Vertical Dimension of the Face
Analyzed by Digital Photographs

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Abstract

Esthetics is a primary consideration for patients seeking prosthodontic treatment. The alteration of the facial vertical dimension can deteriorate the orofacial harmony. When it is essential to assess dentofacial attractiveness, there is a consensus in the research community that the soft tissue evaluation in digital photographs is much more consistent than the traditional cephalometric analyses. The aim of this study was to compare the lower third of the face with the facial segment (ie, the distance between the outer canthus of the eye and the labial commissural), to verify whether or not there are statistical correlations and significant differences between them. Front-view standardized digital photographs of 84 dentate Brazilian subjects were used to measure all facial segments through an image-processing program. The Student t test showed no significant difference between the left facial segment and the lower third of the face. Pearson’s product-moment coefficient showed significant correlations between both facial segments and the lower third of the face. After the regression analysis, two mathematical equations were used to correlate the facial segment to the lower third of the face. The distance between the outer canthus of the eye and the labial commissurae can be a reliable guide to estimate the vertical dimension of the rest position. Moreover, when it is measured on the left side of the face there is a better chance to correctly estimate the appropriate size.

Anthropometry is the study of the measurement of the human body. Conventional, simple instruments have been used to measure the body surface landmarks such as circumferences, lengths, and breadths. Size and shape measurements of the human body are an important source of information for scientists involved in the study of abnormalities, effects of aging and disease, changes due to body growth, and ethnic and racial differences.

Since the introduction of a standardized method for obtaining skull radiographs, cephalometrics has become one of the major diagnostic tools of oral rehabilitation treatments. Its principles are patterned closely with those of craniometry, which has long been used in the quantitative study of dried skulls. Cephalometry, hence, is an indirect form of facial anthropometry. Nevertheless, the cephalometric analyses are reported to perform unsatisfactorily in diagnosis and treatment planning, and so dental professionals still rely on their clinical evaluation.

Farkas has influenced modern facial soft-tissue anthropometry by defining standards for almost every soft-tissue measurement in the head and face in more than 120 publications. Today, people are performing anthropometry with two-dimensional photographs and with three-dimensional scanners. Photographs are good representations of clinical reality as they are significantly more accurate than cephalometric analyses when measurements of soft tissue are required.

Soft tissue is not only related to the adjacent hard tissue. Once thickness, length, and facial muscle tonus varies, it is not safe to evaluate these tissues simply with the radiographic examination. Most facial plastic surgeons are concerned with total facial esthetics and work primarily from photographs, not radiographs.

Esthetics is a primary consideration for patients seeking prostodontic treatment. It is known that the lower third of the face presents two main positions in the maxillomandibular relation: the rest vertical dimension (RVD) and the occlusal vertical dimension (OVD). The RVD, or the physiologic rest position, is the mandible placement when all muscles that open the arch are in state of minimal tonic contracture sufficient only to maintain the posture. The OVD, on the other hand, is the vertical dimension of the face when the teeth or occlusion rims are in contact.

Reestablishing the height of the lower third of the face is a very important procedure in the production of complete dentures. An error at this stage and an excessive OVD may result in increased risk of trauma to the soft tissues underlying the denture base, once the absence of space causes the clenching of teeth. Also, during speech, the teeth are predisposed to make contact causing both clicking and difficulty in bringing the lips together. As a consequence, the patient may have problems pronouncing some sounds such as ‘p’, ‘b’ and ‘m’.

Facial esthetics can be debilitating and there is a possibility of developing temporomandibular joint dysfunction. Also, an underestimation of OVD may cause undesirable results to the oral rehabilitation treatment. The lack of support of the angles of the mouth can lead, in addition to dribbling in labial commissurae, to cheilitis angularis. Masticatory efficiency may also be reduced. The lack of soft tissue support may be evident from the decreased lip vermilion and the alteration of nasolabial sulci and nasal angle. Chin protrusion on the closure of the arch may
also be observed. There is no consensus regarding a reliable method to estimate an adequate maxillomandibular relation, and an assortment of methods is suggested to provide the correct vertical dimension of the lower third of the face.\textsuperscript{13–16}

The alteration of the facial vertical dimension can depreciate the orofacial harmony considerably.\textsuperscript{10,11,14} Balance, harmony, and unity are pillars in the concept of facial beauty. Interestingly, intercultural differences in perception of beauty are minimal. Certain facial proportions apparently play a major role in beauty.\textsuperscript{4,17}

One classical concept is of the five equal parts, in which ideally the face is five eye widths wide, the eyes are one eye width apart, and the distance from each outer cantus to the lateral margin of the face is one eye width.\textsuperscript{17} During the Renaissance, Leonardo Da Vinci (1452–1519) believed that a well-proportioned face was divided in three equal parts: from the trichion to the eyebrow, from the eyebrow to the base of the nose, and from the nose to the chin.\textsuperscript{2,17}

Willis\textsuperscript{11}, after evaluating dentate individuals, concluded that the distance between the base of the nose and the lower edge of the mandible should equal the distance from the pupil of the eye to the rima oris, or parting line of the lips. This relationship could be used to guide the rehabilitation of the vertical dimension in an edentulous patient, when the occlusion rims or the finished dentures are inside the mouth.

The aim of this study was to establish a reliable anatomical parameter in facial analysis to support the planning of the rehabilitation of the vertical dimension, as observed by Willis\textsuperscript{17}. Dentate individuals had their face measured to verify if there is statistical correlation between some facial segments: the distance between the outer cantus of the eye and the labial commissurae, measured at the right side (RE-LO) and at the left side of the face (LE-LO), and the lower third of the face measured by the distance between the base of the nose and lower edge of the mandible (BN-M).

Materials and methods

Ethical approval was obtained from the local committee on research ethics. A total of 96 dentate Brazilian subjects, from the Federal University of Uberlandia (MG, Brazil), signed an informed consent form and answered a questionnaire to investigate the dental arch conditions.

Front-view standardized digital photographs of the face were taken using a digital camera. The subject was instructed to position his/her face on a Wavrin Modified Set Square (Wavrin Trutype Tooth Guide, Dentist’s Supply, New York, USA), which was modified by adding 2 millimeter rules: one in a vertical and another in a horizontal direction. This modified square standardized the head position and provided a measurable relationship between the image and the actual dimension (Fig 1).\textsuperscript{18}

During the capture of all photos, the volunteer was asked to sit and look forward towards the horizon. The method used to achieve the Vertical Dimension of Rest Position (VDR) was the instruction to relax the mandible and lightly touch the lips together in a comfortable posture.\textsuperscript{12,15,19} The volunteers remained in state of minimal tonic contracture sufficient only to maintain the posture.

Two reference lines were used to standardize the adequate facial position on the image: the median facial line, represented by the face’s vertical axis of symmetry
(black line in Fig 1); and the pupil line, represented by the face’s horizontal axis which was perpendicular to the vertical axis at the height of the eye center (red line in Fig 1).²⁰

The photographic images were taken by one trained photographer. A distance of 56.0 cm between the digital camera lens and the tip of the subject's nose was established by the use of a top cord. The digital camera was positioned on a tripod (VT40 Tron, 013002, Manaus, Amazonia, Brazil), which was 112.0 cm in height. An image processing program (HL IMAGE ++97, Western Vision Software, LC, East Layton, Utah, USA) was used to measure the facial segments.¹⁸

Exclusion criteria included subjects who had already undergone tooth extraction, large restorations, artificial crowns, tooth agenesis, facial alterations, and had a history of congenital facial anomalies or facial surgery. Both reference lines (median facial line and pupil line) also served as exclusion criteria where subjects whose facial position did not achieve the standard were not included in the study.

To verify if there was a reliable relationship between some facial segments (Fig 2), the following was measured: the distance BN-M (labeled in green), the distance LE-LC (labeled in blue), and the distance RE-LC (labeled in pink).
Fig 3  BN-M: distance between the base of the nose and lower edge of the mandible; LE-LC: distance between the outer canthus of the left eye and the labial commissurae; RE-LC: distance between the outer canthus of the right eye and the labial commissurae.

For the sake of consistency, the same examiner made all of the records and performed all of the measurements three times, on different days and times. From the three results, a mean value was calculated to establish a consistency in the measurements and reliability of the evaluator.

Results

A total of 84 facial digital images of students from the Federal University of Uberlandia (MG, Brazil) constituted the sample (38 men and 46 women). The volunteers ranged from 17 to 33 years of age, with a mean age of 21 years. For each recorded measurement (BN-M, RE-CL, and LE-CL), Fig 3 and Table 1 present the mean values and standard deviation for the total sample.

To verify if both sides of the face (RE-CL and LE-CL) are different for the total sample, a paired $t$ test was calculated ($\alpha = 0.05$). The paired $t$ test determines whether or not the sides differ from each other in a significant way under the assumptions that the paired differences are independent and identically normally distributed. As shown in Table 2, there was no significant difference between both sides of the face for the total sample ($P = 0.055$).

After observing that both sides of face were not significantly different for the total sample, the sample was divided according to gender and the paired $t$ test was used to evaluate whether both sides of face were significantly different in males and females. Table 2 shows no significant difference for the opposite sides of the face in males ($P = 0.127$) as well as for females ($P = 0.245$).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean and standard deviation values</th>
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<tr>
<td>Segments</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>BN-M</td>
<td>73.892 (6.565)</td>
</tr>
<tr>
<td>RE-LC</td>
<td>75.361 (5.650)</td>
</tr>
<tr>
<td>LE-LC</td>
<td>74.964 (5.714)</td>
</tr>
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*Mean values in millimeters

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Student $t$ test results for both sides of the face</th>
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<tr>
<td>RE-LC to LE-LC</td>
<td>$P$</td>
</tr>
<tr>
<td>Total sample</td>
<td>.055</td>
</tr>
<tr>
<td>Males</td>
<td>.127</td>
</tr>
<tr>
<td>Females</td>
<td>.245</td>
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<tr>
<th>Table 3</th>
<th>Student $t$ test results for facial segments and vertical dimension of rest position</th>
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<tr>
<td>Evaluation</td>
<td>$P$</td>
</tr>
<tr>
<td>RE-LC to BN-M</td>
<td>.017</td>
</tr>
<tr>
<td>LE-LC to BN-M</td>
<td>.070</td>
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<th>Table 4</th>
<th>Pearson product-moment correlation coefficient test</th>
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<tr>
<td>Evaluation</td>
<td>$r$</td>
</tr>
<tr>
<td>RE-LC to BN-M</td>
<td>.604</td>
</tr>
<tr>
<td>LE-LC to BN-M</td>
<td>.625</td>
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</table>
The Student $t$ test was conducted to determine if there were significant differences between BN-M and the facial segments RE-LC and LE-LC (Table 3). A significant statistical difference was found between BN-M and RE-LC, and the largest values were recorded for the segment RE-LC. However, there were no significant differences between the BN-M and LE-LC segments.

The Pearson product-moment correlation coefficient was used to determine if there was a linear relationship between the following pairs of variables: BN-M and RE-LC, and BN-M and LE-LC. Table 4 shows high positive correlation coefficients for both comparisons. Linear regression analysis was then used to provide mathematical equations to relate both quantities compared (Figs 4 and 5). The linear least squares fitting technique is the simplest and most commonly applied form of linear regression and provides a solution to the problem of finding the best fitting straight line through a set of points.

**Discussion**

Morphological symmetry refers to a balance in size, form, and arrangement of anatomical features on opposites sides of a constructed median reference plane.\(^{21,22}\) As shown in Table 2, the sample of this study presented similarity between both sides of the face. Even when the sample was divided according to gender, there were no significant differences between the opposite sides of the face.

However, there is no perfectly symmetrical face, and absolute symmetry presents an artificial appearance. Usually at a subclinical level, asymmetry is the typical finding even among those rated the most esthetically pleasing.\(^{21}\) Baudouin and Tiberghien\(^{20}\) published the relationship between asymmetry and less attractive faces. In this study, despite finding no significant differences between the opposite sides of the face, the mean values were slightly bigger for the segment RE-LC. As shown in Fig 3 and Table 1, the mean values for the RE-LC segment was 75.361 mm and for the LE-LC segment was 74.964 mm.

Willis\(^{11}\) published that the distance between the base of the nose and the lower edge of the mandible should equal the distance from the pupil of the eye to the rima...
The Willis gauge measures the distance between the septum of the nose and the chin. Inaccuracies resulting from the use of the Willis gauge method are caused by the following: inconsistent angulations of the instrument (especially for convex profiles, and patients with moustaches and beards, short necks, full lips, and round chins) and compression of the soft tissue under the chin and septum of the nose through pressure exerted by the gauge.

The advantages of facial digital images in dental practice are substantial. The professional can evaluate the patient's face without his/her presence, thereby reducing time in the clinic. Digital images allow for facial analysis through an image processing program, which offers efficiency while converting the virtual to the actual dimension.

Another advantage is the lack of soft tissue compression. The use of simple instruments, such as Boley gauge, compasses, and dividers can offer inaccurate measurements when they distort the soft tissues. They can also injure soft tissue if the tips of modified dividers are in contact with the patient's skin.

The sample of this study represents the ethnic diversity of the Brazilian population. It is not satisfactory to accept esthetic concepts which result from studies of different ethnic populations. In this view, it is essential to publish anthropometric measurements from different ethnic populations. The sample of this study represents the ethnic diversity of the Brazilian population. It is not satisfactory to accept esthetic concepts which result from studies of different ethnic populations.

In conclusion, it is necessary to develop studies, which relate the measurements presented in this study, to other ethnic groups to determine if the associations observed by Willis can be utilized in oral rehabilitation treatments of the lower third of the face for edentulous patients.
Conclusions

After analyzing front-view facial digital images, there were no significant differences between the opposite sides of the face (RE-LC and LE-LC). The distance of segment RE-LC presented values with significant differences to BN-M. However, the distance measured for the LE-LC segment showed no significant difference to segment BN-M. Significant statistical correlations were found between the facial measurements, and two equations of linear regression were calculated to estimate the values for the vertical dimension of the face.

References