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RESEARCH ARTICLE

Comparative Analysis of the Lip's Soft Tissue by Using 3D Stereophotogrammetry: Age and Gender

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Abstract

Introduction: Facial analysis of soft tissue using 3D stereophotogrammetry can contribute to the process of facial identification through the smile.

Aim: To compare measures of linear, angular and area variables in three-dimensional images of the lip's soft tissues between gender and age, to contribute to the process of human face identification based on smile images.

Methods: The total sample consisted of 120 Brazilian subjects, 60 men and 60 women, divided into three different age groups: 18 to 35 years; 36 to 50-years-old and 50 to 70-years-old (20 male volunteers and 20 women in each age group, male and female). 32 points were marked on the face, after that 3D images were taken (Vectra® H1, Canfield Scientific, Parsippany, NJ, USA) and linear, angular and area measures of the lip's soft tissue were analyzed (ANOVA, $p < 0.05$ as significance).

Results: Age showed more expressive differences when compared to variables between genders. This can be analyzed since the variables of the upper and lower lip vermilion area, mentolabial angle, upper lip vermilion height and lower lip vermilion height presented the values of $p = 0.01$, respectively; 0.02; 0.04; 0.0001; 0.002; while in relation to gender, only the nasolabial angle variable had a p-value of 0.03.

Conclusion: In conclusion, the variations that can be observed through three-dimensional images in soft tissue of the lips are only significant when comparing different age groups. Several analysis techniques for human identification based on smile images have been studied and developed, and these results indicate that perioral soft tissue variations can be a comparison variable focused only on age estimation and should not be considered in the estimation of gender.

Keywords

Face, Human identification, Stereophotogrammetry

Introduction

The facial identification of each human being is performed by analyzing individual characteristics related to dental occlusion, harmony, musculature, shape and the anatomical configuration of structures [1]. The identification is related to the set of procedures and techniques to individualize a person or an object. This form of identification must be carried out by professionals trained in Legal Dentistry and Legal Medicine.

One of the areas of study of Legal Dentistry is the facial identification of individuals, making it possible to observe variations through each person's anthropometric structures and facial organs. Therefore, Forensic Facial Identification consists of a process of capturing and comparing facial biometric characteristics using scientific methods [2]. Given that contemporary society has a high frequency of photos found on social networks, Forensic Dentistry can contribute to facial identification *post-mortem* through the *ante-mortem* photos. In view of the various facial analysis techniques, stereophotogrammetry can be better applied since it presents soft tissues analysis.

The two-dimensional image has limitations due to

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the difficulty in analyzing depth and volume [3]. For this reason, three-dimensional (3D) stereophotogrammetry technique is the most used in clinical situations, as it does not have contact with soft tissue and has less distortion. The method is formed by registering two or more images to acquire a 3D image, using specific software. After the images are sent to the computer, the 3D models of stereophotogrammetry can be analyzed employing linear, volumetric, angular or area measurements and/or comparison of patterns of reference points or the entire face [4]. These comparisons can be made considering gender, ethnicity, and age. This method is also important because these images allow registration in software that allows comparisons with other images during clinical follow-up. The possibility of manipulating the 3D image in different directions allows the performance of several types of soft tissue analysis [5].

So, the present study aimed to compare measures of linear, angular and area variables in three-dimensional images of the lip's soft tissues between gender and age, to contribute to the process of human face identification based on smile images.

Materials and Methods

This descriptive observational cross-sectional study was submitted to and approved by the Research Ethics Committee (REC) of the School of Dentistry of Ribeirão Preto/São Paulo University (FORP/USP), CAAE: 09281919.2.000.5419. All research volunteers were informed regarding the research objectives, risks and benefits, and signed an informed consent form.

The total sample consisted of 120 Brazilian subjects, 60 men and 60 women, divided into three different age groups: 18 to 35 years; 36 to 50-years-old and 50 to 70-years-old (20 male volunteers and 20 women in each age group, male and female). These volunteers were invited to participate in the research through verbal communication, e-mail or telephone contact.

To be included in this study, individuals should be Brazilian, aged between 18 and 70-years-old, without facial deformities. Volunteers with a history of tumors and/or surgery in the head and neck region, patients with cognitive disorders and/or the presence of congenital syndromes, patients with a history of paralysis or facial neuralgia were excluded.

The 3D photos were obtained at the Stomatognathic System Electromyography Research Laboratory (LAPESE) of the Department of Restorative Dentistry of School of Dentistry of Ribeirão Preto/São Paulo University (FORP/USP) according to the laboratory's specific and standardized protocol.

The device used to capture the images was the Vectra® H1 (Canfield Scientific, Parsippany, NJ, USA), which results from a different technique than the fixed system from the same manufacturer (Vectra® M3). As the device has no screen and only has a set of two lenses, three captures are necessary at different times. The first image is taken with the focus on the right side of the participant's face. The portable system is positioned 45 degrees to the right, being about 30 cm below the subnasal region (area that coincides with the height of the bust). The distance that the camera must remain from the participant's face is defined by the convergence of two points of light, created from the camera lens itself. This convergence of points defines the focal distance necessary for the correct acquisition of the image, as well as its perfect framing. The points must converge and point to the intersection of two lines: A horizontal one, drawn at the point *Subnasale*; and vertical, passing through the point *Exocantion [r]*.

The second image is captured frontally to the participant; however, the camera's vertical positioning should be just slightly below the *Subnasale* point. This reference point now becomes the region where the camera's luminous points should converge. Finally, the third image is obtained similarly to the first, but on the participant's left side: Average height of 30 cm below the *Subnasale* point, with the luminous points converging at the intersection of the horizontal line that passes through the *Subnasale* point and the vertical line that passes through the *Exocantion [l]* point.

After the stage of capturing the images, the digital files were transferred to the computer employing a memory card. This type of transfer was chosen because it does not require the camera to be connected to the wired computer, which facilitates the handling of the camera. Furthermore, this method of transferring files seems much more interesting to us, as it is this form that makes the system truly portable and useful in locations far from the computer.

Then, the software automatically converted each captured image into a 3D image of the photographed region. By selecting the necessary images, the command was made to "stitch" the images, forming the 3D model of the participant's face.

The operator responsible for marking the reference points and capturing the images received previous training. In this study, to test the reliability and accuracy of landmarks before capturing the images, a calibration test was performed. The sample consisted of 20 adults. An experienced and two inexperienced operators were calibrated; 2 photos were taken for each volunteer: One at rest and one smiling and 28 linear measurements were calculated for each image.

The establishment of facial reference points for marking and recording measurements was based on previous studies [6]. In total, 32 points were marked on the face, which is considered protocol by the research group. However, in this study, 11 of these points were used for analysis (Table 1).

First, for each patient, a head band was placed to

Table 1: Landmarks used in the study with their abbreviations and definitions according to Farkas, 1987 [7].

Abbreviation	Reference point	Definition
C	Columella	Most anterior point of the columella
Sn	Subnasale	Midpoint at the junction of the lower edge of the nasal septum and the upper lip
Ls	Labiale superius	Midpoint at the beginning of the vermillion of the upper lip
Cph [r], Cph [l]	Crista philtri	On each raised edge of the filter, above the upper vermilion line
Ch [r], Ch [l]	Cheilion	Lip commissure
Sto	Stomion	Intercession of facial midline and horizontal cleft lip
Li	Labiale inferius	Midpoint at the beginning of the lower lip vermilion
Sl	Sublabiale	In the midline of the nasolabial fold
Pg	Pogonion	Most anterior point of the chin

Note: Own elaboration.

Table 2: Means and standard deviations according to each age group analyzed.

	18-35 years		36-50 years		50-70 years			
	Mean	SD	Mean	SD	Mean	SD	P (Gender)	P (Age)
Vermillion of the upper lip	4.6	1.0	3.6	0.2	3.1	0.6	0.78	0.01*
Vermillion of the lower lip	4.5	0.6	3.4	0.9	3.0	1.2	0.34	0.01*
Nasolabial angle	111.2	9.7	110.2	12.8	109.6	6.5	0.03*	0.87
Mentolabial angle	131.2	17.2	144.3	9.4	157.1	20.8	0.21	0.02*
Lip width	45.5	3.3	48.6	5.2	50.5	4.1	0.11	0.16
Upper lip vermilion height	8.0	0.7	6.7	1.4	5.6	1.0	0.79	0.0001**
Lower lip vermilion height	10	2.0	7.6	2.0	5.9	2.1	0.24	0.002**

Note: Own elaboration; SD: Standard Deviation

remove the hair from the region, avoid overlapping the image, facilitate the marking of points by the operator and promote better reading in the region. A sterile gauze soaked with 70% alcohol was used to clean each patient's face to remove any impurities, oil, and makeup from the skin. All male patients had facial trichotomy performed so that the marked points were clearly seen in the images. Subsequently, the reference points marking was performed manually with a Pretolino eyeliner (Quem Disse, Berenice?®, Registro, SP, Brazil), such procedure being performed by the same operator in all evaluated patients. The reference points Ch [r], Ch [l] and Sto were directly marked after capturing the images, as they are well delimited by facial anatomy and can be reliably reproduced on the computer, and also, due to the difficulty of marking these points on the face.

Variables analyzed

Areas (mm^2):

- Vermillion of the upper lip: Area around the vermilion of the upper lip, passing through the points Ch [r], Ch [l], Ls, Sto, Cph [r] and Cph [l];
- Lower lip vermilion: Area around the lower lip vermilion, passing through points Ch [r], Ch [l], Sto and Li.

Angles (degrees):

- Nasolabial angle: angle formed by points C, Sn and Ls;
- Mentolabial angle: angle formed by the points Li, Sl and Pg.

Linear Measurements (mm):

- Lip's width: distance between the labial commissures, taking the points Ch [r] and Ch [l] as reference;
- Upper lip vermilion height: distance between points Ls and Sto;
- Height of the lower lip vermilion: distance between the points Sto and Li.

Initially, data were organized in spreadsheets and analyzed according to their distribution using the Shapiro-Wilk Normality Test (adopting $p > 0.05$ as parametric). From this first analysis, the measurements obtained (linear, angular, area) were compared between the independent variables (gender and age group) through Analysis of Variance (One-Way ANOVA). The level of significance adopted was 5%.

Results

Table 2 shows the average and standard deviation according to each age group analyzed: 18-35 years, 36-50 years and 50-70 years. Statistically significant differences were found especially for age. Age showed more expressive differences when compared to

variables between genders. This can be analyzed since the variables of the upper and lower lip vermilion area, mentolabial angle, upper lip vermilion height and lower lip vermilion height presented the values of p = 0.01, respectively; 0.02; 0.04; 0.0001; 0.002; while in relation to gender, only the nasolabial angle variable had a p-value of 0.03.

Statistically, it was demonstrated that, according to the age groups, the vermilion of the upper lip (p = 0.01), vermilion of the lower lip (p = 0.01) and the mentolabial angle (p = 0.02) over the years show significant changes with low values. Regarding the nasolabial angle (p = 0.87) and the width of the lips (p = 0.16), they did not show significant changes because they obtained higher values. When observing the values of the vermilion height of the upper lip (p = 0.0001) and the height of the lower lip (p = 0.002), significant differences can be observed.

When analyzing the statistical data related to the differences between the sexes, a significant difference can be observed in relation to the nasolabial angle (p = 0.03). When the other variables are analyzed, upper lip vermilion (p = 0.78), lower lip vermilion (p = 0.34), mentolabial angle (p = 0.21), lip width (p = 0.11), height of the vermilion of the upper lip (p = 0.79) and height of the vermilion of the lower lip (p = 0.24) did not present significant differences.

Discussion

The evaluation of anthropometric measurements of the face is of great importance for scientific research, as they can be registered and verified allowing the classification of an individual according to the analyzes performed [2]. Another important point is that these measurements can provide us in addition to linear measurements, angles, areas, and volumes that specifically characterize everyone. The stereophotogrammetry technique has been used since the mid-1940s. This system shows promising results in 3D analysis [8], since it is a method capable of producing three-dimensional images in a fast, precise, safe, non-invasive manner, providing high-resolution images of soft tissues and enabling studies with high accuracy [5,9,10].

The stereophotogrammetry method adopted in the present study was carried out using a portable device (for capturing images at different angles, which allows us to be more practical and simple in handling the equipment. And, in addition to the other advantages already mentioned, this mobile method is also highlighted by the fact that patients who are unable to move around do not need to go to the location of the fixed device, the device can be taken to the patient [11].

In this study, it was observed that, with advancing of age, the analysis of anthropometric measurements of soft tissues showed significant differences, and in this context, other articles were analyzed to observe, comparatively, what are the relations of the analysis of facial measurements with the age range and check if the results are equivalent to this work.

Among both sexes, a significant decrease in the nasolabial angle was found. The opposite was found by Edelstein, et al. [12] who noticed an augmentation in this angle as the age increased due to the stretching of the upper lip and the maxillary alveolar ridge's resorption. A possible justification for this disagreement would have been the method used for the acquisition and measurement. In our study stereophotogrammetry was used, that is, a three-dimensional method and the second, photographs, a two-dimensional method, assuming that the spatial notion of the images could influence the results.

Furthermore, it has been proposed by some authors that bone changes in the middle third of the face may be the result of a clockwise rotation of the maxilla in relation to the skull base, producing a loss of tissue support [13,14]. This could explain the increase in the nasolabial angle since we would have less bone support and consequently less soft tissue coverage.

In relation to age, the upper and lower lip's vermilion area decreased significantly with the advancement of the years. This type of change was already expected, since fuller lips with greater exposure of their vermilion are considered a sign of beauty and youth [15]. On the other hand, a reduction in the vermilion border, thinner lips, less tonicity of mastication muscles, and mimicry-mainly of the orbicularis of the mouth- and disappearance of Cupid's bow are usually associated with an aged mouth [16,17].

In relation to the mentolabial angle, in the aging process, two important factors can be identified: The morphological changes of the hard tissue and the soft tissue's transformations. The sum of these two aspects results in macroscopic changes related to age described in the literature, such as the position of the lip lines, thickness and length of the lips, and reduction of their redness [16]. In addition, with advancing age many patients tend to become edentulous, losing the main support for the soft tissue, which are the teeth [18]. This would explain the increase in the angle between the sexes with increasing age.

The upper and lower lip height also decreased significantly over the years. The literature offers several descriptions of changes in facial soft tissue aging. Studies have reported that aging of the soft tissues of the face, including the lips, is characterized by weakening of the underlying muscles, thinning of the epidermis, atrophy of the layers of subcutaneous fat, progressive loss of the organization of elastic fibers and collagen in the dermis and bone resorption [19]. Poor organization of these structure's arrangement due to age can explain the loss of height of both the upper and lower lip [20].

Even though this study presents a series of significant differences in the perioral regions between men and women and young and elderly patients, it is worth mentioning that there are no rules for attractiveness. There may be several subjective factors to evaluate it, being extremely important the obtaining a 3D image acquisition device. In this study, the stereophotogrammetry method was used, which is considered a valuable tool with proven repeatability.

Conclusion

In conclusion, the variations that can be observed through three-dimensional images in soft tissue of the lips are only significant when comparing different age groups. Several analysis techniques for human identification based on smile images have been studied and developed, and these results indicate that perioral soft tissue variations can be a comparison variable focused only on age estimation and should not be considered in the estimation of gender. As 3D stereophotogrammetry is a soft tissue analysis technique, it can greatly contribute to facial identification techniques, especially with the dissemination of smile photos on social networks.

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