

Comorbidity of TMD and malocclusion: impacts on quality of life, masticatory capacity and emotional features

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Aim: to evaluate the synergic impact of muscular TMD and malocclusion on quality of life, masticatory capacity and emotional features of young adults. **Methods:** this cross-sectional study comprised 4 groups (n= 15): G1, individuals without TMD or malocclusion; G2, with TMD and malocclusion; G3, with TMD and without malocclusion, and G4, without TMD and with malocclusion. Muscular TMD was diagnosed by RCD/TMD. Data included quality of life (OHIP-14), masticatory capacity test (X50), emotional stress (PSS-14), depression (MDI), pain intensity and salivary cortisol. Comparative statistical analysis included One-way ANOVA and Tukey post hoc test (X50, stress and cortisol) and GENMOD followed by Wald test (OHIP-14 and pain data). Fisher's and Pearson's association analysis were carried out. **Results:** Comorbidity of muscular TMD and malocclusion leads to significant lower masticatory capacity ($p<0.05$). TMD groups independently of the occlusal condition had considerably lower OHIP-14 scores and higher stress levels (self-perceived and hormonal) ($p<0.05$). There was no statistically significant difference of emotional depression among groups. A significant positive correlation was observed among quality of life, stress and pain perception. **Conclusion:** muscular TMD in the overlap of malocclusion potentializes their negative effect on masticatory capacity. In addition, the hindering effect of the comorbidity is variable, however, TMD has a greater negative impact on quality of life and stress, whilst malocclusion on mastication.

Keywords: Temporomandibular joint disorders. Mastication. Malocclusion. Quality of life. Stress, psychological.



Introduction

Association of temporomandibular disorders (TMD) and occlusal characteristics is controversial and evidences, at present, does not support a cause-effect relationship between these highly prevalent conditions of the population¹. In addition, comorbid occlusal disturbances and self-perceived psychological conditions make difficult to draw the real impact of TMD on patients' quality of life and on the functional response of their masticatory system².

Structural variations in components of the masticatory system, such as muscular disturbances, have now been characterized as main etiological factors for TMD³. However, occlusal disturbances have been considered as triggers, perpetuating and even contributory factors for TMD^{4,5}. This lack of concordance may be related with the individual capacity of the body for adaptation to occlusal discrepancies overlapped with the predisposition to chronic pain conditions^{1,6}.

The pain related to TMD may generate changes in the mandibular kinematics, increasing the number of occlusal interferences and consequently, changing the masticatory pattern⁶. Furthermore, this may lead to compensation of muscles and other associated structures for the purpose of bearing excessive functional loads however, in a cyclic manner, this adaptation may accentuate the pain, and if not treated, lead to important tissue damage.

Masticatory function in individuals with TMD has been suggested to be limited because the functional response of the masticatory system is subject to a complex interaction between physical and emotional aspects. The number of occlusal contacts, dimension of the grinding area, sagittal and transverse changes in the teeth and bony bases modulate masticatory capacity^{7,8}. In addition to the occlusal factor, malocclusion may correlate with a reduction in masticatory capacity by hindering the ability of the muscle to work^{9,10}.

Since malocclusion and TMD may lead to functional harm, self-perception of oral health may determine a decline in the quality of life⁹. However, the pain component of TMD and compromised esthetic appearance resulting from malocclusion are subjective factors that may be influenced by the emotional state¹⁰. Therefore, the levels of stress and depression are capable of changing the self-perception of the impact of these conditions on quality of life¹¹.

Thus, in patients with TMD or occlusal discrepancies, we may recognize a poorer masticatory function with concomitant impairment of quality of life. However, the direction of a mutual influence remains obscure. Thus, the aim of this study was to evaluate the role of TMD, malocclusion and their interaction in quality of life, masticatory capacity, and emotional aspects.

Materials and methods

Experimental design and participants

This double-blind cross-sectional study had a parallel-group design, in which four independent groups were evaluated. Malocclusion and muscular TMD were considered

independent variables while the dependent variables were masticatory efficiency, quality of life, self-perception of pain, emotional stress, depression and salivary cortisol level. The subjects entry order for the different experimental tests was randomized (simple randomization by lottery method). The participants were not informed about their diagnoses regarding muscular TMD and malocclusion till the end of the study. The investigator who performed the examination for muscular TMD diagnoses and malocclusion assessment was blinded regarding the study objectives. The other investigator that carried out the experimental tests was blinded to the patient allocation group. This study was approved by the Research Ethics Committee of the University Center of the Hermínio Ometto Foundation - FHO under protocol number 1.329.422. All participants gave their informed consent prior to their inclusion in the study.

The participants, 210 young adults with the same educational level, were recruited at a University Dental Clinic (Araras, Brazil). The exclusion criteria were: missing teeth, use of orthodontic appliance, periodontal disease, subjects taking antidepressant, anti-inflammatory, analgesic medications or those with the potential to change salivary flow, subjects undergoing treatment for TMD, and those with a history of trauma or surgery in the region of the head and neck. A total of 60 participants (mean age = 25.3, s.d. = 5.1) met the criteria and were selected and allocated to four gender paired groups (n=15). Group I (control) comprised individuals who were asymptomatic for TMD and with clinically normal occlusion; Group II, subjects with TMD and malocclusion; Group III, made up of individuals with TMD and with clinically normal occlusion; and Group IV, asymptomatic for TMD and with malocclusion. To diagnose the presence of TMD, the RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders) was used¹². Individuals with muscular TMD (RDC/TMD Groups Ia and Ib) were included in the sample.

Occlusion that was considered clinically normal was based on the Angle Class I dental relationship, with a positive horizontal overjet and vertical overlap of less than 3 mm, a normal transverse relationship and Class I molar and canine relationship, among others characteristics as described previously by Manfredini et al.¹³ (2016). Subjects that didn't presented two or more of the established occlusal features were considered with malocclusion. The sample size of 15 participants per group, provided a test power of over 80% to detect differences of 5 in IMC, 2 in OHIP, 8 in PSS-14, 3 in cortisol, 0.7 in masticatory efficiency (assessed by the particle median (X50)), and 10 in the self-perception of pain (as assessed using a visual analog scale (VAS)), between means of the groups, with a level of significance of 5%.

Masticatory capacity

The masticatory capacity was determined using the masticatory performance test (X50)¹⁴. Briefly, the participants were instructed to chew, in the habitual manner, a portion of 17 standardized cubes of a chewable test material (Optosil Plus, Heraeus Kulzer, Hanau, Germany) (weight = 3.4 g; edges = 5.6 mm) in a total of 20 masticatory cycles. The produced particles were fractionated by a system of 10 sieves with meshes with openings that ranged between 5.6 mm and 0.5 mm, coupled to a vibratory table for 20 minutes. The amount accumulated in each sieve was weighed on an analytical balance with a precision of 0.0001 g (Mark, 2060, Bel Engineering, Milan, Italy). Masticatory performance was evaluated by calculating the median particle size (X50) by means of the

Rosin-Rammler equation¹⁵. In the equation, X50 é is the opening in a hypothetical sieve through which 50% of the weight is capable of passing. Thus, the lowest mean values of the particles (X50) denote the highest masticatory performance.

Self-evaluation scales

The impact of oral health conditions on quality of life was evaluated by the validated Brazilian version of the Oral Health Impact Profile (OHIP-14) questionnaire. This self-applicable questionnaire consists of 14 questions about oral-health related problems experienced over the past year, with answers based on a Likert-type scale of 0 (never), 1 (hardly ever), 2 (occasionally), 3 (almost always) and 4 (always). The sum scores of responses obtained may vary from 0 to 56 points, and the higher the score, the greater the negative impact on the quality of life¹⁶.

The self-applicable questionnaire PSS-14 (Perceived Stress Scale) was used to determine the impact of the level of emotional stress perceived¹⁷. This is made up of 14 questions that must be answered by considering only the last month. The responses are as follows: 0 (never), 1 (hardly ever), 2 (occasionally), 3 (almost always) and 4 (always). To calculate the total score, answers to questions with a positive connotation (4, 5, 6, 7, 9, 10 e and 13) were inverted. The result of the sum of the instrument score varies from zero to 56. The higher the final score, the higher will be the level of emotional stress perceived.

The level of depression was determined using the validated Brazilian version of the Major Depression Inventory (MDI) questionnaire¹⁸. This comprises 10 questions with reference to the past weeks. As a measurer of severity, the score of the MDI varies from 0 to 50, because each of the 10 items may receive a score ranging from 0 (never) to 5 points (all the time). Thus a score between 20 and 24 classifies the depression as light, from 25 to 29 as moderate, and over 30 points, as severe depression¹⁹.

Self-perception of pain intensity, immediately before and after the masticatory performance test, was evaluated using a visual analogue scale (VAS)²⁰. VAS score was determined by using a 10-cm line presenting in one extremity the “no pain” anchor and in the other “worst pain imaginable”. The participant was asked to place a line perpendicular to the VAS line at the point that represents their pain intensity. The distance (mm) from the vertical line traced from the value zero (absence of pain) was considered the pain intensity present. All tests were conducted by the same examiner, who was trained for to apply the experimental instruments and collecting the data in a standardized manner.

Salivary cortisol

As a biomarker of self-reported mental stress, the salivary cortisol level was determined. Stimulated whole saliva was collected with the use of Salivette® (Sarstedt AG & Co, Nümbrecht, Germany). Salivary collections were carried out under the same sampling strategy respecting the avoidance of recent food intake, exposure to mental stressors and the circadian rhythms of glucocorticoid²¹. The samples were stored in accordance with the manufacturer’s specifications, and evaluated in a laboratory with ISO 9001 certification. The exam was performed after the Salivette tubes were centrifuged at 1000g to separate the saliva, and subsequently submitted to chemiluminescence analysis. The results were expressed in nmol/L.

Statistical analysis

The mean PSS14 score, salivary cortisol and masticatory performance (X50) values were submitted to analysis of variance (one-way ANOVA), followed by the Tukey test. The cortisol data were transformed into log base 10. The OHIP data were analysed using generalized linear models (Genmod) and the pain intensity scores using generalized linear models for repeated measures, followed by the Wald test. The association of TMD and malocclusion with depression (MDI) was analysed using the Fisher Exact test. The Pearson correlation analysis was used to correlate the other variables. All analyses were performed using the SAS (SAS Institute Inc., Cary, NC, USA, Release 9.2, 2010) and R (R Core Team (R Foundation for Statistical Computing, Vienna, Austria) programs, with a level of significance of 5%.

Results

The comparisons between groups regarding body mass index (BMI), masticatory performance (X50), impact of oral health conditions on quality of life (OHIP-14), perceived level of emotional stress (PSS14) and salivary cortisol, are presented in Table 1. The sample did not differ with regard to BMI ($p=0.1337$). The worst masticatory performance (highest X50 score) was observed in the comorbidity group (G2) ($p<0.05$). The higher masticatory performance were showed by individuals without malocclusion (G1 and G3), independently of muscular TMD presence ($p<0.05$).

Table 1. Groups comparisons for BMI, X50, OHIP-14, PSS14 and salivary cortisol. (mean \pm SD)

Group	Condition		BMI	x50	OHIP -14	PSS14	Cortisol †
	TMD	Malocclusion					
G1	absence	absence	21.8 \pm 2.6 a	2.71 \pm 0.65 c	0.53 \pm 1.3 c	16.27 \pm 762 b	3,83 \pm 2,72 c
G2	present	present	20.3 \pm 4.4 a	6.09 \pm 0.89 a	6.53 \pm 5.9 a	26.13 \pm 6.33 a	7,45 \pm 4,93 ab
G3	present	absence	23.0 \pm 3.5 a	3.22 \pm 0.62 c	5.20 \pm 4.0 ab	23.53 \pm 5.07a	7,87 \pm 3,52 a
G4	absence	present	23.4 \pm 4.8 a	4.90 \pm 0.30 b	2.07 \pm 2.5 bc	21.00 \pm 5.59 ab	4,35 \pm 2,59 bc
p-value			0.1337	≤ 0.05	≤ 0.05	≤ 0.05	≤ 0.05

Different lowercase letters in the columns indicate the statistical difference. †Salivary cortisol level in micrograms per deciliter ($\mu\text{G} / \text{dL}$).

Compared with the negative control group (G1), the impact of oral health conditions on quality of life (OHIP-14), self-perceived emotional stress (PSS14) and salivary cortisol level was significantly higher in individuals with TMD (G2 and G3), independently of the presence/absence of malocclusion ($p<0.05$).

Individuals whose overlapped muscular TMD and malocclusion (G2) and those with muscular TMD without malocclusion (G3) showed higher mean values of self-perceived pain even before mastication ($p<0.05$). After the masticatory function muscular TMD implies higher pain levels independently of occlusal condition (G2 and G3) ($p<0.05$) (Figure 1).

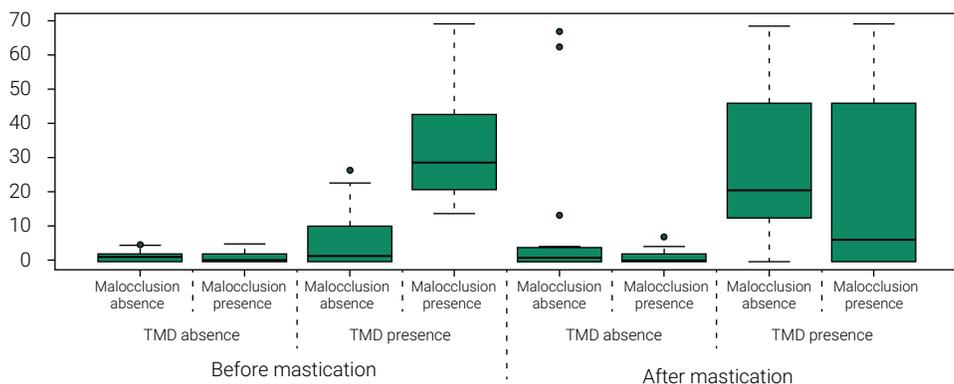


Figure 1. Pain self-perception by visual analogue scale (VAS) in as a function of groups and time.

Figure 2 presents the distribution of frequency of the degree of depression (MDI) in the groups. There was no significant differences among groups ($p=0.5686$). The majority of the volunteers presented no depression.

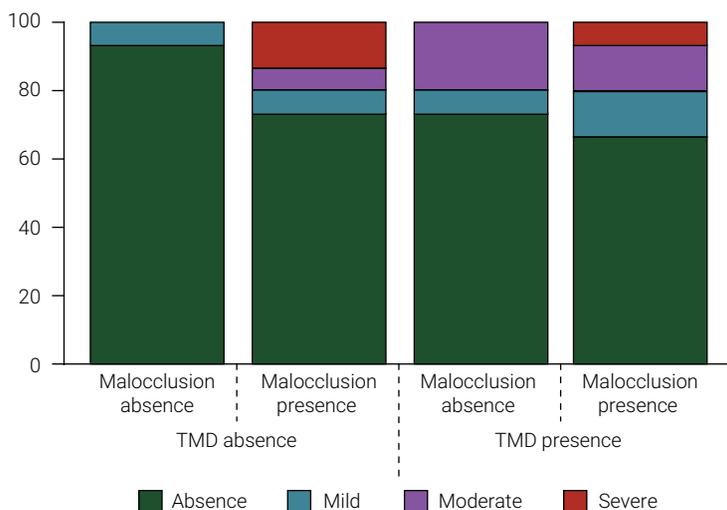


Figure 2. Relative frequency (%) of the degree of self-perception of depression (MDI) according to the different groups.

Table 2 shows the correlations between the variables. A significant moderately positive correlation was observed ($p<0.05$) between the impact of oral health conditions and the quality of life, stress ($r=0.40$), and self-perception of pain before ($r=0.39$) and after mastication ($r=0.44$). Self-perception of pain before mastication presented a significant positive correlation ($p<0.05$) with X50 ($r=0.64$); that is, the higher the pain level before mastication, the worse was the masticatory performance. In contrast, the median particle size arising from mastication was not correlated with pain after the test ($p=0.8879$).

Table 2. Pearson correlation coefficient (p-value) among assessed variables

	Quality of life	Emotional Stress	Pain before mastication	Pain after mastication	Salivary Cortisol	X50
BMI	-0.04 (0.7340)	-0.10 (0.4307)	-0.10 (0.4470)	-0.04 (0.7647)	-0.05 (0.6844)	-0.14 (0.2661)
Quality of life	-	0.40 (0.0014)	0.39 (0.0022)	0.44 (0.0004)	0.13 (0.3343)	0.22 (0.0964)
Emotional Stress	-	-	0.31 (0.0145)	0.13 (0.3137)	0.13 (0.3309)	0.29 (0.0245)
Pain before mastication	-	-	-	0.24 (0.0701)	0.20 (0.1251)	0.64 (<0.001)
Pain after mastication	-	-	-	-	0.12 (0.3646)	0.02 (0.8879)
Salivary cortisol	-	-	-	-	-	0.15 (0.2517)

Discussion

In this study the different carried out tests provided a substantial amount of information to suggest the impairment in masticatory function and quality of life due to muscular TMD, malocclusion, pain and emotional stress. The masticatory performance can be considered as an important method for evaluating the functionality of the stomatognathic system and it is capable of measuring food comminution potential, by quantifying the particle size. Patients with malocclusion evaluated during food chewing, showed significant lower masticatory performance when compared to controls (G1 e G3). Similar results were obtained in previous studies, showing that malocclusion had a negative impact on masticatory capacity^{22,23}. The literature shows that patients with malocclusion usually have less occlusal contacts and reductions in the occlusal functional areas of teeth during mastication²⁴. Greater masticatory function impairment was observed in muscular TMD co-occurrence patients (G2) (Table1). Possibly, the limitation of masticatory performance aims to avoid the pain exacerbation, which could explain the lower food comminution rates in patients with muscular TMD.

Patients with TMD (G2 and G3) presented higher levels of pain before and after mastication, irrespective of the presence or absence of malocclusion. However, the pain generated by mastication was not necessarily correlated with the particle size obtained. The pain of patients with TMD probably limited their masticatory performance, leading to compensatory mechanisms such as a larger number of cycles, slower rate of mastication and accessory muscle recruitment^{22-24,25}. Therefore, despite the presence of pain during mastication in the groups with TMD, the presence of malocclusion had a greater impact on masticatory capacity. It must also be remarked that static or dynamic occlusal characteristics were not associated with TMD pain conditions.

Pain or the structural changes associated with TMD limit or even deviate mandibular kinetics, and consequently affect the masticatory pattern^{4,6}. However, it is important to emphasize that masticatory capacity may not be affected, even in individuals with TMD. The authors suggest that compensatory mechanisms that lead to greater

recruitment of other masticatory muscles, such as the temporal muscles, may compensate for debilities resulting from TMD^{11,26}. Thus, the results demonstrated that the impact on the functional response only became relevant when associated with the presence of malocclusion.

Although TMD had no impact on masticatory capacity, we observed a negative impact on to the oral health-related quality of life (OHIP-14). Pain, a common symptom of TMD is believed to be the main factor related to compromised social behaviour, and the emotional and psychological state of the individual^{12,27}. The impact of the oral health condition on quality of life was higher when TMD was associated with the presence of malocclusion. Nevertheless, malocclusion alone did not determine greater compromise of quality of life, corroborating the findings of other studies^{25,28}. The behavioural variations of each individual and non-experience of a clinically adequate occlusion made it difficult to evaluate the real impact on to the quality of life due to malocclusion^{28,29}. Studies have suggested that when malocclusion has an impact on quality of life, this is due to the aesthetic-emotional component, and not due to the functional impact^{25,28}.

Moreover, both quality of life and TMD may be modulated by emotional aspects such as stress. In the present study, individuals with TMD not only presented self-perception about stress, but also had higher salivary cortisol levels, a biomarker of physiological stress, corroborating with previous studies³⁰. Emotional stress may be associated with muscle hyperactivity and overload of the stomatognathic system, causing inflammation in the retrodiscal tissues, muscle fatigue and muscular TMD. The results demonstrated no direct correlation between stress and pain. It can be due to the fact that individuals with chronic stress, even with pain, may present lower levels of salivary cortisol as a result of the reduction in hormone secretion by the adrenal gland^{31,32}.

In the present study, no statistical difference in self-perception of depression was observed. Besides depression has an influence on TMD^{11,33}, the onset time of the TMD of the included volunteers may be responsible for the non-association. The limitations of the present study included lack in information regarding the time-onset and frequency of TMD related pain, the non-selection of participants at random from the population and the absence of other emotional variables such as anxiety that may be related to TMD. However, sample homogeneity regarding to gender, age and BMI avoided biases. Clinically, the results indicate that although malocclusion has more effect on masticatory capacity, this functional impairment has less influence on the quality of life. Thus, the impact on quality of life is probably not related to the reduction in masticatory function, but rather to the pain component of muscular TMD.

According to the evaluated parameters, it is possible to conclude that co-occurring conditions, muscular TMD and malocclusion had a greater negative influence on masticatory capacity. Quality of life, pain and emotional stress are associated and seems to be impaired by the TMD condition, regardless of malocclusion presence.

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