Computerized morphometry of the area of the hard palate and of palatal rugae: a cross-sectional study

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Abstract

Background: The evaluation of palatal rugae in human identification is important because these structures can remain intact for up to seven days after death. **Aim:** To compare the area and density of the palatal rugae between ages groups and genders. **Settings and Design:** A cross-sectional study. **Methods and Material:** Dental plaster models obtained from patients at the Orthodontic Clinic of University of Uberaba were selected. Two hundred patients were divided into four groups: Group 1:10-15 years; Group 2:16-30 years; Group 3:31-50 years; and Group 4:51-70 years. The palatal rugae and hard palate of each plaster model were outlined and photographed. The evaluation of the area of the hard palate and palatal rugae was performed using the ImageJ software. **Statistical analysis used:** Kolmogorov-Smirnov, Kruskal-Wallis, Chi-square and Spearman correlation tests using GraphPad Prism 5 statistical software. **Results and conclusion**: The areas of the palatal rugae and of the hard palate were significantly smaller in the group 4. There was a significant negative correlation between age and palatal rugae area, and between age and hard palatal area. The present study was the first to demonstrate that patients between 51 and 70 years have a smaller palatal rugae area and a smaller hard palate area when compared to other groups. Thus, the evaluation of the hard palate area and of palatal rugae could be used as an adjunct with other methods to determine the age group of an individual; however studies using larger sample size are needed to validate this observation.

Key words

Anatomy; Forensic Dentistry; Morphometry; Palatal Rugae
Source: DeCS (Descriptors in Health Sciences)

INTRODUCTION

Human identification is one of the main fields of study and research in forensic sciences, as it deals with bone remains of unknown corpses in order to establish their identity [1]. Identification is very important in mass disaster situations, air and road accidents, fires and even criminal investigations. [2]
Identification can be performed by different methods such as DNA typing, finger printing, dental arch and skeleton identification, facial reconstruction and the study of palatal rugae. The study of the palatal rugae pattern offers a unique method for identification cases due to its uniqueness, heat resistance and lifelong resistance [3,4,32] with advantages such as low cost, speed and ease of execution. [5]
Palatal rugae are located in the anterior part of the palatal mucosa behind the incisive papilla and bilaterally to the midpalatal raphe. [33] These structures are formed in the third month of intrauterine life and generally do not change from childhood to adulthood. [6] The length of palatal rugae increases during normal growth, but their orientation remains throughout the individual's life. However, the anatomy of the palatal rugae may be altered by tooth extraction, finger sucking during childhood and orthodontic treatment, which affect the action on the tooth and alveolar bone. [8] The pattern of rugae is unique to each individual, even in monozygotic twins, [9,10] facilitating the identification of fresh corpses and charred or amputated individuals. [11]
Because of their fibrous origin, palatal rugae can resist changes by decomposition for up to seven days after death. [3] In addition, palatal rugae are preserved longer in trauma processes, especially in the case of carbonization of the body, as they are protected by anatomical structures such as a cheeks, lips and tongue, [12] due to their location in the oral cavity [13].
Palatal rugae are classified by inspection and intraoral photographs, stereoscopy, stereophotogrammetry and plaster model analysis. [14] Several classification systems have been proposed in the literature according to the shape, distribution, direction and position of rugae [15,16]. However, to date, there are no studies that perform a computerized evaluation of the hard palate area and palatal rugae, that compare changes between the sex and age groups. Therefore, the aim of this study was to compare an area and a density of palatal rugae between age groups and genders by analyzing human palatal plaster models.

MATERIALS AND METHODS

Selection of patients and formation of groups

This cross-sectional study was approved by the Ethics Committee in Human Research of the Federal University of Triangulo Mineiro (*CEP-UFTM*), Uberaba, Minas Gerais state, Brazil, under Certificate of Presentation for Ethical Consideration (*CAAE*) number 39208714.1.0000.5154. Data on patients treated between the years 2000 and 2014 was obtained through medical record review at the Orthodontic Clinic of the University of Uberaba (*UNIUBE*) in the city of Uberaba, MG, Brazil. Demographic data, such as age and gender, were evaluated for homogeneous distribution among groups.
After selection, the study included 200 patients between 10 and 70 years whose plaster models of the upper arch had been filed. The patients were divided into four groups according to age, as follows: Group 1: 10-15 years (n = 50); Group 2: 16-30 years (n = 50); Group 3: 31-50 years (n = 50); and Group 4: 51-70 years (n = 50). The patients were homogenized according to gender.
Exclusion criteria included patients below 10 and above 70 years, patients with palatal abnormalities, patients with failure in the reproduction of the palatal rugae, patients with removable prosthesis and edentulous patients.

Recording of pattern of the hard palate and of the palatal rugae

The patterns of both the hard palate and the all palatal rugae of each plaster model were outlined with the aid of a 0.7mm black mechanical pencil, and were, hence, evidenced in white model (Figure 1).
The 200 dental models were photographed individually using a Canon EOS Digital Rebel Xti camera (Canon Brasil, São Paulo, SP, Brazil) placed 30 cm above the model with the aid of a Fuji tripod (Fujifilm do Brasil, São Paulo, SP, Brazil).
The plaster model to be photographed was placed on a flat surface, parallel to the floor, with the palatal surface facing up. The camera was coupled to a tripod and positioned in order to be as perpendicular as possible to the imaginary line through the center of the lens to the plaster model on the table plane, parallel to the floor. A millimeter scale ruler (ABFO scale number 2, Crime Scene, Phoenix, Arizona, United States) was placed next to the model in order to standardize as well as demonstrate the parallelism of the lens to the plaster model (Figure 1).

Figure 1. Millimeter scale ruler (ABFO scale nº. 2) placed next to the model outlined to the photographic register of hard palate and the palatal rugae areas.

Evaluation of palatal rugae area was performed using ImageJ software (Bethesda, Maryland, USA). At first, the software was calibrated by drawing a milliliter line with ABFO scale next to the image of the model. After calibration, morphometry was performed with the aid of a cursor by outlining the hard palate and each of the palatal rugae in the plaster models. The areas of each palatal rugae and the area of the hard palate were expressed in square millimeters (mm^2). This analysis was performed by a single calibrated blind examiner, who recorded the data of each rugae in a Microsoft Excel spreadsheet. After having measured the area of the hard palate and the total number of palatal rugae, the density of the latter was calculated and expressed as a number of palatal rugae per square millimeter of the hard palate (n/mm^2).

Statistical analysis

The data entered into the Microsoft Excel spreadsheet were analyzed using GraphPad Prism 5 statistical software (GraphPad, California, USA), and the Kolmogorov-Smirnov test was used to assess the normality. The Kruskal-Wallis test was used to compare variables with non-normal distribution between the four groups, and the chi-square test was used for qualitative variables (male/female). BioEstat 5.0

software (Sociedade Civil Mamirauá, CNPq, Brazil) was used for correlation, and Spearman correlation test was used for non-normal distributions. The significance level was 5% ($p < 0.05$).

RESULTS

The demographics of Groups 1, 2, 3 and 4 are shown in Table 1. There was no statistically significant difference concerning gender between the patients of the four groups. Within each group, there was no significant difference when comparing age between genders demonstrating that there was a homogeneous distribution between the groups.

Table 1. Demographic characteristics of Groups 1,2,3 and 4

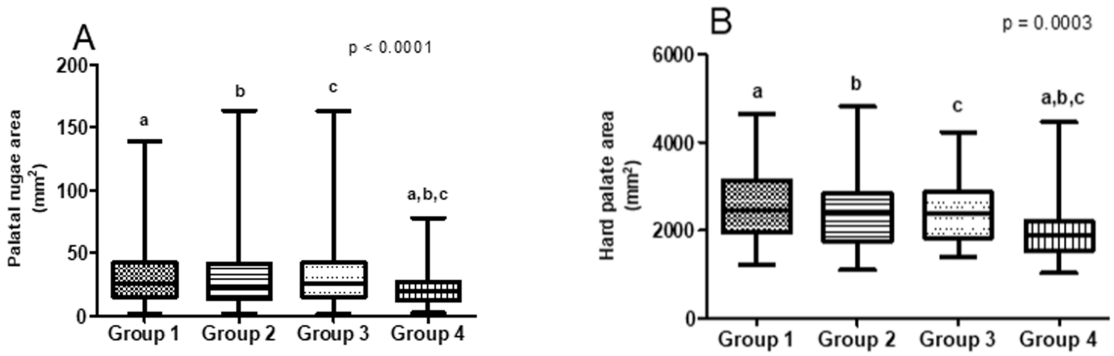
Table 1 – Demographic characteristics of Groups 1, 2, 3 and 4.

	Group 1 (n = 50)	Group 2 (n = 50)	Group 3 (n = 50)	Group 4 (n = 50)
Gender[a] (M/F)	25:25	25:25	25:25	25:25
Age (years, mean ± SD)	12,36±1,48[b]	21,96±4,93[c]	37,88±4,52[d]	53,50±3,48[e]

M, male; F, female; SD, standard deviation; [a] Male x Female; Chi-square test, p = 1,00; [b] Male x Female; Mann-Whitney test, p = 0,77; [c] Male x Female; Mann-Whitney test, p = 0,22; [d] Male x Female; Mann-Whitney test, p = 0,62; [e] Male x Female; Mann-Whitney test, p = 0,42.

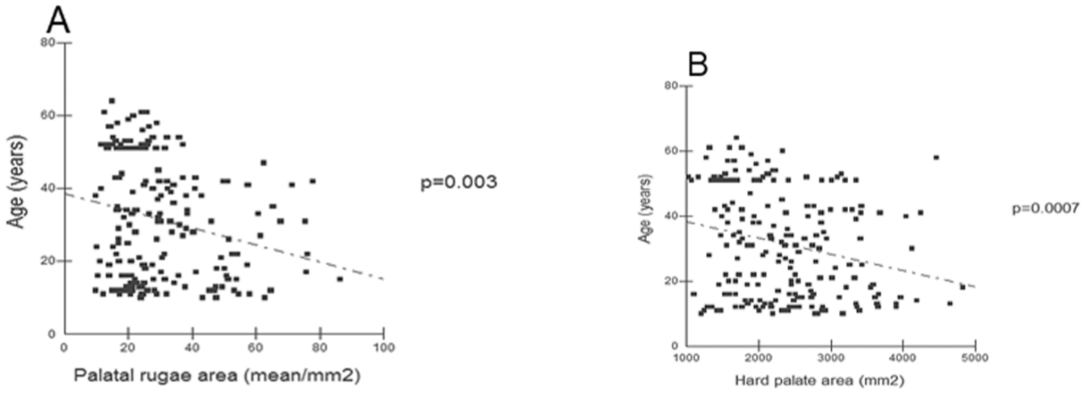
The palatal rugae area was significantly smaller in Group 4 compared to the other groups (Figure 2A). There was no significant difference in the area of rugae palatal between genders (data not shown).
The hard palate area was significantly smaller in Group 4 compared to the other groups (Figure 2B).

Figure 2. (**A**) Palatal rugae area in Groups 1, 2, 3 and 4, regardless of age. Kruskal-Wallis test, $p<0.0001$. The values were expressed in mm^2. Similar letters indicate statistically significant difference in groups; (**B**) Hard palate area in Groups 1, 2, 3 and 4, regardless of age. Kruskal-Wallis test, $p=0.0003$. The values were expressed in mm^2. Similar letters indicate statistically significant difference in groups.



When evaluating the patients of the four groups, it was possible to observe that there was significant negative correlation between age and palatal rugae area (Figure 3A) and between age and hard palate area (Figure 3B).
There was no statistical difference regarding the density of palatal rugae between genders and between age groups (data not shown).

Figure 3. (A) Correlation between age and palatal rugae area. Spearman correlation coefficient, rS = -0.208; p=0.003; (B) Correlation between age and hard palate area. Spearman correlation coefficient, rS = -0.237; p=0,0007



DISCUSSION

Although some studies have already evaluated the number, length, shape, direction of the palatal rugae and the distance of the palatal rugae to certain reference points in order to make a comparison between the genders,[8,1217,18,19,20,21] the determination of the area and of density of the palatal rugae, as well as the comparison between age groups were not performed in any study so far. The present study was the first to evaluate the area and density of the palatal rugae and also to use the computerized morphometry for this purpose.

The determination of gender is crucial in forensic investigation, so that the biological profile of human remains can be constructed.[22] Although there are few studies comparing the area of palatal rugae between genders, it is known that in males the epidermis is thicker and has a higher amount of collagen,[23,24] which could lead to an increase in the area of palatal rugae in men. However, in the present study, there was no significant difference between the area of palatal rugae between genders. Therefore, new investigations should be carried out with a greater number of cases in order to corroborate the results of the present study. Although no studies have been found comparing the density of palatal rugae between genders, some studies have already shown that women have a lower number of palatal rugae than men. [6,25] On the other hand, other studies reported a higher average number of palatal rugae in Indian women compared to men.[6,26] However, in the present study, no significant differences were observed in relation to the density of palatal rugae between the genders, which corroborates previous studies in indigenous populations, where the authors did not find differences in the number of palatal rugae comparing men and women.[15,17,19,27] In Brazil only one study compared the number of palatal rugae between genders, but the authors also did not find significant differences.[28] Our study was the first to compare the density of palatine palatal rugae between genders.

When comparing the palatal rugae area between the four age groups, a significantly smaller area of palatal rugae was observed in Group 4. Furthermore, in the present study there was a significant negative correlation between age and palatal rugae area. Although studies assessing the area of the palatal rugae and the thickness of the palatal epithelium could not be found in the literature, it is known that elderly skin has flattening of the dermal-epidermal junction and reduction of epidermal thickness.[29] Furthermore, thinning of the epidermis and flattening of the dermal-epidermal junctions are partly responsible for cutaneous atrophy in the elderly.[30,31] In periauricular tissue of the elderly there is fragmentation of collagen fibers with loss of normal fibrillar pattern and destruction of elastin.[32] Tissue atrophy has also been described in skeletal

muscle, brain, kidney and heart in the elderly, which may be due to the reduction in capillary density with aging.[30] Therefore, tissue changes due to aging can be happening in the palatal rugae of patients in the present study, the which would justify the smaller area of these rugae in the patients aged 51-70 years.

The area of the hard palate in group 4 was significantly smaller when compared to the other groups. In addition, there was a negative and significant correlation between age and the hard palate area, demonstrating that the hard palate decreases with aging, even in dentate patients. Although it is known that organs decrease in size with aging,[33] the present study was the first to demonstrate a decrease in the area of the hard palate in individuals over fifty years of age.

Therefore, within the limitations of the present study, it may be concluded that patients between 51 and 70 years have a smaller palatal rugae area and a smaller hard palate area when compared to other groups. Thus, the evaluation of the palate area and of palatal rugae could be used as an adjunct with other methods to determine the age group of an individual; however, studies using larger sample size are needed to validate this observation.

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