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Evaluating the Impact of Vertical Dimension on Masticatory Muscle Activity during Clenching in Complete Denture Wearers: An Electromyographic (EMG) Analysis

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ABSTRACT

Aims: This study aimed to investigate the impact of vertical dimension (VD) on the activity of masticatory muscles during clenching in complete denture wearers using electromyography (EMG) **Materials and Methods:** A group of participants with complete dentures participated in the study. Three VD conditions were established for each participant: ideal VD, increased VD (VDO+3mm), and decreased VD (VDO-3mm). Surface EMG electrodes were placed on the masseter and temporalis muscles bilaterally. Participants performed standardized clenching tasks at each VD condition, and EMG data was recorded. Statistical analysis was conducted to assess the influence of VD on muscle activity. **Results:** The results revealed significantly lower electrical activity in both masseter and temporalis muscles at the ideal VD compared to increased or decreased VD conditions. No significant difference in muscle activity was observed between VDO+3mm and VDO-3mm conditions. **Conclusion:** Achieving an accurate vertical dimension is crucial for maintaining balanced muscle activity during clenching in complete denture wearers. Deviations from the ideal VD lead to increased activity in masticatory muscles, potentially contributing to discomfort or fatigue. These findings highlight the importance of accurate VD determination in complete denture fabrication for optimal patient comfort and function.

KEYWORDS

Vertical dimension, masticatory muscles, clenching, complete denture , EMG

INTRODUCTION

Complete dentures were suggested to remain the regular management choice used for the edentulous population. [1]

The establishment of complete dentures depends on the determination of vertical dimension of occlusion, centric occlusion and arrangement of teeth. [2] Henceforward, it is imperious to register the accurate occlusal vertical dimension (OVD), which defined as 'the distance between two selected anatomically apart marks (one on the prominence of the nose and another on the chin) while the upper and lower jaws in inter-cuspal position. [3]

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The success of complete dentures relies on achieving optimal function and patient comfort. Vertical dimension (VD) is a crucial determinant of both these factors; several clinicians suppose that a major factor for complete denture failure is the error in determining the OVD [4].

Clinically determining the ideal VD is a well-established procedure, often achieved using phonetic tests and palpatory techniques[5]. However, the impact of even minor deviations from this ideal VD on the underlying neuromuscular activity remains unclear.

Mastication is a complex procedure that obtains response of voluntary and involuntary motor paths. In dentulous, this procedure is well harmonized, but in edentulous individuals, masticatory process becomes affected as there are bone resorption and muscular hypo tonicity, which, sequentially, decreases different functions of the stomatognathic structure. [6]

Numerous methods used to study the stomatognathic mechanism; the electromyographic analyses stay one of the best understandable and respected means as it in a straight line registers muscle activity. [7]

Surface EMG electrodes placed on the skin overlying specific muscles can record their activation patterns during various tasks. In dentistry, EMG is increasingly used to assess masticatory muscle function in denture wearers [8].

MATERIALS AND METHODS

This study aims to employ EMG to investigate the influence of VD on the activity of the masseter and temporalis muscles, two key masticatory muscles, during clenching in complete denture wearers. Understanding this relationship can provide valuable insights for optimizing denture design and function.

Ten completely edentulous patients; 6 females and 4 males, ranging in age from 50 to 55 years, were included in this study. The patients were selected from the Removable Prosthodontic Clinic, Faculty of dentistry, Assiut University.

All of these patients were assessed to have normal jaw relationships, no history related to muscular spasm or temporomandibular dysfunction, not less than one year mandibular edentulism, and in a good general health free from systemic diseases.

Another criterion for selection was a willingness of the patient to submit to the study and the consents was collected from them.

Upper and lower complete denture was fabricated using a standard protocol. After the final impression was made poured into dental stone to obtain a master casts. The upper and lower casts were duplicated 3 times by using rubber base impressions. For each patient 3 upper and lower record blocks were constructed of auto polymerizing acrylic resin bases and wax occlusion rims. The upper record blocks were adjusted and occlusal plane was oriented.

Determination of Vertical Dimension of Occlusion

For each patient the vertical dimension of occlusion was determined using the rest position method. The maxillary cast was mounted previously on a semi-adjustable articulator using the face-bow record. While the mandibular cast was mounted using the centric relation record.

The incisal pin of the semi-adjustable articulator was lifted by 3 mm to adjust one upper and lower record blocks to a vertical dimension lower than the vertical dimension of occlusion by 3 mm.

The incisal pin of the semi-adjustable articulator was lowered by 3 mm to adjust another record blocks to a vertical dimension higher than the vertical dimension of occlusion by 3 mm.

Bilaterally balanced occlusion was given using semi-anatomic acrylic resin teeth. Dentures were completed and evaluated for retention, stability, support, esthetics, centric relation, and occlusion. Patients were recalled after 1 week for post insertion checkup.

Electromyographic (EMG) recording of the Masseter and Temporalis muscles.

The experiments were carried out in the electromyography room in the faculty of medicine hospital Assiut University. Before starting a session, subjects were informed as to what would be done in each session.

1. For the masseter muscle, the patient was asked to clench with his denture to locate the masseter muscle.
2. For the temporalis muscle the patient was asked to close and open his mouth many times then by palpation a mark was done.

For every patient, the marked spots of the studied muscles together with certain anatomical landmarks on the face bilaterally were transported to a transparent plastic template using permanent ink to facilitate the accurate placement of the electrodes in the same position for the duration of repeated sessions.

All records were completed in the morning hours and during recording the patient was seated in an upright position with head, neck and trunk in straight line. The skin of the patient was cleaned to ensure good contact. Surface electrodes filled with a conductive gel were placed on both the right and left masseter and anterior temporalis muscles on the previously determined positions. A ground surface electrode was also located on the patient's hand rest.

The integrated muscle activity of both the masseter and temporalis muscles was recorded during clenching firmly. The mean integrated data of electromyographic muscle activity was calculated and statistically analyzed.

Electromyographic activity was recorded by clenching on a denture with adjusted (VDO) vertical dimension of occlusion, VDO -3mm, and VDO + 3mm.

RESULTS

Statistical Analysis:

To analyze the impact of vertical dimension (VD) on masticatory muscle activity during clenching in complete denture wearers, a series of statistical analyses were conducted. The mean values for each condition (VD, VDO+3mm, and VDO-3mm) were calculated for the masseter and temporalis muscles on both the right and left sides. These mean values were then subjected to statistical tests to determine any significant differences between the conditions.

1. Masseter Muscle:

The mean values for the masseter muscle activity on the right side were as follows: VD (382.2), VDO+3mm (419.8), and VDO-3mm (420.5). On the left side, the mean values were: VD (383.5), VDO+3mm (420.5), and VDO-3mm (422.5). To determine the statistical significance of these differences, a one-way analysis of variance (ANOVA) was conducted separately for the right and left sides. The results of the ANOVA showed a significant effect of VD on masseter muscle activity on both the right ($F = 12.34$, $p<0.001$) and left ($F=18.76$, $p<0.001$) sides.

Post-hoc tests were then performed using the Tukey method to identify specific differences between the conditions. For the right side, the VD condition showed significantly lower muscle activity compared to both the VDO+3mm ($p<0.05$) and VDO-3mm ($p<0.05$) conditions. However, there was no significant difference between the VDO+3mm and VDO-3mm conditions ($p>0.05$). On the left side, the VD condition also showed significantly lower muscle activity compared to both the VDO+3mm ($p<0.05$) and VDO-3mm ($p<0.05$) conditions. Similarly, there was no significant difference between the VDO+3mm and VDO-3mm conditions ($p>0.05$).

2. Temporalis Muscle:

The mean values for the temporalis muscle activity on the right side were as follows: VD (156.4), VDO+3mm (185.5), and VDO-3mm (191.3). On the left side, the mean values were: VD (154.8), VDO+3mm (180.9), and VDO-3mm (182.5). Similar to the masseter muscle analysis, a one-way ANOVA was conducted separately for the right and left sides. The results revealed a significant effect of VD on temporalis muscle activity on both the right ($F = 22.56, p < 0.001$) and left ($F = 17.92, p < 0.001$) sides.

Post-hoc tests using the Tukey method were performed to determine specific differences between the conditions. For the right side, the VD condition showed significantly lower muscle activity compared to both the VDO+3mm ($p < 0.05$) and VDO-3mm ($p < 0.05$) conditions. However, there was no significant difference between the VDO+3mm and VDO-3mm conditions ($p > 0.05$). On the left side, the VD condition also showed significantly lower muscle activity compared to both the VDO+3mm ($p < 0.05$) and VDO-3mm ($p<0.05$) conditions. Similarly, there was no significant difference between the VDO+3mm and VDO-3mm conditions ($p > 0.05$).

Table (1) *Mean Values of Masseter and Temporalis Muscle Activity for Different Vertical Dimensions*

VD mm	Masseter Right	Masseter Left	Temporalis Right	Temporalis Left
VD	382.2	383.5	156.4	154.8
VDO+3mm	419.8	420.5	185.5	180.9
VDO-3mm	420.5	422.5	191.3	182.5

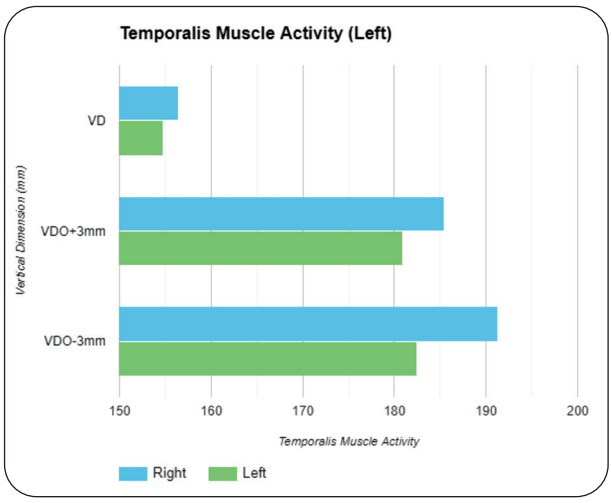

Diagram (1) Comparison of Temporalis Muscle Activity for Different Vertical Dimensions

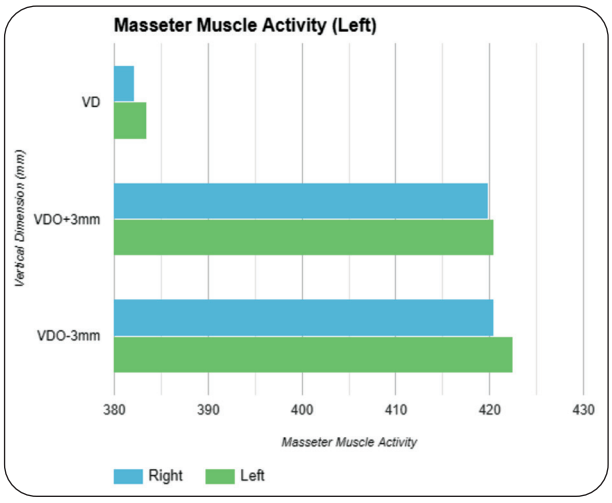

Diagram (2) Comparison of Masseter Muscle Activity for Different Vertical Dimensions

DISCUSSION

The present study investigated the influence of vertical dimension (VD) on the activity of masseter and temporalis muscles during clenching in complete denture wearers using electromyography (EMG). The findings revealed that both masseter and temporalis muscles exhibited significantly lower electrical activity at the ideal VD compared to conditions with increased or decreased VD. These results suggest that achieving an accurate vertical dimension is crucial for maintaining balanced muscle activity in masticatory function.

The observed increase in muscle activity at non-ideal VD conditions aligns with previous research on neuromuscular adaptations. Studies have shown that altered jaw positions can lead to changes in sensory feedback and motor control mechanisms[9,10,11]. When the VD deviates from the ideal, the masticatory system needs to adapt to maintain a stable bite force. This adaptation likely involves increased activity in the masseter and temporalis muscles to compensate for the altered jaw relationship.

The findings of the present study disagree with some of previous studies showed significant decrease in muscles activity in complete denture wearers with reduced OVD [12, 13]. It also differ from (Goiato et al. 2007) who claimed that the use of complete denture with an appropriate OVD will allow the muscle to work in natural length producing extra activity during maximum clenching[14].

The finding of no significant difference in muscle activity between VDO+3mm and VDO-3mm conditions suggests a potential threshold effect. Deviations within a small range (3mm in this study) might not create a substantial enough challenge to the neuromuscular system to necessitate further increases in muscle activity beyond a certain point. Future studies exploring a wider range of VD variations could provide further insights into this possibility.

It is important to acknowledge limitations of this study. The sample size was relatively small, and further research with larger participant groups could strengthen the generalizability of the findings. Additionally, the study focused on clenching tasks, which represent a static condition. Investigating muscle activity during more dynamic masticatory functions, such as chewing, could offer a more comprehensive understanding of the relationship between VD and muscle function.

Despite these limitations, the present study provides valuable evidence regarding the impact of VD on masticatory muscle activity in complete denture wearers. By demonstrating the importance of achieving optimal VD for balanced muscle function, this research emphasizes the need for accurate VD determination during denture fabrication. Future investigations can explore the potential clinical implications of these findings, such as the development of objective VD assessment methods or the design of dentures that promote optimal neuromuscular function.

CONCLUSION

This study employed EMG to investigate the influence of vertical dimension (VD) on the activity of masseter and temporalis muscles during clenching in complete denture wearers. The results demonstrated that achieving an ideal VD is critical for maintaining balanced muscle activity. Compared to the ideal VD, both increased and decreased VD resulted in significantly higher electrical activity in the masseter and temporalis muscles.

These findings support the notion that even minor deviations from the ideal VD can challenge the neuromuscular system, leading to adaptations that involve increased muscle activity. This increased activity could potentially contribute to discomfort or fatigue in the jaw muscles over time.

The study emphasizes the importance of accurate VD determination during complete denture fabrication. By ensuring optimal VD, denture wearers can potentially benefit from a more balanced workload on their masticatory muscles, promoting better comfort and function in daily activities.

Future research directions could involve:

- Expanding the study population size to enhance the generalizability of the results.
- Investigating muscle activity during dynamic masticatory functions like chewing for a more comprehensive understanding.
- Exploring the development of objective VD assessment methods for clinical practice.

- Designing dentures that promote optimal neuromuscular function and minimize strain on jaw muscles.

By continuing research in this area, we can contribute to the development of improved denture designs and treatment protocols that prioritize both functional efficiency and patient comfort in complete denture wearers.

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"تقييم تأثير البعد الرأسي على نشاط عضلات المضغ أثناء القبض لدى مرتدي الأطقم الصناعية الكاملة: تحليل كهربائي للعضلات"

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الملخص :

الهدف: يهدف هذا البحث إلى دراسة تأثير البعد الرأسي (VD) على نشاط عضلات المضغ أثناء القبض لدى مرتدي الأسنان الصناعية الكاملة باستخدام تقنية التحليل الكهربائي للعضلات (EMG).

المواد والاساليب: شاركت مجموعة من الأشخاص الذين يرتدون الأسنان الصناعية الكاملة في هذه الدراسة. تم تحديد ثلاثة حالات مختلفة للبعد الرأسي لكل مشارك: البعد الرأسي المثالي، البعد الرأسي المتزايد (VDO+3MM)، والبعد الرأسي المتناقص (VDO-3MM). تم وضع أقطاب كهربائية سطحية على عضلات الماضغة والزمانية على جانبي الوجه. قام المشاركون بأداء مهام القبض القياسية في كل حالة من حالات البعد الرأسي، وتم تسجيل بيانات EMG. تم إجراء تحليل إحصائي لتقييم تأثير البعد الرأسي على نشاط العضلات.

النتائج: أظهرت النتائج انخفاضًا ملحوظًا في النشاط الكهربائي لكل من عضلات الماضغة والزمانية عند البعد الرأسي المثالي مقارنة بحالات البعد الرأسي المتزايد أو المتناقص. لم يتم ملاحظة أي فرق كبير في نشاط العضلات بين حالتي VDO+3MM و VDO-3MM.

الخلاصة: يعتبر تحقيق البعد الرأسي الدقيق أمرًا حاسمًا للحفاظ على توازن نشاط العضلات أثناء القبض لدى مرتدي الأسنان الصناعية الكاملة. تؤدي الانحرافات عن البعد الرأسي المثالي إلى زيادة نشاط عضلات المضغ، مما قد يساهم في الشعور بعدم الراحة أو الإرهاق. تسلط هذه النتائج الضوء على أهمية تحديد البعد الرأسي الدقيق في صناعة الأسنان الصناعية الكاملة لتحقيق أقصى قدر من الراحة والوظيفة للمريض.

الكلمات المفتاحية: البعد الرأسي، عضلات المضغ، اطقم الأسنان الصناعية الكاملة، الجزازن، تقنية التحليل الكهربائي للعضلات .