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Determination of Biometric Characteristics of Palatine Rugae Patterns in North Karnataka Population

Lata Mushannavar[1], Dalal Abhay Suresh[2], Atul Sattur[3], Santosh Gowdru Shivanandappa[4]

[1,] *Department of Prosthodontics and Crown and Bridge, SDM college of dental sciences and hospital,Dharwad,India* **.**
[2,] *Department of General Dentistry, SDM college of dental sciences and hospital,Dharwad,India .*
[3,] *Department of Oral Medicine and Radiology, SDM college of dental sciences and hospital,Dharwad,India .*
[4,] *Department of Oral Medicine and Radiology, Annoor dental college and hospital,Muvattupuzha,Keral, India*

I. Introduction

Human identification is based on scientific principles mainly involving fingerprints, dental records and DNA analysis. Use of fingerprints has some limitations in situations where the hands are charred or mutilated. Similarly DNA isolation may be expensive and technique sensitive hence, dental records provide durable evidence in post mortem identification[1,2].

Palatal rugae refers to the asymmetrical, irregular ridges on the anterior part of palatal mucosa on each side of the median palatine raphae and behind the incisive papillae[3].Winslow was the first to describe them in 1732, and the earliest illustration was probably by Santorini in 1775 [4,5]. The study of palatal rugae is called as Rugoscopy. Apart from other fields like anthropology; rugoscopy is used in the fields of dentistry like forensic odontology, prosthodontics and orthodontics[6]. They are also called "plica palatinae" or "rugae palatine[7].

Anatomically, the rugae consist of around 37 ridge and oblique ridges that radiate out tangentially from the incisive papillae. Histologically, the rugae are stratified squamous; mainly para keratinized epithelium on a connective tissue base, similar to the adjacent tissue of the palate[8].Palatal rugae appear towards the third month of intrauterine life & its development and growth is controlled by epithelial- mesenchymal interactions [9]. Once formed, they do not undergo any changes except in length, due to normal growth, remaining in the same position throughout the entire person's life[10]. The form, layout, and characteristics of rugae are not affected by either eruption or loss of teeth. They are stable and resist decomposition for up to 7 days after death[11]. Even if palatal rugae are destroyed due to any trauma; they are reproduced exactly on the same site[12]. Thus, with all the above characteristics palatal rugae acts as ideal post mortem evidence that is present in all victims. It is resistant to change with age or with trauma and thus palatoscopy has been used as an important tool in forensic odontology. With this background, this study was undertaken to study and record the rugae pattern with respect to biometric characteristics of shape, size, direction, number and position in a cross section of the population in north Karnataka. The individuality of the rugae pattern and their correlation with sex of the individual was also evaluated.

II. Materials and methods

A total of 100 subjects, 50 males and 50 females who were healthy and free of congenital abnormalities, inflammation or trauma related to palate, subjects who were wearing partial dentures and braces within the age group of 18-35 years the belonging to North Karnataka population were randomly selected for this study. The study was conducted after obtaining approval from the Institutional Ethics Committee (IRB No.2014/S/-PROS/44) and informed Verbal consent from the subjects.

Alginate impressions were made in perforated metal maxillary impression trays and dental stone casts were made. Black marker pen was used to delineate the outline of palatal rugae. The casts were coded by a dental intern. Flexible brass wire and digital Vernier caliper of 0.01 mm accuracy were used to measure the length of rugae which was recorded according to the classification by Thomas and Kotze[12]. Similarly the pattern of rugae was recorded using the classification given by Kapali et al[13].

2.1Method of Identification. The study was based on the classification given byThomas and Kotze [12] andKapali et al. [13]. (Fig.1and Fig.2)

2.1.1.Length of Rugae. The length of rugae is as follows:
primary (>5 mm).
secondary (3–5 mm),
fragmentary (<3 mm),

2.1.2.Shape of Rugae. The shapes of individual rugae were classified into 4 major types.
Curvy: the curved type had a simple crescent shape with a gentle curve.
Wavy: the wavy rugae were serpentine (snake-like) in shape.
Straight: the straight types ran directly from their origin to insertion.
Circular: they are classified as rugae that showed definite continuous ring formation.

2.1.3.Unification. This occurs when two rugae are joined at their origin or termination. Unification is classified into two categories.
Diverging: rugae were considered to be diverging if two rugae had the same origin but immediately branched.
Converging: rugae were considered to be converging if two rugae with different origins join on their lateral portions.

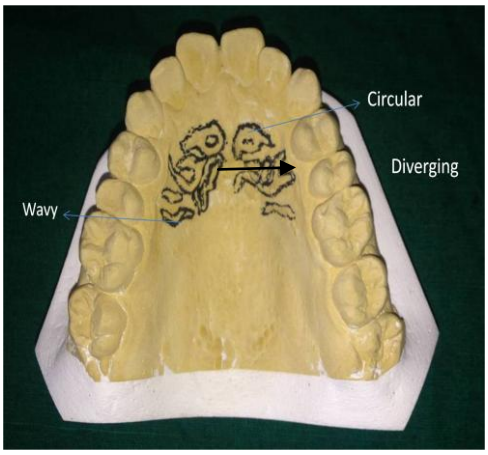

Fig 1

Fig 2

III. Statistical analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to data editor of SPSS version 15.0 (SPSS Inc.,Chicago, Illinois, USA). Chi square and mann-whitney tests, were used for comparison of mean and relationship between the attributes. For all the tests, confidence interval and p-value were set at 95% and ≤0.05 respectively.

IV. Results

The total number of rugae was predominant on left side compared to right side in both males and females. The average number of rugae was slightly more in females(407) than in males(387).Table 1 illustrates the descriptive statistics of the total number of rugae on the right side showed mean number of 4.16 and 4.20 for males and females respectively ;whereas left rugae showed mean number of 4.44 and 4.84 for males and females respectively. There was no statistically significant difference between the number of rugae between right and left sides and gender ($p=0.556>0.05$) .

Table 2 illustrates the frequency distribution of palatal rugae pattern ,in decreasing order of predominance were wavy, straight, curved, and circular patterns in both males and females There was no statistically significant difference between rugae pattern and gender ($p=0.201>0.05$) (Figure3.a and 3.b) .

Table3 illustrates the mean length of primary rugae was 80.7and 76.7 ($p=0.485>0.05$), tertiary rugae was 0.34 and 0.63 ($p=0.355>0.05$) in males and females respectively ,which indicates insignificant difference between the primary and tertiary palatal rugae lengths and gender .Where as the mean length of secondary rugae was 3.7 and 5.5 in males and females respectively, which indicates a significant difference between the secondary palatal rugae lengths and gender ($p=0.019<0.05$).

Table 4 illustrates the gender wise distribution of mode of unification of the rugae which showed predominant diverging pattern 11.8% and 9.8% in males and females respectively with a chi sq-0.816 and p value of 0.366 which shows that difference was statistically insignificant between gender and unification.

Table :1

Frequency distribution of the study sample based on the number according to the gender and sides,Test applied chi square test,*indicates statistical insignificance at p>0.05.

Gender	Number		p-value	Chi-sq
	Right side	Left side	0.556*	0.882
	Mean(SD)	Mean(SD)		
Males	187 (4.16±1.086)	200(4.44±1.307)		
Females	189(4.20±1.23)	218(4.84±1.27)		

Table :2

Frequency distribution of the study sample based on the shape according to the gender. Test applied chi-square test, *indicates statistical insignificance at p>0.05

Gender	Shape				p-value	Chi-sq
	Straight	curve	wavy	Circular		
	Mean(SD)	Mean(SD)	Mean(SD)	Mean(SD	0.201*	4.625
Males	1.89(1.39)	1.87(1.03)	4.64(1.78)	0.16(0.47)		
Females	2.47(1.90)	1.60(1.52)	4.78(1.98)	0.24(0.52)		

Table: 3

Frequency distribution of the study sample based on the length according to the gender. Test applied mann-whitney test, *indicates statistical insignificance at p>0.05, **indicates statistical significance at p<0.05

Gender		Length	
	Primary	Secondary	Tertiary
	Mean(SD)	Mean(SD)	Mean(SD)
Males (n=45)	80.70(21.3)	3.7(5.1)	0.34(1.05)
Females(n=45)	76.79(17.9)	5.5(4.7)	0.63(1.61)
p-value	0.485*	0.019**	0.355*

Table:4

Analysis of unification pattern in males and females,Test applied chi square test,*indicates statistical insignificance at p>0.05.

Gender	Unification pattern	Unification within gender n(%)	p-value	Chi-sq
Males	Converging	18(3.93)	0.366*	0.816
	Diverging	54(11.8)		
Females	Converging	22(4.60)		
	Diverging	47(9.83)		

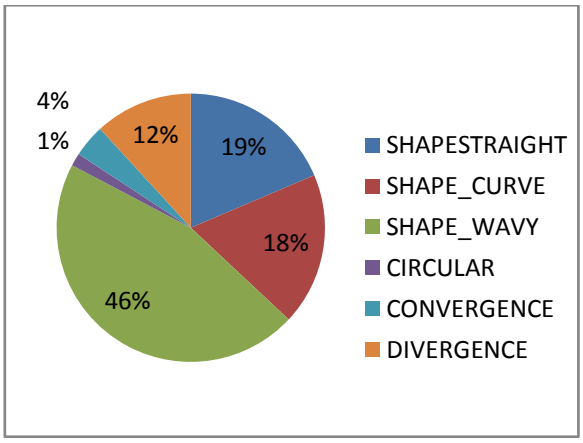

Fig.3(a) percentage distribution for males

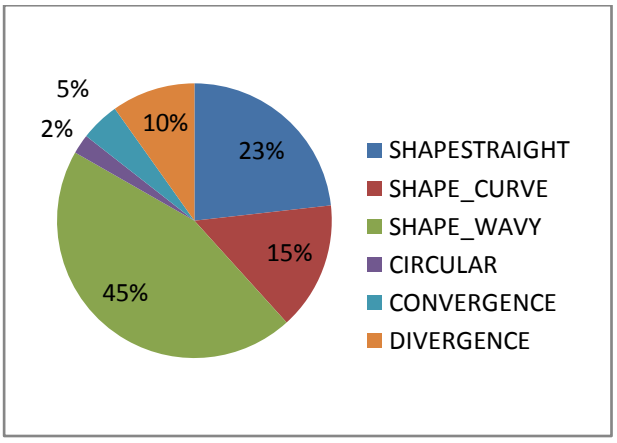

Fig.3(b) percentage distribution for females

V. Discussion

Palatoscopy, or palatal rugoscopy, is the name given to the study of palatal rugae to aid in establishing a person's identity.[6] With the possible exception of few cases where a denture with a name is found, it is highly unlikely that an unknown body would be identified by dental means simply from examination of the corpse. In every other case the postmortem findings have to be compared with some existing data on the individual thought to be involved in order to establish identification. Unlike lip prints antemortem records of

palatal rugae may be found in dental practice in many forms such as dental casts, old maxillary dentures, and intraoral photographs.

Now-a-days, palatal rugae patterns may be considered as a useful adjunct for identification purposes.[14]].This study was undertaken to establish the indivualality of palatal rugae patterns by their biometric characteristics that include the shape, size, direction, number and to compare the rugae pattern among males and females to analyze its usefulness as an additional method in human identification and sex determination.

In our study, the rugae patterns were studied using Thomaz and Kotz classification. This method was found to be practical and easy to perform and less time consuming. According to our analysis, the palatal rugae patterns of all 100 individuals were different from each other. Thus the rugae patterns are highly individualistic.

According to the present study, total number of rugae was more on left side compared to the right in both gender, however it was not statistically significant. The study done by Surekha et al. [15], Kallianpur et al.[16], S. Goyal and S. Goyal [17], Bajracharya et al. [18]and ,Ibeachu et al [19] also proved left side of palatal rugae to be dominant, and explained it to be the phenomenon of regressive evolution. This contradicts with Kapali et al. [13], Paliwal et al. [20], and Madhankumar et al. [21] who did not observe much difference between the left and right sides in their various population.

In our study the length of primary and tertiary rugae showed an insignificant statistical difference,where as secondary rugae showed an significant difference between males and females. The evaluation of rugae length showed that they were basically primary rugae. The males had more primary rugae than females . This finding is in accordance with Surekha et al. [18] who said that primary rugae were considerably longer in Kerala population than in Manipuri population, whereas secondary rugae were longer in Manipuri population. Our finding was also similar to Shetty et al. [15] who reported that the Mysorean males had more numbers of primary rugae than their female counterparts. and in accordance to the study by Kapali et al,[13] which did not reveal any significant difference in the number of primary rugae between aboriginal Australian males and females. This observation was in contrast to Madan kumar et al. [21] who reported significant difference in the length of rugae between the genders among Indian population of Chennai.

Our study showed predominant diverging pattern in both males and females and showed an statistically insignificant difference between gender and unification. In a study conducted by Jibi et al.[23] showed that diverging type were more common in females and converging type were more prevalent in males. These findings are in disagreement with Manjunath et al., [24] who said that comparisons of the unification of rugae both converging and diverging did not show any specific trend.

The most predominant rugae pattern was the wavy ,straight followed by curvy and circular in both males and females. The high incidence of predominance in wavy patterns has been reported by Nayak et al. [25], Kotrashetti et al. [26], Kumar et al. [27], Surekha et al. [15], Shanmugam et al. [28], Mohammed et al. [29], Bajracharya et al., [18], and Kapali et al. [13], and this effect could be regarded as dominant pattern in most populations. In our study second predominant pattern was straight pattern which was in accordance with Kallianpur et al., [16] and Rath and Reginald [30] in their study of palatal rugae but in contrast

to the findings by Ibeachu et al [19] **,**Shanmugam et al. [28] and Paliwal et al. [20] who reported the straight type to be the most predominant rugae pattern. In contrast to our study ,Curved pattern was more predominant in the study done by Ibeachu et al [19] in ikwerre population,and shetty et al.,[22].These differences in proportionality found in wavy, straight and curved patterns could be attributed to population differences due to environmental factors.

VI. Conclusion

Within the limitations of the present study it may be concluded that rugae pattern are highly individualistic and can be used as a supplementary method for personal identification and sex determination. The average number of rugae was slightly more in females than in males. The total number of rugae was predominant on left side compared to right side in both genders. Wavy and straight shapes were more prevalent in both gender. An insignificant difference between the primary and tertiary palatal rugae lengths and gender and a significant difference between the secondary palatal rugae lengths. Commonly observed pattern in the mode of unification diverging pattern in both genders.

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