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Analysis of Occlusal Force Distributions at the Position of Maximum Intercuspation in Patients with Fixed Restorations

Rajmonda Halili[1], Jadranka Bundevska[2], Venera Bimbashi [1,3], Sotir Maja[2], Goce Dimoski[2], Sebahate Hamiti Alidema[1*]

[1]*Department of Prosthodontics Alma Mater Europaea, Campus College Rezonanca, Prishtina, Republic of Kosovo*
[2]*Department of Prosthodontics, Faculty of Dentistry, "Ss. Cyril and Methodius" University, Skopje, Republic of North Macedonia*
[3]*Department of Prosthodontics, Faculty of Dentistry, "Hasan Prishtina" University, Prishtina, Republic of Kosovo*

Abstract

The aim of the study was to determine maximum bite force (MBF) and the percentage of bite force distribution at the position of maximum intercuspation for patients with fixed restorations.

Methods and Results: This study enrolled 60 subjects [33(55%) female and 27(45%) male] divided into two groups: The control group (CG) included 30 patients with intact teeth; the experimental group (EG) included 30 patients with fixed restorations. In EG, occlusion was analyzed before and after fixed restoration insertion (FRI). We used the T-Scan III Computerized Occlusal Analysis System 7.0 (Tekscan Inc., South Boston, MA, USA) for analysis. The present study showed a significant difference in MBF between CG and EG before and after FRI ($P<0.05$). In the present study, there were no statistically significant differences in force distribution in the right and left half of the string between groups ($P>0.05$).

Conclusion: Occlusal analysis with T-Scan III is the only method that enables us to estimate the force differences between the natural teeth and fixed restorations in occlusion.(**International Journal of Biomedicine. 2022;12(3):423-427.**).

Keywords: maximum bite force • occlusal force • fixed restoration • T-Scan III

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Abbreviations

FR, fixed restoration; **FRI**, FR insertion; **bFRI**, before FRI; **aFRI**, after FRI; **OF**, occlusal force; **MBF**, maximum bite force.

Introduction

The static relations in occlusion, as centric occlusion, must be balanced with the simultaneous contacts of all the teeth on both sides of the arch at their first contact. The cuspal inclines should be developed so that the teeth can glide from more centric occlusion to eccentric positions without interference and without the introduction of rotating or tipping forces.(1) In conservative restorative dentistry, the presence of a harmonious and smooth occlusion is considered essential to the physiological function of the stomatognathic system and is deemed essential to protect against excessive loading and fracture of inserted restorations.(2) Occlusal disturbances cause pain symptoms in patients who have a headache and show occlusal trauma.(3) Since most common methods of diagnosing occlusion are based on the patient's subjective sensations, those sensations cannot be the main reference point for occlusion correction, as all the components of the balance of occlusion need to be studied.(4) T-Scan, one of the modern technologies for evaluating occlusion, is used for digital occlusal analysis.

This device delivers more objective and clearer results, which are based on accuracy and reproducibility, and the exact definition of supra-contacts, both at intact teeth and after fixed reconstruction replacement, in order to reduce the possibility of errors.[4,5] The T-Scan III is a digital modality that uses an array of pressure sensors to establish contact time sequence, relative occlusal force (OF), and relative distribution of pressure.[6]

The aim of the study was to determine maximum bite force (MBF) and the percentage of bite force distribution at the position of maximum intercuspation for patients with fixed restoration (FRs). The T-Scan is much more informative than an examination with an articulator paper due to the simultaneous examination of the entire arch with proper visualization of the problem.

Materials and Methods

This study was conducted at Alma Mater Europaea Campus College "Rezonanca" (Pristina, Kosovo) with prior approval from the Ethical Committee (AD-3406/22, 14.06.2022) of this institution and enrolled 60 subjects [33(55%) female and 27(45%) male] divided into two groups: The control group (CG) included 30 patients with intact teeth; the experimental group (EG) included 30 patients with FRs. In EG, occlusion was analyzed before and after fixed restoration insertion (FRI). Inclusion criteria were patients with partial edentulism (Kennedy class III) in one of their jaws without treatment, no signs or symptoms of temporomandibular joint disorders, and no systemic disease that might affect the neuromuscular system (such as Parkinson's disease or Bell's palsy). FRs were made by Zirconia-based Ceramics.

We used the T-Scan III Computerized Occlusal Analysis System 7.0 (Tekscan Inc., South Boston, MA, USA) for analysis. The recording handle with the sensor and arch support was placed between the maxillary central incisors of the patients. The recording was initiated by pressing the button on the recording handle. The patients were asked to close the mouth until reaching the complete intercuspation without making any excursive movement. After the handle button was pressed, the arch model was automatically created on the screen. The Intercuspal Position-Centric Relation (IP-CO) option in the software menu was used for registration. The parameters recorded for these measurements were MBF and percentage of bite force distribution for the left and right halves of the string.

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0 (SPSS Inc, Armonk, NY: IBM Corp). The mean, standard deviation (SD), standard error of the mean (SEM), and confidence interval (CI) were calculated. Means of 2 continuous variables were compared by independent samples t-test (Student's t-test). A probability value of $P<0.05$ was considered statistically significant.

Results

Table 1 presents descriptive statistics for CG and EG (bFRI). In CG, the mean±SD for MBF during occlusion was 96.450±3.442N. In EG, the mean±SD for MBF (bFRI) was 91.597±9.137N. Mean±SD for occlusal force (OF) on the left side (L) was 48.700±7.298% for CG and 44.683±27.523% for EG (bFRI). Mean±SD for OF on the right side (R) was 51.366±7.216% in CG and 55.273±27.459% in EG (bFRI).

Table 1.

Descriptive statistics for CG and EG (bFRI).

Variable	Mean	n	SD	SEM
MMF_CG, N	96.450	30	3.4418	0.6284
MMF_EG (bFRI), N	91.597	30	9.1374	1.6682
OF_L_CG, %	48.700	30	7.2976	1.3323
OF_L_EG (bFRI), %	44.683	30	27.5230	5.0250
OF_R_CG,%	51.367	30	7.2155	1.3174
OF_R_EG (bFRI), %	55.273	30	27.4588	5.0133

Table 2 presents the comparison of MBF and percentage of bite force distribution for left and right halves of the string between CG and EG (bFRI). A paired sample t-test was used to compare the significance between two groups. The difference in the MBF means between CG and EG (bFRI) was statistically significant – 4.85N (P=0.011). The difference in

Table 2.

Comparison of MBF and percentage of bite force distribution for left and right halves of the string between CG and EG (bFRI).

Paired Samples T-Test									
		Paired differences					T	df	Sig. (2-tailed)
		Mean	SD	SEM	95%CI of the differences				
					Lower	Upper			
Pair	MMF_CG, N MMF_EG (bFRI), N	4.8533	9.7389	1.7781	1.2168	8.4899	2.730	29	0.011
Pair	OF_L_CG,% OF_L_EG (bFRI), %	4.0167	25.6755	4.6877	-5.5707	13.6040	0.857	29	0.399
Pair	OF_R_CG,% OF_R_EG (bFRI), %	-3.9067	25.7334	4.6983	-13.5157	5.7024	-0.832	29	0.412

the OF means on the left side between CG and EG (bFRI) was 4.02% without statistical significance (*P*=0.399). The difference in the OF means on the right side between CG and EG (bFRI) was -3.91% without statistical significance (*P*=0.412).

Table 3 presents descriptive statistics for CG and EG (aFRI). In CG, the mean±SD for MBF during occlusion was 96.450±3.442N. In EG, the mean±SD for MBF (aFRI) was 93.870±5.402N. Mean±SD for OF on the left side was 48.700±7.298% for CG and 62.960±73.934% for EG (aFRI). Mean±SD for OF on the right side was 51.367±7.216% in CG and 50.593±12.319% in EG (aFRI).

Table 3.

Descriptive statistics for CG and EG (aFRI).

Variable	Mean	n	SD	SEM
MMF_CG, N	96.450	30	3.4418	0.6284
MMF_EG (aFRI), N	93.870	30	5.4016	0.9862
OF_L_CG, %	48.700	30	7.2976	1.3323
OF_L_EG (aFRI),%	62.960	30	73.9336	13.4984
OF_R_CG, %	51.367	30	7.2155	1.3174
OF_R_EG (aFRI),%	50.593	30	12.3191	2.2492

Table 4 presents the comparison of MBF and percentage of bite force distribution for left and right halves of the string between CG and EG (aFRI). The difference in the MBF means between CG and EC (aFRI) was statistically significant – 2.58N (P=0.035). The difference in the OF means on the left side between CG and EG (aFRI) was -14.26% without statistical significance (*P*=0.291). The difference in the OF means on the right side between CG and EG (aFRI) was 0.77% without statistical significance (*P*=0.737).

Table 5 presents descriptive statistics for EG (bFRI and aFRI). The mean±SD MBF for bFRI and atRI was 91.597±9.137N and 93.870±5.402N. Mean±SD for OF on the left side was 44.683±27.523 for bFRI and 62.960±73.934% for aFRI. Mean±SD for OF on the right side was 55.273±27.459% for bFRI and 50.593±12.319% for aFRI.

Table 5.

Descriptive statistics for EG (bFRI and aFRI).

Variable	Mean	n	SD	SEM
MMF_EG (bFRI), N	91.597	30	9.1374	1.6682
MMF_EG (aFRI), N	93.870	30	5.4016	0.9862
OF_L_EG (bFRI),%	44.683	30	27.5230	5.0250
OF_L_EG (aFRI),%	62.960	30	73.9336	13.4984
OF_R_EG (bFRI),%	55.273	30	27.4588	5.0133
OF_R_EG (aFRI),%	50.593	30	12.3191	2.2492

Table 6 presents the comparison of MBF and percentage of bite force distribution for left and right halves of the string in EG between bFRI and aFRI. The difference in the MBF means between bFRI and aFRI was -2.27% without statistical significance (*P*=0.230). The difference in the OF means on the left side between bFRI and aFRI was -18.27% without statistical significance (*P*=0.232). The difference in the OF means on the right side between bFRI and aFRI was 4.68% without statistical significance (*P*=0.344).

Discussion

In the present study, the T-Scan III occlusal system was used to analyze OF at the maximal occlusal intercuspation of the teeth before and after FRI. When analyzing the data, we focused on the MBF used to achieve occlusal contacts and the balance of occlusion (the percentage ratio of occlusal contacts on the left to right at the final moment of jaw-closing).[4,5] Dental status is an important factor for the MBF value. The number of teeth and contact appears to be an important parameter affecting MBF.[7] Miyaura K. et al.[8] concluded that the individuals with natural dentition had shown the highest MBF; the biting forces were 80%, 35%, and 11% for fixed partial dentures, removable partial dentures, and complete denture groups, respectively, when expressed as a percentage of the natural dentition group.[8] The present study showed a significant difference in MBF between CG and EG before and after FRI (*P*<0.05). At the same time, there was no statistically significant difference between bFRI and aFRI in EG (*P*>0.05).

Table 4.

Comparison of MBF and percentage of bite force distribution for left and right halves of the string between CG and EG (aFRI).

Paired Samples T-Test									
		Paired differences					T	df	Sig. (2-tailed)
		Mean	SD	SEM	95% CI of the difference				
					Lower	Upper			
Pair	MMF_CG, N MMF_EG (aFRI), N	2.5800	6.3770	1.1643	0.1988	4.9612	2.216	29	0.035
Pair	OF_L_CG,% OF_L_EG (aFRI),%	-14.2600	72.5762	13.2505	-41.3604	12.8404	-1.076	29	0.291
Pair	OF_R_CG,% OF_R_EG (aFRI),%	0.7733	12.4833	2.2791	-3.8880	5.4347	0.339	29	0.737

Table 6.

Comparison of MBF and percentage of bite force distribution for left and right halves of the string in EG between bFRI and aFRI.

Paired Samples T-Test									
Variable		Paired differences					T	df	Sig. (2-tailed)
		Mean	SD	SEM	95% CI of the differences				
					Lower	Upper			
Pair	MMF_EG (bFRI), N MMF_EG (aFRI), N	-2.2733	10.1653	1.8559	-6.0691	1.5224	-1.225	29	0.230
Pair	OF_L_EG (bFRI), % OF_L_EG (aFRI), %	-18.2767	82.0345	14.9774	-48.9089	12.3555	-1.220	29	0.232
Pair	OF_R_EG (bFRI), % OF_R_EG (aFRI), %	4.6800	26.6626	4.8679	-5.2760	14.6360	0.961	29	0.344

Our results are consistent with data obtained in a study by Blamphin et al.,[9] who concluded that MBF in subjects with fixed partial dentures was significantly lower than in a group of young male subjects with natural dentition. The number, location, and size of occlusal contacts, as well as the forces applied, are important for the good functioning of the TMJ system.[10] Information from the T-Scan system helps locate and identify traumatic occlusal contacts and can be used to compare OF symmetry before and after treatment.[11]

In a study by Chaithanya et al.,[12] one week into post prosthetic phase evaluation of OF distribution 70% of patients had an imbalance in force distribution between the right and left sides of the arch. Use of the T-Scan showed occlusal disharmonies in spite of corrections performed during cementation of prosthesis guided by articulating paper, till the patient and operator were satisfied. Furthermore, in patients with increased force on the segment with a fixed partial denture, the reason for disharmonies can be attributed to premature contact. Our study supports the conclusions of these studies. In the present study, there were no statistically significant differences in force distribution in the right and left half of the string between groups (P>0.05). Our results are also consistent with the study data of Trpevska et al.[13] that in subjects with neutral occlusion, there was a tendency for bilateral equality of the tooth contacts about the sagittal axis with a high degree of force equality per half arch.

The T-Scan is considered a valuable method for clinical evaluation and understanding of occlusal difficulties.[14] After cementation, if any uneven force distribution was noticed with T-Scan III, it was corrected to achieve equilibrium of forces. The T-Scan can determine the high points, premature contacts, regions of excessive loads, and the concentration of the uneven force. Considering that masticatory efficiency is a combination of bite force and occlusal contact area, studies suggest that the higher the bite force and the larger the occlusal areas, the more efficient the mastication.[14-16] Moreover, considering that the largest interocclusal contacts are in the maximum intercuspation occlusion situation, this position is used to compare force symmetry before and after treatment.[17,18] The symmetry of the OF distribution and the MBF analysis are still important to verify patients' perception of the clinical data presented in order to achieve maximum adaptation with fixed construction.

In conclusion, patients with intact teeth have ideal physiological, balanced occlusion. After FRI, disproportionate OF with unbalanced occlusion is determined. In long arch ceramic restorations, OF must be redistributed. Occlusal analysis with T-Scan III is the only method that enables us to estimate the force differences between the natural teeth and fixed restorations in occlusion.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical Committee of Alma Mater Europaea Campus College Rezonanca, Pristina, Kosovo (AD-3406/22,14.06.2022). Written informed consent was obtained from all subjects involved in the study.

Competing Interests

The authors declare that they have no competing interests.

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***Corresponding author:** Sebahate Hamiti Alidema, Teaching Assistant, Alma Mater Europaea, Campus College Rezonanca, Pristina, Republic of Kosovo. E-mail: sebih@hotmail.com*

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