

DR. MOHAMMED NASSER ALHAJJ (Orcid ID : 0000-0003-4477-3024)

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Determination of Occlusal Vertical Dimension for Complete Dentures Patients: An Updated Review

Mohammed Nasser Alhadj^{1,2}, Nadia Khalifa^{1,3}, Jaafar Abduo⁴, Abdullah G. Amran⁵, Ibrahim A. Ismail¹

- 1- Department of Oral Rehabilitation, Faculty of Dentistry, Khartoum University, Khartoum, Sudan.
- 2- Department of Prosthodontics, Faculty of Dentistry, Tamar University, Dhamar, Yemen.
- 3- Department of General and Specialist Dental Practice, College of Dental Medicine, University of Sharjah, Sharjah, UAE.
- 4- Restorative Section, Melbourne Dental School, Melbourne University, Melbourne, Australia.
- 5- Department of Periodontics, Faculty of Dentistry, Tamar University, Dhamar, Yemen.

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Corresponding Author:

Mohammed Nasser Alhadj
Department of Oral Rehabilitation
Faculty of Dentistry, Khartoum University
Khartoum, Sudan

Email: m.n.alhadj@hotmail.com

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Abstract

Determination of the occlusal vertical dimension (OVD) is an integral part of complete dentures fabrication. Due to the lack of teeth, the clinician faces the challenge of how to accurately establish the OVD of the new denture. Therefore, the purpose of this review article was to present, discuss and critique the available methods used in determining the OVD for complete dentures patients. This review identified two main streams to determine the OVD: (1) pre-extraction methods and (2) post-extraction methods. For the pre-extraction methods, the OVD of the natural dentition is transferred to the new dentures mainly by intraoral measurements, profile tracing and cephalometric analysis. The post-extraction methods rely on mandibular rest position, facial esthetic appearance, swallowing pattern, craniofacial landmarks measurements, cephalometric analysis, phonetics and existing dentures. In general, all the available techniques have merits and are helpful for routine clinical use. However, they are empirical in nature, controversial and lack the scientific support. Further, there is no single accurate method for OVD determination. To overcome the limitations of the techniques, the clinician will benefit from applying combination of techniques to approximate the OVD.

Keywords: Vertical dimension; occlusion; complete dentures; measurements, Rest position, Review.

Introduction

According to the Glossary of Prosthodontic Terms, the occlusal vertical dimension (OVD) is defined as the distance measured between two points when the occluding members are in contact.¹ For dentate individuals, the OVD is established by the occluding mandibular and maxillary teeth. As a result, among the consequences of edentulism is the loss of OVD which can further impair the masticatory function, phonetics, dental esthetics and facial appearance.^{2,3} Therefore, any rehabilitative treatment needs to restore the physiologic OVD by replacing the missing teeth and associated tissues. Restoring the physiologic OVD is believed to achieve balance and harmony of the lower third of the face and ensure most ideal function.⁴⁻⁶ Several clinicians foresee that a major factor for complete denture failure is the error in determining the OVD.⁵⁻¹⁰

In order to restore the OVD by a prosthesis, the clinician needs to accurately approximate the ideal OVD of the patient. This can be achieved by measuring the OVD loss, or by determining the original OVD. For many decades, several techniques to determine the ideal OVD were proposed and discussed in textbooks, case reports and research articles. However, few questions remain unanswered. For example, what constitute an ideal OVD, and how accurate are the available methods to determine the OVD? Therefore, the aim of this review is to discuss and critique the available proposed techniques for OVD determination. This includes pre-extraction methods and post-extraction methods (Table 1).

Pre-extraction methods

The pre-extraction methods are based on the assumption that the patient's OVD during the dentate state is the ideal dimension from the esthetic, functional and comfort perspective.⁶ Therefore, these methods were proposed to maintain OVD of the pre-extraction situation and transferring it to the subsequent dentures.^{4,5,11,12} The main pre-extraction methods are measurements of intraoral dimensions, profile tracing, cephalometric tracing and pre-extraction phonetics. However, these methods are only suitable if the measurements are performed for dentate patient with acceptable OVD and stable occlusion.

Measurements of intraoral dimensions

In this category, the intraoral OVD is measured when the dentition is in occlusion. The available methods are maintaining pre-extraction casts' dimension, measuring the vertical distance between points marked by the treating clinician and measuring the vertical distance between maxillary and mandibular fixed landmarks.

If pre-extraction diagnostic casts are available, Heintz and Peter suggested using the vertical dimension and occlusal relation of these cast for subsequent dentures fabrication.¹³ On the definitive edentulous maxillary and mandibular casts, thin aluminum foil can be adapted to serve as a separating layer. Impressions of the pre-extraction diagnostic casts are made and poured until the impressions of teeth are filled. Before setting of stone material, the edentulous casts with the separating aluminum foil are placed into the impressions. After setting of the stone, the stone teeth can be removed from the impression and attached to the edentulous casts by sticky wax. The stone casts are then mounted in the articulator with stone teeth in maximal intercuspation. The artificial teeth can be set according to the position and orientation of the stone teeth. However, this technique is useful in situations where the pre-extraction diagnostic casts exhibit stable occlusion and acceptable tooth arrangement. In addition, the patient should be accepting the display and

appearance of the natural teeth. Prasad and Alva proposed an alternative method for using pre-extraction casts.¹² In their report, the distance from the frenal attachment and the incisal edge or the tip of the corresponding tooth was measured. Thus, the measured distance can be used to determine the original vertical position of the occlusal plane and, eventually, the OVD. Similarly, other authors used specific landmarks to approximate the vertical height of each denture. For example, the distance from the center of the incisive papilla to the incisal edge of the maxillary central incisors can be measured and recorded for future use when the patient becomes edentulous.^{4,6,14} For the mandibular arch, the distance between the anterior attachment of stretched lingual frenum and incisal edge of the mandibular central incisors was reported to be relatively stable.¹⁴⁻¹⁷ In addition, the distance between the incisal edge and mucolingual reflection was found to be stable and suitable for use as pre-extraction record.¹⁶ Similarly, the distance between the mucolabial reflections of the upper and lower lips at the midline was proposed as a guide for the initial determination of the OVD.¹⁸ The distance from the mucobuccal reflection of the maxilla to the tip of the mesiobuccal cusp of the first molar was also suggested by Yanikoglu et al. to be used as starting point for the construction of the record bases and occlusal rims and for the selection and positioning of the posterior teeth.¹⁹ However, the clinician should be aware of the considerable variation that can exist between individuals and their aesthetic demands.

Silverman suggested the tattoo dots placement in the attached gingiva of the maxillary and mandibular arches.²⁰ If the dots are placed before extraction, the vertical distance between them can be measured when the teeth are in maximal intercuspation, and maintained whenever new dentures are fabricated. Alternatively, stretched maxillary and mandibular labial frena have been suggested to be suitable landmarks for OVD measurements by Turrell.²¹ However, the dilemma with using this method is the resilience associated with soft tissue that hinders accurate reproduction of distances.

Profile tracing

Several authors described techniques to register the existing OVD via fabricating a template that traces the profile of the lower third of the face. The template aims to record the sagittal plane of the face and is fabricated on the extraoral facial tissues when the dentition is in maximal intercuspation. Therefore, whenever new dentures are fabricated, the OVD is determined by adapting the tracing template against the lower third of the face. The template can be produced by adjusting metal wire on the facial contour²², trimming cardboard on the basis of pantographic tracing^{4,23}, registering the profile by alginate or strip of plaster, or fabricating resin mask.⁵ Alternatively, the template can be generated from lateral photograph or cephalogram of the patient.²⁴ In addition to preserving the

OVD, the template has the advantage of recording the lips contour which can guide anterior teeth positioning. The use of template was reported to exhibit inaccuracy of 2 mm or more.⁵ A simpler method is the use of Sorenson profile scale that measures the distance between two facial points when the dentition is in maximal intercuspation. The nasion locator is placed in the depression at the nose bridge. The inferior part of the scale is raised until it contacts the most anterior and inferior part of the chin.⁴ Alternatively, the facial tissues dimensions can be measured by measuring devices such as Dakometer or Willis gauge.^{5,6} Nevertheless, using the soft tissues will not yield accurate result due to inevitable distortion during the measurement procedure by the operator.^{5,6,25} Further, facial soft tissues changes do not precisely reflect the skeletal changes. For example, Gross et al found increasing the OVD up to 6 mm for dental individuals minimally affected the appearance of the facial tissues.²⁶ In addition, complete edentulism will lead to significant loss of horizontal support of facial tissues², which may potentially prevent accurate template adaptation. Smith investigated the suitability of 5 pre-extraction methods for OVD measurement including profile template, Sorenson profile scale, interfrenal distance, measurement the distance between 2 dots, and nose-chin distance measurement. All of the methods had clinical merit and yielded outcome with variation within clinically acceptable level (1.1 to 1.4 mm).⁴

Cephalometric approach

This method requires obtaining a cephalometric radiograph before extraction. After extraction, another cephalometric radiograph is made with the occlusal rims. The pre- and post-extraction images are compared and the occlusal rims are adjusted accordingly.^{6,27} While some authors found correlation, others found significant variation in the outcome. One study measured the distance between the nose and the chin as an approximate of the face height.²⁷ They considered this distance to be unique and constant through the life time. As a result, they recommended that analysis of pre-extraction cephalogram prior to new denture fabrication. With the aid of computer programs, Edwards et al measured the OVD on cephalometric images. They found the analysis of the OVD was not reliable in the population of the study and the average alteration of the OVD was 8.4 mm.²⁸ Similarly, Orthlieb et al observed large variation in their cephalometric measurements.²⁹ They attributed the findings to individual differences and image distortions. Therefore, according to the current state of evidence, cephalometric images cannot be used solely to precisely determine the OVD. Instead, it can help in understanding the direction of treatment involving the height of the lower face.³⁰ For example, with the aid of cephalometric analysis, Ciftci et al confirmed the positive effect of new dentures on restoring facial profile.³¹ Overall, cephalometric analysis appears suitable research tool more than routine dentures treatment.³²

Pre-extraction phonetics

For many decades, the importance of phonetics in determining OVD was acknowledged. Silverman described the use of the closest speaking space (CSS) during the pronunciation of the “S” sound.¹¹ A line is drawn on the lower anterior teeth at the level of the incisal edge of the upper anterior teeth when the dentition is in maximal intercuspation. During the pronunciation of the “S” sound, another line is drawn on the same lower anterior teeth at the new level of the incisal edge of the upper anterior teeth. The distance between these two lines is the CSS, which is recorded for the purpose of reproducing it during full dentures construction. Silverman claimed that this space is constant for each individual. In addition, Silverman suggested other sibilant letters (S, Z, Zh, Sh, Ch) that produce similar mandibular position in relation to maxilla. The CSS may range from 0-10 mm. In addition, Pound explained the benefit of using “S” sound when measuring the OVD before extraction and when verifying this measurement in the try-in stage in complete dentures construction.^{33,34} It was emphasized that this method is easily recordable, repeatable and can serve as a guide for more difficult cases. Burnett and Clifford investigated the smallest vertical movement of the mandible during different phonetic exercises.^{35,36} The CSS was measured when their participants were reading paragraphs containing sibilant sounds. Their recommendation was that the “S” sound cannot be relied upon solely for the determination of the CSS. Instead, it is necessary to use a phonetic test that covers range of the sibilant sounds.

In contrast, Rivera-Morales and Mohl compared the CSS with interocclusal distance in 30 dentate individuals.³⁷ Although the clinical difference appeared minimal, the CSS and the interocclusal distance were statistically difference. As a result, this study did not support the use of sibilant sounds in establishing or even evaluating the vertical dimension of occlusion. de Souza et al assessed the relation between interocclusal distance and the speaking space of “S” sound for dentate and edentate individuals.³⁸ Interestingly, their results showed a difference between the two studied groups and there was a weak correlation between the interocclusal distance and CSS in dentate subjects and strong correlation in edentulous subjects. It was concluded that the anatomical changes following complete dentures provision cause functional adaptation and similarity between interocclusal distance and CSS. Thus, it appears that CSS is a useful OVD verification tool at the try-in stage for patients at the edentulous state, more than at the dentate state. Nevertheless, it is likely that patients have the ability to adapt to produce phonetics even with minor alterations of the OVD.³⁹

Additional methods

Other authors suggested alternative methods such as pre-extraction photographs and orofacial devices. Wright mentioned a method of establishing the OVD using the pre-extraction photographs where the distances between certain anatomical landmarks are recorded for the purpose of reestablishing them when fabricating the dentures after extraction.⁴⁰ Even though this method seems easy and simple, the associated aging process will render the facial expression muscles flaccid.⁶ Moreover, the skin is a movable tissue, which makes it not reliable to approximate precise vertical dimension.²⁶ Group of authors developed orofacial device for the purpose of establishing the occlusal plane and recording the vertical dimension of occlusion.⁴¹ The angle formed by the junction of Frankfort plane and the inferior border of the mandible is measured and recorded before teeth extraction for purpose of preserving the angle during future dentures construction. In the era of digital dentistry, it is likely that facial scanning will be employed to analyze the face and the vertical height. The digital scanning of the face has the advantages of simplicity, quick image acquisition, and saving the record digitally instead of physically. Further, with the aid of relevant software, digital visualization of the image allows accurate quantification of distances between facial landmarks.⁴²

Summary

In summary, the pre-extraction methods seem to be valuable in determining the OVD. Nevertheless, the reliability of these techniques is based on the availability of pre-extraction records or patient presentation in the dentate state. In addition, the clinician should be aware of their limitations and their suitability as adjunctive methods rather than sole methods for determining the OVD.

Post-extraction methods

In many instances, the edentulous patients present for dentures treatment without any form of pre-extraction record. Due to the inevitable loss of lower third of the face and associated reference landmarks, the clinician should implement post-extraction methods to approximate the ideal OVD. Post-extraction methods are based on the assumption that the missing OVD can be predicted by measuring alternative dimension on the face, cranium, or fingers. The proposed post-extraction methods are establishment of physiologic rest position, evaluation of facial esthetic appearance, swallowing, craniofacial measurements, cephalometric measurements, phonetics, evaluation of former dentures and finger length measurement.

Physiologic rest position and interocclusal distance

The rest position of the mandible is defined by the Glossary of Prosthodontic Terms as “The mandibular position assumed when the head is in an upright position and the involved muscles,

particularly the elevator and depressor groups are in equilibrium in tonic contraction and the condyles are in a neutral unstrained position". The rest position of the mandible can potentially be used to establish the OVD by subtracting the interocclusal distance of 2-4 mm from the rest position.⁴³ The registration of the rest position of the mandible is facilitated by two dots marking on least movable skin spots (e.g. nose and chin). In addition, different measuring devices have been suggested for this purpose⁴⁴⁻⁵¹ such as Willis gauge, sprung divider (caliper), millimeter ruler, and digital caliper. In general, the mandibular rest position can be established by three methods. The most popular one is phonetics where the patient is directed to say the labial "M" sound without tensing the lips. However, some difficulties may be encountered when the patient leaves his lips parted after saying "M" sound. To overcome such difficulties some words have been suggested (Emma - Mississippi) to maintain the mandible at rest position without any parting on the lips. In the second method, the patient is asked to swallow and relax to place the mandible in rest position. Exercises maybe helpful to teach the patient how to swallow and hold the mandible at the correct position. The third adjunctive method is "no command" or relaxation where the patient is asked to relax and hold the mandible at the position he feels comfort.^{52,53} In clinical practice, frequently, combination of these techniques is used to place the mandible in rest position.

Although several studies^{10,52-60} found stability in the mandible at a constant position at rest and recommended the use of this position for the determination of the OVD, many other studies^{35,61-77} found a large variation and instability of the mandible at rest position and concluded against relying solely on physiologic rest position for the determination of the OVD. The physiologic rest position varies between individuals, from time to time in the same sitting and between sittings in the same patient, and between dental practitioners.^{8,62,66} This position of the mandible was found to be influenced by a number of factors such as pain, fear, anxiety, any disorder(s) involving the mandibular motor complex⁷², activity of the lips⁷³, head posture⁶¹, wearing denture^{65,68}, parafunctional habits, time of recording, weight of soft tissue attached to the mandible^{75,76}, and the technique used for obtaining the rest position.⁶⁴ Further, the interocclusal distance can adapt to the loss of OVD, which means that the OVD obtained by the rest position is masked and underestimated. To overcome such limitations, group of authors suggested dealing with the rest position of the mandible as a range rather than a specific spot.⁷⁸

Facial esthetic appearance

Evaluation of the OVD by appearance is based on the establishment of esthetic harmony of the lower third of the face.^{79,80} Ideal OVD is associated with unstrained face with the lips are in slight contact. Strained lower third face indicates excessive increase of the OVD. On the other hand,

dropped corners of the mouth can occur with reduced OVD. This method can be utilized as a guide to evaluate OVD in young or middle aged patients with good tonus of the skin. When this tonus is lost or when the lips are incompetent, this method may not be very reliable in establishing ideal OVD.^{81,82} Even though the facial esthetic appearance is used commonly as adjunctive method with different techniques for establishing OVD, its ability to distinguish between incremental changes in OVD is limited when used by the dentist or the patient. Orenstein et al⁸³ evaluated the changes in OVD subjectively by patients and objectively by prosthodontists. Interestingly, 5 mm increase of the OVD by gradual increments (2, 3, 4, and 5 mm) did not reflect similar increase in the facial height.

Deglutition/Swallowing

This method relies on the consistency of mandibular movement pattern during swallowing throughout individual's life.^{84,85} The swallowing cycle commences as the mandible travels from the rest position until the occurrence of slight contact between the teeth, after which the mandible returns back to the rest position. Shanahan⁸⁴ used this concept to establish the OVD, by attaching soft cone-shaped waxes on the mandibular occlusal rim. These cones were reduced during swallowing to the correct OVD. Other researchers^{86,87} tested the accuracy of the swallowing method in determining the OVD and compared it to different measuring methods (pre-extraction records, physiologic rest position, and esthetic appearance). They found that the swallowing method was comparable to the other techniques and can be used for establishing the OVD. On the other hand, according to Boucher⁸², the accuracy of this method is largely affected by the duration of the swallowing and the softness of the wax cones. In addition, no consistency was found in the final position of the mandible. Moreover, Cimic et al⁸⁸ did not recommend using the swallowing method as the only method to determine the OVD. Instead, it can be used in conjunction with other techniques.

Craniofacial landmarks Measurements:

Craniofacial distances have been widely discussed in the literature as a tool to approximate the height of the lower third of the face which indicate the missing OVD. Several authors assumed that relationships existed between the different craniofacial distances, which allow using them to predict the OVD. The discussed distances that can be used to establish the OVD are distance between septum of the nose (Sn) to the base of the chin (Me) and distance from the tip of the nose (N) and tip of the chin (Gn).

Boyanov^{89,90} correlated the length of the upper lip and the desired visibility of the upper incisors edges to the distance measured from the tubercle of the mouth to the lower border of the chin.

Although the author concluded that this method can produce accurate results, he stated that it cannot be applied to people with deformities and scars in the lower part of the face or those with deep bite.

A more reliable method is to approximate the OVD from the Sn-Me distance. In a study by Chou et al⁹¹, it was concluded that the Eye-Ear distance is reliable in predicting OVD measured from the Sn-Me distance. The authors proposed an equation for more accurate measurements. After comparing different craniofacial distances, Delic and co-workers^{92,93} recommended the use of Eye-Ear distance in daily practice as a method for Sn-Me approximation. Such observation was confirmed by Abdul-Rassol⁹⁴ on Iraqi adults and by Alhaji⁹⁵ on Sudanese males and on Yemeni males and females. Brar and co-workers⁹⁶ compared (Sn-Me) against the distance from the pupil of the eye to the angle of the mouth and found such relationship can be used to verify the OVD. Nagpal et al⁹⁷ evaluated the reliability of different craniofacial measurements used to predict OVD of both right and left sides by comparing them with the distance (Sn-Me) at rest and occlusion. It was concluded that the distance from the outer canthus of the eye to the angle of the mouth and the distance from the distal canthus of the eye to the tragus of the ear can be used as valuable adjuncts in determining the OVD. On the other hand, Al-Dhaher et al⁹⁸ analyzed the accuracy of using Eye-Ear distance clinically to predict the OVD measured from Sn-Me. The results of the study showed that there was a significant variation between males and females for the measured distances. Moreover, a non-significant correlation was found between the clinical OVD and Eye-Ear distances in males but it was significant in the females group.

Alternatively, N-Gn distance was suggested as a tool to measure the OVD. Basnet et al⁹⁹ carried out a study to compare different craniofacial measurements against N-Gn distance in two ethnic groups of Nepal. The results showed that all the four measurements (Pupil-Rima Oris, Eye-Ear, Ear height, Outer canthus of the eye-Inner canthus of the other eye) were significantly correlated with N-Gn distance. A correlation between the distance measured from outer canthus of the eye to the angle of the mouth and N-Gn was also confirmed Alhaji et al¹⁰⁰ on Yemeni sample. In addition, Delic et al^{92,93} reported a relationship between the distance zigon to zigon and N-Gn distance. After comparing the Sn-Me and N-Gn distances, Sakar and colleagues¹⁰¹ reported the N-Gn distance was more correlated to intraoral alterations than Sn-Me distance. It was concluded that although the facial measurements are not ideal to predict the OVD, the N-Gn distance is more reliable than the Sn-Me distance. This was also confirmed in a study conducted among two different populations.⁹⁵

On the other hand, measuring craniofacial distances has been critiqued due to the reliance on soft tissue¹⁰² and the likelihood of variation due to gender dimorphism and racial differences.^{92,93} Thus, reliance solely on these methods will not ensure accurate OVD determination.¹⁰³

Cephalometric radiographs

This method is based on utilizing skeletal landmarks that are not affected by edentulism to approximate distances relevant to vertical dimension. Some researchers^{29,104} correlated skeletal angles traced and measured on cephalometric radiographs with the lower third of the face. Other authors^{105,106} traced a number of skeletal and soft tissue landmarks on cephalograms to predict the vertical dimension of the lower third of the face. Strajnic et al³⁰ measured averages for specific cephalometric parameters for both sexes in Serbia. Even though the results of this study outlined number of parameters that can be used in establishing the OVD, it is specific for limited population. Brazilian study by Morais et al¹⁰⁷ concluded that this method can not be used as a principal method and should be accompany other clinical methods in determining OVD. An equation was formulated by Yamashita et al¹⁰⁸ to predict lower facial height using cephalometric analysis. This formula, however, is only applicable in a specific range of the lower facial height. A simple method has been proposed by Alhajj and Daer¹⁰⁹ to predict the OVD based on the distance between Nasion and Sella. Although this method seems practical, the authors found it not applicable in females. In general, the cephalometric approach seems to be accurate since it is based on fixed skeletal landmarks. On the other hand, this approach needs radiographic set-up which is not available in most dental clinics and the related hazardous exposure to radiation makes its use limited.

Post-extraction phonetics

In addition to phonetics use at the pre-extraction stage and in establishment of physiologic rest position, they can be used for establishing OVD after edentulism. Marko and co-workers¹¹⁰ used phonetic vowel letters “O” and “E” to establish a fixed position for the mandible. This position is different from the rest position as it represents the pronunciation of these letters. They requested their participants to pronounce the words “OLO and ELE”. The distance from the tip of the nose to the tip of the chin was measured and recorded. The authors concluded that to estimate the OVD a distance of 5.5 mm should be subtracted from the position of the mandible in pronunciation of the word “OLO” and 7.5 mm in pronunciation of the word “ELE”. With the presence of linguistic and phonological variations as well as different articulations of the consonant and vowel letters among different populations it might be quite difficult to generalize this technique for wide population.

Further, since the mandible is a movable bone, the patient may not be able to maintain the mandible in that position which will negatively affect the measurement.

Measurement of the former dentures

The OVD may be measured from the existing dentures and used if the existing OVD is within the acceptable range.¹¹¹ The distance between the inner surfaces of the dentures at the site corresponding to the residual ridges is measured and re-established with bite-rims and record bases. Another method using the former dentures is measuring the distance from the incisive papilla to the incisal edge of the lower central incisor.⁸⁰ This method seems to be impractical in patients with worn dentition or resorbed residual ridges when there is a need for OVD reestablishment. Alternatively, for patients with severely worn dentures, the ideal OVD can be established via interim pivot appliance or occlusal splint. Although this method will extend the duration of the treatment, it has the advantage of allowing the patient to try the new OVD.¹¹² As a result, the patient will be more aware of the aesthetic, comfort and function of the final dentures. Due to the increased treatment duration, this method seems practical when the OVD requires excessive increase the patient adaptation ability is doubtful.

Fingers length

Finger length has been used extensively as anthropometric measurement in medicine for characterisation of individuals and genders differences. Recently, it has been used in dentistry to predict the OVD. Thumb finger length, distance from tip of the thumb to tip of the index fingers, index finger length, ring finger length, and little finger length have been measured and correlated to the distance from the septum of the nose to the base of the chin and the distance from tip of the nose and tip of the chin among different populations.¹¹³⁻¹¹⁸ Once these distances are determined, the OVD can be approximated. Nevertheless, different conclusions were obtained from these studies and the conflicts in results were attributed to the variations in gender and race.

Additional methods

Tactile sense is a method assumes that patients are capable to determine the preferred OVD. The most common device for this purpose is the patient adjusted screw-jack.¹¹⁹⁻¹²¹ The screw is adjustable and can be manipulated to alter the OVD. However, the presence of the screw-jack in the patient's mouth may affect the accuracy of the oral perception and may restrict the freedom of the tongue.

Measuring the biting force by Bimeter in edentulous patients was proposed by Boos.^{122,123} This method is based on the assumption that maximum bite force occurs at a constant OVD. Thus, the bite can be evaluated at different intermaxillary relation, until the relation associated with maximum force is determined. Nevertheless, multiple physiological and morphological factors can influence the bite force measurements. Findings of Boucher et al¹²⁴ and Morimoto et al¹²⁵ revealed that the vertical dimension obtained by Bimeter was greater than that obtained clinically by the electromyographic method. The conclusions of their studies were against the use of Bimeter for determining the OVD.

Open-rest method aims to establish unstrained mouth breathing position where the lips are slightly parted.¹²⁶ The upper occlusal plane is set 3 mm above the corner of the mouth and the lower occlusal rim is 2 mm below the corner of the mouth. Despite the authors claimed that this method is more accurate than the other methods in determining the OVD, these distances vary considerably between patients as the relationship between the occlusal plane and corner of the mouth is a time-dependent and is expected to change throughout life.

Faust¹²⁷ presented a method to confirm the OVD using magnetic plates. After a tentative determination of the OVD and centric relation, the bite-rims on the casts are articulated. The maxillary record base is then prepared with the anterior teeth and the anterior part of the mandibular bite-rim is removed and filled with the magnetic plates up to the incisal edges of the maxillary incisors. The record bases are then inserted in the mouth and the patient is asked to pronounce words and sentences containing the "S", "M" and "Ch" sounds. The space between the incisal edges of the maxillary incisors and the magnetic plates is observed and the number of plates can be increased or decreased until an amount of 2-3 mm of space is obtained during speech.

Summary

The review of the post-extraction methods revealed great controversial and diversity in the measuring methods. Even though the physiologic rest position is the most commonly used method for establishing OVD, it is still vulnerable for error. Using combination of methods is recommended to overcome the limitations of each individual technique.

Conclusion

This review indicates that there are many methods available to estimate the OVD. However the methods are empirical in nature and, currently, there is minimal scientific proof or universally accepted method for precise determination of OVD. Therefore, determination of the OVD is not a

precise procedure since no natural teeth are available to guide in reestablishing the previous vertical relation. Nevertheless, due to the long history of successful denture treatment, most likely relative errors in measuring the OVD can be accepted clinically and may not necessary lead to denture rejection. Clinical judgment, dentist preference and individualized patient treatment still play an important role in the assessment of OVD. Whatever the method used, the clinician should be aware of its merits and limitations. Further, combination of more than one method is recommended in routine practice to overcome the limitations of each individual method. Facial esthetics might be included with physiologic rest position, as these methods can be used to establish a physiological position of the mandible. Cephalometric radiographs can be combined with the craniofacial landmarks. Since the two methods are on landmarks, one of them on external features the other on radiographic landmarks. In addition, the clinician should be flexible when implementing the different techniques as less difference between these techniques within the accepted limits maybe clinically neglected, and the OVD has to be re-evaluated at the waxed denture try-in phase. The new OVD has to be confirmed at this stage. This can be done by applying the same vertical dimension measurement method(s) and confirming the accuracy of the OVD. Moreover, an appropriate inter-occlusal distance and harmonious facial appearance should be taken into consideration.

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Table 1: Occlusal Vertical Dimension Measurements

<i>Pre-extraction Methods</i>	<i>Post-extraction Methods</i>
- Measurements of intraoral dimensions	- Physiologic rest position and interocclusal distance
- Profile tracing	- Facial esthetic appearance
- Cephalometric approach	- Deglutition/Swallowing

- Pre-extraction phonetics
- Pre-extraction photographs
- Orofacial device

- Craniofacial landmarks measurements
- Cephalometric radiographs.
- Post-extraction phonetics
- Measurement of the former denture
- Fingers length
- Tactile sense
- Biting force
- Open-Rest method
- Magnetic plates

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