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Effects of bruxism on the maximum bite force

Uticaj bruksizma na maksimalnu zagrižajnu silu

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Abstract

Background/Aim. Bruxism is a parafunctional activity of the masticatory system, which is characterized by clenching or grinding of teeth. The purpose of this study was to determine whether the presence of bruxism has impact on maximum bite force, with particular reference to the potential impact of gender on bite force values. **Methods**. This study included two groups of subjects: without and with bruxism. The presence of bruxism in the subjects was registered using a specific clinical questionnaire on bruxism and physical examination. The subjects from both groups were submitted to the procedure of measuring the maximum bite pressure and occlusal contact area using a single-sheet pressure-sensitive films (Fuji Prescale MS and HS Film). Maximal bite force was obtained by multiplying maximal bite pressure and occlusal contact area values. **Results**. The average values of maximal bite force were significantly higher in the subjects with bruxism compared to those without bruxism ($p < 0.001$). Occlusal contact area was significantly higher in the subjects suffering from bruxism ($p < 0.001$), while the maximal bite pressure values did not show a significant difference between the studied groups ($p > 0.01$). Maximal bite force was significantly higher in the males compared to the females in all segments of the research. **Conclusion**. The presence of bruxism influences the increase in the maximum bite force as shown in this study. Gender is a significant determinant of bite force. Registration of maximum bite force can be used in diagnosing and analysing pathophysiological events during bruxism.

Key words:
bruxism; bite force; dental occlusion; sex; male; female.

Apstrakt

Uvod/Cilj. Bruksizam je parafunkcionalna aktivnost mastikatornog sistema, koja se karakteriše stezanjem ili struganjem zubima. Cilj ove studije bio je da se utvrdi da li prisustvo bruksizma ima uticaja na maksimalnu zagrižajnu silu, sa posebnim osvrtom na potencijalni uticaj pola na vrednosti zagrižajne sile. **Metode**. Ova studija je obuhvatila dve grupe ispitanika: ispitanike sa bruksizmom i bez bruksizma. Prisustvo bruksizma kod ispitanika je registrovano upotrebom specifičnog kliničkog upitnika za bruksizam i kliničkim pregledom. Ispitanici obe grupe bili su podvrgnuti postupku merenja maksimalnog zagrižajnog pritiska i okluzalne kontaktne površine upotrebom jednoslojnih filmova osetjivih na pritisak (Fuji Prescale MS i HS Film). Maksimalna zagrižajna sila dobijena je množenjem vrednosti maksimalnog zagrižajnog pritiska i okluzalne kontaktne površine. **Rezultati**. Prosečne vrednosti maksimalne zagrižajne sile bile su značajno veće kod ispitanika sa bruksizmom nego kod ispitanika bez bruksizma ($p < 0{,}001$). Okluzalna kontaktna površina bila je značajno veća kod ispitanika koji pate od bruksizma ($p < 0{,}001$), dok vrednosti maksimalnog zagrižajnog pritiska nisu pokazale značajnu razliku između ispitivanih grupa ($p < 0{,}01$). Maksimalna zagrižajna sila bila je veća kod muških ispitanika nego kod ženskih ispitanika, u svim segmentima istraživanja. **Zaključak**. Prisustvo bruksizma uticalo je na povećanje maksimalne zagrižajne sile u ovoj studiji. Pol je bio značajna determinata zagrižajne sile. Registracija maksimalne zagrižajne sile može se koristiti za dijagnozu i analizu patofizioloških događaja tokom bruksizma.

Ključne reči:
bruksizam; zagrižajna sila; zubi, okluzija; pol; muškarci; žene.

Introduction

Bruxism is a parafunctional activity of the masticatory system, which is characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible [1]. It may happen while awake (awake bruxism) or while sleeping (sleep bruxism). Bruxism during daytime is commonly a semi-voluntary clenching activity or diurnal bruxism. Awake bruxism can be associated with life stress caused by familial responsibility or work pressure. Sleep bruxism is an oromandibular behavior that is defined as a stereotyped movement disorder occurring during sleep and characterized by tooth grinding and/or clenching [2].

Bruxism is a multifactorial disorder. Bruxism and grinding have been associated with peripheral factors, such as to-

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oth interference in dental occlusion, psychosocial influences, such as stress or anxiety [3], and central or pathophysiological causes involving brain neurotransmitters or basal ganglia [4]. Manfredini et al. [5] indicate that occlusal factors do not seem to have any significant role in the development of bruxism. Depression, increased level of hostility [6] and stress sensitivity [7] distinguish a "bruxer" from a healthy individual. However, factors like smoking, alcohol, drugs, diseases, and trauma may also be involved in the bruxism etiology [8].

Factors that may indicate the presence of bruxism include physical symptoms and changes in hard and soft oral tissues. The physical symptoms of bruxism may include: headache, facial myalgia (muscle pain) and temporomandibular joint (TMJ) discomfort. The most common oral symptoms include: abnormal tooth wear (attrition on occlusal or incisal surfaces), fracture of the teeth and excessive tooth mobility.

In "bruxers", the distribution of muscular force to the teeth and surrounding tissues may result in tooth wear and orofacial pain, as well as hyperactivity and hypertrophy of the masticatory muscles, especially the masseter muscle. In view of the fact that muscles are the main bite force generators, the changes in their function may be reflected in the maximum bite force (MBF) value. MBF is a result of the masticatory muscle activity, which is regulated by the central nervous system receptors and orofacial structures (muscle spindles, proprioceptors, mechanoreceptors). Previous studies report that MBF may be influenced by gender, craniofacial morphology, periodontal sensitivity, dental occlusal status and signs and symptoms of temporomandibular disorders [9–11].

Reports of certain studies on the effects of bruxism on MBF appear to be contradictory. Helkimo and Ingervall [12] found that individuals with clenching and grinding habits had higher bite force only on the incisors, but not on the molars. On the other hand, Gibbs et al. [13] found higher bite force values on the posterior region for subjects with bruxism than for the control group. Lyons and Baxendale [14] suggested that the jaw-closing muscles of subjects with bruxism might have benefited from a "training effect" as a result of all this activity, resulting in muscles that are stronger and possibly more resistant to fatigue. Cosme et al. [15] believe that bruxism does not affect MBF, while some of the authors find that MBF is increased in 54.5% of the subjects suffering from bruxism [16]. According to Nunes [17], for some patients pain plays a modulator role in parafunctional activity, decreasing the electromyographic activity of masticatory muscles and MBF.

There seems to be no clear correlation between the MBF and bruxism. In view of the aforementioned, the main purpose of this study was to determine whether bruxism has impact on MBF, assessing the potential gender impact on the MBF values.

Methods

This trial was conducted ensuring the full adherence to the principles of the "Good Clinical Practice (GCP)" which means that the trial included only participants who had given their full informed consent to participate in writing, with a prior access to the full information about the aims and scope of the trial. This trial was conducted with the approval of the Ethics Committee at the Faculty of Medicine, University of Priština/Kosovska Mitrovica.

The trial was conducted on the subjects selected among the students of the Faculty of Medicine in Kosovska Mitrovica and the patients who visited the Prosthodontics Clinic, Dentistry Department, Faculty of Medicine in Kosovska Mitrovica.

The presence/absence of bruxism in subjects were registered using a specific clinical questionnaire on bruxism by Molina et al. [18] and specific physical examinations.

The Molina questionnaire included the following questions: 1) Do you wake up in the morning or during the night to find yourself grinding or clenching? 2) Do you feel fatigue or masticatory muscle pain on awakening? 3) Do you wake up in the morning or during the night with the jaws locked? 4) Do you feel discomfort on the teeth on awakening? 5) Do you have recent history of chronic dislocation of permanent or temporary restorations? 6) Do you have recent history of noises associated with nocturnal teeth grinding as reported by a third person?

Physical examination included observation of attrition on occlusal or incisal surfaces, detectable scars and buccal mucosa changes, changes on the lateral border of the tongue (tongue indentations) and verification of masticatory muscle hypertrophy by means of digital palpation in maximum intercuspation.

Signs and symptoms of temporomandibular disorders (TMD) were recorded by Helkimos clinical functional analysis [19]. This analysis includes the case history (questionnaire relating to the signs and symptoms of TMD), clinical functional analysis of the orofacial system and occlusal analysis.

Group formation

The following exclusion criteria were applied for all participants: more than two missing posterior teeth (excluding third molars); previous orthodontic or prosthodontic treatment; the presence of active phase of periodontal disease; signs and symptoms of TMD or spontaneous orofacial pain; the presence of malocclusion (anterior open bite, unilateral cross bite, class II and III malocclusion according to Angle).

Further criteria for inclusion subjects in the study implied: the intact dental arch (third molars not taken into account); the presence of no more than three fillings; Class I neutro-occlusion according to Angle's classification; age between 18 to 23 years.

The subjects included in the study, in terms of the registered presence/absence of bruxism, were divided into two groups: the study and the control group. The study group consisted of 41 patients with bruxism, while the control group consisted of 48 subjects without bruxism (18–23 years of age).

Registration of maximum bite force

Further research implied registration of maximum bite pressure (MBP), occlusal contact area and calculation of

MBF value in both the control and the experimental (study) group. MBP was registered by means of a single sheet pressure-sensitive sheet (Fuji Prescale, Tokyo), type: MS and HS. MS pressure-sensitive sheet registered pressure within the range of 10–50 megapascal (Mpa), while HS sheet registered the pressure of 50–130 MPa. Fuji Prescale Film technology and its principle of operation is based on indicating applied pressure differences as red color density variations. This feature is enabled by particle size control (PCS) technology based on microcapsule layers designed to respond to different pressures relieving color whose intensity is proportional to the pressure applied.

The MBP registration procedure was conducted in both the study and the control group. The subjects were comfortably seated with the head erect and torso in upright position. Drying provided a relatively dry environment in biting surfaces for placing a horseshoe-shaped pressure sensitive sheet in-between. The subjects were instructed to bite stronger in maximum intercuspation and maintain the bite force the following 10 s (Figure 1 a and b).

The registration procedure was conducted by means of MS and HS pressure sensitive sheet in all the patients, with a 2-minute break between the two registration protocols, to allow for the masticatory muscles to relax. The films applied were further on scanned using a Canon device generating 300 dpi A4 scans. Visual comparison of the occlusal contact color and color intensity scale (0.1 to 1.5) was used for the purpose of defining color density (intensity) for each occlusal contact registered (Figure 2).

Based on the color density, reading of the bite pressure values was carried out for each occlusal contact (Figure 3). The graph shows two curves (A and B).

Occlusal contact area (OCA) was measured by means of Adobe Photoshop 7.0 applied to pressure sensitive sheet

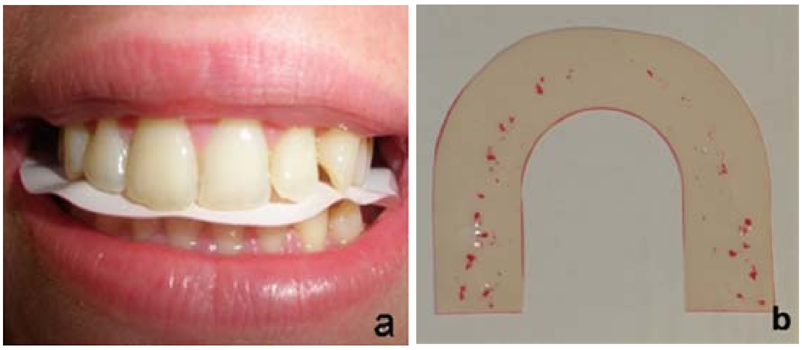

Fig. 1 – Registration of maximum bite pressure (MBP): a) registration procedure; b) registered occlusal contacts on a prescale film.

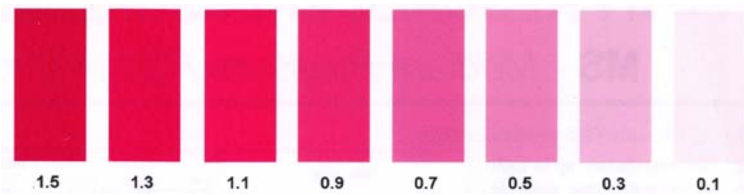

Fig. 2 – Scale for reading color intensity of the registered occlusal contact.

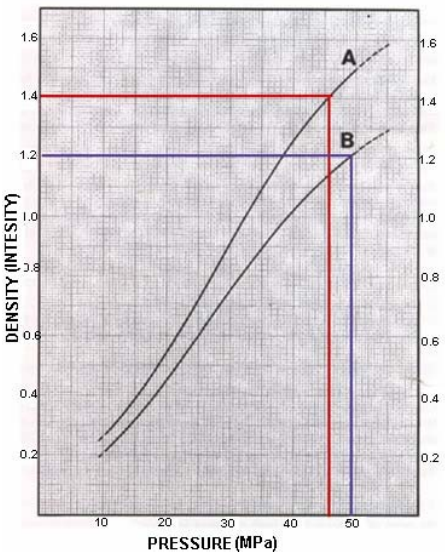

Fig. 3 – Graph for determining values of bite pressure.

scans. Multiplying the values of MBP and OCA, gave the bite force for each occlusal contact observed:

$$F (N) = P (MPa) \times A (mm^2)$$

The sum of all occlusal forces acting in the contact points registered in one patient gave MBF *per* patient.

$$\Sigma Fn = F1 + F2 + F3 + ... F_n$$

For the purpose of primary data analysis, methods of descriptive statistics were used, which included measures of central tendency (mean and median), measures of variability (standard deviation) and relative numbers. The influence of bruxism on the MBF value was determined by the Student's *t*-test and the Mann-Whitney Test (Rank Sum Test). Statistical hypotheses were tested at the level of statistical significance of 0.01 and 0.001. For statistical data analysis, a PASW Statistics was used.

Concerning the MBP analysis, values expressed *per* unit area (MBP/mm^2) were used in order to simplify the analysis. Similarly, OCA (mm^2) was analyzed as the sum of the values of each OCA registered in one patient (ОКП = ΣA). However, in calculating the MBF, the values of MBP and contact surface values *per* occlusal contact were used.

Results

Distribution of participants in the study in relation to bruxism and gender is given in Table 1. The first segment of the analysis was conducted in order to test the impact of gender on MBF, which further determined the method of data processing. Thus, comparative analysis of average MBP/mm^2, OCA and MBF values was conducted between the males and females within the control group – patients without bruxism (Table 2). In the male subjects without bruxism, the values of MBF, OCA and MBP/mm^2 were significantly higher than in the female subjects (t = -2975, DF = 54, $p < 0.01$ for MBF; t = -6.825, DF = 54, $p < 0.001$ for OCA; t = -6.944, DF = 54, $p < 0.001$ for MBP/mm^2). Since significant effects of gender on MBP/mm^2, OCA and MBF were found, there was the need to test the values of these parameters comparing separately the male and female participants of both groups (the study group and controls). It was the only way to determine the actual impact of bruxism on the MBF.

In the female subjects with bruxism, the values of MBF and OCA were significantly higher than in the females without bruxism (t = -6.5, DF = 46, $p < 0.001$ and t = -6786, DF = 46, $p < 0.001$, respectively). However, the MBP/mm^2 values did not show any statistically significant difference between the female subjects with and without bruxism (Mann-Whitney test, U = 178.0; p = 0,247) (Table 3).Comparative analysis between the males of both groups showed a statistically significant difference in average values of MBF and OCA (t = -5.440, DF = 27, $p < 0.001$ and t = -4.288, DF=27, $p < 0.001$, respectively). However, in male subjects with bruxism, the MBP/mm^2 values did not show statistically significant difference compared to the males without bruxism (Table 4).

Disscusion

MBF is often analyzed as an indicator of functional status of the masticatory system. Bruxism is one of the parafunctional activities accompanied by rapid contractions of the masseter muscle and development of forces excessively burdening structures of the masticatory system. Harmful effects of bruxism can be seen in non-physiological tooth wear, masticatory muscle hyperactivity and potential development of orofacial system dysfunction. The hypothesis that bruxism is capable to change the bite force by muscle strengthening is still unproven. If the bite force was truly affected by bruxism, its measurement could be an important feature in the diagnosis of such a habit.

Table 1

Distribution of the subjects in relation to bruxism and gender

Gender	Study group, n (%)	Control group, n (%)	Total, n (%)
Females	22 (53.7)	25 (52.1)	47 (52.8)
Males	19 (46.3)	23 (47.9)	42 (47.2)
Total	41 (100.0)	48 (100.0)	89 (100.0)

Study group – subjects with bruxism;
Control group – subjects without bruxism.

Table 2

Comparative analysis of maximum bite pressure (MBP), occlusal contact area (OCA) and maximum bite force (MBF) between the female and male subjects of the control group (without bruxism)

Parameter	Females (n = 25) $\bar{x} \pm SD$	Males (n = 23) $\bar{x} \pm SD$	p*
Number (n)	25	23	
MBP (MPa/mm^2)	36.9 ± 2.50	39.3 ± 3.73	< 0.01
OCA (mm^2)	12.1 ± 3.92	19.5 ± 3.88	< 0.001
MBF (N)	522.60 ± 147.99	793.80 ± 129.78	< 0.001

*** *p* – statistical significance (Student's *t*-test).**

Table 3

Comparative analysis of maximum bite pressure (MBP), occlusal contact area (OCA) and maximum bite force (MBF) between female subjects of both groups

Female subject	Study group (n = 22) x̄ ± SD	Control group (n = 25) x̄ ± SD	*p**
Number	22	25	
MBP (MPa/mm^2)	37.5 ± 3.62	36.9 ± 2.50	0.247
OCA (mm^2)	20.5 ± 3.54	12.1 ± 3.92	< 0.001
MBF (N)	811.8 ± 27.60	522.6 ± 25.01	< 0.001

***p* – statistical significance at the level < 0.001 for Mann-Whitney *U*-test and < 0.001 for Student's *t*-test;**
Study group – subjects with bruxism;
Control group – subjects without bruxism.

Table 4

Comparative analysis of maximum bite pressure (MBP), occlusal contact area (OCA) and maximum bite force (MBF) between the male subjects of the studied groups

Male subject	Study group (n = 19) x̄ ± SD	Control group (n = 23) x̄ ± SD	*p**
Number (n)	19	23	
MBP (MPa/mm^2)	42.0 ± 2.83	39.3 ± 3.73	0.079
OCA (mm^2)	25.9 ± 2.77	19.5 ± 3.88	< 0.001
MBF (N)	1,058.4 ± 68.677	793.8 ± 129.78	< 0.001

***p* statistical significance (Student's *t*-test);**
Study group – subjects with bruxism;
Control group – subjects without bruxism.

Our study showed that the average values of MBP/mm^2, OCA and MBF were significantly higher in males compared to females. Some of studies support the results obtained accordingly [20]. Pereira-Cenci et al. [21] and Bonakdarchian et al. [22] believe that greater muscle potential of masticatory muscles in males can be attributed to anatomical gender differences. Bakke [23] points out that masseter muscles of males are type II muscle fibers, which are larger in diameter compared to those in females. Pizolato et al. [24] suggest that hormonal differences between sexes affect the structure of muscle fibers. Estimating contribution of masseter, temporal muscle, and anterior angle of digastric muscle to bite force, Raadsheer et al. [25] demonstrated that masseter thickness significantly correlates with the magnitude of MBF. However, up to 18 years of age, gender does not affect the MBF. Following a post-pubertal period, MBF tends to increase significantly and to a greater extent in men than in women, becoming thus gender-related [26]. According to Olthoff et al. [27], bite force and the number of teeth in occlusion are determining factors in masticatory performance, whereas occlusal contacts determine 10–20% of MBF variation. Ferrario et al. [20] emphasize that dental size is larger in males, making thus the occlusal surfaces greater as well as those of the periodontal ligament, which in turn results in higher level of bite force. They stated that average value of the MBF in healthy female subjects was 522.6 ± 25.01 N, and that in men it amounted to 811.8 ± 27.6 N. These findings are consistent with the results of our study. However, it is noteworthy that the MBF values obtained by different studies are difficult to compare. MBF value varies depending on the type of measuring instrument applied [27], the position of the measuring instrument within the dental arch, and the number of teeth included [28]. Therefore, the literature offers MBF values ranging from 388 N to 1,109 N [29, 30].

Based on the results of this study it was found that MBF was significantly higher in participants with bruxism compared to those without it, taking into account the gender difference. The findings of our study are consistent with the findings of the study conducted by Killiaridis et al. [31]. Some authors like Gibbs et al. [13] for instance, find that MBF in persons with bruxism was six times the one in those without it. However, Cosme et al. [15] did not find a significant difference between persons with bruxism and those without it, taking into account the gender difference between the subjects. Similar results were reported by some other authors, as well [32]. However, in these studies bite force was measured using a compressive transducer at the first molar region. Tortopidis et al. [33] addressed the issue of measuring instrument reliability and found that the variability in MBF values was highest when using a gnathodynamometer. The use of these measurement systems does not take into account OCA, which among other things can affect the results.

Our study shows no statistically significant difference in MBP/mm^2 between the persons with bruxism and those without it. Perhaps it is this segment of the research that indicates that masticatory muscles potential does not increase in patients with bruxism. However, the research shows that OCA is significantly higher in patients with bruxism, which is most probably due to teeth attrition and contact area expansions. According to Hatch et al. [34], bite force and the number of teeth in occlusion are determining factors in masticatory performance, whereas occlusal contacts determine 10–20% of MBF variation. Hidaka et al. [35] believe that

OCA, the number of occlusal contacts and the number of teeth present are significant determining factors for MBF. Increased levels of teeth clenching lead to greater intimacy between occlusal contacts in maxillary and mandibular dental arches. For example, with increasing teeth clenching/grinding levels from 30% to 100%, the occlusal contact areas are doubled. As our study shows, MBP/mm^2 was not significantly different between persons with bruxism and those without it, whereas OCA was significantly higher in persons with bruxism; therefore, the MBF was also higher.

Using a measuring system based on the prescale pressure sensitive sheet, Miyaura et al. [36] found that the bite potential closely correlated to the number of teeth present. Alkan et al. [37] monitored MBF values in persons with bruxism before and after stabilization splint treatment. They found that the occlusal contact area and bite force decline in patients using a splint for three months. Similar results were demonstrated by Kurita et al. [38] and Karakis et al. [39] In light of these data it is possible to comment on the muscle activity in relation to changes in the OCA and bite force.

The gold standard diagnostic method for bruxism is the use of polysomnographic recordings in a specialized sleep laboratory [40]. For the purposes of our study, the questionnaire and physical examination of the patients was used in the diagnosis of the patients with bruxism. Some studies compared clinical outcomes with the results of polysomnography to diagnose bruxism and found that the clinical criteria had a reliability of 83% in patients with bruxism and 81% in asymptomatic control subjects [41]. However, Baba et al. [42] did not find any associations between tooth wear status and ongoing bruxism. Therefore, an insufficient reliability of clinical methods in the diagnosis of bruxism may somewhat affect the results of this study.

Conclusion

Bruxism influences the increase of MBF. It also affects the increase in OCA, but not MBP. Therefore, registration of MBF can be used in the diagnosis and analysis of pathophysiological events during bruxism.

Gender is a significant determinant of bite force, which is why gender difference must be taken into account during analysis of MBF. These results may be considered as an initiative calling for further research for the sake of complete clarification of bruxism and its impact on the stomatognathic system.

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