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Original Article

Analysis of coherence between Vertical Dimension of Occlusion (VDO) obtained clinically and through cephalometric analysis. A cross-sectional study

Análise da coerência entre Dimensão Vertical de Oclusão (DVO) estabelecida clinicamente e por análise cefalométrica. Estudo transversal

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Resumo

Introdução: A determinação da Dimensão Vertical de Oclusão (DVO) é um dos requisitos mais importantes na Odontologia estauradora, já que é essencial para a boa estética e função. Entretanto, devido à sua natureza empírica uma combinação de métodos é clinicamente recomendada, e a análise cefalométrica é um dos procedimentos disponíveis. **Objetivo:** O objetivo deste estudo é avaliar a coerência entre a DVO estabelecida clinicamente e a DVO determinada pela análise cefalométrica Seraidarian-Tavano em pacientes completamente edêntulos. **Material e método:** Foram realizados registros em pacientes desdentados totais usando uma combinação de métodos recomendados para determinação clínica da DVO (método métrico, método da deglutição e método da plenitude facial). Com os registros em boca, foram realizadas teleradiografias perfil estando os pacientes em oclusão. **Resultado:** A amostra foi composta por 18 pacientes, 11 mulheres (61.1%) e 7 homens (38,9%) com idade média de 65,8 ± 1,9 anos. Para os 18 pacientes, a média das medidas dos ângulos superiores e médios foram 54,1 e 54,0, respectivamente. Não foi encontrada diferença estatisticamente significante entre os dois ângulos (p 0,772). **Conclusão:** Com base nos dados, parece lícito concluir que a análise cefalométrica aqui testada pode ser um método utilizado para auxiliar na determinação clínica da DVO.

Descritores: Dimensão vertical de oclusão; dentadura; oclusão dental; análise cefalométrica.

Abstract

Introduction: Determining the VDO is one of the most important requirements in restorative dentistry, as it is crucial for good aesthetic and functional harmony. However, due to its empirical nature, a combination of methods is clinically recommended, and cephalometric analysis is one of the procedures available. **Objective:** The objective of this study is to evaluate the coherence between VDO clinically established with VDO determined in Seraidarian-Tavano cephalometric analysis in completely edentulous patients. **Material and method:** Registrations were carried out on completely edentulous patients using a combination of clinically recommended methods (metric method from VDR, swallowing method, and facial fullness method). With the registration in the mouth, lateral cephalometric X-ray images were taken with the patient in occlusion for cephalometric analysis. **Result:** The sample consisted of 18 patients, 11 females (61.1%) and 7 males (38.9%) with a mean age of 65.8 ± 1.9 years. For the 18 patients, the mean measurements of the upper and middle angles were 54.1 and 54.0, respectively. No statistically significant difference was found between the two angles (*p* 0.772). These results show that the VDO considered ideal from a clinical point of view was confirmed by the cephalometric analysis used. **Conclusion:** Based on the data, it seems fair to conclude that the tested cephalometric analysis can be a method used to assist the clinical determination of VDO.

Descriptors: Vertical dimension of occlusion; dentures; dental occlusion; cephalometric analysis.

INTRODUCTION

The VDO refers to the distance between two anatomical or marked points on the lower third of the face (usually one at the base of the nose and the other on the chin) when the teeth are in occlusion[1]. There are multiple clinical methods to evaluate and reestablish the VDO in completely edentulous patients. The facial proportion technique described in 1930 proposes the assessment of VDO by establishing the harmony of the face dividing it into the upper, middle, and lower thirds of the face. It is widely used in association with the facial fullness, phonetic, and swallowing methods. However, these methods are considered empirical and have not been scientifically proven[2]. Therefore, due to the importance and variability of the techniques, it is recommended that the clinical measurement be obtained by the combination of several techniques[2-4].

VDO is understood as dynamic within a tolerance zone. Its modification, when necessary in edentulous and dentate individuals, can affect masticatory function, phonetics, dental aesthetics, and facial profile, requiring physiological rehabilitation to achieve balance and harmony of the lower third of the face[4], with a study[5] that considers the effect to be noticeable not only in the lower third but in the face as a whole.

Some techniques use the vertical dimension at rest (VDR) as a starting point, considering it an unchanging reference. By using VDR and subtracting the free functional space (approximately 3 mm), a reference value for the VDO is determined. However, the assumption of VDR's immutability is debatable. Study[6] describes VDR as a three-dimensional measurement with minimal evidence of change over a lifetime. Yet, aging can lead to a decrease in muscle tone, potentially impacting VDR. Additionally, the value of the functional freeway space (FWS) varies[6], even among different facial types[7].

Given that soft-tissue reference points are unstable and clinical methods tend to be subjective, hard-tissue reference methods have been tested, and software programs have been developed to provide more objective measurements, reducing reliance on professional expertise. However, when comparing the four primary methods proposed by these programs to determine VDO, a study[8] involving 24 dentate patients with satisfactory VDO found that adjustments in height were still required. The study concluded that the methods showed a low correlation with clinical reality.

The technique of cephalometry by angular reconstruction has been considered suitable for estimating VDO in dentate patients[9], showing promising results in denture fabrication[10]. Additionally, specific parameters have been proposed for the Japanese population with posterior tooth loss[11]. However, a study[12] that examined patients rehabilitated with complete dentures, where VDO was clinically established using cephalometry, does not recommend this method as a standard diagnostic tool. The study emphasized that orthodontic standards, derived from dentate populations, may not account for continued facial growth or other confounding factors in edentulous patients, such as facial type.

A pilot study[13] tested a cephalometric method for assessing VDO that is independent of the presence or absence of posterior teeth by measuring facial angles (upper and middle). The study argues that when these two angles are correlated, they determine the lower facial position, making the method suitable in cases where parameters, such as in edentulous patients, are lacking. This method is referred to as the Seraidarian-Tavano cephalometric analysis.

Therefore, given the ongoing controversy on this subject, the objective of this study is to evaluate completely edentulous patients with clinically established VDO positions, to determine whether the proposed method[13] yields correlated results.

The null hypothesis to be tested is that the clinically established VDO, deemed acceptable for each patient, will also be considered acceptable by the proposed cephalometric analysis.

MATERIAL AND METHOD

Patient Selection

This project was approved by the Research Ethics Committee of the Bauru School of Dentistry under CAAE number 46102921.7.0000.5417. Eighteen patients (numbered 001 to 018) were selected at the

Brånemark Institute (Bauru) to undergo implant-supported mandibular rehabilitation with immediate loading and total mucosa-supported prostheses in the maxilla. They were recruited through internal advertising by the Bauru Municipal Health Council, with no additional media publicity.

The inclusion criteria required participants to be 18 years or older, completely edentulous, and eligible for mandibular rehabilitation with full-arch prostheses supported by four implants. Exclusion criteria included patients with signs of allergy or hypersensitivity to titanium, acute infectious or inflammatory conditions, inadequate bone volume or quality, systemic diseases or complications such as bone metabolism disorders, coagulation issues, poor healing, or incomplete jaw growth. Additionally, uncooperative or unmotivated individuals, patients with hypochondria, alcoholism, psychoses, prolonged functional disorders resistant to treatment, xerostomia, immunodeficiency, steroid-dependent conditions, endocrine disorders, poor oral hygiene, and pregnant or lactating women were excluded.

Patients received all information regarding the research and signed the informed consent form.

Prosthetic Preparation Before Surgery

For the pre-existing prostheses, the VDO, seating base lengths, and occlusal and aesthetic relationships were analyzed (Figure 1). In cases where the patient had maxillary and mandibular prostheses and restoration or aesthetic correction of the teeth-lips relationship was necessary, a functional and aesthetic JIG was fabricated using pattern LS acrylic resin (GC AMERICA INC., Alsip, IL, USA) over the upper central incisors. The vertical dimension of rest (VDR) was measured using a Willis bite gauge, and 3 mm was subtracted to establish an initial reference point for the JIG construction.

Figure 1. Initial extraoral images.

The acrylic resin was manipulated and placed on the incisal area of the upper incisors. The patient's mandible was guided to the centric relation (CR) position using a guided, non-forced method. After the material polymerized, measurements were checked, and if necessary, additional material was added, repeating the procedure. If the VDO was considered too high, grinding was performed to adjust the JIG. Once adjusted, the patient was asked to swallow (swallowing method). The patient's facial characteristics were then analyzed following the facial fullness method, with the patient in an upright position without head support.

The VDO obtained was also verified using the phonetic method. Once the recompositing was deemed appropriate, the presence of functional freeway space (FWS) was confirmed, which is the difference between the VDR and VDO. Upon acceptance of the registration, the JIG length was evaluated. Material was added or removed as needed to ensure a harmonious relationship between the JIG length and the lips at rest. To achieve this, the patient was asked to open their lips and rest them naturally, and the length was assessed. Then, a maximum forced smile was requested to evaluate the relationship between the JIG length and the smile line (Figure 2).

Figure 2. JIG produced by determining the desired VDO, CR, and tooth/lip ratio.

After approving the JIG dimensions, two bilateral occlusal registrations were made using the same acrylic resin. Proper peripheral sealing of the complete denture edges was achieved with low-fusion Godiva (Kerr, Kerr Corporation, USA). After applying adhesive to the tray, a functional impression was taken using light silicone (VPS, Neodent, Brazil) with the closed-mouth technique. In cases where the patient lacked one or both prostheses, the ridge was molded, and a test base and wax planes were created on the model. These planes were adjusted in the mouth following the same methodology, and the bases were relined using the same technique. Therefore, the registrations varied depending on the clinical condition (Figure 3). All patients underwent a lateral X-ray with this registration in the mouth and were instructed to be in occlusion (Figure 4A).

Figure 3. Types of registrations: (A) used when the patient had both prostheses; (B) When the patient only had the maxillary prosthesis; (C) when the patient had none.

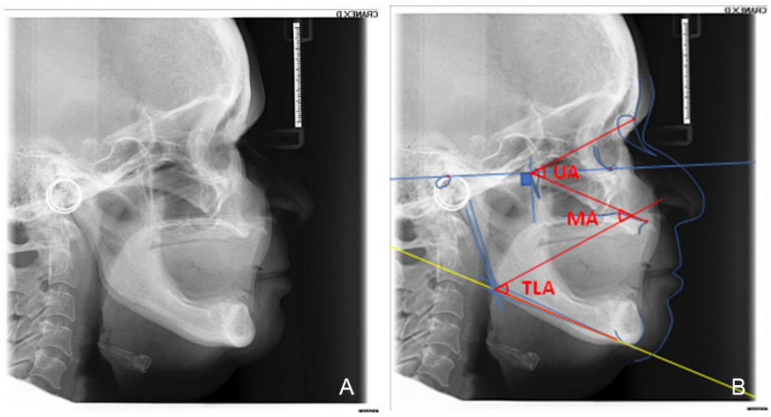

Figure 4. Lateral X-ray obtained in occlusion with the registration completed (A). Cephalometric analysis (B). UA upper angle. TLA – transferred lower angle. MA – middle angle.

Cephalometric Tracing

Lateral X-ray images were taken using the SOREDEX Cranex D device (Tuusula, Finland) at a maximum voltage of 85 kVp and a maximum current of 10 mA, with 8x10 inch AGFA film (Mortsel, Belgium). The radiographs were traced according to the Seraidarian-Tavano technique[13] by a trained professional unfamiliar with the cases. Anatomical structures such as the frontal bone,

orbit, palate, mandible, maxilla, zygomatic, and nasal bones were traced, along with the external auditory meatus and the pterygomaxillary fissure. Key points were marked, lines and planes were drawn, and cephalometric angles were calculated. When correlated, these angles determine the upper, middle, and lower thirds of the face. The following were established: the upper third angle (UA), the transferred lower angle (TLA), which is the transfer of the center of the UA angle (Na – CF – ENA) to the Goc point along the lower line of the mandibular plane, and the intersection of the upper line of the TLA with the lower plane of the UA (CF-ENA plane), generating a third angle, called the middle angle (MA) (Figure 4B), as outlined in the study methodology[13].

Statistical Analysis

The data for the upper and middle angles were recorded for each patient, and the average measurements were calculated. Statistical analysis was performed to compare the measurements of the upper angle (UA) and middle angle (MA) for each participant. The data were subjected to analysis of variance (ANOVA), and a paired t-test was used to compare the two angles.

RESULT

This study included 18 patients, with a mean age of 65.8 ± 1.9 years, comprising 11 female patients (61.1%) and 7 male patients (38.9%). The values for the upper and middle angles ranged between 47° and 61°, with the mean upper angle being 54.1° and the middle angle 54.0°. Individual patient data are presented in Table 1.

Table 1. Values of the upper and middle angles (in degrees) obtained through Seraidarian-Tavano cephalometric analysis in each patient and mean values.

age	sex	upper angle	middle angle
		T1	T1
57a1m	F	50	48
61a8m	F	50	49
53a8m	M	56	56
75a1m	M	60	60
77a9m	M	59	59
61a3m	F	53	53
71a7m	F	52	53
56a11m	M	47	47
71a8m	M	52	52
74a6m	F	55	55
58a9m	M	52	52
73a9m	F	59	60
55a9m	F	54	55
66a5m	F	54	53
68a10m	F	50	50
54a1m	M	54	54
72a10m	M	56	55
72a10m	F	60	61
		54.1	54.0

* T1 – initial radiograph

In the statistical analysis comparing the upper and middle angles for each patient, no significant difference was found between the two. The paired t-test was used for this comparison, with a 95% confidence interval. The results are shown in Table 2.

Table 2. Statistical comparison for the upper and middle angles (paired *t*-test). SD – standard deviation; SE – standard error; Diff – Difference.

	n	mean	SD	Min	Max	SE	p	Diff-mean	Diff-SE
Upper angle	18	54.1	3.76	47	60	0.887	0.772	0.0556	0.189
Middle angle	18	54	4.13	47	61	0.974			

DISCUSSION

The vertical dimension of occlusion (VDO) in centric relation (CR) position for the edentulous patients in this study was determined by trained professionals using the clinical method, which involves the combination of several techniques that have been recommended for many years[2-4,6,14]. The results were then compared to the cephalometric analysis method proposed by Serainadan-Tavano[13]. Correlations were found between the upper and middle angles for all 18 patients, indicating that the clinical method was effective in determining VDO. This supports the idea that clinical methods can be reliable when a well-planned treatment approach is adopted[6,15,16].

Moreover, the cephalometric analysis used here could serve as a valuable tool in VDO planning for patients with vertical discrepancies in terminal dentition[15], as the study[13] suggests VDO is acceptable when the two angles are equivalent. When clinical registrations are challenging or impractical, this cephalometric method can offer an alternative, as corroborated by previous findings[10]. The cephalometric method may also be particularly useful in determining VDO for patients with neuromuscular issues, uncooperative patients, or those with conditions requiring reduced chair time. Additionally, it can help estimate VDO for patients with terminal dentition and long facial profiles, assisting in reducing the lower third of the face[15].

The challenge of determining the correct VDO in patients with missing posterior teeth is well recognized[11], and no clinical method is considered scientifically definitive for establishing an ideal VDO for prosthetic treatment[2]. The existence of a "comfort range" is often noted when determining VDO in rehabilitations[9]. As such, the use of temporary prostheses to restore function and aesthetics in the early stages of treatment is recommended before placing definitive prostheses[14], although this cautious approach is not always possible when creating complete dentures. However, in this study, trained professionals used a variety of clinical methods to achieve good rehabilitation of the lower third of the face, demonstrating that satisfactory results can indeed be achieved through clinical methods, as supported by other studies[6,15].

The JIG used both as a deprogrammer and for registering VDO, CR, and aesthetic relationships with the lips, proved to be an effective tool. Similar techniques have been previously described[16]. For recording the CR position, a guided, non-forced manipulation technique with hand support on the chin was used. Studies suggest that there are no significant differences between various manipulation techniques[17,18]. While clinical methods are generally reliable, soft tissue reference points are unstable, which is why hard tissue points have increasingly been used to enhance measurement accuracy[8,10].

Various techniques using lateral teleradiographs have been described, and cephalometric methods for determining VDO differ. Some methods focus on the relationship between mandibular shape (gonial angle) and the height of the lower third of the face[9,10,19], while others derive predictive values for specific populations based on studies conducted on dentate patients[11]. However, cephalometric analysis based on the gonial angle has been criticized for evaluating VDO in edentulous patients[12]. The mandible undergoes significant dimensional changes with tooth loss,

including an increase in the gonial angle, making it more obtuse[20,21]. Differences between genders also influence these analyses[21], particularly when parameters are based on studies involving dentate patients[12]. Moreover, cephalometric parameters have been considered suboptimal for determining the positioning of posterior[22] and anterior[23] teeth in complete dentures. However, patient satisfaction has been reported to be satisfactory when VDO is determined through cephalometry during the fabrication of complete dentures, as compared to the clinical method[10].

In the cephalometric analysis method used in this study, the gonial angle is calculated but not included in the final assessment. This allows the method to be applied to both dentate and edentulous patients, as the gonial angle is not used to position the mandible but rather to align the mandibular plane with the maxilla. An increased gonial angle does not affect the analysis because the focus is on the difference between the initial, incorrect mandibular plane and the new plane determined through cephalometric analysis by transferring the parallel line between CF and ENA. When the upper angle (UA) and the middle angle (TLA) are correlated, they provide the measurement for the lower third of the face.

In this study, a correlation was found between the two angles in patients with clinically established VDO, supporting the acceptance of the null hypothesis. Patients with well-established clinical VDO also demonstrated acceptable VDO values according to the cephalometric analysis.

CONCLUSION

Based on the data found in this study, the cephalometric analysis used (Seraidarian-Tavano) may be a valuable method to assist in the clinical determination of VDO.

AUTHORS' CONTRIBUTIONS

Marcelo Noboru Tanizaka - Investigation (lead), writing – original draft (lead); Elisa Mattias Sartori - Conceptualization (equal), funding acquisition (lead), investigation (equal), supervision (equal), writing – original draft (equal); Farid Jamil Silva de Arruda - Investigation (equal), methodology (equal), visualization (equal); Eduardo Romagna Machado - Investigation (equal), writing – original draft (equal); Ana Cláudia Moreira Melo Toyofuku - Methodology (supporting), formal analysis (lead), writing – review and editing (equal); Ivete Aparecida de Mattias Sartori - Conceptualization (lead), supervision (lead), project administration (lead), methodology (equal), writing – review and editing (lead).

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CONFLICTS OF INTERESTS

Ivete Aparecida de Mattias Sartori declares that she provides scientific consulting services to the company Neodent, which financed this clinical study. The other authors declare that they have no conflict of interest.

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