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Dentistry

EVALUATION OF MASTICATORY PERFORMANCE OF COMPLETE DENTURES FABRICATED BY DIFFERENT VERTICAL JAW RELATION METHODS: AN IN-VIVO STUDY

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ABSTRACT **Statement of Problem:** The recording of vertical jaw relation in the treatment of edentulous patients aim at facilitating the adaptation of complete dentures to the masticatory system to give them an optimal and comfortable function. There are various techniques described in the literature to record vertical jaw relation, but there is a need to intercompare these methods based on masticatory performance. **Aim:** To evaluate the masticatory performance of complete dentures fabricated by different vertical jaw relation methods. **Methodology:** 8 completely edentulous subjects, each of three groups which includes methods to record vertical jaw relations (Group A- Niswonger's method, Group B-Swallowing method and Group C-Silverman's method) on patients between age group of 45-60 years were selected for the study. After 30 days of denture use by the patient, Bite force and Masticatory force were recorded by electromyography. The readings thus obtained were compiled and subjected to statistical analysis. **Result:** The present study concludes that dentures fabricated in Group A (Niswonger's method) had better results for bite force in comparison to Group B (Swallowing method) and Group C (Silverman's method). But at the same time, dentures fabricated in Group B (Swallowing method) showed best masticatory force than rest of the two. Niswonger's and Swallowing methods gave comparable results. **Conclusion:** It is concluded that Niswonger's method is better than other two methods shows in terms of Bite force and Swallowing method results in greater masticatory force as compared to other two methods. Within the limitations of this study, it can be suggested that a single method is not a reliable tool for vertical dimension determination but a combination of methods to record vertical jaw relation should be performed to achieve good masticatory performance. Clinical analysis and dentist's understanding for different cases of edentulousness together, are crucial for excellent prognosis and longevity of denture.

KEYWORDS : Edentulous patients, Niswonger method, Swallowing method, Silverman's method, Electromyography.

INTRODUCTION

The accuracy of recording vertical dimension at occlusion in edentulous patients has always been a prime consideration for any dentist. Despite of numerous advances in recording methods and techniques, there is no definite clinical method of assessing vertical dimension of occlusion in edentulous patients, till date.

Different techniques for recording vertical jaw relation include pre-extraction methods and post-extraction methods. Pre-extraction methods include intraoral measurements, profile tracing, cephalometric approach, pre-extraction phonetics, pre-extraction photographs and Oro-facial device. Post-extraction methods include physiologic rest position, interocclusal distance, facial aesthetic appearance, deglutition/swallowing method, craniofacial landmarks measurements, and cephalometric radiographs. Post-extraction phonetics, measurement of the former denture, fingers length, tactile sense, biting force, open-rest method, magnetic plates.[1] Niswonger, Silverman closest speaking space and swallowing methods are most accepted and commonly used methods of recording vertical jaw relation in clinics.

The values for maximum bite force in patient wearing dentures were only one-fifth to one-sixth the value reached by dentate subjects. There have been several objective measures of masticatory functions, such as masticatory performance, swallowing threshold and occlusal force. The measurement of bite force can provide useful data for the evaluation of jaw muscle function and activity. Masticatory muscle activity balance during maximum voluntary clenching and the cumulative amount of near contact area significantly influences masticatory performance, which suggests that, in addition to the amount of occlusal contact area, the balance of masticatory muscle activity plays a role in masticatory performance. It is also an adjunctive value in assessing the performance of dentures and so EMG values are the predictor for masticatory performance.[2] Various methods have been used for testing masticatory efficiency namely ultrasonography, photo colorimetry, direct method-chewing method known as sieve method (R.S Manly and Braley) and electromyography (EMG) (Moyers R E) .

This study provides a most appropriate method to record patient's vertical dimension to furnish good masticatory performance in the dentures by measuring the Bite Force and Masticatory force, thus improving the quality of life of the patient. Methods of recording vertical dimension that are well supported and encouraged in literature which are Niswonger's, Swallowing threshold and Silverman closest speaking space were used & masticatory performance compared.

METHODOLOGY

This clinical study was done to determine the most reliable method of recording vertical jaw relation by measuring bite force and masticatory force in complete dentures to analyze the masticatory performance.

In this study, a total number of 8 patients fulfilling the following pre-defined inclusion and exclusion criteria were included.

Inclusion Criteria

All the patients irrespective of sex, age ranging from 45- 80 years who were completely edentulous from past 3 months, without any presence of existing oral mucosal diseases with no history of radiotherapy and other systemic diseases were included in the study.

Exclusion Criteria

Patients with Severe stomatognathic discrepancy, Extra oral or intraoral pathology, Temporomandibular joint disorder, Major facial asymmetry and Poor oral hygiene were not included from the study.

Primary impressions were made using medium fusing impression compound and impressions were poured using dental plaster. Custom trays were fabricated on the primary cast. Border moulding was done using low fusing compound and final impressions were made with Zinc oxide eugenol impression paste. Master impressions were poured in dental stone. Temporary denture bases and occlusal rims were fabricated.

The anterior level of maxillary occlusal rim was adjusted according to patients' aesthetics and phonetics. Anterior plane was established parallel to the interpupillary line and posterior plane was made parallel to the camper's plane. Putty index was made to fabricate denture base and occlusal rim for other two group with similar dimesion. Plane of mandibular rim was adjusted accordingly.

Grouping Of Dentures

Group A- Dentures fabricated with Niswonger's method of recoding vertical jaw relation.
Group B- Dentures fabricated with Swallowing threshold method of recoding vertical jaw relation.
Group C- Dentures fabricated with Silverman's closest speaking space method of recoding vertical jaw relation.

Fabrication of Dentures by Niswonger's Method of Recording Vertical Jaw Relation (GROUP – A)

To record vertical dimension by this Method, a standard method was used which was given by Niswonger ME.Maxillary occlusal rim was placed in the mouth and Triangular pieces of adhesive tape were placed on the patient's nose and chin. The lower rim was placed in the mouth and adjusted to achieve uniform contact with the upper occlusal rim. The patient was asked to pronounce the letter 'M' twice or thrice and then asked to relax. Distance between the points on nose and chin was measured using vernier caliper. This was the Vertical Dimension at Rest (VDR). The lower rim was adjusted in such a way that there was 2 mm clearance between upper and lower rims during recording of VDR. The patient was asked to close lightly on the occlusal rims and distance between the points on nose and chin was measured. This was the Vertical Dimension at Occlusion (VDO). If three successive trials gave difference of 2mm between VDR and VDO, the vertical jaw relation thus achieved was accepted. Facebow transfer was done and maxillary cast was mounted on semi-adjustable articulator (Hanau 96H2). Tentative centric jaw relation was recorded and the mandibular cast was mounted. A complete conventional tooth arrangement was done and centric occlusion was verified in the patient mouth. Programming of articulator was done to obtained condylar guidance by using protrusive interocclusial record with aluwax and balancing was done in conventional manner.The trial dentures once checked for balanced occlusion, were fabricated by conventional curing method and were delivered to the patients. Patients were recalled after 24-48 hours for post denture insertion assessment of soft tissues and their comfort. Adjustments were made as required.After a period of 1 month of denture use, the patient was recalled for measurement of Bite force and Masticatory force.

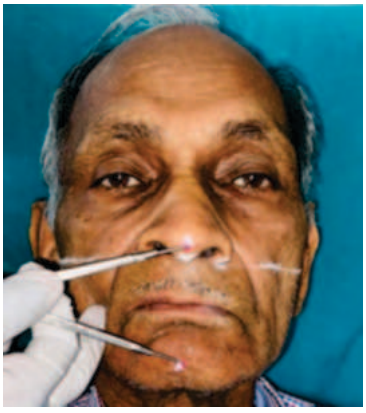

Fig.1: Measurement of VDO by Niswonger's Method

Fabrication Of Dentures By Swallowing Method Of Recording Vertical Jaw Relation (Group – B)

One month after measurement of Bite force and Masticatory force of Group A Dentures, second denture (Group B denture) was fabricated using Swallowing method of recording Vertical Jaw Relation. The occlusal vertical dimension was tentatively determined, and then the mandibular occlusal rim was reduced in height about 3 to 5 mm. 3 cones of Alu wax were built on the mandibular wax rim. The patient was instructed to swallow his saliva several times and repeated action of swallowing gradually reduced the height of wax cones to allow the mandible to reach the level of natural centric occlusal position and vertical dimension of occlusion was achieved. Facebow transfer was done and maxillary cast was mounted on semi-adjustable articulator (Hanau 96H2). Tentative centric jaw relation was recorded and the mandibular cast was mounted. A complete conventional tooth arrangement was done and centric occlusion was verified in the patient mouth. Programming of articulator was done to obtained condylar guidance by using protrusive interocclusial record with aluwax and balancing was done in conventional manner.The trial dentures once checked for balanced occlusion, were fabricated by conventional curing method and were delivered to the patients. Patients were recalled after 24-48 hours for post denture insertion assessment of soft tissues and their comfort. Adjustments were made as required.After a period of 1 month of denture use, the patient was recalled for measurement of Bite force and Masticatory force.

Fig.2: Measurement of VDO by Swallowing Method

Fabrication of Dentures by Silverman's Closest Speaking Space Method of Recording Vertical Jaw Relation (Group – C)

One month after measurement of Bite force and Masticatory force of Group- B Dentures, third denture (Group –C denture) was fabricated using Silverman's Closest Speaking Space method of recording Vertical Jaw Relation. To record vertical dimension by closest speaking space ,a standard method was used which was given by Meyer M. Silverman.The patient was seated in an upright position without the use of the headrest, with the eyes forward, relaxed and calm manner. The subjects were asked to pronounce words with sibilants like 'six', 'sixty-six' and the amount of space between the maxillary rims and mandibular rims were observed. Height of the lower occlusal rim was adjusted until a minimum of 2mm space was achieved. Thus, vertical jaw relation was recorded when the mandible & muscles involved were in physiologic function of speech.Facebow transfer was done and maxillary cast was mounted on semi-adjustable articulator (Hanau 96H2). Tentative centric jaw relation was recorded and the mandibular cast was mounted.

A complete conventional tooth arrangement was done and centric occlusion was verified in the patient mouth. Programming of articulator was done to obtained condylar guidance by using protrusive interocclusial record with aluwax and balancing was done in conventional manner.The trial dentures once checked for balanced occlusion, were fabricated by conventional curing method and were delivered to the patients. Patients were recalled after 24-48 hours for post denture insertion assessment of soft tissues and their comfort. Adjustments were made as required.After a period of 1 month of denture use, the patient was recalled for measurement of Bite force and Masticatory force.

Fig.3: Measurement Of VDO By Silverman's Closest Speaking Space Method.

Measurement Of Bite Force And Masticatory Force Of Dentures

Bite Force

The disc surface electrode of the EMG having 10mm diameter of AgCl material was used. The first procedure was performed while clenching of two muscles. First, the masseter muscle was palpated over the centre of the fleshiest part of the superficial portion of the muscle. The patient was asked to clench to locate the centre of the superficial masseter. Likewise, the anterior temporalis muscle was located by palpation when the patient was asked to clench where the temporal line crossed the zygomatic process of the frontal bone at the level of the supraorbital margin. This was done separately for the EMG measurements. There were three electrodes –reference electrode (red colour), measuring electrode (black colour),ground electrode (green) respectively. The reference electrode (red colour) and the measuring electrode (Black colour) were attached to the muscle using a white tape. Prior to the electrode attachment, the skin was carefully degreased with alcohol and the electrode gel(Ele fix conductive paste)was applied. Recordings were taken 5 to 6 minutes later so as to allow the conductive paste to adequately moisten the skin surface. Then the ground electrode (green colour) was placed around the left forearm. With the help of the software, activity of the masseter and temporalis muscle were observed in the maximum voluntary contraction(MVC)with patient having denture in the mouth in clenched position. The sEMG recording was recorded for masseter and temporalis muscles respectively first on the right side and then on the left side separately.

Masticatory Force

Again, the superficial masseter and anterior temporalis muscles were palpated and the electrodes were attached. For recording the masticatory force, the patient was given 10 grams of peanuts to chew for 1min with 20 chewing strokes. Then the EMG was recorded and the results were obtained in the software. (fig -5)The peak-to-peak amplitude of the muscle activity was recorded. There were eight values that were measured accurately from peak to peakamplitude and mean values obtained from those average value were taken as final recordings.After this, patient was instructed not to wear denture till the delivery of new denture.Same procedure was done for other two groups to measure bite force and masticatory force.

Fig.4: Measurement Of Electrical Activity Of Masticatory Muscles Using Surface Electrode Myography.

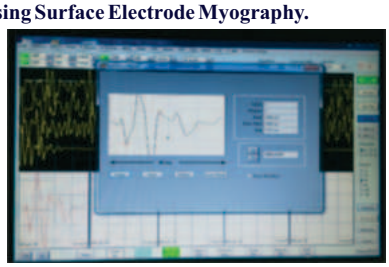

Fig.5: sEMG Readings

RESULTS

s-EMG (mV) For Bite Force & Masticatory Force Of Masseter Muscle

Comparison Of s-EMG Values Of Bite Force (mV) Of Masseter Muscle For Subjects In All Groups.

Table:1 shows comparison of mean s-EMG values of Bite force (mV) of Masseter muscle of all three groups(Group A,B and C) using One-way ANOVA test. There was a significant difference in mean Bite Force of Masseter muscle between Group A, Group B and Group C ($p < 0.05$). Bite Force of Masseter was higher for Group A Subjects(Niswongers Method) compared to other groups.

Table:2 shows inter-group comparison of mean s-EMG values of Bite Force of Masseter muscle using the Post-hoc Bonferronitest . It was observed that there was Non Significant difference Between Group A & Group B (Bite force of Masseter Muscle was almost similar for Groups A & B) but there was Significant difference between Group A & Group C and between Group B & Group C. ($p < 0.05$).

Comparison Of s-EMG Values Of Masticatory Force (mV) Of Masseter Muscle For Subjects In All Groups.

Table:3 shows comparison of mean s-EMG values of Masticatory force (mV) of Masseter Muscles of all three groups(Group A,B and C) using the One-way ANOVA test. There was a significant difference in mean Masticatory force of Masseter Muscle between Group A, Group B and Group C ($p < 0.05$). Masticatory Force of Masseter was higher for Group B Subjects (Swallowing Method) compared to other groups.

Table:4 shows inter-group comparison of mean s-EMG values of Masticatory Force of Masseter Muscle using the Post-hoc Bonferroni test .It was observed that there was Non Significant difference Between group A & group B (Masticatory force of Masseter was almost similar for Groups A & B) but there was Significant difference between Group A & Group C and between Group B & Group C ($p < 0.05$).

s-EMG (mV) For Bite Force & Masticatory Force Of Temporalis Muscle

Comparison of s-EMG Values Of Bite Force (mV)of Temporalis Muscle For Subjects In All Groups.

Table:5 shows comparison of mean s-EMG values of Bite force (mV) of Temporalis muscle of all three groups(Group A,B and C) using the One-way ANOVA test. There was a significant difference in mean Bite Force of Temporalis muscle between Group A, Group B and Group C ($p < 0.05$) Bite Force of Temporalis was higher for Group A Subjects(Niswongers Method) compared to other groups.

Table 6 shows inter-group comparison of mean s-EMG values of Bite Force of Temporalis muscle using the Post-hoc Bonferronitest . It was observed that there was Significant difference Between group A & group B and group A & group C but there was Non-Significant difference between group B & group C .

Comparison Of s-EMG Values Of Masticatory Force (mV) Of Temporalis Muscle For Subjects In All Groups.

Table 7 shows comparison of mean s-EMG values of Masticatory force (mV) of Temporalis muscle of all three groups(Group A,B and C) using the One-way ANOVA test. There was a significant difference in mean Masticatory force of Temporalis muscle between Group A, Group B and Group C ($p < 0.05$) Masticatory Force of Temporalis was higher for Group B Subjects (Swallowing Method) compared to other groups.

Table 8 shows inter-group comparison of mean s-EMG values of Masticatory force of Temporalis Muscles using the Post-hoc Bonferroni test and it was observed that there was Significant difference Between group A & group B and group B & group C but Non Significant between group A & group C.

Table-1:One-way ANOVA Test For Bite Force (mV) Of Masseter Muscle Among All Groups By s-EMG .

	Bite force (mV) Masseter muscle			
	Mean	Std. Deviation	F-value	p-value
Group A	3.15	0.06	7.430	0.004*
Group B	3.13	0.05		
Group C	3.06	0.04		

Table-2:Post-hoc Bonferroni Test For Bite Force (mV) Of Masseter Muscle By s-EMG .

		Mean Difference	p-value
Group A	Group B	0.01	1.000
Group A	Group C	0.09	0.005*
Group B	Group C	0.07	0.021*

Table-3 One-way ANOVA Test For Masticatory Force (mV) Of Masseter Muscle Among All Groups By s-EMG .

	Masticatory force (mV) Masseter muscle			
	Mean	Std. Deviation	F-value	p-value
Group A	2.94	0.03	8.719	0.002*
Group B	3.03	0.09		
Group C	2.81	0.15		

Table-4: Post-hoc Bonferroni Test For Masticatory Force(mV) of Masseter Muscle by s-EMG.

		Mean Difference	p-value
Group A	Group B	-0.08	0.379
Group A	Group C	0.13	0.046*
Group B	Group C	0.21	0.001*

Table- 5: One-way ANOVA Test For Bite Force (mV Of Temporalis Muscle Among All Groups By s-EMG.

	Bite force (mV) Temporalis muscle			
	Mean	Std. Deviation	F-value	p-value
Group A	2.99	0.17	9.186	0.001*
Group B	2.83	0.09		
Group C	2.73	0.08		

Table- 6 Post-hoc Bonferroni Test For Bite Force(mV) Of Temporalis Muscle By s-EMG.

		Mean Difference	p-value
Group A	Group B	0.16	0.049*
Group A	Group C	0.26	0.001*
Group B	Group C	0.10	0.346

Table-7: One-way ANOVA Test For Masticatory Force (mV) Of Temporalis Muscle Among All Groups By s-EMG.

	Masticatory force (mV) Temporalis muscle			
	Mean	Std. Deviation	F-value	p-value
Group A	2.77	0.09	10.345	0.001*
Group B	2.91	0.03		
Group C	2.72	0.11		

Table-8 :Post-hoc bonferroni test for Masticatory force(mV) of Temporalis Muscle by s-EMG.

		Mean Difference	p-value
Group A	Group B	-0.14	0.014*
Group A	Group C	0.05	0.702
Group B	Group C	0.19	0.001*

DISCUSSION

Recording of vertical jaw relation should always aim at creating equilibrium of function and aesthetics. Incorrect measurement can lead to problems related to chewing force, speech difficulties, aesthetic issues, and temporomandibular joint complications.[3]

The purpose of this study was to evaluate a vertical jaw relation method that incorporates maximum bite force and masticatory force in a complete denture.Niswonger, Silverman closest speaking space and swallowing methods are most accepted and commonly used methods of recording vertical jaw relation in clinics.A research article by Mathews L et al concluded that, 90% of the doctors preferred Niswonger's technique while recording vertical dimension at occlusion whereas speech technique while recording vertical dimension at rest[4].C.KAnulekhaet al evaluate different methods (Swallowing, Phonetics, &physiological) of estimating vertical dimension of occlusion based on clinical perception of patients and concluded that swallowing threshold was acceptable to both operator and the patient, as statistical significant difference was found with the vertical dimension values obtained by other two methods.[5] Though there are various methods to determine masticatory force and bite force of complete denture like sieve system (R.S. Manly and Braley), ultrasonography, electromyography, photocolorimetry, this study was objectively evaluated by Surface EMG as Surface Electromyography (sEMG) (Moyers RE) is a reliable and non-invasive method for evaluation of activity of temporalis and masseter muscles.[6]

The anterior temporalis and superficial masseter muscles were selected for surface electromyography as these muscles are strongest, superficial and easy to record the force exerted by them.This is in accordance with the study done by Bilt A et al which involved the evaluation of muscle activity of jaw muscles by electromyography. The present study evaluated muscle activity both during clenching (static) and mastication (dynamic) as this combination determines the masticatory performance.[7]

In this study, 8 edentulous patients were selected. Three pair of dentures were delivered to each patient. Each pair was fabricated by different vertical jaw relation recording method in a gap of 30 days and categorized as group A (Niswonger's method), Group B (Silverman's closest speaking method) ,and Group C (swallowing method). After 30 days of denture use by the patient, Bite force and Masticatory force were recorded by surface electromyography.The peak to peak amplitude of the muscle activity was recorded. There were eight values that were measured accurately from peak to peak amplitude and mean values obtained from those average values were taken as final recordings.sEMG value of Bite force and Masticatory force of both left and right temporalis and masseter muscles were presented in a tabular form .This made the statistic analysis of the data more convenient.

After assessing the results of sEMG, it was observed that temporalis and masseter showed greater bite force for Group A and B as compared to C; meanwhile between group A and B, value of group A were comparably higher.

Another observation pointed that temporalis and masseter had greater masticatory force for Group A and B as compared to C; meanwhile between group A and B, value of group B was comparably higher.

When an individual bites, the teeth close at vertical dimension of occlusion which is best recorded by Niswonger's method hence the relation of bite force and vertical dimension can be established. The accuracy of recording vertical dimension clearly indicate that the masticatory musculature is in harmony hence there will be improved bite force in the denture provided to the patient. The best masticatory force comes when the muscles are not strained but at rest i.e. at Vertical dimension at rest. The Swallowing method records vertical dimension at rest most precisely (James E. Pyott. 1954)[8]. Hence, highest masticatory force is seen with Group B. The Silverman's method majorly focus on phonetics and the effect on masticatory musculature is minimum compared to other two methods.The results of this study are supported by various researchers.Study performed by A. Prombonas et al. (1994)[9], support our justification for better bite force and masticatory force with accurate vertical dimension by concluding that the normal range of physiologic activity is always under the optimum degree of muscular force for which vertical dimension has to be recorded precisely.The present study results differ from the studies performed by some researchers. In a study conducted by Ward and osterboltz, it was stated that swallowing can be used only as guide in determining VDO and Swerdlow in his study suggested that phonetic method as a method in determination of interocclusal distance is more reliable than techniques of swallowing.[10]

In the present study it is concluded that Niswonger's method is better than other two methods shows in terms of Bite force and Swallowing method results in greater masticatory force as compared to other two methods.

Despite of presence of large number of methods for determining vertical jaw relation based on different systems, techniques and clinical experience, an abosolutely safe method for vertical dimension of occlusion is still lacking. The study needs to be conducted on larger sample size for more precise results.Within the limitations of this study, it can be suggested that a single method is not a reliable tool for vertical dimension determination but a combination of methods to record vertical jaw relation should be performed to achieve good masticatory performance.

CONCLUSION

After assessing the results of sEMG, it was observedthat denture fabricated with Swallowing method (Group B) had better but comparable Masticatory force than Niswonger's method (Group A), and Silverman's (Group C) had least masticatory force.The results of this study depict that dentures fabricated with Niswongers method (Group A) show maximum bite force followed by Swallowing method (Group B) and then Silverman's (Group C).

Overall, it was concluded that Niswonger's method is better than other two methods shows in terms of Bite force and Swallowing method results in greater masticatory force as compared to other two methods.Within the limitations of this study, it can be suggested that a single method is not a reliable tool for vertical dimension determination but a combination of methods to record vertical jaw relation should be performed to achieve good masticatory performance. Clinical analysis and dentist's understanding for

different cases of edentulousness together, are crucial for excellent prognosis and longevity of denture.

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