

# OCCLUSAL VERTICAL DIMENSION: AN ANALYSIS OF THE ACCURACY OF THE WILLIS METHOD

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**ABSTRACT: Purpose:** The accuracy of the Willis method in determining the occlusal vertical dimension was evaluated. The subjects were 32 dentate individuals attending the occlusion clinic of the dentistry course at the Universidade do Vale do Itajaí, Santa Catarina, Brazil. **Materials and methods:** The survey was conducted with patients between 18 and 50 years old. Measurements of the middle third and lower third of the face were taken with a Willis compass and recorded in the clinical records for analysis based on statements made by Willis regarding proportionality. This method has been used since its introduction in the 1930s as a clinical reference in occlusal reconstruction; however, its effectiveness has been challenged considering that changes in the physical structure of individuals in recent decades has occurred. The average of these measurements differed from the values given in the method recommended by Willis. The sample had a predominance of females and the average age of the patients studied was 30 years old. **Results:** The average measurement taken from the outer corner of the eye to the labial commissure was larger than the average measured distance from the base of the nose to the base of the

mentum (habitual maximum intercuspation – HMI). **Conclusions:** Within the limitations of this study, it was concluded that the Willis method is not completely reliable for use as the only form of measurement for the proper reestablishment of the occlusal vertical dimension. **KEYWORDS:** Vertical dimension. Dental occlusion.

## INTRODUCTION

The measurement of the lower third of the face, as the distance between two points, the first in the maxilla and the second in the jaw, selected in the vertical plane, is known as the vertical dimension and it is divided into two types: occlusal vertical dimension (VDO) and rest vertical dimension (RVD). In the case of the VDO, the distance is measured from one point in the maxilla to another in the jaw in the vertical plane, as the occlusal surfaces of the teeth or the orientation planes are in contact. The RVD corresponds to that same distance between the maxilla and the jaw but in the rest position. The correct reestablishment of the VDO is considered one of the most important requirements in the oral rehabilitation of toothless people. The inaccurate determination of the VDO can result in failure of the prosthetic treatment. According to the metric method proposed by Willis in the 1930s, the distance from the upper bone crest of the nose to the chin base is similar to the distance from the interpupillary line to the corner of the lip. The author used this reference to reestablish the occlusal vertical dimension lost over time after the teeth had been lost. (1,2)

“A” and “L” shaped compasses were used for the measurements and these were fixed to a semi-adjustable articulator developed by the author, which has a stem that is 1 mm larger, via an adjustable screw at the required distance, this being known as the Willis compass. (3)

This method recommended by Willis has been used for decades in the reconstruction of occlusions where the occlusal vertical dimension has changed.

The purpose of this study was to evaluate the current effectiveness of the Willis method considering changes in the maxillofacial dimensions of the population since the 1930s.

## MATERIALS AND METHODS

This research was carried out with a quantitative sample and 32 subjects participated. These were in the age range of 18 to 50 years old, of both sexes, being treated at the Occlusion Clinic of the Dentistry Course of UNIVALI. They agreed to participate in this study and signed an informed consent form. The data were collected over a period of 8 months. The criteria for the inclusion of the subjects in the research were the presence of all teeth in both arcs and that the integrity of these teeth did not adversely affect the occlusal relationship.

The specific clinic records used to register data on the patients treated at the clinic were consulted in this study and the Willis compass was used in the measurement technique. Measurements were taken with the patient seated, with the head and the torso in the upright position and the backrest and head support in fixed positions.

The distances from the corner of the eye to the corner of the mouth and from the base of the nose to the base of the mentum of patients were measured. Care was taken to support the compass firmly on the base of the mentum sliding the upper shaft of the instrument until it was firmly supported on the base of the nose.

These measurements were taken with the patients in the resting position and with the habitual maximum intercuspation (HMI), the latter being considered the occlusal dimension. When the measurement was taken at rest, 3 mm were subtracted to obtain the occlusal vertical dimension. The data collected were analyzed considering the mean of the measurements obtained in this study and the corresponding value found at the time the method was recommended by Willis. This was performed through a linear regression equation, in order to estimate the expected value for the measurement between two points (the base of the mentum and the base of the nose) and after that to determine the relationship between the two measurements. This equation establishes the correlation between these measurements, enabling a comparison with the results obtained in the study by Willis.

This research was carried out at the Universidade do Vale do Itajaí and it was submitted and approved by the Research Ethics Committee (Comitê de Ética em Pesquisa - CEP) under number CEP 685859.

## RESULTS

The results obtained in the statistical analysis using the linear regression equation are shown in Figure 1. The behavior observed based on the points of the new model differed from that obtained with the Willis method. The percentage of the sample by gender showed a predominance of females (Figure 2). The mean age of the individuals who contributed to this research was 30 years old (Figure 3). The average measured distance between the outer corner of the eye and the labial commissure (5.97 cm) was larger than the average measurement for the distance between the base of the nose and the base of the mentum (HMI; 5.81 cm) as shown in Figure 4.

In this study, based on the results reported in Table 1, only one of the dentate subjects (3.12%) showed the ratio of 1:1 mm, as in the study by Willis. The other results of this study showed that, in the sample studied, 20 patients (62.5%) had a variation of 0.5 mm (mm) when compared with the Willis method and for 11 patients (34.37%) this value was >0.5 mm to 13 mm. The interocclusal rest space (IRS) varied considerably between participants (0.1 mm to 10 mm), with the average value being 0.39 mm. According to Willis, this space is 0.3 mm and in this study this was true only in the case of 7 patients (21.87%).

The variation in relation to the Willis method is based on the difference between the following two distances: the outer corner of the eye to the labial commissure and base of the nose to the base of the mentum (HMI). Negative and positive values indicate, respectively, that the occlusal vertical dimension of the subject would reduce or increase if they became totally edentulous or lost the height of the physiological vertical dimension and needed prosthetic rehabilitation, with the application of the Willis method.

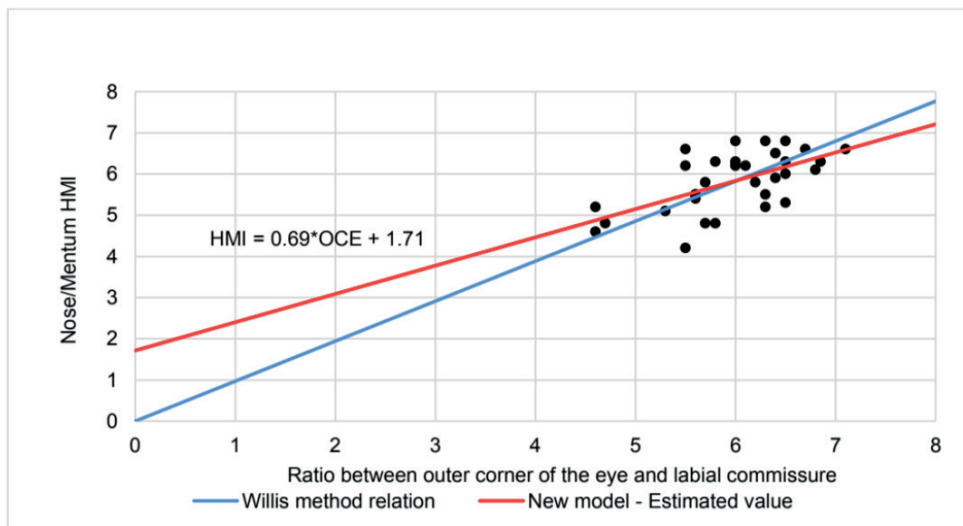


Figure 1. Difference between the value obtained with the Willis method and in this study (new model).

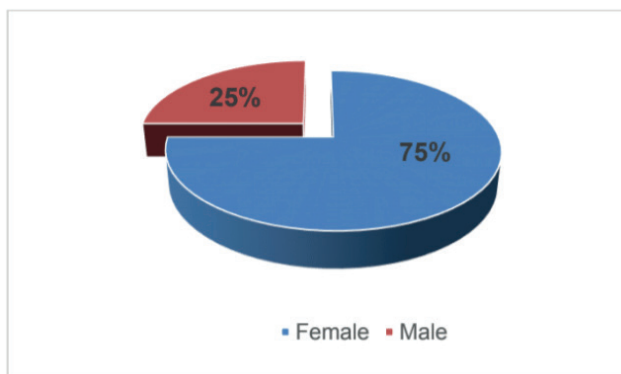


Figure 2. Distribution of the sample by gender.

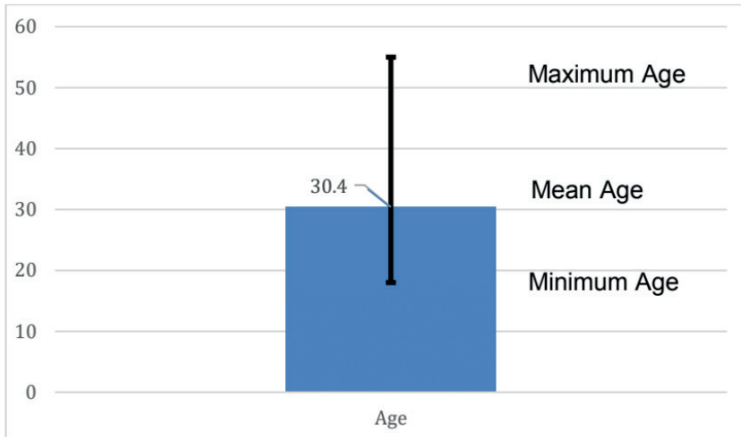


Figure 3. Distribution of the sample by age.

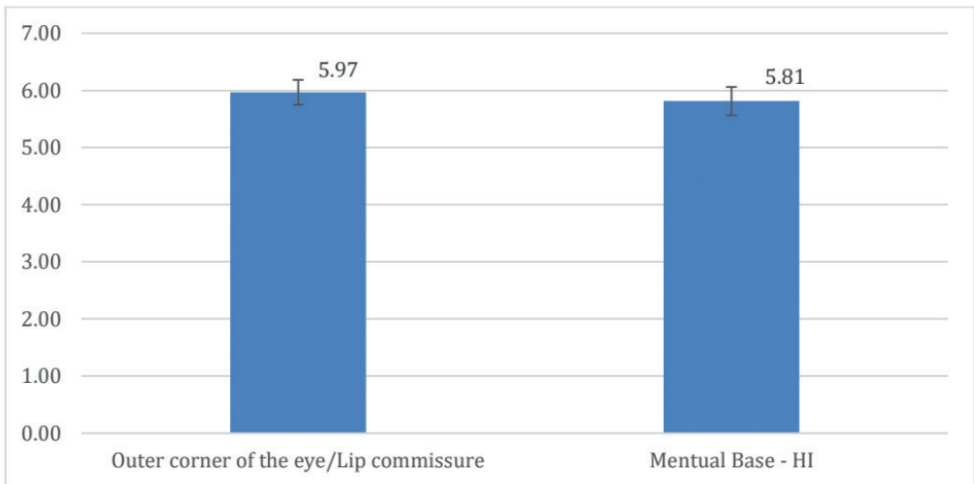


Figure 4. The average measurement and standard deviation of the measured distances between the outer corner of the eye and labial commissure and between the base of the nose and the base of the mentum (HMI).

Subject	Gender	Age	MEASUREMENT 1*	MEASUREMENT 2**	MEASUREMENT 3***	Interocclusal Rest Space	Standard Variation of Willis
1	Female	35	5.5cm	4.2cm	4.5cm	0.3cm	1.3cm
2	Female	21	6.0cm	6.2cm	6.3cm	0.1cm	-0.2cm
3	Female	34	6.4cm	5.9cm	6.15cm	0.25cm	0.5cm
4	Female	45	6.5cm	5.3cm	5.5cm	0.2cm	1.2cm
5	Female	45	5.8cm	4.8cm	5.6cm	0.8cm	1.0cm
6	Female	36	6.1cm	6.2cm	6.3cm	0.1cm	-0.1cm
7	Female	18	6.3cm	5.2cm	5.4cm	0.2cm	1.1cm
8	Female	20	5.5cm	6.6cm	6.9cm	0.3cm	-1.1cm
10	Female	39	5.6cm	5.5cm	6.5cm	1.0cm	0.1cm
11	Female	25	6.3cm	5.5cm	5.9cm	0.4cm	0.8cm
11	Female	21	6cm	6.3cm	6.7cm	0.4cm	-0.3cm
12	Female	46	6.5cm	6.0cm	6.3cm	0.3cm	0.5cm
13	Female	22	6.5cm	6.3cm	6.4cm	0.1cm	0.2cm
14	Female	21	4.6cm	5.2cm	5.5cm	0.3cm	-0.6cm
15	Female	50	5.7cm	4.8cm	5.2cm	0.4cm	0.9cm
16	Female	20	6.5cm	6.8cm	6.0cm	0.8cm	-0.3cm
17	Female	24	5.5cm	6.2cm	6.5cm	0.3cm	-0.7cm
18	Female	20	5.7cm	5.8cm	6.0cm	0.2cm	-0.1cm
19	Female	20	6.4cm	6.5cm	6.3cm	0.2cm	-0.1cm
20	Female	45	5.6cm	5.5cm	6.5cm	1.0cm	0.1cm
21	Female	21	5.8cm	6.3cm	6.5cm	0.2cm	-0.5cm
22	Female	22	5.6cm	5.4cm	5.8cm	0.4cm	0.2cm
23	Female	22	4.6cm	4.6cm	4.8cm	0.2cm	0cm
24	Female	22	4.7cm	4.8cm	5.0cm	0.2cm	-0.1cm
25	Male	18	6.85cm	6.3cm	6.95cm	0.65cm	0.55cm
26	Male	50	5.3cm	5.1cm	5.2cm	0.1cm	0.2cm
27	Male	29	6.2cm	5.8cm	6.1cm	0.3cm	0.4cm
28	Male	50	7.1cm	6.6cm	6.9cm	0.3cm	0.5cm
29	Male	23	6.3cm	6.8cm	7.5cm	0.7cm	-0.5cm
30	Male	35	6.0cm	6.8cm	7.2cm	0.4cm	-0.8cm
31	Male	25	6.8cm	6.1cm	7.0cm	0.9cm	0.7cm
32	Male	44	6.7cm	6.6cm	7.2cm	0.6cm	0.1cm

\* Measurement 1 = outer corner of the eye to labial commissure

\*\* Measurement 2 = base of nose to base of mentum– HMI

\*\*\* Measurement 3 = base of nose to base of mentum – rest

Table 1. Comparison of values for the subjects of the research.

## DISCUSSION

The distance between two points measured on the lower third of the face selected in the vertical plan is known as the vertical dimension and it is divided into two types: occlusal vertical dimension (VDO) and rest vertical dimension (RVD). (1, 2, 4, 5, 6, 7) One of the first studies to determine the vertical dimension was conducted by Willis in the 1930s. The Willis compass was then proposed as a measurement technique, to determine the proportions of the middle and lower third of the face, and suggested result is a ratio of 1:1 mm. (3) The Willis compass which appeared on the market in 1930 facilitates these measurements. (8-9) The results of this research showed that only one toothed patient (3.12%) had the ratio of 1:1 mm.

These results were obtained with a predominance of female participants (75%); however, this research was developed in a dental environment and according to Chou 1994 the presence of men in health services is lower than that of women. (10)

Inaccuracies resulting from the use of the Willis method occurs due to several factors: misalignment of the instrument (especially for convex profiles, patients with a mustach and/or beard, short neck, fleshy lips or round chin) and compression of the soft tissue over the mentum and the septum of the nose. (11)

The correct restoration of the occlusal vertical dimension (VDO) has been considered one of the most important requirements for dental rehabilitation for edentulous patients. (8,12) The correct VDO has a direct influence on the final quality of the total prosthesis. This measurement is responsible of the satisfactory restoration of the stomatognathic system and consequently of the functions of phonation, chewing and swallowing, besides giving the patient a pleasant aesthetic appearance. (13)

The incorrect determination of the OVD can have adverse results on prosthetic treatment. A disharmonic function between the occlusion and temporomandibular joint may be manifested by disease and/or joint, tooth or muscle dysfunction, the most common of which is bruxism. (8,11,12)

An increase in the vertical dimension results in distortion of the face because the patient has difficulty closing the teeth at the sides and it becomes difficult to swallow. This can cause pain or tenderness at the edges, tension of the facial muscles, difficulty speaking and decreased masticatory ability. (13) An increase in the vertical dimension also changes the position of the condyle (forward and downward) and the degree of change is dependent on the amount of opening. There is also an increase in the functional length of muscle lifts. (8) Of the 32 participants in this study, in the case of 18 (56.25%) the middle third of the was larger than the lower third, that is, if these patients became totally edentulous, lost the height of the physiological vertical dimension, or needed prosthetic rehabilitation their vertical dimension of occlusion would be increased.

The decreased vertical dimension when the teeth are in occlusion causes excessive closure, which is detrimental to the temporomandibular joint (TMJ) (5). This can cause angular cheilitis and affect facial harmony. Patients with a decreased VDO present an aged appearance as the lower third of the face is reduced, the cheeks and lips become flaccid, and the chin protrudes forward. (8)

The patient tends to have a harmonic appearance when the VDO is stable. (7,12). In this research study, in the case of 13 participants (40.62%) the measurement of the middle third of the face (outer corner of the eye to the labial commissure) was smaller than the measurement of the lower third (base of the nose to the base of the mentum) when the facial thirds are measured. If these patients were to become totally edentulous, lose the height of the physiological vertical dimension or need prosthetic rehabilitation, their vertical dimension of occlusion would be decreased.

The determination of the rest vertical dimension, when the occlusal vertical dimension is obtained with the interocclusal rest space, is one of the most significant clinic steps in dentistry treatment. (14,15)

Although several studies have been focused on the formulation of a protocol to obtain these vertical dimensions for the mandible and maxilla, there is still no fully reliable method available. (16)

The multiple anatomical variations between individuals lead to different facial measurements and a diversity of dimension values for the VDO. (5,17,18,19,20)

It is thus important for dentists to obtain precise measurements for an adequate VDO. Though researchers have challenged the theory of a constant vertical dimension at rest, it is still seen as the first step by most dentists. The author observed that the position of the mandible at rest, due to its inconsistency, should not be constituted as a reliable reference position for assessment of vertical dimension during construction of complete dentures. (21) Ayoub reports that interpupillary distance can be used as a VDO determination factor in males. Alhadj, et al report that measurements from the outer canthus of the eye to the oral commissure are more reliable for VDO prediction for edentulous patients. According to Bajunaid et al, facial landmarks mentioned by Misch (about 12 measurements with a difference range between 1-2 mm) are used to determine VDO in edentulous patients reliably and objectively. The use of bone points by cephalometric analysis leads to increased accuracy in measurements because there is no facial or positional manipulation determining freeway space, but a functional method must also be used to improve measurements provided by lateral RX in edentulous patients. One of the most frequently analyzed concerns is considered by Behrendorf, who says that age and time using dentures affect VDO reestablishment and mandibular movements. (16, 21, 22, 23)

Soft tissue landmarks are also commonly used to determine the vertical dimension of edentulous subjects. Willis's method relationship between medial and lateral canthus of the



eye distance and to determine the usefulness of this measurement in predicting the base of the nose-inferior border of lower lip distance for ascertaining occlusal vertical dimension in edentulous subjects. Purely for an explanatory purpose, a pilot study was conducted and to compare this distance with a distance between maxilla and mandible to ascertain vertical dimension. It was found that the intercanthus distance closely equaled the distance between the base of the nose to the inferior border of the lower lip among 50 students. This prompted to conduct of a study among young adults to verify this hypothesis. The results of the study show that a significantly high percentage of both males and females showed very close coincidence to the distance between medial and lateral canthus of the eye to the base of the nose to lower border of the lower lip when mandible was in the occlusal vertical dimension. Since 91.5% accuracy was observed in both sexes it is suggested that intercanthus distance can be used as a guide to develop active vertical dimension in edentulous subjects. This can be done by adjusting the height of the occlusal rims and measuring the distance between the base of the nose to the inferior border of the lower lip till it equals the intercanthus distance. This method should be later verified by clinical judgment as well as speech test suggested by Silverman. (21)

Failing to determine VDO accurately can lead to various issues like temporomandibular joint disorders, muscle problems, bone loss, soft tissue injuries, speech difficulties, aesthetics concerns, and chewing and swallowing problems. An increased VDO can cause tissue trauma and aesthetic and speech issues, while a decreased VDO may affect chewing efficiency and aesthetics. Thus, establishing the correct VDO is crucial for improving function, aesthetics, patient satisfaction, and overall quality of life. (24, 25)

Purba R (2022) compared Willis's method (direct method) with VDO measurements with digital photo software analysis. This showed that the VDO measurement value of the indirect method was closed to the direct measurement result. The results showed that there was no significant difference between direct and digital photos measurements, but this software was rarely used in Indonesia, so the researcher used other softwares that had the same features and functions were be measured by digital photos. The results of the VDO value with digital photo software analysis were closest to direct measurement (Willis's method). There was no difference in the measurement of VDO using analysis of several versions of digital photo softwares. Further study is needed on the measurement of VDO digital photo analysis in partial or full edentulous patients and can provide new software innovations for helping process of dentures manufacture especially VDO measurement. (26)

With the measurement data obtained in this research we performed linear regression and the behavior of the curve differed from that recommended by Willis. Based on the equation described by Willis, the ratio of the facial thirds was 1:1 cm, while in this research it was concluded that, theoretically, when the measured distance from the outer corner of the eye to the labial commissure is 0.0 cm (null hypothesis) the measured distance from the

base of the nose to the mentum base in habitual maximum intercuspatation will be 1.71 cm and with an increase of 1.00 cm in the former the latter increases by 0.69 cm. These data lead to the equation:  $HMI = 0.69 \cdot CEO + 1.71$ , where HMI is the measured distance from the base of the nose to the base of the mentum in the habitual maximum intercuspatation and CEO is the measured distance from the outer corner of the eye to the labial commissure.

The average value obtained for the measured distance from the outer corner of the eye to the labial commissure was 5.97 cm and the measured distance from the base of nose to the base of the mentum was 5.81 cm. Based on the confidence interval adopted, it was observed that these mean values did not differ significantly, since there is a 95% chance of their being within this variation.

## CONCLUSIONS

Based on the results reported above, it is concluded that the proportionality established by the Willis method was not observed in the great majority of the patients evaluated in this study. Thus, this method is not suitable as the only form of measurement for the correct reestablishment of the occlusal vertical dimension. It is possible that the results of this research differ from those reported by Willis because of changes in the anatomical measurements of the facial skull that could have occurred over the period (nearly a century) since his research was conducted.

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