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Correlation Between the Anatomical Morphology of Palatal Rugae and Sex

Correlación entre la Morfología Anatómica de las Rugas Palatinas y el Sexo

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SUMMARY: To investigate the correlation between the anatomical morphology of palatal rugae and sex. The study sample consisted of 120 students studying from Shanxi Medical University, of which 60 were females and 60 were males. The digital model of the palatal rugae was obtained by the 3 Shape TRIOS intraoral scanner. And the shapes of palatal rugae were recorded. Association between palatal rugae shape and sex were tested using Chi-square analysis. And logistic regression analysis (LRA) was carried out to calculate the accuracy of gender prediction using rugae shapes. There was a statistically significant difference between males and females in terms of the distribution of wavy and circular palate rugae. The use of logistic regression analysis obtained a sex predictive value of 65 % when all the rugae shapes were analyzed. Digital images of the palatal rugae morphology contribute to more accurate and convenient for data collection and transformation. It was found that rugae patterns can moderately identify the sex of the specific population when multivariate statistics such as LRA is applied. The palatal rugae morphology can be utilized as an assistant measure for sex identification.

KEY WORDS: Forensic anthropology; Forensic stomatology; Palatal rugae morphology; Sex identification.

INTRODUCTION

Palatal rugae are irregular and asymmetrical ridges on both sides of the median palatal raphe in the anterior part of the maxillary hard palate. The morphology of palatal rugae is individual-specific, and its development is strictly controlled by genes (Suhartono *et al*., 2016; Syed *et al*., 2016; Trakanant *et al*., 2020). They are stable and consistent in morphology throughout the life following completion of growth (Hermosilla *et al*., 2009; Selvamani *et al*., 2015). Constraints to the use of DNA analysis, fingerprints and dental record comparisons occur in situations where mass disasters occur. A useful method of human identification in this circumstance is by identifying the palatal rugae (De Angelis *et al*., 2012; Buyuk *et al*., 2017; Basman *et al*., 2018). Sexual dimorphism has made a significant contribution to rebuilding the identity of victims, and it has played an important role in narrowing lists of missing persons (Adserias-Garriga *et al*., 2018; Andrade *et al*., 2019). Several body parts have been used for sexual dimorphisms, such as the pelvis, humerus, femur, and skull. In this study, the correlation between the anatomical morphology and sex of palatal rugae was studied, which provides a theoretical basis for sex inference in forensic dentistry.

MATERIAL AND METHOD

Research object. The study sample consisted of 120 students studying from Shanxi Medical University within the age group of 18-30 years, of which 60 were females and 60 were males. All of them belonged to the same geographical population, Shanxi, China. And they were healthy, free of congenital abnormalities, systemic diseases, skull and jaw trauma, orthodontic treatment or any other palatal pathology. The

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subjects who have a history of wearing maxillary dentures and palatal surgery were excluded from the study. Institutional ethical clearance was obtained to conduct the study.

Instruments and software. 3 ShapeTRIOS Intraoral Scanner (3Shape, Denmark); 3 Shape3DViewer software (3Shape, Denmark); the SPSS version 21.0 statistical package.

Harvesting of palatal rugae images. The purpose of this study was explained to the subjects and informed consent was obtained; the basic information from subjects was recorded. The digital model of the palatal rugae was obtained by the 3 ShapeTRIOS intraoral scanner (Fig. 1). The model requires that the surface of the palatal rugae is clear and complete, and accurately reflect the structure of the soft and hard tissues of the oral cavity. The color images of palatal rugae were grayed out and normalized by 3Shape3DViewer software. The median palatine raphe, incisor papilla, and the edges of palatal rugae were marked. The method of the shape of palatal rugae analysis used in this study was based on the classification of the single palatal rugae by Kapali and the further classification of the Unification/branching palatal rugae by Thomas and Kotze (Thomas & Kotze, 1983; Kapali *et al*., 1997). The shape of palatal rugae can be divided into wavy, straight, curved, circular, diverging, converging. Any other form which did not fit into the criteria was classified as non-specific. All parameters were analyzed by one independent observer. Palatal rugae were observed repeatedly by the same observer to rule out intra-observer variability.

Fig. 1. The digital palatal rugae images.

Statistical analysis. All statistical analyses were performed using the SPSS version 21.0 statistical package. Association between palatal rugae shape and sex were tested using Chi-square analysis. And logistic regression analysis (LRA) was carried out to calculate the accuracy of sex prediction using rugae shapes.

RESULTS

The number of occurrences of different rugae shapes is described. The total number of rugae was 1205, including 608 in males and 597 in females. The wavy, straight and curved types are the most common rugae types while converging and non-specific shapes are rare (Fig. 2).

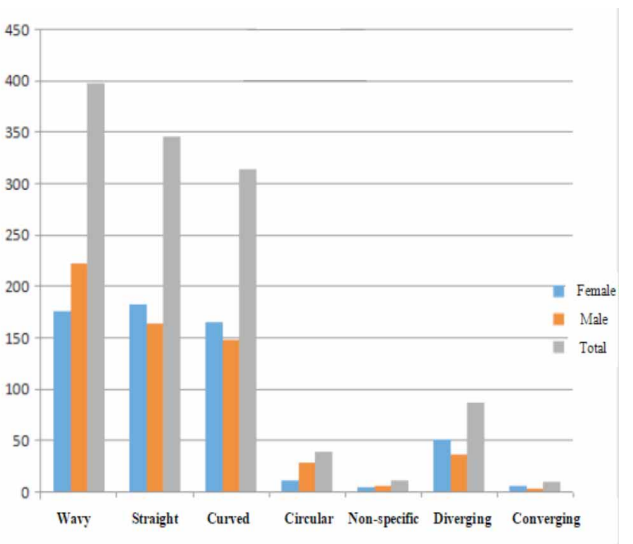

Fig. 2. Distribution of the different types of rugae shape in males and females.

Table I. Chi-square analysis for assessing sex differences in rugae pattern.

Rugae pattern	Female		Male		Chi-square value	P value
	N	Percentage (%)	N	Percentage (%)		
Wavy	176	29.48	222	36.51	6.735	0.009 (S)
Straight	182	30.49	164	26.97	1.815	0.178 (NS)
Curved	166	27.80	148	24.34	1.875	0.171 (NS)
Circular	11	1.84	28	4.61	7.341	0.007 (S)
Non-Specific	5	0.84	6	0.99	0.074	0.785 (NS)
Diverging	51	8.54	36	5.92	3.091	0.079 (NS)
Converging	6	1.01	4	0.66	0.12	0.729 (NS)
Total	597	100	608	100		

P value < 0.05- Significant (S) ; P value > 0.05 -Non-Significant (NS).

Chi-square analysis done to assess the sexual dimorphism showed a significant difference in the wavy and circular pattern. Males had a greater number of wavy and circular rugae than females. There was no statistically significant difference between males and females in terms of the distribution of other patterns (Table I).

The logistic regression analysis is used for multiple variables that can handle both discrete and continuous variables successfully. A logistic regression model was established, with sex (where Male=1 and Female=0) as a dependent variable and rugae shapes as an independent variable. The model has a high accuracy of fit with the obtained data. Only wavy and circular forms were statistically significant (Table II). A predictive value of 65 % was obtained in determining the sex prediction correctly when all rugae shapes were analyzed.

Table II. Classification table of Logistic Regression Analysis (LRA).

Rugae pattern	Regression coefficient (b)	OR(95%CI)	P value
Wavy	-0.349	0.705_0.529-0.940_	0.017 (S)
Straight	0.075	1.077_0.843-1.376_	0.550 (NS)
Curved	0.101	1.106_0.807-1.517_	0.530 (NS)
Circular	-1.276	0.279_0.121-0.646_	0.003 (S)
Non-Specific	-0.337	0.714_0.191-2.669_	0.617 (NS)
Diverging	0.371	1.449_0.811-2.588_	0.211 (NS)
Converging	0.456	1.577_0.381-6.539_	0.530 (NS)

P value < 0.05- Significant (S) ; P value > 0.05 -Non-Significant (NS).

DISCUSSION

Palatal rugae are made up of dense connective tissue and are well protected by lips, cheeks, teeth, and bones. Hence it can resist physical and chemical trauma, time and physical changes (Muthusubramanian *et al*., 2005; Caldas *et al*., 2007). In the event of a catastrophe, it may happen that commonly identification methods such as analysis of DNA analysis, fingerprints and dental records cannot be used (De Angelis *et al*.; Buyuk *et al*.; Basman *et al*.). Then a useful method of human identification methods, like the palatal rugae analysis, could help. At present, the plaster model is mostly used in the study of palatal rugae morphology, which has the disadvantage of poor accuracy, heavy workload and it is not easy to store (Saadeh *et al*., 2017; Andrade *et al*.). In this study, the image of the palatal rugae collected by intraoral scanning has high rate of accuracy and can be directly transmitted to the computer for preservation to facilitate future analysis.

Palatal rugae are unique to the individual (Suhartono *et al*.; Syed *et al*.). In the present study, no identical palatal rugae pattern was found. Therefore, Palatal rugae can be used effectively in the forensic sciences for person identification. Among the population studied the most common form of palatal rugae seen was wavy, followed by straight and curved types (Fig. 2). Our results are consistent with other reports. The wavy rugae pattern was reported as the most commonly observed rugae type in the studies (Selvamani *et al*.; Buyuk *et al*.; Basman *et al*.). However, some have reported a predominance of straight patterns (Goyal & Goyal, 2013). In short, the difference in the predominant shape of palatal rugae was noted in different regions.

The link between the pattern of palatal rugae and sex of the subject has been the focus of the interest of many researchers. There are significant differences in the distribution of wavy and circular rugae between males and females in the present study. Males had a greater number of wavy and circular rugae than females. Selvamani *et al*. in their research of the Kerala population indicated that circular pattern was significantly greater in males than females, and hence can be utilized as a valuable parameter for sex determination. Kotrashetti *et al*. (2011), found significant differences in straight patterns between males and females. Buyuk *et al*. found curved type rugae were the most common of the first primary rugae on the right side in females, whereas the unification type rugae pattern was the most common type in males. In contrast, Muhasilovic *et al*. (2016), did not find any statistically significant difference between the pattern of palatal rugae in Sarajevo males and females. The statistical analysis for assessing sex differences in the rugae shapes did not find a significant difference in Rwandan and Jordanian population studies (Goyal & Goyal; Mustafa *et al*., 2014). It is likely that the results of the sex difference of palatal rugae are closely related to race and probably genetic predisposition.

The logistic regression analysis can handle both discrete and continuous variables, and it has been successfully used in forensic odontology in race determination and age estimation. A logistic regression model was established to evaluate the effectiveness of the palatal rugae pattern as a sex predictor. In the present study, wavy and circular forms were found to be statistically significant on LRA. A predictive value of 65 % was obtained in determining sex prediction. The presence of the wavy and circular pattern type was found to be significantly higher in males. This means that the power of sex prediction may be higher when the wavy and circular pattern types of rugae are used. Saraf *et al*. (2011), in their study was revealed the use of LRA enabled highly accurate sex prediction (>99 %), which is a very high degree of prediction. However, these results do not conform to the results presented by other authors (Muhasilovic

et al.). In addition, This study is limited to the study of samples from the Shanxi region of China. Thus further studies are required with a larger sample size to study the correlation between the rugae morphology and sex.

In the present study, the digital model of palatal rugae patterns was established by three-dimensional scanning, which makes the measured results more accurate and convenient for data collection and transformation. Palatal rugae are unique to the individual and can be used effectively in the forensic sciences for identification. It was found that rugae patterns can moderately identify the sex of the specific population when multivariate statistics such as LRA is applied. The palatal rugae morphology can be utilized as an assistant measure for sex prediction.

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RESUMEN: Investigar la correlación entre la morfología anatómica de las rugas palatinas y el sexo. En la muestra de este estudio se incluyeron 120 estudiantes de la Universidad Médica de Shanxi, (60 mujeres y 60 hombres). El modelo digital de las rugas palatinas se obtuvo mediante escáner intraoral 3 Shape TRIOS, y se registraron las formas de las rugas palatinas. La asociación entre la forma de las rugas palatinas y el sexo se evaluó mediante un análisis de Chi-cuadrado; para calcular la precisión de la predicción de sexo se llevó a cabo un análisis de regresión logística (ARL) Se observó una diferencia estadísticamente significativa entre hombres y mujeres en términos de la distribución de las rugas palatinas onduladas y circulares. El uso de análisis de regresión logística obtuvo un valor predictivo de sexo del 65 % cuando se analizaron todas las formas de las rugas. Las imágenes digitales de la morfología de las rugas palatinas contribuyen a una recopilación de datos más precisa. En este análisis se determinó que los patrones de rugas pueden identificar relativamente el sexo de una población específica, cuando se aplican estadísticas multivariadas como ARL. La morfología de las rugas palatinas se puede utilizar como medida de ayuda para la identificación de sexo.

PALABRAS CLAVE: Antropología forense; Estomatología forense; Morfología de las rugas palatinas; Identificación de sexo.

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