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Cephalometric Determination of the Vertical Dimension of Occlusion: Clinical Study

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ABSTRACT

The following is a retrospective descriptive cross-sectional stud aimed at determining the vertical cephalometric standards of a Moroccan population. The values found will be used to orient the choice of the VDO during complex prosthetic rehabilitations where all dental references are absent. The study was conducted on 80 teleradiographies of subjects consulting the ODF department of the CCTD Casablanca with a skeletal class 1 dental occlusion in the absence of any previous or current orthodontic treatment. After performing the cephalometric tracings, we correlated the VDO with 7 angular measurements: ENA-Xi-Pm, GoGn/SN, Occ/SN, Occ/Fr, SGn/Fr, FMA, GoGn/GoENA.

Our study led us to the following results:

- For the ENA-Xi-Pm angle, we found a mean value of 47.9.
- The GoGn/SN angle averaged 38.3°, it varied in 37.29.°
- For the Occ/SN angle, it was found that the average value was 21.2° for the whole sample.
- The Occ/Fr angle was on average 9.9.°
- The SGn/Fr angle averaged 60° in the Moroccan population.
- The measurement of the FMA angle showed an average of 27.
- Finally, for the GoGn/GoENA angle, we found a mean value of 50.

The comparison of our results with those of studies conducted on different populations showed significant differences. This can be explained by the tendency to hyperdivergence in the Moroccan population, hence the interest in using the mean values specific to each population. The comparison of the global means with the means of each group showed that the angular values in hyperdivergent cases are significantly higher than the global values and the angular values in hypodivergent cases are significantly lower than the global values, and for the normodivergent cases, we found a significant difference only for the values of the FMA angle which is lower than the global value of the sample. And thus, the determination of the VDO using cephalometric analysis represents one of the best methods to correctly restore the occlusal environment in a complex prosthetic project, given that the restauration is based on cephalometric standards of the corresponding population.

Keywords

Vertical Dimension of occlusion, Cephalometry.

Introduction

The vertical dimension of occlusion (DVO) is one of the main occlusal references. It was defined by Batarec as the height of the lower face when the dental arches are in occlusion. It is measured between two arbitrary sagittal points located above the upper lip and below the lower lip [1].

More precisely, it corresponds to the height of the lower face when the dental arches are in maximum intercuspidation [2]. Another definition is also acceptable: DVO refers to the vertical position of the mandible in relation to the maxilla when the upper and lower teeth are intercuspidated in the most closed position [2].
According to Orthlieb, it would be reasonable to assume that there is an optimal space for locating the DVO instead of a single point. The practitioner has room to adapt to variations in DVO, provided that this variation is strictly rotational around the hinge axis [3].

However, the cephalometric standards considered today as international reference values are in fact based on morphometric data carried out on populations of European, North American and Australian origin. These standards differ significantly from those of ethnic groups in Africa, the Middle East and Asia. With this in mind, several studies have been carried out in various ethnic groups [4-6] with the aim of establishing adequate cephalometric reference standards to guide therapeutics and prosthetic rehabilitation.

The aim of our work is to determine the vertical cephalometric standards of a normocclusion Moroccan population in normocclusion, never treated orthodontically, with a balanced facial ratio and Class I occlusion. The secondary objective is to use the averages obtained to establish a lost DVO in Moroccan patients.

Methods and Materials

Type of study

We carried out a descriptive cross-sectional study of 80 profile teleradiographs of young Moroccan adults, of both sexes, meeting precise criteria of facial and occlusal normality, in particular a skeletal class 1 dental occlusion in the absence of any previous or current orthodontic treatment, consulting in the Orthodontics department of the CCTD Casablanca. The data collected represent angular constructions performed according to the rules of cephalometric tracings.

Studied Population

From the total number of patients attending the CCTD dental consultation and treatment center at the CHU INB ROCHD in CASABLANCA, we selected patients attending the dentofacial orthopedics department.

The inclusion criteria used to select our sample were as follows:
-Patients, young adults or adults with complete permanent dentition.
-No previous or ongoing orthodontic and/or orthopedic treatment.
-Class 1 occlusion.
-Absence of vertical alveolar anomalies (open bite or overbite).
-Little overlap or tooth spacing.
-Harmonious, symmetrical face.

Excluded from the study:
-Any unexploitable profile teleradiography.
-All non-Moroccan patients.

Methodology

Cephalometric tracing was carried out using 0.5-criterium pencil on a film-bonded tracing paper placed on a viewbox. According to the standard technique, the subject's profile was turned to the right and the film was oriented so that the line (SN) was horizontal. All tracings were made by a single, experienced operator and professor of orthodontics. On the tracings thus obtained, we marked the points and then drew the lines suitable for cephalometric analysis.

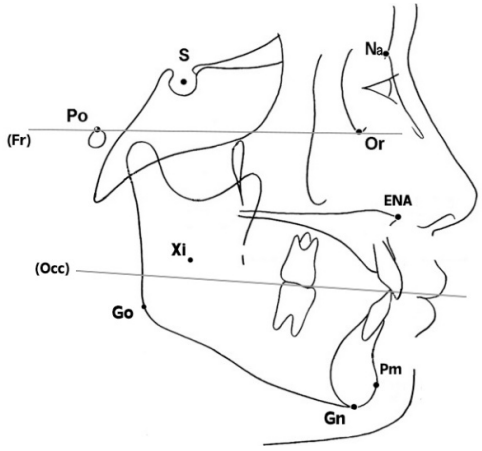

Figure 1: The various points and planes studied.

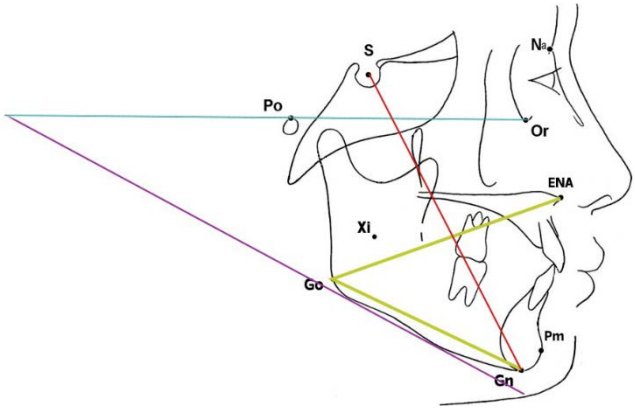

Figure 2: Tracing showing the angles: SGn/Fr ; FMA ; GoGn/GoENA

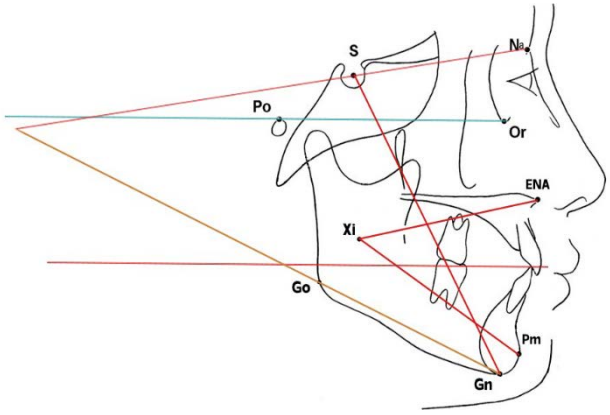

Figure 3: Tracing showing the angles: ENA-Xi-Pm; GoGn/SN; Occ/SN; Occ/Fr

Statistical analysis

Statistical analysis of the study was carried out using the French version of the EPI INFO 6 PC statistical software, under the EPI Table statistical module.

The Student's t-test was used to compare our means with those of other studies. For our study (ddl = n - 1, i.e. 71 - 1 = 70), the difference between the two means is significant if the "t" value is greater than 1.96.

Results

Sample distribution:

Measurement of the FMA angle enabled us to divide the 80 subjects according to facial typology as follows:

- Group 1: 34 normodivergent cases
- Group 2: 41 hyperdivergent cases
- Group 3 : 5 hypodivergent cases

Angular value results for each group

The results for each group are summarized in tables 1 2 3.

Table 1: Overall results of Group 1 angular measurements.

Variable	ENA-Xi Pm	GoGn/SN	Occ/SN	Occ/Fr	SGn/Fr	FMA	GoGn/GoENA
Mean Standard deviation	47,06° 6,74	37,29° 3,7	20,35° 4,1	9,9° 2,7	59,03° 2.4	25,29° 2	47,63° 8,5

Table 2: Overall results of Group 2 angular measurements.

Variable	ENA-Xi Pm	GoGn/SN	Occ/SN	Occ/Fr	SGn/Fr	FMA	GoGn/GoENA
Mean Standard devation	49,51° 3,1	40,63° 3,9	22,46° 4,3	11,09° 3,5	61,65° 2.6	31,2° 2,5	53,15° 3

Table 3: Overall results of Group 3 angular measurements.

Variable	ENA-Xi Pm	GoGn/SN	Occ/SN	Occ/Fr	SGn/Fr	FMA	GoGn/GoENA
Mean Standard devation	41,4° 1,3	26,8° 3,5	16,9° 1,9	8,8° 3.4	58,4° 1,1	15,4° 0,9	42,9° 2,3

Angular value results for the entire sample

The overall results are summarized in Table 4.

Table 4: Overall angular measurement results for the entire sample.

Variable	ENA-Xi Pm	GoGn/SN	Occ/SN	Occ/Fr	SGn/Fr	FMA	GoGn/GoENA
Mean Standard Deviation	47,9° 5.3	38,3° 5	21,2° 4,3	9,9° 3.3	60° 2.7	27° 4,8	50° 6,7

Table 5: Summary table of all results.

	Global sample			Groupe 1			Groupe 2			Groupe 3		
	M	SD	S	M	SD	S	M	SD	S	M	SD	S
ENA-Xi Pm	47,9°	5,3	80	47,06°	6,74	34	49,51°	3,1	41	41,4°	1,3	5
GoGn/SN	38,3°	5	80	37,29°	3,7	34	40,63°	3,9	41	26,8°	3.5	5
Occ/SN	21,2°	4,3	80	20,35°	4,1	34	22,46°	4,3	41	16,9°	1,9	5
Occ/Fr	9,9°	3,3	80	8,69°	2,7	34	11,06°	3,5	41	8,8°	3,4	5
SGn/Fr	60°	2,7	80	59,03°	2,4	34	61,65°	2,6	41	58,4°	1,1	5
FMA	27°	4,8	80	25,29°	2	34	31,2°	2,5	41	15,4°	0,9	5
GoGn/GoENA	50°	6,7	80	47,63°	8,5	34	53,15°	3	41	42,9°	2,3	5

***M:** mean;**SD :** Standard Deviation*; ***S :** Sample size*

Statistical comparison of overall angular values and cephalometric values by group:

Statistical comparison of angular values of the overall sample and Group 1 (normodivergent) showed no significant differences except for the FMA angle (p=0.04), which had a lower value than that of the overall sample (Table 6).

Table 6: Comparison of overall sample values and Group 1 values.

	Global sample			Group 1			P
	M	SD	S	M	SD	S	
ENA-Xi Pm	47,9°	5,3	80	47,06°	6,74	34	0,47
GoGn/SN	38,3°	5	80	37,29°	3,7	34	0,29
Occ/SN	21,2°	4,3	80	20,35°	4,1	34	0,32
Occ/Fr	9,9°	3,3	80	8,69°	2,7	34	0,85
SGn/Fr	60°	2,7	80	59,03°	2,4	34	0,07
FMA	27°	4,8	80	25,29°	2	34	0,04
GoGn/GoENA	50°	6,7	80	47,63°	8,5	34	0,11

Statistical comparison of angular values of the overall sample and group 2 (hyperdivergent) showed significant differences for the 4 angles GoGn/SN (p=0.01), SGn/Fr (p=0.0016), FMA (p <0.0001), GoGn/GoENA (p=0.005). In this group, the values of the seven angles were significantly higher than those of the general population (Table7).

Table 7: Comparison of overall sample values and Group 2 values.

	Global Sample			Groupe 2			P
	M	SD	S	M	SD	S	
ENA-Xi Pm	47,9°	5,3	80	49,51°	3,1	41	0,075
GoGn/SN	38,3°	5	80	40,63°	3,9	41	0,010
Occ/SN	21,2°	4,3	80	22,46°	4,3	41	0,12
Occ/Fr	9,9°	3,3	80	11,06°	3,5	41	0,075
SGn/Fr	60°	2,7	80	61,65°	2,6	41	0,0016
FMA	27°	4,8	80	31,2°	2,5	41	< 0 ,0001
GoGn/GoENA	50°	6,7	80	53,15°	3	41	0,005

With regard to Group 3, statistical comparison revealed that the differences between the values of this hypodivergent group and those of the overall sample were significant for all five variables: ENA-Xi Pm angle (p=0.007), GoGn/SN (p<0.001), Occ/SN (p=0.02), FMA (p<0.0001), GoGn/GoENA (p=0.021). Angular values in this group were significantly lower than in the general population (Table 8).

Table 8: Comparison of overall sample values and Group 3 values.

	Global Sample			Groupe 3			P
	M	SD	S	M	SD	S	
ENA-Xi Pm	47,9°	5,3	80	41,4°	1,3	5	0,007
GoGn/SN	38,3°	5	80	26,8°	3,5	5	< 0,0001
Occ/SN	21,2°	4,3	80	16,9°	1,9	5	0,02
Occ/Fr	9,9°	3,3	80	8,8°	3,4	5	0,47
SGn/Fr	60°	2,7	80	58,4°	1,1	5	0,19
FMA	27°	4,8	80	15,4°	0,9	5	< 0,0001
GoGn/GoENA	50°	6,7	80	42,9°	2,3	5	0,0212

Comparison with Steiner Standards

To compare the values, we obtained with the norms accepted by Steiner's analysis [12,13], we used Student's t-test, which showed a significant difference with the angles GoGn/SN (p< 0.000001), FMA (p=0.0265). Both angles had values that were lower than the Steiner norms (Table 9).

Table 9: Comparison of overall sample values and Steiner's standard values.

	Global sample			Normes de Steiner			P
	M	SD	S	M	SD	S	
ENA-Xi Pm	47,9°	5,3	80	47°	5	34	0,40
GoGn/SN	38,3°	5	80	32°	4	34	< 0.000001
Occ/SN	21,2°	4,3	80	14°		34	
Occ/Fr	9,9°	3,3	80	10°	2	34	0,869
SGn/Fr	60°	2,7	80	59°	4	34	0,122
FMA	27°	4,8	80	25°	3	34	0,0265

Discussion

Discussion of materials and methods

The validity of the sample studied is conditioned by the reduction of selection bias, which is of paramount importance when establishing population standards [7]. For this reason, we selected our sample from a population meeting specific objective criteria, such as absence of prior orthodontic treatment, Class I occlusion, etc. The only subjective inclusion criterion was the assessment of facial symmetry and harmony.

The population consulting the Casablanca CCTD included individuals from different regions of Morocco. Hence, we could say that our target population and therefore our sample presented a certain ethnic diversity, although this was not quantified or statistically proven in our study [8].

The tracing and location of certain points in the analysis are not universally defined and may be subject to projection errors due to the 2D nature of the cliches, or to misidentification of the various points and structures [4]. For example, the Gonion point can be estimated as the most posterior-inferior point of the mandibular angle image, or constructed by the intersection of the bisector of the mandibular plane/ramal plane angle with the mandibular angle image. As a result, measurements taken on points located differently could not be compared. However, the majority of published studies do not specify the registration techniques used [9].

- In the literature, we found 2 Moroccan studies that had the same objectives as our study:
L. Ousehal et al. [8] in 2012 who conducted a descriptive cross-sectional study of 71 subjects who consulted the Casablanca CCTD all in skeletal class 1 and presenting facial harmony and an acceptable profile, we note that our sample size is larger. And L. Ousehal et al. [10] in 2016 who worked on a sample of 98 students from the Faculty of Dentistry in Casablanca, meeting precise criteria of facial and occlusal normality namely skeletal class 1 with no dental overlap or overlap greater than 6mm.
Profile teleradiographs were performed on the subjects from the 2 previous studies, and cephalometric landmarks were then determined by a single experienced operator, a professor of orthodontics.
- Other international studies, with the same objective as our study, have adopted a classification according to sex:
O.P. Kharbanda and co [11] in 1991 selected 48 subjects (25 males and 23 females) from northern India, who met the following criteria: excellent facial harmony, complete dentition, class I molar and canine.

In 2019, Ouédraogo Y. and co [12] divided a sample of 84 people into 2 equal groups according to sex, with the aim of establishing cephalometric standards for a population from the city of Ouagadougou (Burkina Faso). The same classification was adopted in 2006 by Ali H. Hassan and colleagues to assess the cephalometric characteristics of a Saudi population living in western Saudi Arabia, establish Saudi norms in this region and present them in polygon form for ease of use [13]. Lj. Strajnic and co [9] in 2008 worked on a sample of 60 students from the Vojvodina region of Serbia, subdivided into 2 equal groups according to gender.

In 2000, J.-D. Orthlieb and co [2], based on a study of 505 adult subjects, attempted to deduce a correlation between mandibular shape and lower face height, and set out equations for determining the patient's VDO. Gonzalez MB and co [14] in 2013 carried out a study to establish specific cephalometric standards for a Mexican ethnic group, working on a total of 130 cases divided into 3 groups: Group 1 comprised 50 male subjects, while Group 2 included 50 female subjects. Both groups featured fully toothed subjects with a Class I skeletal relationship of the jaw with normal overhang and overlap, while Group 3 selected 30 subjects with harmonious, well-balanced profiles.

In 1996**,** K. Miyajima and co [15] classified a total of 179 patients according to ethnic origin into 2 groups: the 1st group comprised patients of Japanese origin, while the 2nd group included patients of European-American origin, to determine the aesthetic standards characterizing each race. Concerning the angles studied, we correlated VDO with 7 angular measurements: ENA-Xi-Pm, GoGn/SN, Occ/SN, Occ/Fr, SGn/Fr, FMA, GoGn/GoENA. Taking as an example the study carried out by Ousehal and co [10] in 2016, the angles studied were ENA-Xi-Pm, GoGn/SN, Occ/SN, Occ/Fr, SGn/Fr, FMA, in addition to an ENA-Me distance which was not measured in our study following the unreliability of the magnification of certain profile teleradiographs. Ousehal and co [8] in 2012, to establish specific cephalometric standards for a Moroccan sample, several angles were used, including GoGn/SN and Occ/SN, while the other measurements provided information on the sagittal direction.

In the study by Orthlieb and co [2], the following angles were used: ENA Xi Pm, FMA and GoGn/GoENA, in addition to the goniac angle, to derive a simple regression equation relating these

four angles to the VDO. Correlations were statistically significant, but dispersion was high. In 2013, Gonzalez and co [14] used, among others, the GoGn/SN, Occ/SN and FMA angles to derive cephalometric norms for a Mexican population, according to the analyses of Steiner, Tweed and Ricketts. This study focused on ethnic purity, giving a significant value representative of this sample.

The study conducted by Garcia J. [16] in 1975 found that the mean values of the Mexican-American sample, notably the GoGn/SN, Occ/SN, Occ/Fr and SGn/Fr angles, were significantly different, for all measurable values, and thus demonstrated the fact that the norms and standards of one racial group could not be used without modification for another. Similarly, averages cannot be exchanged from one racial group to another without a thorough understanding of breed differences and their ranges of normality. As for Ajayi O [4], Ouédraogo and co [12] and Hassan A.[13], the only angle that was also introduced in our study was the FMA angle. VDO assessment is a delicate stage in prosthetic rehabilitation. Many clinical situations, such as tooth loss, posterior occlusal collapse, periodontal disease and sometimes bruxism, require correction of the VDO. It is essential to re-establish neuromuscular balance, recreate prosthetic space and restore facial aesthetics.

Discussion of results

Variations in the Vertical Dimension of Occlusion (V.D.O.) are achieved at the cost of mandibular rotation around the TMJs. It is therefore only once the condylar position has been defined (therapeutic position) that the most favourable V.D.O. can be decided. Bearing in mind that 1 mm of inter-incisal variation corresponds to just 1° of condylar rotation, a VDO variation of just a few millimetres cannot directly induce joint stress, rotation being a perfectly physiological movement for this joint [17].

While there is no precise, reproducible method for determining VDO (18), there is generally a high degree of adaptability to VDO variations. According to Palla, its determination must meet the following criteria:

- The presence of an inocclusion space in the postural rest position,
- The absence of contacts between the dental arches during phonetic activity,
- A pleasing appearance of the lower face in occlusion.

After this literature review, it therefore proves useful to use cephalometric methods to determine the vertical dimension of occlusion. This is the aim of our study. Our results were compared with those of other studies carried out in various populations.

Comparison to Moroccan studies

Comparing our values with those of the Moroccan studies for (p value < 0.05), we can deduce:

– For the study conducted by Ousehal and co 2012: we found a statistically significant difference with the GoGn/SN angles (p = 0.00084) and the Occ/SN angle (p = 0.000016).

– For the study conducted by Ousehal and co in 2014: a statistically significant difference was found with ENA-Xi-Pm (p = 0.02); GoGn/SN (p = 0.00026) and Occ/SN angle (p = 0.0058), and a non-significant difference with Occ/Fr (p = 0.15), SGn/Fr (p = 0.089), FMA (p = 0.063) angles.

Comparison with foreign studies

Several foreign studies similar to ours have set out to establish norms for their respective populations according to several variables.

Comparison of ENA-Xi-Pm angle

The mean value established by our study was 47.9° in the Moroccan population. Orthlieb and co [2] found a mean of 43.44° for the Austrian population.

Comparison of GoGn/SN angle

For our sample, the average GoGn/SN angle is 38.3°. Whereas the study by Gonzalez and co [14] showed it to be 33.8°. Garcia J. [16] found an average of 31.1° for the Mexican population.

Occ/SN angle comparison

In our study, we found the mean value to be 21.2°, with a mean of 16.1° according to Gonzalez and co [14], and 15.8° according to Garcia J. [16] for the Mexican population.

Occ/Fr angle comparison

The mean value established by our study was 9.9°, and for Garcia J. [16] found a mean value of 8.2°.

Table 10: Comparison of our sample averages and other Moroccan studies' averages.

	OUR STUDY			OTHER STUDIES				P value
Variable	**Mean**	**Total**	**Population**	**Author**	**Moyenne**	**Total**	**Population**	
ENA-Xi-Pm	47,9±5,3	80	Moroccan	Ousehal and co 2	46,2±4,4	98	Moroccan	0,02
GoGn/SN	38,3±5	80	Moroccan	Ousehal and co	35,3±5,6	71	Moroccan	0,00084
GoGn/SN	38,3±5	80	Moroccan	Ousehal and co 2	35,4±5,3	98	Moroccan	0,00026
Occ/SN	21,2±4,3	80	Moroccan	Ousehal and co	17,94±4,5	71	Moroccan	0,000016
Occ/SN	21,2±4,3	80	Moroccan	Ousehal and co 2	19,3±4,7	98	Moroccan	0,0058
Occ/Fr	9,9±3,3	80	Moroccan	Ousehal and co 2	9,1±4	98	Moroccan	0,1532
SGn/Fr	60±2,7	80	Moroccan	Ousehal and co 2	59,2±3,4	98	Moroccan	0,089
FMA	27±4,8	80	Moroccan	Ousehal and co 2	25,6±5,1	98	Moroccan	0,063

Ousehal and co: Study done in 2012
Ousehal and co 2: study done in 2016

Comparison of SGn/Fr angle

We found the mean value to be 60°. The average was 59.2° according to Garcia J. [16] for a Mexican population.

FMA angle comparison

The norm found in our sample for the FMA angle is 27°. Gonzalez and co [14] determined an average equal to 27°. Ouédraogo and co [12], on the other hand, found a mean of 24.9° for a Burkinese population. Orthlieb and co [2] found an average of 23.03° for the Austrian population. The average was 28.5° for the study by Hassan A. [13] carried out on a Saudi population, and 26° for the Nigerian population following a study by AjayiO. [4].

Comparison of the GoGn/GoENA angle

The value found in our study was 50°, whereas Orthlieb and co [2] found it to be 48.46°.

Determining VDO remains a difficult task, due to the fact that different practitioners adopt several techniques to determine it, notably aesthetic and cephalometric techniques, adding to the difference between the averages observed in different populations. Applying foreign standards to African populations can prove to be erroneous. This is why the orthodontic literature includes studies of cephalometric standards specific to each population studied. We also believe that further studies should be carried out in the future, in particular a similar study of the Moroccan population in skeletal classes II and III, to complement and reinforce our results.

Conclusion

This work enabled us to determine the vertical cephalometric standards of a Moroccan population in normocclusion, with a balanced facies and Class I skeletal ratios, through the study of 7 angular measurements. Determining DVO using average values found in the Moroccan population will assist practitioners in designing prostheses with the aim of restoring DVO. However, comparison of the averages found with those of other authors has shown that there are clearly several cephalometric differences in the Moroccan population compared with foreign populations. Thus, we suggest that prosthetic rehabilitation carried out by Moroccan dentists should adopt a system of cephalometric standards specific to our population. Further, more comprehensive studies on statistically representative samples are needed to reinforce our findings and establish norms specific to the Moroccan population.

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