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**Original Research**

# The Study of the Effect of Altering the Vertical Dimension of Occlusion on the Magnitude of Biting Force

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***Abstract:***

**Background:** Determination of the correct vertical dimension of occlusion (VDO) for the edentulous patients is one of the most important steps in making dentures for optimum esthetics and functions. Knowledge of the magnitude, direction, and distribution of the masticatory forces are of special value in designing a prosthesis, which has high masticatory efficiency and which transfers a minimum load to the supporting tissue.

**Aim:** To develop a device capable of measuring the biting force generated during maximum biting. To measure the biting force generated during a change in VD. To determine, the relationship between the VDO and the biting force.

**Materials and Methods:** Indigenously fabricated electronic gnathodynamometer was used to record biting force of 10 individuals at altered VD. The range of alteration was chosen from increased 7.5 mm to decreased 4.5 mm and established VDO as base line. This study was done at KLES's Institute of Dental Sciences, Belgaum, Karnataka.

**Results:** Mean biting force for males and females was 15.29 kg and 5.71 kg at VDO established by Niswonger's method respectively.

**Conclusion:** Bite force was maximum at the VDO in edentulous subjects. Maximum biting force recorded at VDO was reduced with subsequent increase or decrease in VD. Clinically highest biting force could act as an aid in determining and verifying VDO for edentulous patients.

***Key Words***: Biting force, occlusion, vertical dimension

## Introduction

The present era with the latest advancements of science around has made us more innovative so that we can make everything possible which was impossible in yester years. Many techniques have been advocated for determining the occlusal vertical dimension (VD) of edentulous patients.[1,2] Alteration of VD of occlusion (VDO), in terms of either increase or decrease, causes disastrous effects on muscles, supporting basal tissues, temporomandibular joint and thus overall stomatognathic system.[3] The construction of any type of a denture should be always aimed at the high masticatory efficiency with minimal load transfer to the supporting tissues for optimum preservation of the tissues. Thus, the knowledge of magnitude, direction and duration of masticatory forces is the most important criteria to be considered while designing the prosthesis, so that it will maintain optimum health of the tissues. This study was undertaken to study the effect of altering the VDO on the magnitude of biting force and to verify if this relationship could be used to establish the optimal VDO for edentulous patients. In this study, the biting force was measured by indigenously designed electronic gnathodynamometer.[4]

## Materials and Methods

Ten edentulous subjects, five males, and five females were selected for this study. The subject inclusion criteria's were subjects with age ranging from 55 to 65 years, with favorable well healed residual alveolar ridges with class I ridge relationship. The subjects who had normal tone of orofacial muscles and no past or present evidence of dysfunction of the stomatognathic system. The initial steps in the construction of complete dentures were performed in the conventional manner. The VDO was established by Niswonger's method. Orientation jaw relation record was transferred to Hanau articulator. Centric relation was recorded and transferred to Hanau articulator. Impression compound occlusal rims with 3 U-shaped bioacryl sheets on upper occlusal rims and 2 bioacryl sheets on lower occlusal rims were adjusted on Hanau articulator to recorded VDO. The range of alteration was chosen from increased 7.5 mm to decreased 4.5 mm to that of established VDO as base line. To increase VD by 7.5 mm three additional "U" shaped biocryl sheets were placed on the lower occlusal rim. Three sheets of 1.5 mm thickness each in addition to intraoral bite trays having thickness of 3.0 mm provided the VDO increase by 7.5 mm. At this position of 7.5 mm increased VD, the patient was asked to exert maximum biting force on the

intra-oral biting tray of gnathodynamometer for five seconds. The reading on digital display was recorded. Total eight biocryl sheets were incorporated in upper and lower bite rims three in upper and five in lower bite rims. Biocryl sheets were reduced in number one by one thus reducing the VD by 1.5 mm at each stage. The patient was asked to rest for sometime before proceeding with the every change in the VD. Three readings of biting force were recorded for every change in VD at a short interval giving rest to the jaws to avoid muscle fatigue. The readings were compiled and subjected to statistical analysis.

***Design of electronic gnathodynamometer***

Newly designed indigenously fabricated device was divided into two main parts: Biting force unit and microprocessor with digital display.

*Biting force unit*

The device consisted of two "U" shaped stainless steel plates one upper and one lower called intra-oral biting trays. The thickness of these biting trays was 1.5 mm each. Upper biting tray was movable, and a section was reinforced with a stainless steel plate, of 1.5 mm thickness which was also used as a guide for placement of labial surface of occlusal rims touching to its periphery. The free moving end of the upper biting tray was provided with acrylic extension block of triangular shape for smooth sliding movement of the horizontal sliding plate. The lower biting tray was fixed to the rectangular aluminum box which had two compartments. The rectangular box was of 13 cm in length and 4 cm in width and 4 cm in height. The thickness of aluminum sheets used for fabrication of this box was of 3 mm. A 5 mm diameter hole was made in a vertical plate, present between the two compartments. A horizontal plate fixed to the vertical plate was present in the second compartment with spring notches to hold springs. In the second compartment a horizontal sliding plate was present which had a V shaped notch to which a metal ball was attached by cold cure acrylic resin toward the intra-oral biting trays. This sliding horizontal plate moved forward and backward as the triangular sliding surface of an acrylic block of upper biting tray moved upward and downward. Sliding horizontal plate slides between side wall railing for horizontal sliding plate along with stops. Two tension springs were attached to sliding horizontal plate which pulled the sliding horizontal plates toward the first compartment (Figure 1).

A light source was fixed on posterior end of the aluminum framework in the first compartment. The light dependent sensor (LDS) was fixed on the posterior edge of sliding horizontal plate facing toward the light source.

*Microprocessor with digital display*

The movement of horizontal plate enabled the movement of LDS. The intensity of light from light source reduced as LDS moved away from the light source. The forward and backward movement of LDS gave the variation in resistance as it moved away or toward the light source. The change in resistance caused the voltage variation. The variation was next fed to analog to digital convertor (ADC) chip 7109 (ADC) (Figure 2).

This ADC chip 7109 gave the output as required by the 8085 microprocessor. In the processor, the values of pressure were stored. When the pressure was applied on upper biting tray the LDS moved away from the light source depending on the biting pressure. These movements changed light intensity falling on LDS. The change in intensity of light gave the variation in voltage. The variation in voltage at the output stage of ADC integrated chip displayed the digital value on the display board.

***Calibration of gnathodynamometer***

Indigenously fabricated device was calibrated by counter weight set. It proved to be linear in a range of 100 g to 40 kg. The calibration of the apparatus was checked and verified during the course of the investigation.

**Results**

Results of mean biting force of three readings each, for altered VDs, for males and females recorded separately (Table 1). Mean biting force for males and females was 15.29 kg and 5.71 kg at VDO respectively. Two males showed maximum biting force at 1.5 mm increased VDO and values were 15.80 kg and 14.53 kg.

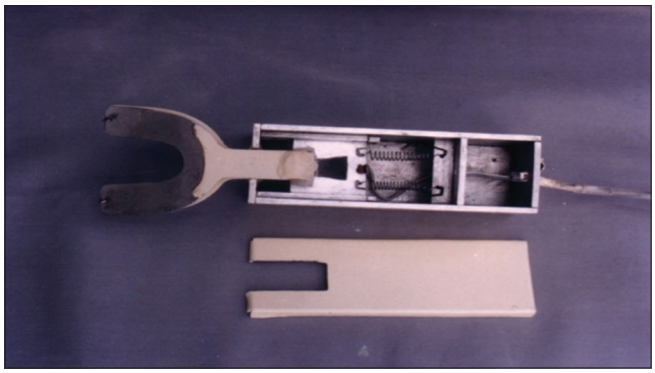


**Figure 1:** Biting force unit.

**Figure 2:** Microprocessor with digital display.

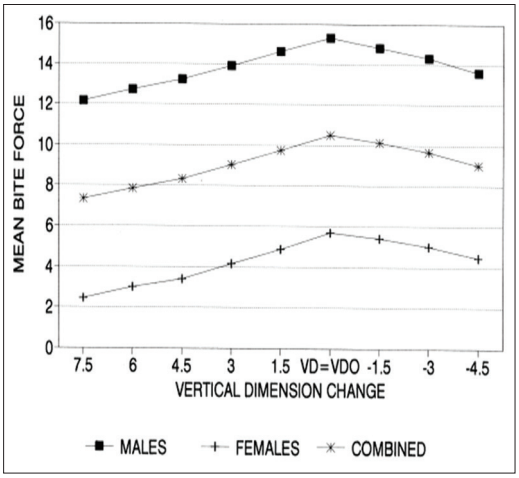
**Table 1: Mean bite force recorded at various altered vertical dimensions for males and females.**

| Serial number | Increasing vertical dimension | | | | | VD=VDO | Decreasing vertical dimension | | |
|---|---|---|---|---|---|---|---|---|---|
| | 7.5 | 6 | 4.5 | 3 | 1.5 | | 1.5 | 3 | 4.5 |
| Male | | | | | | | | | |
| 1 | 11.83 | 12.27 | 12.83 | 13.83 | 14.73 | 15.80 | 15.27 | 14.77 | 13.27 |
| 2 | 11.60 | 12.13 | 12.80 | 13.03 | 13.87 | 15.10 | 14.73 | 13.93 | 13.50 |
| 3 | 12.27 | 12.77 | 13.27 | 14.13 | 14.30 | 15.80 | 15.13 | 14.83 | 14.13 |
| 4 | 13.03 | 13.53 | 14.13 | 14.83 | 15.80 | 15.43 | 15.03 | 14.27 | 13.87 |
| 5 | 12.13 | 12.87 | 13.17 | 13.83 | 14.53 | 14.30 | 14.07 | 13.67 | 13.23 |
| Mean | 12.17 | 12.71 | 13.24 | 13.93 | 14.65 | 15.29 | 14.85 | 14.29 | 13.60 |
| SD | 0.55 | 0.56 | 0.54 | 0.65 | 0.72 | 0.62 | 0.48 | 0.51 | 0.39 |
| C of V | 4.49 | 4.37 | 4.07 | 4.65 | 4.92 | 4.08 | 3.22 | 3.57 | 2.87 |
| Females | | | | | | | | | |
| 1 | 4.63 | 5.17 | 4.97 | 5.77 | 6.40 | 7.23 | 6.77 | 6.23 | 5.53 |
| 2 | 1.97 | 2.70 | 3.17 | 3.93 | 4.57 | 5.10 | 4.80 | 4.43 | 3.87 |
| 3 | 1.43 | 1.87 | 2.37 | 3.17 | 3.80 | 4.43 | 4.20 | 3.83 | 3.20 |
| 4 | 3.10 | 3.83 | 4.27 | 4.83 | 5.80 | 7.40 | 7.17 | 6.70 | 6.13 |
| 5 | 1.07 | 1.33 | 2.27 | 3.13 | 3.83 | 4.40 | 4.13 | 3.83 | 3.50 |
| Mean | 2.44 | 2.98 | 3.41 | 4.17 | 4.88 | 5.71 | 5.41 | 5.01 | 4.45 |
| SD | 1.45 | 1.54 | 1.18 | 1.13 | 1.17 | 1.49 | 1.45 | 1.37 | 1.31 |
| C of V | 59.28 | 51.82 | 34.77 | 27.17 | 24.07 | 26.10 | 26.76 | 27.27 | 29.35 |

VDO: Vertical dimension of occlusion, SD: Standard deviation

Table 2 presents differences of means with respect to VDO for altered VDO separately for males and females. Paired *t*-test was conducted to find the significance of these differences with respect to VDO. These values of "*t*" were also shown in table. The "*t*" value was 1.6389 for males at 1.5 mm increased VD, which was not significant.

Graph 1 depicts maximum biting force at various altered VDs. There was decreased trend on either side of VD = VDO. Trend was similar for males and females as well as combined. The highest values were in males and for the lowest in females.




**Graph 1:** Mean bite force versus vertical dimension change.

## Discussion

The change in VDO, either increase or decrease has many disastrous effects on stomatognathic system. The increased VD can lead to constant strain of muscles of closure leading to masticatory inefficiency, excessive resorption of the residual ridge, unacceptable appearance. When the VD was reduced, the muscles of closure would not be extended to their full capacity, resulting in loss of muscle tone and efficiency. Folds and wrinkles developed would disturb facial appearance. Thus, determination of correct vertical relation at which occlusion should be established is an important step in the construction of complete denture for optimum function, esthetics, and health of the tissues. A search for more definitive and reproducible method to determine correct VDO has lead several investigators to introduce various methods to determine the VDO, but until today there is no single method that guides the dentist to precise point of inter arch distance. This study was undertaken to determine the relationship between the VDO and the biting force and to verify if this relationship could be used to establish the optimal VDO for edentulous patients.

In this study indigenously designed electronic gnathodynamometer was used to measure the biting force generated during change in VDO. Earlier boos introduced biometer for measuring biting force.[5] Pressure transducers[6] were used to measure pressures against tissues supporting functioning complete denture. Prombonas *et al.*[7] registered biting force with a gnathodynamometer that used two strain gauges cemented on its surfaces and a wheat stone bridge connected to a chart recorder. Various other devices were invented ranging from the hydraulic system, strain gauges, and pressure transducers to electronic devices. These devices served the research purpose but for routine use presented problems. The electronic gnathodynamometer used in this study had advantage of intra-oral positioning yet the electronic gauges were extra-oral. The records made during the study were free from saliva and oral temperature, thus more accurate. Specific "U" shape of biting element allowed to record the

**Table 2: Differences of mean bite force recorded at various altered vertical dimensions for males and females.**

| Serial number | Increasing vertical dimension | | | | | Decreasing vertical dimension | | |
|---|---|---|---|---|---|---|---|---|
| | 7.5 | 6 | 4.5 | 3 | 1.5 | 1.5 | 3 | 4.5 |
| Males | | | | | | | | |
| 1 | 3.97 | 3.53 | 2.97 | 1.97 | 1.07 | 0.53 | 1.03 | 2.53 |
| 2 | 3.50 | 2.97 | 2.30 | 2.07 | 1.23 | 0.37 | 1.17 | 1.60 |
| 3 | 3.53 | 3.03 | 2.53 | 1.67 | 1.50 | 0.67 | 0.97 | 1.67 |
| 4 | 2.40 | 1.90 | 1.30 | 0.60 | −0.37 | 0.40 | 1.17 | 1.57 |
| 5 | 2.17 | 1.43 | 1.13 | 0.47 | −0.23 | 0.23 | 0.63 | 1.07 |
| Mean | 3.11 | 2.57 | 2.05 | 1.35 | 0.64 | 0.44 | 0.99 | 1.69 |
| Var | 0.4918 | 0.6082 | 0.5078 | 0.4674 | 0.6100 | 0.0220 | 0.0384 | 0.2247 |
| "*t*" value | 8.8787** | 6.5995** | 5.7441** | 3.9591* | 1.6389$^{NS}$ | 5.9390** | 10.1382*** | 7.1162** |
| Females | | | | | | | | |
| 1 | 2.60 | 2.07 | 2.27 | 1.47 | 0.83 | 0.47 | 1.00 | 1.70 |
| 2 | 3.13 | 2.40 | 1.93 | 1.17 | 0.53 | 0.30 | 0.67 | 1.23 |
| 3 | 3.00 | 2.57 | 2.07 | 1.27 | 0.63 | 0.23 | 0.60 | 1.23 |
| 4 | 4.30 | 3.57 | 3.13 | 2.57 | 1.60 | 0.23 | 0.70 | 1.27 |
| 5 | 3.33 | 3.07 | 2.13 | 1.27 | 0.57 | 0.27 | 0.57 | 0.90 |
| Mean | 3.27 | 2.73 | 2.31 | 1.55 | 0.83 | 0.30 | 0.71 | 1.27 |
| Var | 0.3211 | 0.2778 | 0.1824 | 0.2696 | 0.1578 | 0.0076 | 0.0237 | 0.0649 |
| "*t*" value | 11.5537*** | 10.3723*** | 10.8020*** | 5.9575** | 4.1959* | 6.9027** | 9.1741*** | 9.9451*** |

*Significant ($P<0.05$), ***Highly significant ($P<0.001$), **Very significant ($P<0.01$). NS: Non-significant. VDO: Vertical dimension of occlusion, SD: Standard deviation

resultant bilateral bite force in second premolar and first molar region. Contralateral stabilization of occlusion in complete denture wearers, during the recording had a considerable effect. To assure maximum stability of the record bases and to increase the accuracy of the registration, finished heat-cured acrylic resin denture bases were used as the record bases. The "U" shape of the biting element of the gnathodynamometer did not interfere with the function of the tongue during measurements. The instrument was suitable to measure bite force in large study groups. The outfit proved stable and easy to handle.

One of the most important factors limiting the values of recording bite force was probably apprehension or pain in association with the test, the design of the apparatus, and the earlier experience of the patient. In order to overcome these limitations, each patient was explained the procedure, and implications of the study.

The results of this investigation of correlation between VD change and biting force in the ten edentulous subjects were significant (Table 1, Graph 1). The biting force was decreased irrespective of increase or decrease in the VD. The results obtained were similar to those of boos, who found that the strongest bite force was reached when jaw opening was near occlusion. Later Smith,[8] Tueller[9] also supported the findings of boos. On the contrary Boucher and associates[10] were in disagreement with the findings of boos since they believed that the pain and apprehension might alter the biting force.

In this study, it was observed that male subjects exerted more biting force as compared to females. These findings though not subjected to statistical analysis were similar to the findings of Lassila Veijo.[11] The mean maximum biting force for males and females at correct VDO was 15.29 kg and 5.71 kg, respectively. Males showed no statistically significant difference at 1.5 mm increased VD than the recorded VD. This might be due to small numbers of subjects under study. The "*t*" value was 1.6389 (Table 2).

## Conclusion

From this study, it can be concluded that the maximum bite force can act as reliable guide to compliment the VD of occlusal established by esthetics and phonation to make it a most acceptable precise record. Indigenously fabricated gnathodynamometer could also be used as research tool, for forces applied to teeth, restoration, efficiency of different treatment modalities, different ridge relations, facial heights, bite force in parafunctional habits and to study trauma from occlusion. This versatile device could safely be applied for diversified research field. As a means of education, it might be used to demonstrate the functional efficiency of the natural teeth and comparative inefficiency of an artificial substitute.

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