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Evaluation of Maximum Bite Force in Patients with Complete Dentures

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Abstract

OBJECTIVE: This study aimed to evaluate maximum bite forces (mBF) in dominant (DS) and non-dominant sides (NDS) at certain time periods after the insertion of new complete dentures based on prior experience and gender.

MATERIALS AND METHODS: A total of 88 patients, complete denture wearers (CDWs), were examined. The maximum bite force at the intercuspal position between the first molars in 3 seconds was registered and recorded with piezoelectric gnathodynamometer. The procedure was repeated 3 times in identical conditions, with relaxation intervals of 1 minute between repeats and the limiting factor was the subjective feeling of pain. Testing of parametric data was performed with One Way Repeated Measurement of ANOVA test.

RESULTS: The average mBF values increased during the observational period, both on the DS and NDS, with significant difference in DS, which was greater. The analysis of one-factor variance showed that there were differences of average mBF values in DS and NDS during six consecutive measurements (mBF–DS = 11.3, p = 0.0001, and mBF-NDS = 2.26, p = 0.047). Significant changes in the masticatory force (mBF) on the DS and NDS is explained by different measurement times and with the prior experience with complete dentures, BF–DS = 11.76, p = 0.0000; mBF–NDS = 2.42, p = 0.0351; mBFe–DS = 40.48; P = 0.0000 mBFe–NDS = 39.93, p = 0.0000.

CONCLUSION: mBF represents a significant discriminating variable of the level of functional adaptation of new complete denture wearers (nCDWs) about the initial measurements.

Introduction

Being edentulous is considered a handicap, both concerning the oral function and psychological impact. The restoration of masticatory function and aesthetics is an important aim in dentistry mainly when patients present with extensive tooth loss. The loss of teeth in elderly patients not only impairs the stomatognathic system but also their psychological status and quality of life [1] [2].

Complete dentures should, biologically, establish the relationship with the living tissues. During rehabilitation with prosthetic treatment, forces acting in the oral cavity should be considered, as well as, the way these forces are distributed through the dentures on the denture bearing areas [3]. Distribution of masticatory forces under physiological conditions is as follows: occlusal - articular complex → periodontium → bone foundation. However, the biological organisation of the orofacial system responsible for the distribution of bite forces is complex and differs from the physiological mode of pressure conveyance.

Various methods have been used to numerically assess the masticatory forces while chewing various foods [4]. It is thought that Black was the first researcher who used measurements and estimates of masticatory forces as well as having researched *in vitro* feeding with an instrument, which he nominated a phagodynamometer. Obtained values ranged between 90N and 360N [5]. Howell and Brudevold presented the method for direct measurement of masticatory forces in the oral cavity [6].

The influence of biting forces (BF) on the masticatory system is profound. Incomplete denture wearers (CDWs) consuming tough foods, bite forces

are reduced by 15% to 20% compared to healthy dentate patients, that is 40% [7]. The masticatory load in natural teeth is 200N while the maximum forces during mastication of CDWs range between 60N and 80N [8]. Tooth loss and its consequent prosthetic replacement not only decrease the BF between 20% to 50% compared to the natural dentition but is also associated with other problems such as eventual bone loss [9]. According to De Boever, only 4% of functional forces are utilised, while the maximum bite force (mBF) values during mastication do not exceed 22% of their capacity [10]. Muscle force and the number of functional teeth are determinant factors in mastication. Measuring mBF is an attempt to quantify the force that mandibular elevator muscles can make [11]. The magnitude of bite force has shown to be correlated to the patients' satisfaction with complete dentures, type of food, and the amount of bone resorption under prostheses [12].

This study aimed to evaluate the maximum bite force (mBF) in the dominant side (DS) and non-dominant (NDS) at specific time periods after fitting of new complete dentures based on patient's prior experience and gender.

Material and Methods

A total of 88 patients with complete dentures were included in this study. The research was accepted and approved by the Ethics Committee, School of Dental Medicine, University of Prishtina, Kosovo, and written consent was obtained from each subject.

The research was divided into two experimental groups and compared to experienced complete denture wearers (eCDW). Group 1 consisted of inexperienced (first time) complete denture wearing patients (iCDW) fitted with maxillary and mandibular complete dentures; Group 2 consisted of experienced patients with complete dentures (eCDW). The patients were pooled at the Department of Prosthodontics, Dental School, Faculty of Medicine, the University of Prishtina in Kosovo. After fitting the new complete dentures, all patients were tested for mBF at the intercuspal position. Patients were followed for 6 months. During this period, stabilisation of complete dentures was expected. During the observation period, each subject was measured six times within six months. The first measurement was performed one week after the fitting of the complete dentures, and successive recalls at 2 to 5 weeks, 3 to 10 weeks, 4 to 15 weeks, 5 to 10 weeks and 6 to 25 weeks.

During measurements, patients were invited to sit on a chair in a quiet room so that the Frankfurter plane was approximately horizontal. This test included recordings of the mBF at the intercuspal position between the first molars for 3 seconds with a piezoelectric gnathodynamometer. The procedure was repeated 3 times in identical conditions, with relaxation intervals of 1 minute between repeats and the limiting factor was the subjective feeling of pain.

During each measurement of one side of the jaw, to stabilise the complete dentures during the test, the rubber cylinder was applied on the contralateral side at the first molar region, with 75% hardness according to Shore with the same width as the Gnathodynamometer probe (6 mm). The piezoelectric gnathodynamometer was directly connected to a DynoFigure printer. In this way, apart from the numerical values of the bite forces, Figural data were recorded as well. In the Figural data, the mBF was represented by a basic line of deflection. For the evaluation of the results, the highest expressed value of mBF was recorded. The jaw side, showing greater mBF during measurement was referred as the dominant side (DS), while the opposite as the non-dominant side (NDS).

Statistical analysis was performed using standard software package BMSP (BioMedical Statistical Package), dedicated to research in the biomedical sciences, which included all methods of statistical procedures, (Dixon, 62.). Testing of parametric data was done with One Way Repeated Measurement of ANOVA test.

Results

The basic parameters of bite forces at defined time intervals (N) were presented in tabulated and Figural forms. It can be concluded that the average values increased during the observational period, both on the DS and NDS. Higher values were recorded for the DS with a significant statistical difference. The analysis of one - factor variance showed that there were differences in average values between DS and NDS for the six measurements (mBF - DS = 11.3, p = 0.0001, and mBF - NDS = 2.26, p = 0.047). This indicator showed that on both sides the initial value of mBF changed over time (Table 1, Figure 1).

Table 1: Basic parameters of Maximum Bite Force (mBF) in Set Time Intervals on Dominant (DS) and Non - Dominant Sides (NDS) of the sample (N)

	Maximum Bite Force (mBF) Dominant Side (DS)						Maximum Bite Force (mBF) Non-Dominant Side (NDS)					
Measur.	1	2	3	4	5	6	1	2	3	4	5	6
N	88	88	88	87	88	88	88	88	88	87	88	88
X	138	178	200	208	211	202	102	111	121	119	127	126
Xmin	24	48	64	40	52	60	24	30	34	30	40	44
Xmax	348	392	412	526	416	448	312	290	300	356	320	360
DS	90.1	74.3	74.8	83.9	75.7	73.2	3.5	54.2	55.0	55.7	54.2	50.8
GS	9.6	7.9	8.0	9.0	8.1	7.8	6.8	5.8	5.9	6.0	5.8	5.4

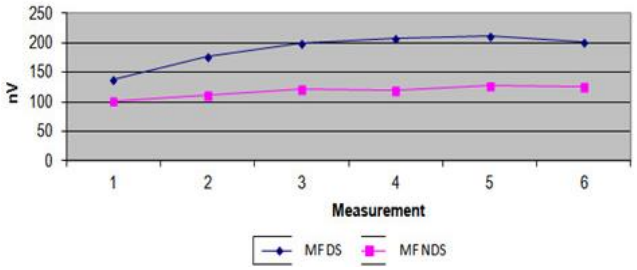

Figure 1: Masticatory Force in Set Time Interval (STI)

By analysing two variance factors (Gender and Time [of mesurement]), the influence of masticatory forces on DS and NDS were investigated. The resulting masticatory forces, for both sides, were influenced by the same factors, with significant difference (Table 2, Figure 2).

Table 2: Maximum Bite Force (mBF) in six Set Time Intervals (STI) in Females (F) and Males (M) on Dominant (DS) and Non - Dominant Sides (NDS)

Sex	Meas	Masticatory Force (mBF) Dominant Side (DS)						Masticatory Force (mBF) Non-Dominant Side (NDS)					
F	N	42	42	42	42	42	42	42	42	42	42	42	42
	X	61	133	156	153	162	170	53	84	85	88	95	101
	Min	24	48	64	40	52	60	24	30	34	30	40	44
	Max	100	202	270	282	290	288	100	160	150	140	160	150
	DS	16.9	40.7	44.7	57	54.2	51.9	17.7	28.9	25.2	27.4	26.7	25.4
	GS	2.6	6.3	6.9	8..8	2.7	4.4	3.9	4.2	4.1	3.9	3.2	3.0
M	N	46	46	46	46	46	46	46	46	46	46	46	46
	X	207	219	240	247	249	249	147	150	153	148	155	149
	Min	84	80	108	128	120	122	66	76	80	90	76	80
	Max	348	392	412	416	416	448	312	290	300	356	321	360
	DS	70.3	74.8	79.7	68.4	69.7	55.8	53.3	55.1	59.7	57.3	57.0	57.4
	GS	10.4	11.0	11.0	11.9	10.1	10.3	8.2	7.9	8.1	8.9	8.4	8.4

Gender: mBF - DS (gender) = 318.43, p=0.0000; mBF - NDS (gender) = 219.89, p = 0.0000. Time: mBF - DS (time) = 18.74, p = 0.0000; BF - NDS (time) = 3.83, p = 0.0020. Interaction: mBF - DS (inter) = 3.68, p = 0.0208, BF- NDS (inter) = 2.7, p = 0.201.

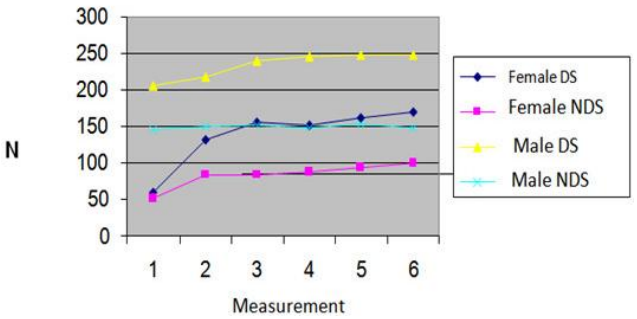

Figure 2: mBF at STI by Gender

Significant differences in the masticatory forces on DS and NDS is explained by different measurement times and with the prior experience wearing complete dentures. However, the interaction of these two factors had a significant impact on the variations in the masticatory force (Table 3, Figure 3).

Table 3: Maximum Bite Force (mBF) in six Set Time Intervals (STI) in Experienced Complete Denture Wearers (eCDW) and Inexperienced Complete Denture Wearers (iCDW) on Dominant (DS) and Non - Dominant Sides (NDS)

		mBF (DS)						mBF (NDS)					
	Msr	1	2	3	4	5	6	1	2	3	4	5	6
iCDW	N	45	45	45	44	45	45	45	45	45	44	45	45
	X	155	194	221	229	230	232	118	132	136	131	143	140
	Min	30	58	78	50	64	74	28	38	42	36	50	54
	Max	348	392	412	416	416	448	312	290	300	356	320	360
	DS	96.9	82.5	80.2	88.1	77.6	77.1	69.3	56.8	60.0	63.1	61.2	60.5
	ES	14.4	12.3	11.9	13.3	11.6	11.5	10.3	8.5	8.9	9.5	9.1	9.0
eCDW	N	43	43	43	43	43	43	43	43	43	43	43	43
	X	119	162	178	175	184	189	86	104	104	107	110	112
	Min	24	48	64	40	52	60	24	30	34	30	40	44
	Max	278	302	320	338	324	334	218	248	216	232	218	196
	DS	79.3	61.3	62.3	70.3	66.6	62.6	52.7	47.9	44.1	44.3	39.9	33.1
	ES	12.1	9.4	9.5	10.7	10.2	9.6	8.0	7.3	6.7	6.8	6.1	5.0

Time: mBF - DS (time) = 11.76, p = 0.0000; mBF - NDS (time) = 2.42, p = 0.0351; mBF - DS (experience) = 40.48; P = 0.0000; mBF - NDS (experience) = 39.93, p = 0.0000; Interaction: mBF - DS (inter) = 0.22, p = 0.9533; mBF - NDS (inter) = 0.09, p = 0.9941

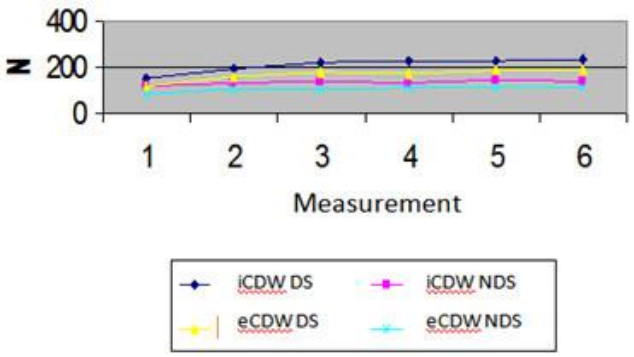

Figure 3: mBF at STI by Experienced and Inexperienced Complete Denture

The measurement time refers to the increase in average values of the masticatory forces in relation to the initial values and since the interaction was insignificant, this means that the same or approximate increase of masticatory forces occurs in eCDW and iCDW.

Experienced Complete Denture Wearers (eCDW) sooner reach the stationary state than Inexperienced Denture Wearers (iCDW) that reach it at their third measurement. The decrease of the values of the masticatory forces in CDW is explained by the fact that the patients lack their natural teeth. Patient age seems to be the cause of the reduction of masticatory forces.

Discussion

For over a century, conventional dentures were the sole treatment option for compromised dentitions. However, the rehabilitation of these patients using conventional dentures, regardless the quality, failed to completely solve either functional or psychological problem [13].

Most authors agree that the mBF increases significantly with newly fit complete dentures. However, the period towards reaching stationary state varies greatly. The results of this study indicate that after fitting of complete dentures the stationary state is reached after the 15th week, and it remains the same until the end of the observation period. Our results support previous findings which state that this period is between 12 and 24 months [14]. A stationary state is influenced by internal factors (fitness, the degree of reduction of the mucosal base, soft tissue condition, the presence of dysfunction) and external factors (related to prosthetic treatment). Niwatcharoenchaikul *et al*. concluded that complete dentures with bilateral balanced occlusion had no significant difference between masticatory performance and move [15].

Various authors (1944) concluded that people prefer unilateral mastication lean towards lateralisation of bite forces. Thus, in these patients, the masticatory force is higher on the preferred side versus the opposing side of the jaw [16] [17] [18] Some authors failed to observe the latter phenomenon [19], nevertheless it has been verified that people with full intact dental arches present with both Ds and NDS, as was also the case with our paper. This fact indicates that there is a preferred side in the functional sense even though the individual is unaware of it. Based on these findings it may be concluded that in the region of the first molar (centre of mastication), in CDW, the bite forces and the duration of the functional loads are greater on the DS versus the NDS. The speed of achievement of masticatory balance in DS and NDS varies. Bite forces in the DS reach the stationary state at the third measurement with no significant changes by the end of the measurements.

Gender does influence the variations in the dynamics of biting. Average values of masticatory forces are lower in females than males. At the time of measurement, there is a difference in the masticatory forces compared to initial values, followed by the stationary state. The influence of combined factors (interaction) is a more pronounced interval between initial and stationary ranges (DS = 109N, NDS = 48N) in females, while in males this change is less pronounced (DS = 42N, NDS = 38N). Probably, males respond faster to newly fit complete dentures regarding functional adaptation compared to females. This is consistent with the previous findings, which revealed a significant difference in gender. Higher mBF in males may be attributed to the larger size of their teeth and the greater muscular potential, therefore anatomical features may come in play. Larger teeth have larger periodontal ligament areas yielding greater biting forces [20] [21] [22]. In contrast, Wichelhaus *et al*. [23] have found no significant difference in mBF between males and females. Most studies have confirmed the differences of mBF values between males and females [20] [24] [25]. In the dynamics of maximum bite forces during observation period, a significant impact was experienced by CDWs. The results of this research have shown that eCDWs have higher initial values of maximum bite force (~ 40 N), and they consequently have better functional adaptation versus new CDWs. Over time, eCDWs have developed regulatory control mechanisms (memory paradigm of previous experience) which are used to compare e test new complete dentures. This minimizes the inhibitory impact of psychological factors and ensures imminent acceptance of complete dentures. Conversely, iCDWs are more cautious during neuromuscular adaptation period, although at the end of the observational period they have higher mBF. Dentists tend to believe that eCDWs, if positive, may readily adapt to new dentures; if negative, may poorly respond to adaptation. Furthermore, duration of denture use was associated with higher satisfaction rates [26].

Rehabilitation of edentulous patients with implant supported dentures is a very invasive and expensive long treatment option [27]. However, the biting forces and masticatory performance increased probably due to improved denture retention and stability [28]. Measurement of bite force has been a reliable method for assessment of the biomechanical properties of the masticatory system and prosthetic treatment. However, one should consider other effective factors when comparing bite force measurement in research [29]. The role of Prosthodontists is to have an understanding of the changes in the orofacial form, function and behavioural consequences and the possible social impact emerging from the complete loss of teeth [30].

Maximum bite force (mBF) represents a significant discriminating variable of the functional adaptation level to new complete dentures. The highest value of this variable is featured by the longer time intervals of function about the initial measurements and is the indicator of better adaptation to the new complete dentures. The region of the centre of occlusion on the DS has greater potential regarding transferring maximum physiological loads relative to the homologous part of the NDS. For the dynamics of this indicator, the progressive increase of values about the initial values with a tendency of restoring the stationary condition after the seventh week of delivery of the new complete dentures is remarkable.

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