Computerized measurement of bite forces for edentulous subjects with denture bases of different impression techniques

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ABSTRACT

Background: Complete denture wearers show lower levels of bite force than dentate subjects. This has a significant influence on their chewing efficiency. In this study an attempt was made to investigate the effect of the impression technique on the maximum bite force in complete denture wearers.

Materials and methods: The patients selected for this research were 12 edentulous patients. Three different techniques for registering the final impression were made; the mucostatic, mucofunctional, and the selective pressure impression technique. Two sets of upper and lower denture bases and one set of upper and lower dentures were constructed for each subject. Intraoral and extraoral instruments and devices, as well as a computer program were used for measuring the maximum bite force.

Results: The subjects without past experience with complete dentures were able to give higher levels of bite force with dentures or denture bases constructed from the mucofunctional impression technique, while those with previous dentures gave higher levels of bite force with the dentures or denture bases constructed from the selective pressure impression technique.

Conclusions: It is recommended that dentures constructed from the mucofunctional impression technique be used for those subjects without previous experience with complete dentures, while for those with previous complete dentures the selective pressure impression technique should be used.

Key words: Maximum bite force, Impression technique, gnathodynamometer (J Bagh Coll Dentistry 2010;22(3):13-17).

INTRODUCTION

Functional performance of complete dentures as a replacement for natural teeth is one of the major concerns in prosthodontic dentistry. It is well known, that complete denture wearers show a lower chewing efficiency in comparison to dentate controls.[1,2] One of the factors leading to the decrease in chewing performance is the reduced bite force that denture wearers can develop,[3] which was five to six times lower than in dentate subjects.[4] Bite force may be limited by sensitivity of the mucoperiosteum covering the alveolar ridge and thus the individual threshold for discomfort.[5,6]

It was stated that dentures constructed from mucostatic impressions distribute uneven load over the underlying bone. Dentures constructed from mucofunctional impressions distribute load more evenly over the underlying bone.[7] Oral mucosa trapped between bone and a hard denture under occlusal load, especially in places where the bone is sharp and the mucosa is thin, generates the sensation of discomfort or pain. If the pressure was distributed more evenly, discomfort or pain would be less common.[8]

This study was conducted to examine the relationship of the bite force for completely edentulous subjects with dentures fabricated from different impression techniques, according to the state of the denture bearing mucosa during the impression, whether at rest or under occlusal load.

MATERIALS & METHODS

Twelve edentulous patients were chosen from the Prosthodontic Clinic, College of Dentistry, Baghdad University, six males and six females with an age range of 48-80 years and a mean age of 64 years with a standard deviation of 8.96.

Three sets of upper and lower denture bases were constructed for each patient. One of these sets was finished in the form of dentures for the patient to use after participating in the research and not for research purposes. Each set was constructed from a master cast obtained from one of the three impression techniques. The mucostatic impression technique was made with impression plaster as the impression material.[9] The selective pressure impression technique was made with zinc oxide eugenol impression material. The dentist's hands subjected the force over the trays to produce the pressure during the registration process.[10] Finally, the mucofunctional impression technique was done under the biting force of the patient with zinc

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oxide eugenol impression material.[7]

In those patients with a previous complete denture, a period of 24-48 hours was given before making the final impression during which he/she did not wear the dentures for complete tissue recovery.[11]

An intraoral device, gnatho-dynamometer, was constructed for the measurement of the bite force, as seen in figure 1. It was a modification of a previous design used by Walsh, Gibbs, Higgins, and Holbrook in 1980.[12] It consisted of two stainless steel plates separated by an adjustable stainless steel screw for adjusting the vertical jaw separation, as shown in figure 2. The sensitive elements were four foil strain gauges (Kyowa Electronic Instrument Co., Ltd., Tokyo, Japan) wired in a Full Wheatstone Bridge.

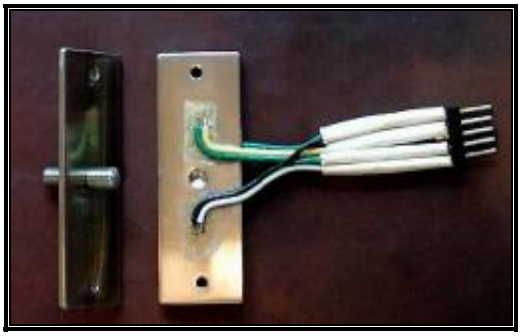

Figure 1: Gnathodynamometer

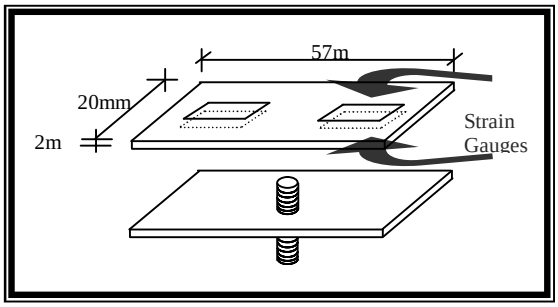

Figure 2: Dimensions and orientation of plates and strain gauges.

The signal, after passing through two electronic devices, was processed with a computer program and displayed in the form of a line graph for interpretation.

Several steps were performed for each patient before recording the bite force. 12-15mm increase in the vertical dimension was depended.[13,14] Registration of the centric relation for that patient was accomplished and at that vertical dimension. This centric relation, recorded with the use of the Hanau face-bow, allowed for the mounting of the dentures and denture bases on the same articulator, Dentatus, and at an identical vertical dimension. With this relationship the gnathodynamometer was secured to these dentures and denture bases in the areas of the molars and second premolars bilaterally by auto-polymerizing acrylic resin, as shown in figure (3).[15,16]

Figure 3: The gnathodynamometer secured on the dentures

The patient was asked to sit in a comfortable, natural, and unstrained position.[1] The patient was then informed to increase his bite force steadily until he reached a point where pain or discomfort prevented him from increasing the bite force or until he felt he had reached his greatest limit.

During the registration sessions the patient was not allowed to see the progression of the biting force on the computer because this may influence the results.[5]Also there was no verbal encouragement because this may encourage the patient to bite stronger thus affecting the results.[17] Three decoy (false) attempts were conducted, without saving them, to help in eliminating/decreasing any fear of breakage of the instruments, dentures or denture bases, damage to the supporting structure...etc.[5] These decoy attempts also allowed the patient to practice the whole process. After these decoy attempts a period of rest was given.

Three (true) attempts were conducted for each set of denture bases for measuring the maximum biting force. Each attempt spent about 5 to 10 seconds from the beginning of the attempt till the end. This period was less than that needed for muscle fatigue.[18]

Several minutes were given between each attempt and 20-30 minutes were given between the different types of denture bases to allow for relaxation of the muscles in case of fatigue.[19]

Those patients who were chosen for this research were divided into two main groups, according to past history of denture wearing. Both of these main groups of patients took into account the impression techniques, and consisted of three groups of attempts for each patient. These groups consisted of those attempts made with the dentures or denture bases of the

mucostatic impression technique, those of the selective pressure impression technique, and those of the mucofunctional impression technique. Each group of attempts consisted of three attempts.

The data was analyzed off-line. The mean of the highest two peaks was obtained for each attempt, as in figure 4. Then the mean of the bite force for the three attempts was taken for each group of attempts, categorized according to one of the denture or denture bases constructed from one of the three impression techniques. Thus, the data was now represented by one value of bite force for each denture/denture base constructed with one of the impression techniques and this was for each patient.

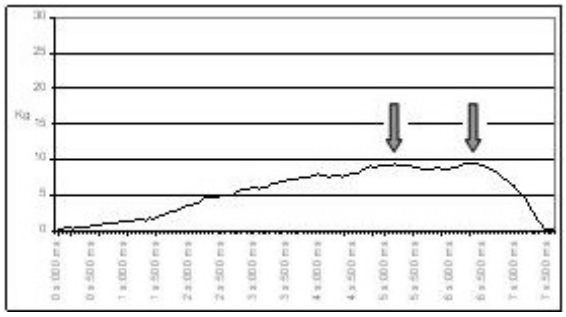

Figure 4: Recording of the maximum bite force.

Statistical analysis was conducted for the data using descriptive statistics and student's paired t-test.

RESULTS

The group sample with no previous experience with dentures showed a significant difference in which the mucofunctional impression group had a maximum bite force greater than both the selective ($P = .024$, $P < .05$) and mucostatic impression group ($P = .023$, $P < .05$), as seen in figure 5 and table 1.

The group sample with previous experience with dentures differed in that the mean maximum biting force for the selective pressure impression technique had the greatest bite force, the mucofunctional impression technique had the least bite force, and the bite force of the mucostatic impression technique was in between, as shown in figure 6 & table 2. Statistically the selective pressure impression technique had the higher mean maximum bite force ($P=.048$, $P<.05$).

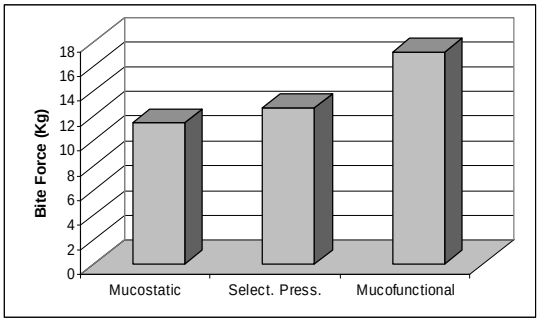

Figure 5: Mean maximum bite force with different types of impressions for the group sample without previous complete dentures.

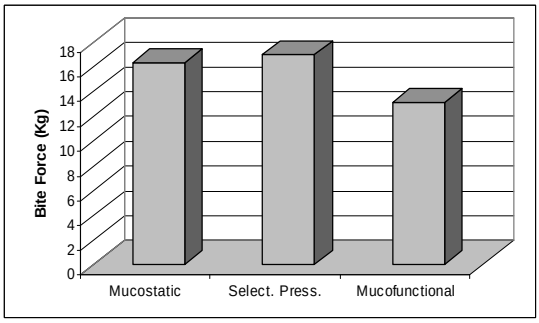

Figure 6: Mean maximum bite force with different types of impressions for the group sample with previous complete dentures.

Table 1: Student's paired t-test for maximum bite forces (in kilograms) and the different impression techniques in the group sample with no previous experience with complete dentures.

Impression Techniques	No.	Mean	Std. Error Mean	P-value
Mucostatic- Select. Press.	6 6	11.450 12.635	2.843 2.768	.460
Mucostatic- Mucofunctional	6 6	11.450 17.124	2.843 3.110	.023
Select. Press. - Mucofunctional	6 6	12.635 17.124	2.768 3.110	.024

P>.05 (insignificant), P<.05 (Significant), and P<.01 (Highly Significant)

DISCUSSION

The type of impression technique used played a significant role in determining to which extent the subject can bite on the newly constructed dentures. For those subjects who had not worn upper and lower complete dentures in the past, the mucofunctional impression technique gave the highest bite force, as in figure 5 & table 1. This could be attributed to the difference in the tissue surfaces of the dentures according to the impression technique and its

association with the underlying residual ridge. Wills & Manderson[20] stated that the thickness and displaceability of the mucosal support for dentures should be considered when recording impressions because the histology of the tissues played a role through the uneven thickness of the denture bearing mucosa at different sites, as seen in figure 7.[21] Thus, the denture bearing mucosa could be compressed under load and this compression could lead to deformation of the mucosa. This was dependent on the amount and duration of load.[11] Each impression technique differed in the amount of compression carried out on to the denture bearing mucosa. [20]

Table 2: Student's paired t-test for maximum bite forces (in kilograms) and different impression techniques in the group sample with previous experience with complete dentures.

Impression Techniques	No.	Mean	Std. Error Mean	P-value
Mucostatic- Select. Press.	6 6	16.288 16.924	1.926 3.1086	.728
Mucostatic- Mucofunctional	6 6	16.288 13.139	1.926 2.827	.168
Select. Press.- Mucofunctional	6 6	16.924 13.139	3.109 2.827	.048

P>.05 (insignificant), P<.05 (Significant), and P<.01 (Highly Significant)

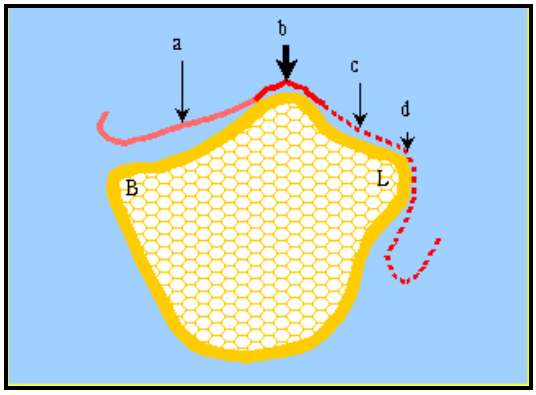

Figure 7: Section through the edentulous mandible in the molar region.
Arrow length and thickness indicate the resilience of the mucosa to loading. The mucosa (a) over the buccal (B) shelf of bone is mobile, resilient, and fairly thick. The mucosa (b) is firmly attached to the underlying bone, and less resilient. The lingual (L) mucosa (c) is very thin and mobile. Over some areas it is resilient, but over sharp ridges of bone (d) there is no resilience.[8]

When the mucofunctional impression technique was used the compression of the mucosa was in respect to the difference in thickness at different areas, so in the thicker parts the mucosa was compressed more.[11] The end result was an impression that was a negative replica of the edentulous ridge under functional load. The denture base constructed from this impression distributed the load over the denture bearing mucosa evenly, as seen in figure 8 (part a), and thus less areas of stress concentration were developed under this type of denture base. This was acknowledged by several researchers.[7,8,22]

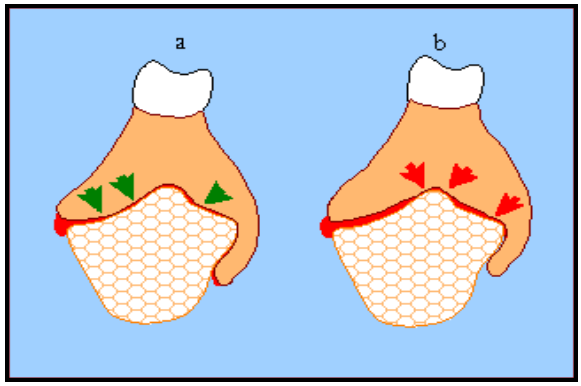

Figure 8: (a) Lower denture constructed from a mucofunctional impression technique.
The resilient parts of the mucosa (arrows) are compressed. (b) Lower denture constructed from a mucostatic impression technique. The impinged areas of the mucosa (arrows).

The mucostatic impression, ideally, should not compress the denture bearing mucosa. This would lead to uneven distribution of pressure to the underlying bone, as in figure 8 (part b). Kydd & Mandley[23] said that areas of irritation under dentures usually occur where the subjacent soft tissue was thin or where forces were being concentrated in a small area. This would lead to the sensation of discomfort or pain in the denture bearing mucosa, which played a role in limiting the bite force of completely edentulous subjects.

In the other group of samples whose subjects had previous complete dentures the highest bite force was for the denture bases constructed from the selective pressure impression technique, as seen in figure 6 and table 2. This could be explained by the histological changes in the denture bearing mucosa when subjected to the physical effects of dentures. Nedelman, Gamer, & Bernick[24] stated that alveolar ridge mucosa from non-denture wearing edentulous individuals exhibited a thickened stratum corneum. The wearing of a denture apparently altered the structural appearance of the ridge mucosa. The stratum corneum was thinner than in non-denture

bearing mucosa and there was a relative increase in the collagenous fibers of the lamina properia. Prolonged wearing of a denture produced a further thinning of the cornified layer with an increase in the thickness of the connective tissue fiber bundles. Watson[25] observed that non-denture bearing mucosa differed histologically from denture bearing mucosa. He also concluded that non-denture bearing mucosa increased in thickness with age and that wearing dentures seemed to prevent the age related increase in the thickness of the epithelium. It could be presumed that the changes that occurred to the denture bearing mucosa after the insertion of dentures decreased the compression of the altered tissues. These alterations were the decrease in the thickness of the stratum corneum with thickening of the collagen fiber bundles and keratinized layer and all these changes decreased the compressibility of the mucosa.

To obtain the greatest amount of bite force, it is recommended that dentures constructed from the mucofunctional impression technique be used for those subjects without previous experience with complete dentures, while for those with complete dentures the selective pressure impression technique should be used.

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