Occlusal vertical dimension: treatment planning decisions and management considerations

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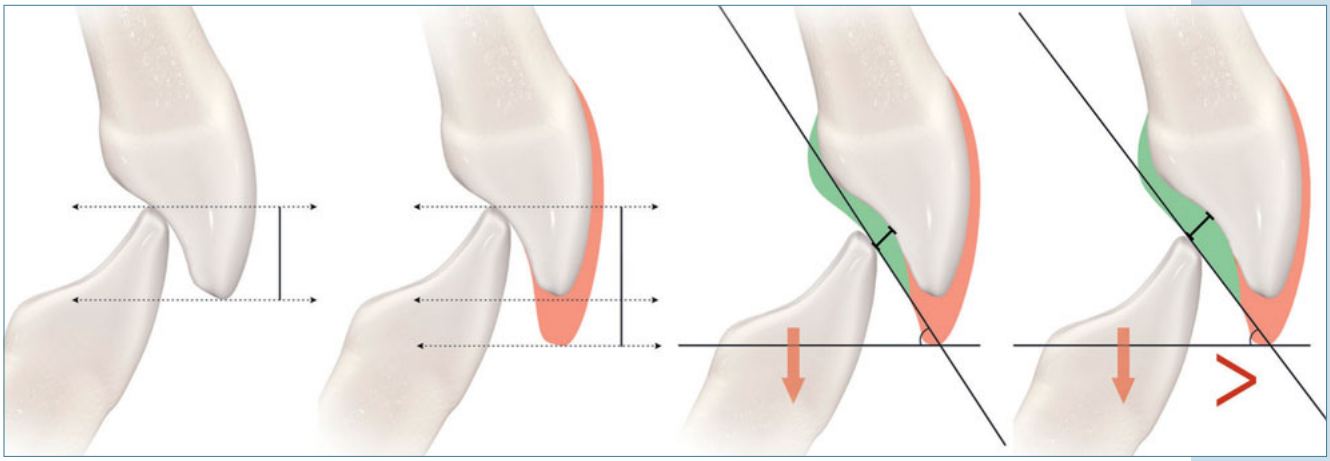

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Abstract

Changing the occlusal vertical dimension (OVD) has been one of the most controversial issues of restorative dentistry. The modification of the OVD may be indicated whenever it is necessary to harmonize dentofacial esthetics, provide space for planned restorations, and improve occlusal relationships. The OVD should not be considered an immutable reference, but rather a dynamic dimension within a zone of physiological tolerance that can be altered as long as the dentist respects the envelope of function. However, vertical changes in the relationship between the maxilla and mandible may have some biological, biomechanical, esthetic, and three-dimensional (3D) functional implications because the initial references of maximum intercuspation and anterior tooth relationships must be reconstructed and adjusted in a new dimension of space. This article aims to present a critical review of the relevant OVD literature and provide the clinical objectives and subjective parameters necessary to guide the clinician and laboratory technician during treatment involving OVD alterations.

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Introduction

Changing the occlusal vertical dimension (OVD) has been one of the most controversial issues in restorative dentistry for a long time. Many of these controversies have been empirically grounded in articles, some published almost 100 years ago, that thus far have not been scientifically validated.

OVD is of extreme relevance because it must be managed by every dentist when performing extensive restorative treatments. Vertical changes in the relationship between the maxilla and the mandible have biological, biomechanical, esthetic, and three-dimensional (3D) functional implications, as the initial references of maximum intercuspation and anterior tooth relationships must be reconstructed in a new dimension of space. Although the literature has shown it to be a safe procedure when properly indicated and performed,[1-8] problems can potentially occur. Due to the irreversibility of some procedures, the complexity of the work involved, and the financial aspect of this type of treatment, the clinician must have a compelling reason to change the OVD from a restorative perspective.

This article critically reviews and objectively discusses the OVD literature with the aim of proposing a treatment rationale to guide clinicians in the oral rehabilitation of dentate patients.

Literature review

Most articles retrieved when searching for 'OVD' related to treatment with complete dentures, with different techniques being recommended for the increase or 'restoration' of the OVD.[9-27] On the other hand, the reduction of the OVD itself has limited indications that relate to cases of skeletal discrepancies such as vertical maxillary excess or anterior open bite, or when there is a need to replace existing dentures or extensive rehabilitations in cases where the final OVD was not appropriate esthetically or functionally.

Among the most commonly accepted techniques to determine the OVD are the morphological or facial proportions,[9-10] the physiological (based on the physiologic rest position),[11-14] phonetic,[15-18] and cephalometric.[19,20] As none of these techniques has been shown to be sufficiently consistent and accurate to be used alone,[21] the clinician should understand their principles and make use of an association of them to ensure greater accuracy in accordance with the patient's case requirements.

In 1928, Turner and Fox[9] recommended that the OVD be determined according to the external appearance of the face, with reference to the conformation of nasolabial folds, the harmony between the lower third and the other thirds of the face, and consistency with the patient's age. Willis,[10] in 1930, suggested that the distance from the outer corner of the eye to the labial commissure was equal to the distance from the base of the nose to the chin, and developed the Willis caliper for such measurement. Niswonger,[11] in 1934, proposed the use of free functional space (FFS) to determine the OVD. In 1951, Pleasure[13] also stated that the physiological rest position provides a stable reference for obtaining the OVD, whereby the average FFS was 3 mm between the maxillary and mandibular teeth, with the mandible at rest. Silverman,[15] in 1951, suggested that the OVD be determined by phonetics. According to this author, the evaluation of the mandibular position during the pronunciation of certain sounds would identify the smallest vertical dimension of pronunciation. Pound,[18] also in 1951, reported that phonetic tests were auxiliary methods to obtain a reliable functional and esthetic diagnostic. He suggested the adoption of the 's' sound, based on the fact that the jaw had a memory of the vertical and

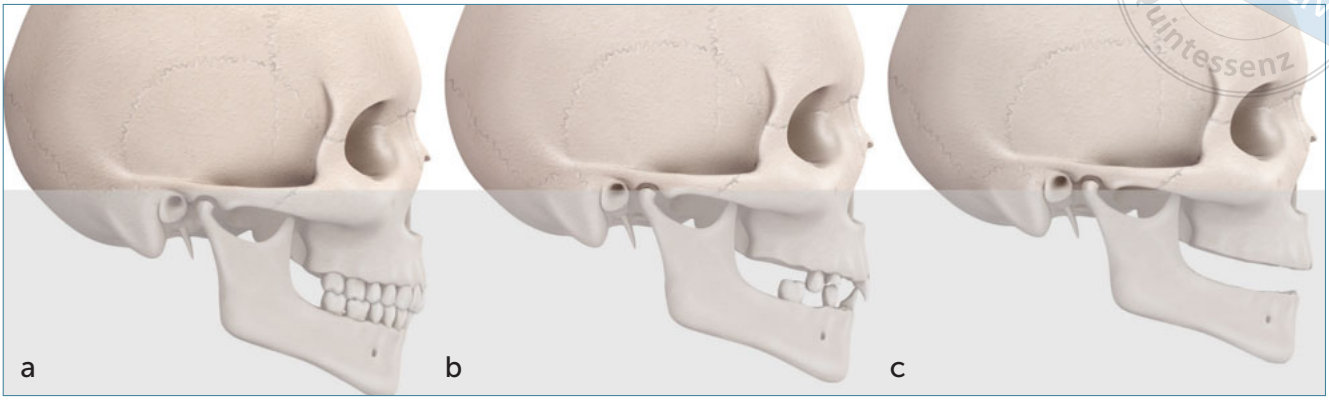

Fig 1 Etiology of a real loss of OVD. (a) Dentate patient with no signs of tooth wear. (b) Posterior bite collapse: loss of OVD depends on the amount of lost posterior support. (c) Edentulous patient: loss of OVD is inevitable and evident.

horizontal position when the patient was pronouncing the 's' sound during phonation. Shanahan,[14] in 1955, proposed to use salivary swallowing as the basis for the establishment of the mandibular occlusal positions. In 1954, Pyott and Shaeffer[19] considered the validity of using radiographs to measure the OVD. The cephalometric analysis would also provide the ideal occlusal plane orientation and position of the anterior teeth.[20] In 1962, Nagle and Sears[22] stated that OVD is not static throughout life, and that it reflects the patient's period of growth, development, and maturity. Rivera-Morales and Mohl,[2] in 1991, concluded that as with any measurable biological aspect, the OVD should not be rigid, specific, and unchangeable.

In 2000, Misch[23] pointed out that the vertical dimension of rest is not a stable and accurate parameter, and depends on several factors such as head posture, emotional state, time of day, presence or absence of teeth, and parafunction. In 2006, Spear[24] noted that using an occlusal splint for a period of time to assess the viability of a new OVD is not valid because the splint lacks natural contours, does not provide maximum stability, and interferes with phonetics, although it may be useful for deprogramming the neuromuscular system and determining the maxillomandibular relationship.

From the literature review it is important to highlight that many authors have stated that from a clinical perspective there is no single static and immutable OVD position, but instead a vertical range of possible OVDs,[21,25,26] called the comfort zone.[27]

Discussions about the reestablishment of the OVD, and to what extent this should occur, have a long history in dentistry. The clinician should be aware that wear on the anterior dentition does not necessarily indicate a loss of OVD. In most cases (Angle Class I and Class II patients), the anterior teeth wear out when the patient protrudes the jaw and makes movements of attrition in this position, often due to dysfunctional or parafunctional activities. Angle Class III patients usually exhibit anterior tooth wear because the edge-to-edge relationship predisposes them to it. The incisal edges gradually wear out and the mandibular position tends to be subsequently positioned in the anterior direction.[28] A severe degree of attrition of the anterior teeth is required so that the posterior teeth are also compromised, and real loss of OVD could occur. Clinically, to confirm this loss, one should observe the

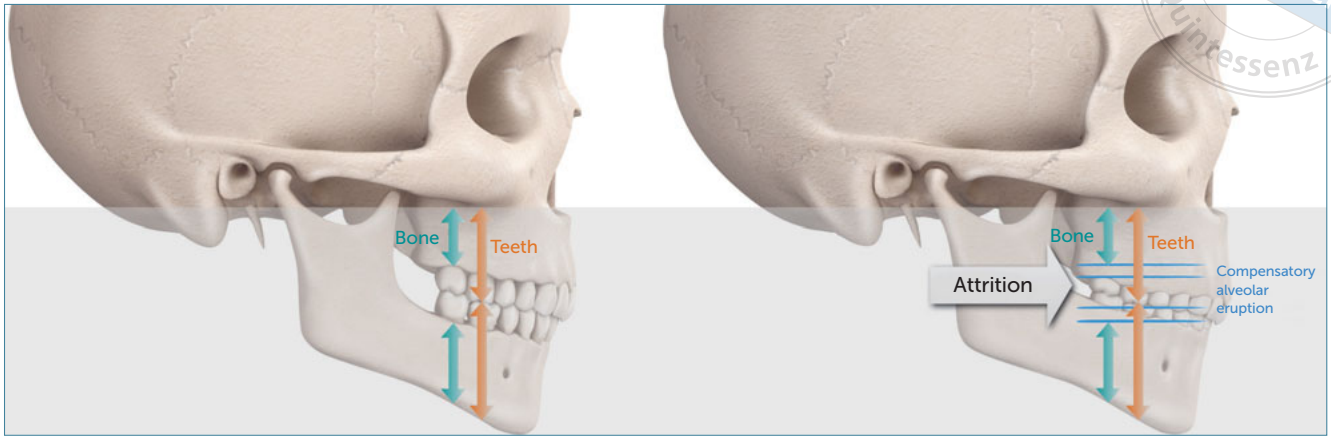

Fig 2 Illustration of the biological mechanism of tooth attrition compensation by dentoalveolar eruption.[30,31]

condition and position of the posterior teeth, as they are responsible for maintaining the OVD. In general, if they are well positioned with minimal signs of attrition, it is unlikely that a loss of OVD has occurred. On the other hand, in cases with posterior bite collapse or in denture wearers, loss of OVD is common (Fig 1).

Murphy,[29] in 1959, reviewed the then current philosophies about the loss of OVD. He noted that different authors measured the loss of OVD using different methodologies and with no consensus to establish the most appropriate method. The dynamic nature of the dentoalveolar complex has long been recognized,[30,31] but it is complicated if not impossible to clinically quantify the amount of compensatory eruption that has occurred (Fig 2). Berry and Poole,[32] in 1976, related the actual loss of OVD to the rate of wear, proposing that the loss occurs only when the degree of wear is higher than the body's ability to promote compensatory dentoalveolar eruption. Despite a coherent theoretical explanation, its clinical occurrence is difficult to estimate. In these authors' opinion, diagnosing the loss of OVD is a secondary aspect to the need to alter it for restorative reasons; it is not a process to search for a predefined ideal OVD or the reestablishment of a previous one, but to design a new dimension that satisfies the patient's esthetic, biomechanical, and functional needs.

Another aspect that interferes with the diagnosis of the alleged loss of OVD is a patient's age. In elderly patients, the effect of cellular aging causes loss of support and texture of the skin and lips, impairing the visualization of the maxillary worn teeth. When treatment is indicated for dentures or full-mouth, implant-supported rehabilitations, where it is possible to significantly increase OVD, reposition the orofacial musculature, and provide lip support by altering the position of the artificial teeth, a pronounced effect of facial rejuvenation can be obtained. However, for dentate patients, this benefit may be limited by the possible interference in anterior teeth relationships, as is discussed later in this article.

In order to offer parameters for predictively managing the OVD safely, four main points are discussed below:

1. What are the reasons to change the OVD?
2. Will it increase the patient's functional or biomechanical risks?
3. How does one determine the magnitude of the alteration?
4. How does one clinically perform the change?

What are the reasons to change the OVD?

The primary indications for changing the OVD are: a) harmonizing dentofacial esthetics; b) providing adequate space for the restorative material; and c) improving incisal and occlusal relationships.

Harmonizing dentofacial esthetics

Exposure of the anterior teeth with the lips at rest and during smile needs to be carefully evaluated and planned, as tooth display has a significant impact on the appearance of the smile. The position of the incisal edges will greatly influence the functional relationships; the more the incisal edges are lengthened, the greater the amount of OVD increase required because the new position and shape of the teeth must not interfere with the envelope of function (the 3D space contained within the envelope of motion that defines mandibular movement during masticatory function and/or phonation).

However, increasing the OVD alone frequently cannot provide a noticeable improvement in patients' facial harmony from the dentist's perspective. Gross et al[33] evaluated dentists' ability to observe esthetic improvements in relation to the face according to the increase in the OVD. These authors concluded that their colleagues were not able to verify alterations of up to 6 mm, whereas it can be difficult to establish good occlusal relationships with an increase of this magnitude for dentate patients.

Providing adequate space for restorative material

The increase of OVD is a great ally for restorative treatment as it can generate space to reestablish the occlusal morphology and for the planned restorative material, often permitting an additive treatment in patients with structural loss due to tooth decay, fracture, attrition, erosion or abrasion. The development of materials with adequate strength, accompanied by the principles of adhesion to different substrates, allows the preparations to be minimally invasive. There is no indication today for generalized endodontic treatment and posts to obtain retention and stability, as there was in the past. This methodology made the treatments extremely complex and costly, both biologically and financially. Additive treatment must be carefully planned and tested with temporary restorations (adhesive mock-ups or provisionals) to evaluate the patient's individual adaptability. Fixed and physiologically contoured restorations are advisable because they permit a realistic clinical evaluation of the proposed OVD changes. Removable prostheses and occlusal splints fail to provide an accurate assessment due to instability and non-physiological contours that may interfere with comfort, function, and phonetics.[24]

Improving incisal and occlusal relationships

It is essential to understand that by increasing the OVD a new occlusion should be reorganized somewhere in space, improving pretreatment 3D relationships such as overbite, overjet, functional pathways, and the direction of loads on teeth. Therefore, function will be directly related to esthetics. The clinician will have to wisely negotiate between the amount of maxillary incisal edge lengthening with lingual contour and the proper angle of the functional pathways in order to diminish the restorative risks. Gurel et al[34] concluded that the risk of failures could increase by 2.3 times in cases of incisal edge lengthening. The rationale about the integration of function with Smile Design is discussed later in this article.

Fig 3 It is essential to equilibrate the occlusion in the new OVD. This is paramount to providing occlusal stability and comfort.

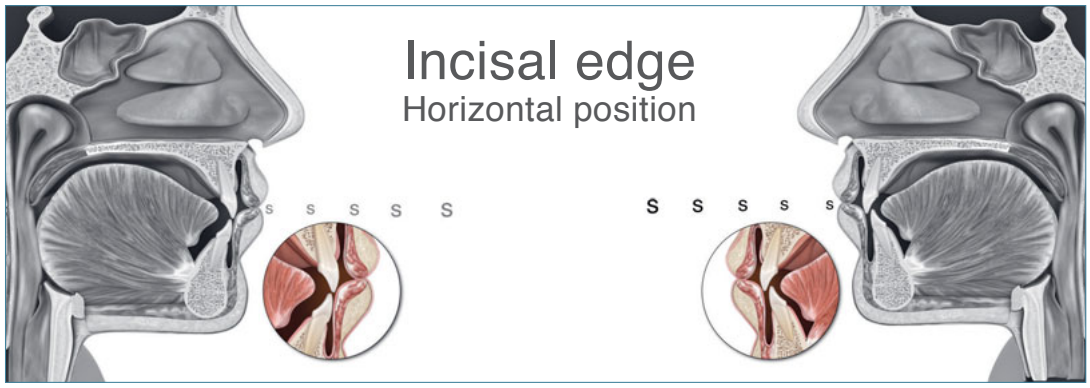

Fig 4 The 3D position of the maxillary incisal edges and its correlation with the mandibular anterior teeth is critical for the correct flow of air and phonetic resonance, especially during the pronunciation of the 's' sound.

Will it increase the patient's functional or biomechanical risks?

Many articles and systematic reviews conclude that OVD alteration is a common and safe procedure once the clinician understands and respects some individual variables. Abduo[6] concluded that, whenever indicated, a permanent increase of the OVD of up to 5 mm is a safe and predictable procedure without detrimental consequences, and that the associated signs and symptoms are self-limiting, with a tendency to resolve within 2 weeks. Moreno-Hay and Okeson[7] stated that the stomatognathic system has the ability to adapt rapidly to moderate changes in the OVD. In some patients, mild transient symptoms may occur, but mostly they are self-limiting and without major consequences. These authors found no indication that permanent OVD alteration produces long-lasting temporomandibular dysfunction (TMD) symptoms. Many other articles[1-3,5,7,23,35-46] have reported the effect of OVD alterations on the temporomandibular joints (TMJs), the neuromuscular system, the teeth, and phonetics. The majority of these studies concluded that the effects on the abovementioned structures were well accepted once the new 3D position is maintained from healthy, adapted, and stable TMJs; once the interocclusal contacts are bilateral and simultaneous and the teeth are receiving axial loads (Fig 3); and once the position of the anterior teeth permits adequate phonetics and a path of closure into the new 3D position (Fig 4).

How does one determine the magnitude of the alteration?

An aspect frequently overlooked in the literature is the differentiation of OVD alteration in edentulous and dentate patients. When

Fig 5 The rehabilitation of edentulous patients goes beyond determining a convenient OVD. The esthetic and functional results depend on the repositioning of the oral musculature and tongue, according to the neutral zone.[47]

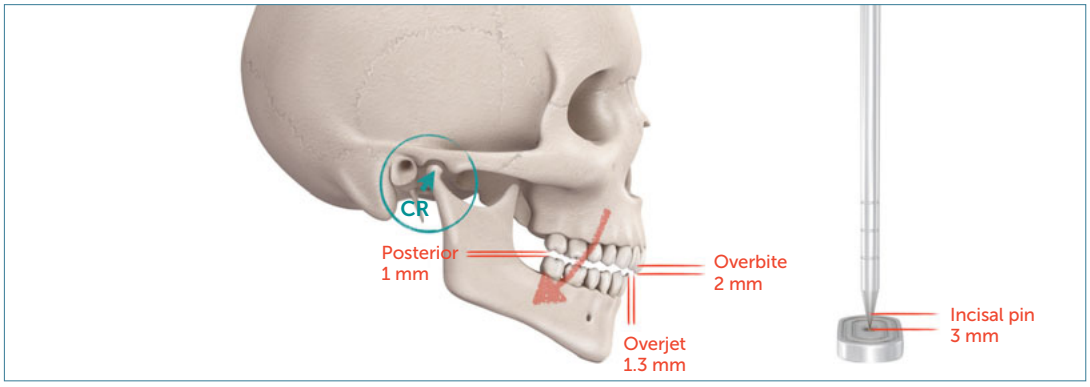

Fig 6 Calculation of the alteration of vertical and horizontal occlusal relationships when planning OVD change.[48]

treating edentulous patients there are fewer clinical reference points because the dental elements are not present, and normally there is a deformation or loss of supporting structures. In these cases, the observation of facial harmony and muscular repositioning while working with wax rims is essential. Thus, with edentulous patients there is greater flexibility for setting up the teeth, since the arrangement of the artificial teeth can be adjusted three-dimensionally on the base, improving or correcting the anterior and posterior relationships (Fig 5). In this scenario, not only is the OVD being increased, but also artificial teeth are being repositioned, along with the cheeks and lips in the horizontal and vertical direction in accordance with the patient's individual esthetic and functional needs and within the limits of the neutral zone.[47]

However, there are several limitations that must be considered when managing the OVD in dentate patients. The relationship of the anterior teeth changes significantly with the increase of the OVD. Depending on the patient's facial morphological type, on average, for each 1 mm that the OVD is vertically increased at the second molars, the overbite decreases about 2 mm, and the overjet increases about 1.3 mm in the incisors. For this example of 1 mm of change, the incisal pin of the articulator used in the experiment increased vertically by 3 mm. This is called a 1:2:3 relationship[48] (Fig 6).

Depending on the patient's Angle classification, the increase of OVD can improve or worsen the arch relationship. Therefore, an important restriction to a significant OVD increase exists, since the lingual surface of the anterior teeth may become too thick to provide proper anterior contacts and physiological contours. For instance, according to this rule,[48] if the goal is to increase the OVD by 6 mm at the incisal pin

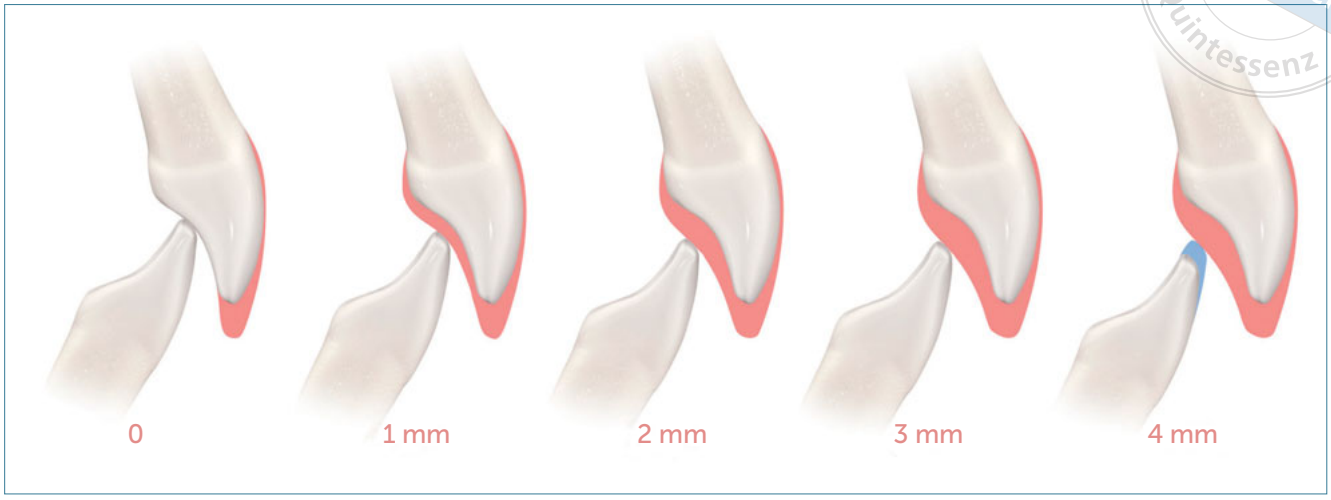

Fig 7 Lingual anatomical modifications according to the increase of OVD. If there is a need to significantly increase the OVD, the lingual morphology may become bulky and create comfort and phonetic issues. It is also possible to add length onto the mandibular incisors to obtain anterior contacts with the new OVD, but esthetics should be carefully analyzed because elderly patients have usually undergone loss of lip support and have enough mandibular anterior tooth display.

for Angle Class I patients, the lingual surface of the anterior teeth would be approximately 4 mm thicker in the vertical direction, resulting in probable problems of esthetics, function, comfort, and speech (Fig 7). If patients are Class II, the situation becomes even more severe, making it almost impossible to provide proper and stable contacts on the anterior teeth because the rotation of the mandible also increases the overjet. On the other hand, it would be helpful for compensating Class III patients in order to uncross the anterior bite. In the authors' opinion, the 'prosthetic compensation' should be used as a last resort because there are compromises associated with every compensation (Fig 8). Whenever indicated, orthodontic and orthognathic treatment should be proposed.

Depending on the treatment goals, the clinician should determine the OVD that satisfies the patient's esthetic, biomechanical, and functional needs with a minimally invasive approach. The smaller the change in OVD, the less the need for an adaptive response from the stomatognathic system.[47]

How does one clinically perform the change?

There is no one single recipe or panacea that provides an ideal and immutable position for OVD modification. Utilizing the concepts and parameters discussed in this article, the authors propose a clinical system that provides adaptability, comfort, and stability in relation to the biological, biomechanical, functional, and esthetic principles in the restored cases.[49] The proposed sequence should consider the factors and steps outlined below.

Mounting the casts in the articulator

After a complete clinical examination, the study casts can be mounted in the articulator utilizing the Kois Dento-Facial Analyzer[50] or a facebow, or by following the Smile Design guidelines.[51,52] Whenever casts are being mounted in the articulator for complex cases, it is fundamental to take the maxillomandibular registration in a clinical reproducible reference position such as centric relation or adapted centric posture.[47] In the

Fig 8 The increase of OVD can improve or worsen the arch relationship, depending on the patient's Angle classification.

authors' opinion, the use of an anterior occlusal device such as the Kois Deprogrammer[53] can effectively erase the previous patient's engrams and permit the elevator muscles to seat the condyles appropriately, providing a reliable and stable anterior stop that also facilitates the registration with proper materials or with the intraoral scanner. The Kois Deprogrammer can be made with acrylic resin at the dental laboratory or it can be digitally manufactured from milled blocks of polymethylmethacrylate (PMMA) or printed with a 3D printer (Figs 9 and 10).

Evaluation of the 3D maxillary teeth incisal edge position in relation to the face and lips

This concept has been used for more than 100 years for denture fabrication, but was revisited by Spear[54] to plan the treatment for dentate patients. Although there are certain parameters to be considered for Smile Design,[55-57] this step is technique sensitive and mostly relates to the dentist's ability to three-dimensionally position the incisal edges of the anterior teeth to provide lip support and the appropriate display, with the lips both at rest and during smile (Fig 11).

Evaluation of the 3D mandibular teeth incisal edge position in relation to the face and lips

The mandibular incisal and occlusal plane should then be addressed in relation to the face, as well as the functional needs to be dictated by the desired position of the maxillary teeth. All the required alterations should be incorporated in the treatment plan.

Integrating the function into esthetics

The process to be described is key and can be executed manually or digitally with scanned teeth or models in the virtual articulator with design software. On the study models, initially only the buccal faces of the maxillary teeth are waxed-up following the patient's needs and dentist's considerations in relation to tooth morphology and occlusal plane alignment according to the patient's face.[51,52] For additive cases, before going to the next step, it is recommended

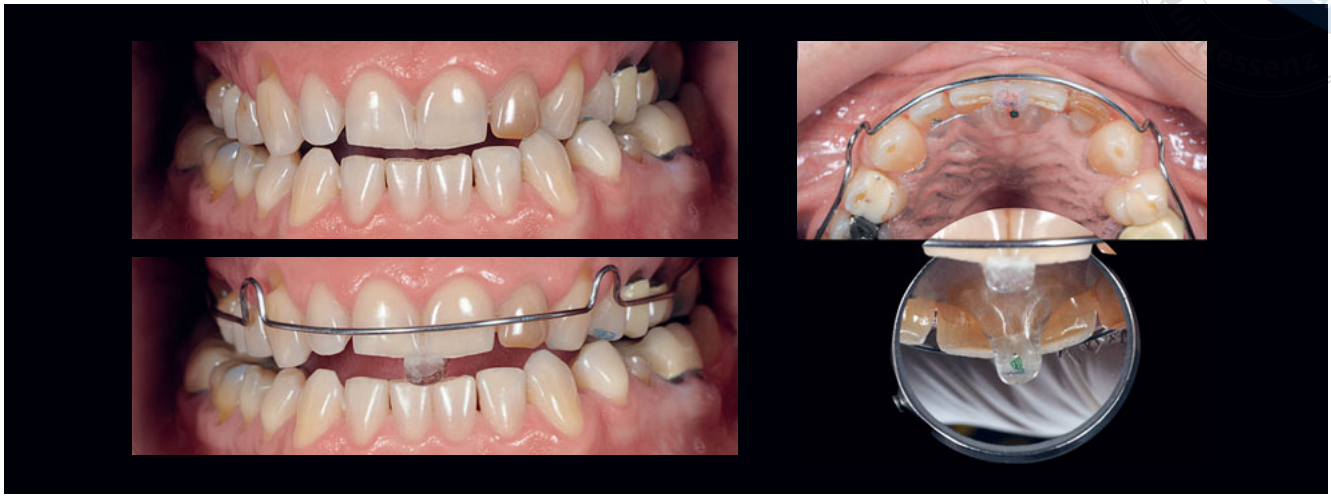

Fig 9 The Kois Deprogrammer providing a reliable and stable position to register the centric relation or adapted centric posture.

Fig 10 The digital Kois Deprogrammer milled from a block of polymethylmethacrylate (Ceramill PMMA; Amann Girrbach).

Fig 11 Facially driven treatment planning,[49,54] oriented by the Digital Smile Design.[51,52]

to make a clinical mock-up from this buccal wax-up through the use of a silicone index or acetate matrix. The position, shape, and harmony of the incisal edges and maxillary occlusal plane alignment are evaluated by the dentist and the patient. If corrections are necessary, they would best be performed at this point because any alterations would influence the required OVD and the forthcoming decisions needed to complete the wax-up (Figs 12, 13, and 14).

Once the incisal edge lengthening has been clinically tested, adjusted, and approved, the final decision about the need and amount of OVD change can be made. With the casts mounted in the analog or digital articulator, what needs to be analyzed is how the occlusion will be reorganized according to the new position of the incisal edges. If the amount of the lengthening of the incisal edges is such that the new tooth position does not interfere with the functional path, then no change in the OVD for functional reasons is required (Fig 15). However, when the maxillary incisal edges are significantly lengthened they can interfere with the envelope of function, and it is paramount to evaluate if it is more appropriate to open the OVD or to orthodontically realign, reshape or restore the antagonists in the anterior region to reduce the risks and maintain an envelope of function free of interferences.

When the incisal edges are being lengthened, the lingual contour of the maxillary anterior teeth should also be modified so as not to increase the steepness of the functional pathways or restrict the envelope of function.[58] The angle of the functional pathways is related to the torque on the abutments and shear forces on the restorative material.[59,60] There are no exact parameters for this process of fine-tuning, but in the authors' opinion the OVD increase is directly related to the amount of incisal edge lengthening, based on the geometry of the opening movement (Fig 16). The goal is to provide smooth and

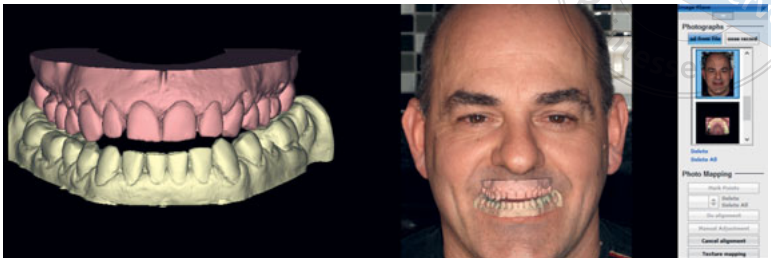

Fig 12 Initial model analysis with models mounted in centric relation at the restorative OVD.

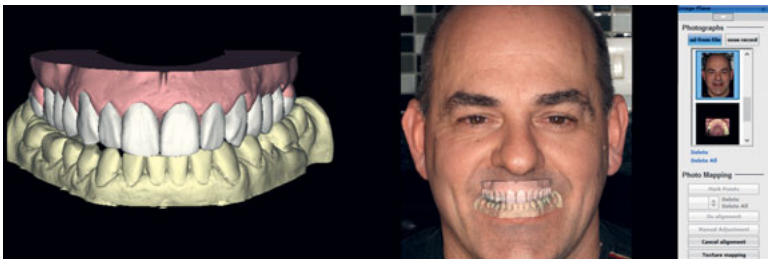

Fig 13 Designing the 3D position of the incisal edges and occlusal plane according to the patient's face, needs, and desires.[49-52]

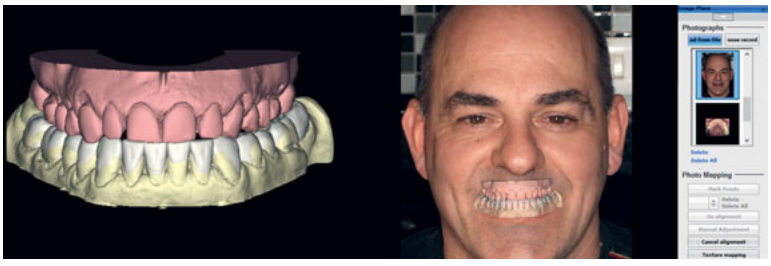

Fig 14 Evaluating and designing the mandibular occlusal plane according to the face and maxillary occlusal plane.

Fig 15 The influence of incisal edge lengthening on the envelope of function. If the position of the incisal edges interferes with the movements of the mandible, the risk of functional or structural issues increases.

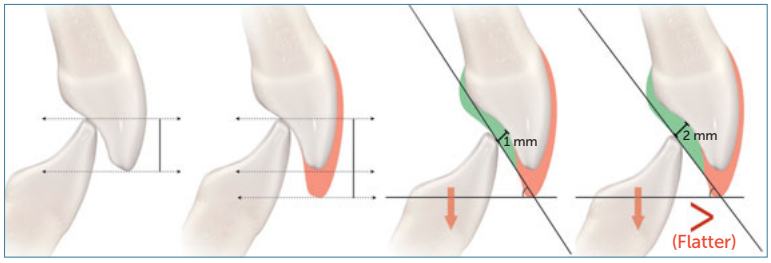

Fig 16 The interrelationship between incisal edge lengthening and the functional pathways. To minimize the risks, the goal is to provide minimal angulation to avoid the restriction of mandibular movements and the presence of posterior interferences during functional movements.

adequate pathways according to the patient's overbite and overjet, avoiding posterior interferences during functional movements.

Posterior occlusal plane design

Once the anterior relationships are determined, the wax-up of the posterior teeth can be finalized. Anteroposterior and laterolateral curves should be incorporated into the occlusal plane to improve functional dynamics, with minimal lateral forces in all excursive and incursive movements (Fig 17).

Recommendations

It is highly recommended that all these alterations to the OVD, position of the incisal edges, and occlusal planes be tested in a reversible and definitive manner such as through adhesive mock-ups or provisionals. The clinician must be confident that all these modifications provide proper masticatory function, phonetics, and comfort before taking irreversible steps such as tooth preparation (Fig 18). After all the abovementioned parameters have been tested and approved, the treatment can be finalized (Figs 19 to 21).

Conclusion

The therapeutically designed OVD should not be considered an immutable reference point but rather a dynamic dimension within a zone of physiological tolerance. In accordance with the literature and the authors' clinical experience, it should basically be considered a flexible parameter that can be modified to meet the clinical goals established by the dentist and the patient.

A clinical demand must be confirmed before the OVD is changed. To be predictable and provide a low-risk outcome, the alteration of the OVD should be the minimum necessary to harmonize dentofacial esthetics, provide space for the planned restorations, and improve the occlusal relationships. Vertical dimension alterations should not provide long-term deleterious esthetic, functional, biomechanical or biological implications, as long as the horizontal components of rehabilitations such as

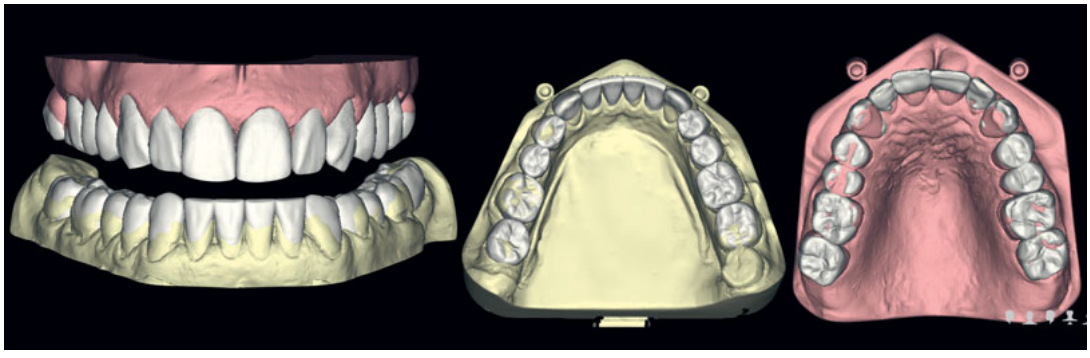

Fig 17 Final digital design of the restorations and occlusal planes.

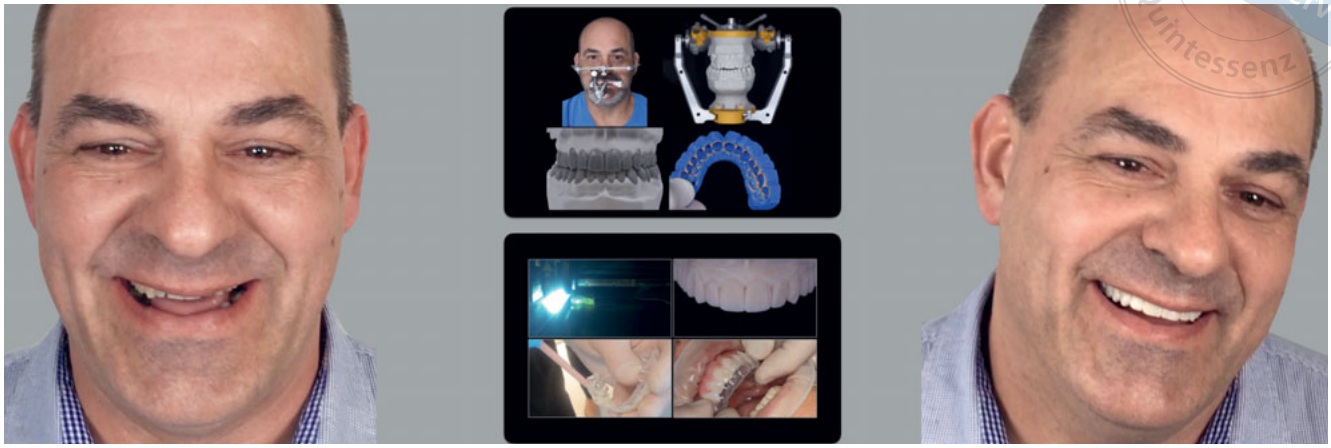

Fig 18 Analog and digital protocols to analyze the esthetic and functional implications of OVD alteration; the same biological principles but different workflows all leading to optimal results.

Fig 19 Prepless adhesive milled PMMA provisionals to test the new esthetic and functional design (VIPI Block Trilux; VIPI Produtos Odontológicos).

Fig 20 Final result after porcelain veneers, onlays, and crown cementation and equilibration (IPS Empress CAD Multi blocks; Ivoclar Vivadent).

Fig 21 Final smile with proper incisal edge position, occlusal planes, and harmonious OVD.

equilibrated and stable maxillomandibular and anterior tooth relationships are respected.

Objective and subjective parameters should be rationally incorporated to minimize the margin of error. Objective parameters are defined by the need to provide a proper thickness for the selected restorative material and establish favorable incisal and occlusal relationships. The 3D position of the incisal edges in the appropriate maxillomandibular relationship will ultimately influence the need for and amount of OVD alteration. Subjective parameters such as facial harmony, speech resonance, and comfort must also be addressed and approved by the patient.

Disclaimer

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