ROSANE AGREDA WALSH

DETERMINATION OF OCCLUSAL VERTICAL DIMENSION IN A COMPLETE REMOVABLE PROSTHETIC REHABILITATION

LITERATURE REVIEW

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Atesto a originalidade do trabalho

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do grau de Mestrado Integrado em Medicina Dentária.

ABSTRACT

When a complete denture wearer presents for restorative treatment, one of the most important challenges for the dentist is to determine the optimal occlusal vertical dimension (OVD). Studies have shown that establishing a correct OVD is of paramount importance, and many techniques have been proposed for determining the OVD, including the use of pre-extraction records, phonetics, swallowing, aesthetic appearance, and correlation with finger length. However, there is no universally accepted scientific method for determining OVD in edentulous patients. This literature review investigates the various methods that are in use and considers which may be most suitable or advisable for the prosthetic dentist. Based on the literature available, no single technique stands out as significantly better than others and the dentist should ideally use more than one technique to achieve the best results.

Keywords : “occlusal vertical dimension”, “complete denture”, “removable complete denture”, “removable prosthetic oral rehabilitation”, “OVD”, “oral rehabilitation with complete dentures”, “determination of occlusal vertical dimension”

RESUMO

Quando um usuário de prótese total removível se apresenta para tratamento restaurador, um dos desafios mais importantes para o dentista é determinar a dimensão vertical de oclusão ideal (DVO). Estudos demonstraram que a determinação de uma DVO correta é de extrema importância. Muitas técnicas foram propostas para determinar a DVO, incluindo a utilização de registos de pré-extração, fonética, deglutição, aparência estética e a correlação com o comprimento dos dedos. No entanto, não existe um método científico universalmente aceito para determinar a DVO em pacientes edêntulos. Esta revisão literária investiga os vários métodos que estão em uso e considera quais podem ser mais adequados ou aconselháveis para o dentista protético. Com base na literatura disponível, nenhuma técnica se destaca como significativamente melhor do que outras e o dentista deve idealmente usar mais do que uma técnica para alcançar os melhores resultados.

Palavras-Chave : “DVO”, “dimensão vertical de oclusão”, “definição da dimensão vertical de oclusão”, “reabilitação com prótese total removível”, “prótese total removível”

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I. INTRODUCTION

The Glossary of Prosthodontic Terms (Driscoll *et al.*, 2017) defines occlusal vertical dimension (OVD) as "the distance between two selected anatomic or marked points (usually one on the tip of the nose and the other on the chin) when in maximal intercuspal position".

A complete denture wearer presenting for restorative treatment may have experienced a reduction in OVD over time due to deterioration of the supporting tissues or tooth wear. Re-establishing a correct OVD is of paramount importance as an incorrect dimension can have significant negative effects upon the patient. There are many techniques available for determining OVD, but none have been proven to be scientifically accurate.

The method followed in producing this review was to use the Google Scholar, PubMed, and ScienceDirect search engines to discover academic and clinical reviews of the various techniques available, to find clinical studies which evaluate or compare the techniques and also to pursue the references listed to better understand the techniques used.

There are two vertical dimensions for any patient: one with the jaws in the rest position (RVD) and one with the teeth in contact (OVD). The difference in height of the two vertical dimensions is accounted for by the amount of interocclusal distance (freeway space) between upper and lower teeth. OVD is therefore equal to RVD minus the interocclusal distance.

An incorrect OVD can lead to problems with altered phonetic and masticatory function, unacceptable facial appearance, muscular discomfort, accelerated alveolar bone loss, sore residual ridges, premature and excessively audible denture tooth contact, and exaggerated gagging (Massad *et al.*, 2004). Various commentators have stressed how important a correct OVD is (Pyott and Schaeffer, 1954; Willie, 1958; Fenlon, Sherriff and Walter, 1999). Thompson and Brodie (1942) and Thompson (1946) showed that encroachment on the freeway space in the course of denture restoration is destructive to alveolar bone. Pyott and Schaeffer (1954) stated that if this factor is not determined correctly in the beginning, the patient will suffer from too great a vertical dimension or overclosure - that is, too much or too little free-way space. An incorrect OVD can lead to classic symptoms, such as fractured artificial teeth, midline fractures in the restorations, discomfort and poor retention, loss of alveolar bone associated with flabby ridges, temporomandibular pain, sore ridges, and sore tongue.

Silverman (1952) performed a scientific study showing that the OVD should not be increased (except for the exceptional patient) otherwise the treatment ends in failure because the teeth click together during speech.

There are many techniques for establishing OVD and there have been a number of reviews of various techniques available (Turrell, 1972; Fayz and Eslami, 1988; Alhajj *et al.*, 2017), however there is currently no universally accepted technique in practice.

It is generally accepted that records or measurements taken when the patient is fully dentate provide the best guide to re-establishing the correct OVD for a denture. This assumes that the OVD of the patient when fully dentate was ideal from an aesthetic functional and comfort perspective. Wright (1939) suggested if such records are not available then photographs could be helpful, but Turrell (1968) states that in the absence of pre-extraction records there is no accurate method of assessing OVD based on scientific principles.

When pre-extraction records are not available the prosthetic dentist must choose from a number of post-extraction techniques to predict OVD. Alhajj *et al*. (2017), found great diversity in post extraction methods for determining OVD. These include using the physiologic rest position, facial aesthetics, swallowing, craniofacial landmarks, cephalometric analysis, phonetics, using the old denture, finger length, tactile sense of the patient, biting force, the open rest methods and the use of diagnostic devices.

Of all of the methods available, none are considered to be scientifically accurate. Turrell (1972) stated that “an accurate scientific method of assessing the OVD clinically is a pressing need of paramount importance”.

This literature review will discuss the various techniques found for re-establishing OVD in edentulous patients and discuss the advantages and disadvantages of each.

II. DEVELOPMENT

1. Pre-Extraction Methods

i. Recording Measurements

Various techniques are available for taking and recording OVD measurements.

Silverman (1955) suggests that tattoo dots are placed on the mucous membrane of the alveolar ridges prior to the removal of natural teeth and the distance between the dots recorded.

Heintz and Peters (1959) described the use of casts to record the jaw relations that existed before the extraction of remaining teeth and then incorporating reproductions of the natural teeth in their original relationship in the occlusal rims and maintains that this technique is easily usable by the dentist in general practice.

Various instruments have been advocated for use in determining the OVD, the most common being the Dakometer (Turrell, 1972; Bissasu, 2004). Others include the Sorenson profile scale (Smith, 1971) and the Willis gauge (Willis, 1935). Aboul-Ela and Razek (1977) described the use of a device for recording both the inclination and height of the occlusal plane claiming that the device records landmarks that do not change as the patient ages.

Another technique is to trace the patient's profile. Turner (1969) describes a method for obtaining accurate pre-extraction records using a 'profile tracer' consisting of adjustable headgear used to trace the patient's facial profile onto a card. Smith (1971) describes the technique of using plumbers pipe strapping moulded to record the facial profile and then traced onto cardboard. However, Turrell (1972) concludes that all such methods displace the skin and inaccuracy may be 2mm or more.

ii. Cephalometric Approach

This technique involves taking radiographs before removing existing teeth and then using these along with adjustment of occlusal rims to achieve matching measurements when making the denture (Hull and Junghans, 1968).

iii. Pre-extraction phonetics

Silverman (1953) describes a technique called the 'speaking method' to establish what he called the 'closest speaking space' which is the difference between a position marked on a

lower anterior tooth when teeth are in maximum occlusal contact and after pronouncing the word “yes” when the phonetic sound “s” is being pronounced. He would then use this measurement for re-establishing OVD. Silverman (1955) later reinforced the reliability of the method and asserted that the ‘closest speaking space’ should be a constant throughout life.

iv. Pre-extraction Photographs

Wright (1939) suggested that if other pre-extraction records were not available then the use of old photographs of the patients could be useful. He suggested that the interpupillary and brow to chin distances could be compared to current measurements.

v. Digital Scanning

Alhajj *et al.* (2017) suggests that in the age of digital dentistry facial scanning will be employed to analyse the face and vertical height which has the advantage of simplicity and saving the record digitally rather than physically. Additionally, with the aid of relevant software, digital visualisation of the image allows accurate quantification of distances between facial landmarks (Abduo, Lyons and Bennamoun, 2014).

2. Post-Extraction Methods

More often than not an edentulous patient may present without any pre-extraction records. In this case there are a variety of post extraction methods that can be used. These methods generally assume that OVD can be predicted by measuring dimensions of the face, cranium or fingers.

i. Physiologic Rest Position and Interocclusal Distance

Niswonger (1934) discussed the natural rest position of the jaw and suggested that it is a constant throughout life. He defined it as “that position of the mandible in which it is involuntarily suspended by the reciprocal coordination of the muscles of mastication and the depressor muscles, with the upper and lower teeth separated, or the neutral position of the mandible.” He said that “the distance can easily be measured on the soft tissue from a point at the juncture of the philtrum with the nasal septum to a point on the center of the chin”. Subtracting 3mm from this measurement to allow for interocclusal space is recommended as the method for determining ideal OVD.

Gillis (1941) reinforced the usefulness of the rest position. Widen (1941) confirmed that the patient retains tactile sense of vertical relation after extraction, even after many years. Thompson and Brodie (1942) asserted that the position of the mandible is maintained throughout life and the absence of teeth has little or no bearing and that the proportions of any face as far as vertical height is concerned is constant throughout life. Thompson (1946) studied this further and confirmed the method of subtracting 2-3mm from the measured rest position to determine OVD.

Pleasure (1951) went on to further develop the technique but pointed out that interocclusal distance is not the same for all patients and can range from 1.5mm to 6mm. Shanahan (1956) stated that existing methods of using the rest position provide an approximation but proposed a refinement involving repeated swallowing to aid in achieving the natural rest position.

Watarai *et al.* (2018) proposed a new method of inducing the rest position using lip contact position with the closed mouth and found excellent reproducibility compared to conventional methods. They suggested that the area of the prolabium of the upper lip might offer an effective index for individual determination of the correct freeway space.

ii. Swallowing/Deglutition

Certain direct swallowing techniques for determining OVD have been proposed, as opposed to the use of swallowing to simply aid in establishing the rest position.

Shanahan (1955, 1956) asserted that the constant function of swallowing saliva is the basis for establishing mandibular positions and occlusion. He proposed a new technique where a tentative OVD is determined using any of the usual methods. The lower occlusion rim is then reduced by 3mm and a layer of soft wax placed on top. Upper and lower rims are placed in the mouth and the patient is asked to swallow several times. As the patient swallows the soft wax is reduced to the natural vertical dimension.

iii. Post-extraction Phonetics

In contrast to pre-extraction phonetic techniques that can then be used to verify OVD at the try-in stage there have also been post extraction phonetic techniques proposed for the determination of OVD.

Igić *et al*. (2015) proposed a technique using fixed mandible positions when pronouncing the sounds O and E. They found that subtracting 5.5mm from the position when pronouncing OLO and 7.5mm when pronouncing ELE gave the OVD value.

iv. Open Rest Method

Douglas and Maritato (1965) proposed a new 'open rest' technique for establishing OVD and contrasted it with the traditional physiological rest technique. The open-rest position is an unstrained mouth breathing position. The authors stated that "the development of the upper occlusal plane approximately 3 mm above the commissure of the lips, and the lower occlusal plane approximately 2 mm, below the commissure of the lips will provide an adequate vertical dimension of occlusion in a high percentage of patients" and that the technique appears to be an improvement over other methods of determining OVD.

v. Facial Aesthetic Appearance

The aesthetic appearance of the face is an important factor relating to OVD and is based upon harmony of the lower third of the face with the rest of the face. It also concerns the contour of the lips together with the appearance of the skin between the lower lip and the chin (Turrell, 1968). Turrell stated that without pre-extraction records he preferred to rely on facial aesthetics but acknowledged its limitations in older patients.

vi. Craniofacial Measurements

The well-known artist and pioneering scientist Leonardo da Vinci proposed ideal facial proportions and the relationships between them. Many techniques suggest a correlation between various cranial and facial measurements and OVD.

McGee (1947) described 3 measurements that can correspond to OVD and claimed that in 95% of subjects 2 or 3 of these measurements actually correspond to OVD.

Hurst (1962) proposed a technique based on an observed correlation, normally found in individuals with natural teeth, of lip length, vertical position of upper central incisors, and interocclusal distance.

Knebelman (1988) patented a device and proposed a corresponding method for using such measurements.

Chou *et al*. (1994) did a study of ear-eye to chin-nose distance correlation using a modified craniometer and concluded that the relationship can be used with some accuracy, but the algorithm is not the same for combinations of sex and ethnic origin.

Banasr and Al-Rafah (2012) evaluated the use of the 'divine proportion' against other techniques and suggested it as a method of choice.

Ladda, Kasat, and Bhandari (2014) proposed a correlation with interpupillary distance.

Nagpal *et al*. (2014) performed a study using different facial measurements and determined that some (the left outer canthus of eye to angle of mouth distance and the right ear–eye distance) can be used as a valuable adjunct in determining OVD.

Morata *et al*. (2020) performed a study of using eye to ear distance for determining OVD and concluded that OVD depends on facial type and sex, both of which are craniometric variables. This study proposed a baseline method of determining OVD by using the left eye-to-ear distance as an initial reference that involves a straightforward mathematical calculation.

vii. Finger Length

Alhajj *et al.* (2017) discussed various studies that suggest a correlation between finger length and OVD and stated that different conclusions can be made due to variations in gender and race. Hussain and Yazdanie (2019) suggested a correlation between index finger length and OVD.

viii. Cephalometric Analysis

This technique utilises skeletal landmarks not affected by edentulism to approximate OVD.

Pyott and Schaeffer (1954) first proposed the technique based upon the work of Broadbent (1931) and the findings of Thompson and Brodie (1942) and Thompson (1946).

Ricketts (1981) further discussed the use of cephalometrics in establishing such measurements. A study by Zielak *et al*. (2014) found that applying Ricketts lateral cephalometric analysis is an accurate and convenient tool in re-establishing OVD.

Brzoza *et al*. (2005) proposed a system for using cephalograms and concluded that with the use of only nine reference landmarks, seven skeletal, and two in the soft tissue, it is possible

to predict the OVD. The study asserts that this is a simple and inexpensive method available to the general practitioner.

Yamashita, Shimizu, and Katada (2015) proposed a new formula for predicting OVD using cephalometric analysis and concluded that the formula was accurate but noted the limitations as the study applied to a single racial group.

ix. Using Old Dentures

McCord and Grant (2000) discussed the use of the old denture in re-establishing OVD.

Marin *et al*. (2015) proposed a two-phase approach using old dentures and acrylic splints. They concluded that the use of diagnostic occlusal acrylic splints on old complete dentures with an altered OVD is an effective and reversible treatment, gradually allowing reestablishment in the OVD, verifying the patient's ability to tolerate the proposed increase before manufacturing a new complete denture set.

x. Tactile Sense

The tactile sense technique is based upon the premise that an edentulous patient, if given the opportunity under proper conditions and guidance, will be able to indicate an acceptable OVD.

Widen (1941) described a technique that combines the physiological rest position and using the patient's tactile sense. McGee (1947) commented that this transfers responsibility from dentist to patient and that patients register a reduced OVD because they feel more comfortable in that position. Basler, Douglas and Moulton (1961) using cephalometric analysis found no significant difference between using this method and phonetics or deglutition.

Lytle (1964) suggested the use of a central bearing device that allows the patient to experience different vertical relations over a short period of time. This establishes a tentative OVD but he stated that the OVD determined by this technique should be evaluated for further aesthetic, phonetic, and other physiologic requirements after the teeth are arranged.

Timmer (1969) proposed the use of an adjustable screw device to use in similar way to Lytle. Results were reproducible within a range of 0.5mm, independent of dentist's views, outside influences and patients previous OVD. Timmer also stated that the former (dentate) OVD is not necessarily the most comfortable so this technique can give a better result.

A study by Wright (1984) found that it made no difference to a patient's preferred OVD whether they were sitting or supine.

Munakata and Kasai (1990) tested a new hydraulic jack which can vary occlusal height and distribute bite pressure and concluded extremely good results.

xi. Biting Force

Boos (1940) proposed a technique using bite pressure to determine ideal OVD. The main objective was to determine the vertical dimension of occlusion at which the patient could exert the greatest biting force. He called this critical dimension the "power point" and assumed this was the mandibular rest position – he then reduced by 2mm to arrive at OVD. A device called the "Boos Bimeter" was used to measure the bite force.

xii. Use of Diagnostic Device

Mays (2003) described the use of a diagnostic prosthesis to evaluate a proposed OVD over 2 months, with gradual increase in OVD.

Massad *et al*. (2004) proposed the fabrication of a diagnostic occlusal device. It involved modification/duplication of existing dentures to evaluate alterations in OVD. In these situations, the use of an occlusal device will serve to: (1) aid in neuromuscular deprogramming of habitual mandibular posturing influenced by the malocclusion of existing ill-fitting complete dentures, and (2) facilitate diagnostic evaluation of the patient's aesthetic, phonetic, and functional tolerance of maxillomandibular relationships proposed for complete denture therapy. Achieving these diagnostic objectives may take weeks or months.

Faust (1978) proposed a technique using micromagnets. It involved placing magnetic plates in the mouth and asking the patient to pronounce certain words and adjust until 2-3mm space is obtained. It concluded that over many years the method "has been a simple, rapid, and accurate method of verifying or ascertaining interridge dimension".

III. DISCUSSION

If it is assumed that the OVD of a patient when fully dentate is ideal from aesthetic, functional and comfort perspective then it would seem clear that reproducing the OVD from pre-extraction records when the patient has dentures is the ideal situation. Measurements taken using devices such as the Sorenson profile scale or even a simple flexible ruler or dividers would seem to be adequate.

Bissasu (2004) did a comprehensive review of the various methods of taking pre-extraction records (PERs) and concluded that PERs are preferred to arbitrary methods (i.e. post-extraction methods) in common use. Alhajj *et al*. (2017), notes that the main PERs, being measurements of intra-oral dimensions, profile tracing, cephalometric tracing and pre-extraction phonetics are only suitable if the measurements are performed for a dentate patient with an acceptable OVD.

Smith (1971) tested 5 methods of measurement: Using the Sorenson Profile Scale, using a cardboard profile, measuring interfrenal distance, using tattoo dots, and measuring the nose to chin distance with a flexible ruler. He found that all methods were within the limits of clinical usefulness and each dentist should choose the most convenient.

Toolson and Smith (1982) evaluated the two simplest methods, the use of the Sorenson Profile Scale and chin-nose measurement and concluded that both were reliable, but the chin-nose method is not only more convenient, but measurement is not taken from chin tissue which is movable.

Turrell (1972) comments on the use of measurement devices for taking pre-extraction measurements and states that the Dakometer is reputed to be an accurate measuring device but the Willis gauge is so inaccurate as to be almost useless. He proposes that a more reliable technique is to use dividers to measure the distance between the upper and lower labial frena.

A cephalometric study of the use of pre-extraction phonetics (Basler, Douglas and Moulton, 1961) found the technique to be no better than any other methods. Similarly, another study (Rivera-Morales and Mohl, 1991) did not support the use of sounds for establishing or even evaluating OVD, although de Souza and Compagnoni (2004) found that the closest speaking space is a useful OVD verification tool at the try-in stage.

Alhajj *et al*. (2017), commented on the use of pre-extraction photographs and stated that though this method seems simple, ageing renders facial muscles flaccid and skin is a movable tissue, therefore this method is unreliable in approximating precise OVD

A recent study by Oancea et al.(2020) found that facial scanning can be used for the predictable registration of OVD and the information stored in a digital file could be preserved through life and used for a patient's oral rehabilitation.

When pre-extraction records are not available the only alternative is to rely upon post-extraction techniques which often assume that the OVD can be predicted by measuring alternative dimensions of the face, cranium or fingers.

Fayz and Eslami (1988) cited a number of studies that casted doubt on the idea that the physiologic rest position remains constant or whether it is reliable. Misch (2000) stated that the freeway space is highly variable from patient to patient, varying from 3mm to 10mm so the distance to subtract is unknown for a specific patient, and because of this the rest position should not be used as the primary method to evaluate OVD. Turrell (1972) pointed out that short and long-term variations in rest position do occur and that various studies had verified this. He further pointed out that various techniques involved in establishing the rest position produced different results.

Alhajj *et al.* (2017) reviewed the use of the rest position and noted that many studies found a large variation and instability of the mandible at rest position and concluded against relying upon it solely for the determination of OVD.

Lytle (1964) stated that "many methods used to determine the vertical relation of occlusion require considerable experience. For instance, when using the physiologic rest position as a reference, the location of the exact physiologic rest position is a difficult task, even for an experienced dentist. If the rest position is properly determined, the desired interocclusal distance must be incorporated in it. It is generally agreed that some patients require more interocclusal rest distance than others. Because this factor is based on professional judgment, the inexperienced dentist is greatly handicapped when using the rest position as a reference point for establishing the ideal occlusal vertical relation for an individual patient."

Basler, Douglas and Moulton (1961) performed a cephalometric analysis of the swallowing technique against others (tactile muscle sense, phonetics, aesthetics) and found insufficient difference between the techniques to set one apart. Ward and Osterholtz (1963) concluded

that swallowing should only be used as a guide and advised that dentures should be removed for some time before measuring to obliterate neuromuscular memory. Ismail and George (1968) found that by measuring before and after extraction the technique produced an increase in OVD between 0 and 5mm (median 2.8). A study by Millet *et al*. (2003) concluded that the swallowing technique is reliable in the evaluation of OVD in edentulous patients. Alhajj *et al.* (2017) noted that this technique relies upon the consistency of the mandibular movement pattern throughout life. However, Čimić *et al*. (2015) concluded that due to subject variability swallowing cannot be recommended as the only method for determining OVD, but only as an auxiliary method.

Alhajj *et al.* (2017) commented on the use of post-extraction phonetics and noted that with linguistic differences this would be difficult to generalise for a wide population and also the patient could find it difficult to maintain mandible position for measurement.

Alhajj *et al.* (2017) also commented upon the use of the open-rest technique and concluded that despite the authors claims, “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”.

Turrell (1972) developed the use of facial aesthetics and noted that it does not work well if skin tone is poor, if resorbed denture-bearing tissues preclude full restoration of lip contour, or with mouth breathing patients or those with degrees of incompetent lip morphology – in these cases a different method must be used. Alhajj *et al.* (2017) indicated that the ideal OVD is associated with unstrained face with lips in slight contact. A strained face suggests excessive OVD and dropped corners of the mouth, reduced OVD. They concluded that though the aesthetic technique works in young/middle aged patients with good skin tone, it is otherwise not reliable and should only be used in adjunct with others.

On the use of cranio-facial measurements, Misch (2000) stated that such measurements offer significant prosthetic advantages but with so many measurements available the clinician should take the average of 5 or more to establish a tentative OVD and then validate using other techniques. Alhajj *et al.* (2017) questioned the reliance on soft tissue measurements and did not recommend the use of such measurements as a sole method.

Tripathi *et al*. (2019) performed a study of various correlations between thumb and finger length and rejected the idea that there is no correlation, however found that there were

inconsistencies and variations and that more research needs to be carried out on a larger sample size over a wider geographical area.

Edwards *et al*. (1993) measured OVD on cephalometric images and found the analysis of OVD was not reliable with an average alteration of OVD of 8.4mm. Another study (Orthlieb, Laurent and Laplanche, 2000) observed a large variation in cephalometric measurements. These findings suggest that cephalometric images cannot be used to precisely determine OVD. A study by Morais *et al*. (2015) concluded that cephalometric analysis is a useful tool but should not be used alone, and also warned that regional population reference is needed to calculate linear discrepancies. Alhajj *et al.* (2017) commented that the technique in general seems to be accurate but relies on a radiographic setup not available to most dentists and involves radiation exposure. A study by Enkling *et al*. (2018) tested the use of cephalometric analysis and concluded that "the determination of the OVD through analysis of a lateral cephalograph is not recommendable to be a standard diagnostic parameter, as the accepted variations of the norms are too large". Orthlieb, Laurent and Laplanche (2000) determined that there is no perfect method and the use of statistical formulae applied to cephalometric analysis is not a very accurate science.

Alhajj *et al.* (2017) discussed using the old denture and commented that the old denture is of little use if the denture is worn and there is a need to re-establish OVD. However, for patients with severely worn dentures, the ideal OVD can be established via an 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.

The tactile sense technique seems to be very useful in conjunction with other methods but Alhajj *et al.* (2017) commented that techniques using devices such as screw jacks may affect accuracy or oral perception. This would apply to the use of any diagnostic device.

On the use of the 'biting force' technique, Shpuntoff and Shpuntoff (1956) found that muscles tense when any device is placed in the mouth. Boucher, Zwemer, and Pflughoeft (1959) investigated the technique and concluded that the registration of closing force with the Boos Bimeter cannot be classed as an objective method for determining vertical dimension. A study by Tueller (1969) seemed to support the method but Turrell (1972) highlighted errors of 9mm and more and suggested the method should not be used.

Willie (1958) did a survey to establish most common methods of determining OVD. Most popular were aesthetic appearance and phonetics. Swallowing and tactile muscle sense were next in popularity. Willis measurement and Boos Bimeter were in the minority.

In addition to stressing the need for an accurate scientific method, Turrell (1972) summarised that when no accurate pre-extraction records exist the dentist must rely on aesthetic appearance supplemented by aids which are often misleading.

Alhajj *et al.* (2017) reviewed many techniques and found great controversy and diversity in the measuring methods and concluded that though the physiologic rest position is the most commonly used method for establishing OVD, it is still vulnerable to error and using a combination of methods is recommended to overcome the limitations of each individual technique.

A study by Oancea *et al*. (2020) concluded that in the absence of teeth or of any pre-extraction records the establishment of OVD is arbitrary and several methods need to be used simultaneously to reach a final decision.

In assessing the many techniques available it is clear that most of the methods have some value and some are more reliable than others. However, no single method stands out and none would work for every patient, every time.

In the absence of pre-extraction records the most widely used starting point appears to be the use of the physiologic rest position as initially proposed by Niswonger (1934). However, doubts cast upon the legitimacy of subtracting the arbitrary distance of 3mm mean that this should never be relied upon alone. The experienced dentist should therefore be familiar with several of the better proven techniques and validate the initial starting point using two or more other techniques such as swallowing, phonetics, or aesthetic appearance. The OVD should then be confirmed by the patient using tactile sense techniques.

IV. CONCLUSION

There is no universally accepted scientific method for determining OVD in edentulous patients. Pre-extraction records are valuable in re-establishing an ideal OVD, however when no such record is available then the prosthetic dentist must rely on some combination of other techniques. As no single technique stands out above others then the dentist should familarise themselves with a number of the more reliable and well-tried methods.

Even if pre-extraction records are available it is wise to validate the recorded OVD with one or more post-extraction techniques.

In the absence of pre-extraction records a widely used post-extraction technique such as the physiologic rest technique (or open rest technique) could be used to suggest a tentative OVD and this could be confirmed using other techniques such as aesthetics, phonetics or swallowing.

In either case, before final fabrication of the denture, the tactile sense technique should be applied to establish how it feels to the patient.

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