assessment of the sleep-time and wake-time EMG activity, the latter also featuring ecological momentary assessment, are strongly recommended to validate the hypotheses drawn from this study. From a methodological viewpoint it must be also borne in mind that other factors (e.g. psychosocial issues) should be included in the multiple variable analysis before crediting the two variables under investigation, namely, clenching-type bruxism and occlusion, as the only possible explanations for the TMD outcomes.

Within these study limitations, the null hypothesis that no differences existed between the patterns of TMD diagnoses between the clenching patients having or not having certain occlusal features was rejected for some occlusal variables (i.e. slide RCP-MI, laterotrusive interferences, molar asymmetry) and not rejected for some others (i.e. deep bite, cross bite, open bite, canine asymmetry, large overjet, mediotrusive interferences).

Taken together, these findings may suggest that occlusal features that may be related to either occlusal instability, namely, the presence of interferences during laterotrusive excursions and a slide from centric relation to maximum intercuspidation, or asymmetry, namely, the presence of different molar classes between the right and left sides of occlusion, are worthy of further investigation as potential mediating factors of the effects of bruxism. These observations fit well with suggestions that orthopedic instability related to an unsteady dental occlusion must be viewed as a risk factor for temporomandibular disorders.[22] Also, they can integrate findings of the several multiple variable studies showing that occlusal interferences, centric slides, and gross occlusal abnormalities are the only occlusal features for which an association was described, even if weak, with TMD.[23–26]

Clinically, findings from this study imply that subjects with the above occlusal features may be potentially predisposed to develop specific patterns of TMD diagnoses in reaction to clenching-type bruxism, and joint disorders in particular (i.e. disc displacements and arthralgia/arthritis/arthrosis). Importantly, as suggested by the multiple variable analysis, centric slide is the main risk factor for the presence of multiple RDC/TMD diagnoses combining muscle and joint disorders.

Further studies are needed to confirm these observations, with focus on the skeletal features that

may be associated with certain occlusal patterns and that may influence the direction, intensity, and consequences of bruxism forces. The adoption of imaging techniques for a better depiction of the TMJ status (i.e. computerized tomography, magnetic resonance) is needed to provide more objective findings to verify these speculations as well as to identify bony loss that might explain the occlusal changes. Also, samples of increased size may be useful to have enough statistical power to avoid risks of type II errors, namely, false negative findings in that subsample of patients with low-prevalence occlusal features (e.g. anterior open bite, large overjet). To that purpose, this study may serve as a basis to share preliminary data for the a priori evaluation of the needed sample size for identifying purported clinically relevant differences in TMD diagnoses between groups of patients with different occlusal features. Moreover, to get deeper into the assessment of skeletal features, the selection of patients on the basis of their cephalometrically diagnosed skeletal types appears to be a good option for designing prospective evaluation studies. Finally, the ongoing researches providing suggestions to define the different bruxism-related motor activities need to be carefully monitored to define standard of reference strategies for the measurement and objective assessment of clenching-type bruxism diagnosis.

Conclusions

Within limitations of this study, it can be suggested that in a population of temporomandibular disorders and clinically-diagnosed clenching-type bruxism, the patterns of TMD diagnoses may be influenced, at least in part, by the presence of some features of dental occlusion, namely, slide RCP-MI, laterotrusive interferences, and molar asymmetry.

Disclaimer Statements

Contributors All listed as authors.

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References

1 Lobbezoo F, Ahlberg J, Glaros A, Kato T, Koyano K, Lavigne GJ, *et al*. Bruxism defined and graded: an international consensus. J Oral Rehabil. 2013;40:2–4.
2 Manfredini D, Poggio CE, Lobbezoo F. Is bruxism a risk factor for dental implants? A systematic review of the literature. Clin Implant Dent Relat Res. 2012 Nov 13 [Epub Ahead of print].
3 Manfredini D, Lobbezoo F. Role of psychosocial factors in the etiology of bruxism. J Orofac Pain. 2009;23:153–66.
4 Manfredini D, Winocur E, Guarda-Nardini L, Paesani D, Lobbezoo F. Epidemiology of bruxism in adults. A systematic review of literature. J Orofac Pain. 2013;27:99–100.
5 Lavigne GJ, Kato T, Kolta A, Sessle BJ. Neurobiological mechanisms involved in sleep bruxism. Crit Rev Oral Biol Med. 2003;14:30–46.
6 Okeson JP. The classification of orofacial pains. Oral Maxillofac Surg Clin North Am. 2008;20:133–44.
7 Greene C. The etiology of temporomandibular disorders: implications for treatment. J Orofac Pain. 2001;15:93–105.
8 Manfredini D, Winocur E, Guarda-Nardini L, Lobbezoo F. Self-reported bruxism and temporomandibular disorders. Findings from two specialised centers. J Oral Rehabil. 2012;39:319–25.
9 Raphael KG, Sirois DA, Janal MN, Wigren PE, Dubrovsky B, Nemelivsky LV, *et al*. Sleep bruxism and myofascial temporomandibular disorders: A laboratory-based polysomnographic investigation. J Am Dent Assoc. 2012;143:1223–31.
10 Lobbezoo F, Lavigne GJ. Do bruxism and temporomandibular disorders have a cause-and-effect relationship? J Orofac Pain. 1997;11:15–23.
11 Svensson P, Jadidi F, Arima T, Baad-Hansen L, Sessle BJ. Relationships between craniofacial pain and bruxism. J Oral Rehabil. 2008;35:524–47.
12 Manfredini D, Lobbezoo F. Relationship between bruxism and temporomandibular disorders: a systematic review of literature from 1998 to 2008. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109:e26–e50.
13 Peretta R, Manfredini D. Future perspectives in TMD pathophysiology. In: Manfredini D, editor. Current concepts on temporomandibular disorders. Berlin: Quintessence Publishing; 2010. p. 153–70.
14 Türp JC, Schindler HJ. The dental occlusion as a suspected cause for TMDs: epidemiological and etiological considerations. J Oral Rehabil. 2012;39:502–12.
15 Manfredini D, Vano M, Peretta R, Guarda-Nardini L. Jaw clenching effects in relation to two extreme occlusal features: patterns of diagnoses in a TMD patient population. J Craniomandib Pract. 2014;32:45–50.
16 Dworkin S, Leresche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria examinations and specifications, critique. J Craniomandib Disord Fac Oral Pain. 1992;6:301–55.
17 Manfredini D, Peretta R, Guarda-Nardini L, Ferronato G. Predictive value of combined clinically diagnosed bruxism and occlusal features for TMJ pain. J Craniomandib Pract. 2010;28:105–13.
18 Paesani D, Lobbezoo F, Gelos C, Guarda-Nardini L, Ahlberg J, Manfredini D. Correlation between self-reported and clinically-based diagnoses of bruxism in TMD patients. J Oral Rehabil. 2013;40:803–9.
19 Suvinen TI, Reade PC, Kemppainen P, Kononen M, Dworkin SF. Review of aetiological concepts of temporomandibular pain disorders: a biopsychosocial model for integration of physical disorder factors with psychological and psychosocial illness impact factors. Eur J Pain. 2005;9:613–33.
20 Türp JC, Greene CS, Strub JR. Dental occlusion: a critical reflection on past, present and future concepts. J Oral Rehabil. 2008;35:446–53.
21 Manfredini D. The triangle bruxism, pain, and psychosocial factors. PhD Thesis, ACTA Amsterdam, 2011.
22 Okeson JP, de Leeuw R. Differential diagnosis of temporomandibular disorders and other orofacial pain disorders. Dent Clin North Am. 2011;55:105–20.
23 Pullinger AG, Seligman DA, Gornbein JA. A multiple logistic regression analysis of the risk and relative odds of temporomandibular disorders as a function of common occlusal features. J Dent Res. 1993;72:968–79.
24 Pullinger AG, Seligman DA. Quantification and validation of predictive values of occlusal variables in temporomandibular disorders using a multifactorial analysis. J Prosthet Dent. 2000;83:66–75.
25 Gesch D, Bernhardt O, Mack F, John U, Kocher T, Alte D. Association of malocclusion and functional occlusion with subjective symptoms of TMD in adults: results of the Study of Health in Pomerania (SHIP). Angle Orthod. 2005;75:183–90.
26 Landi N, Manfredini D, Tognini F, Romagnoli M, Bosco M. Quantification of the relative risk of multiple occlusal variables for muscle disorders of the stomatognathic system. J Prosthet Dent. 2004;92:190–5.