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Rugae patterns as an adjunct to sex differentiation in forensic identification

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SUMMARY

The aim of the study was to identify the different patterns of palatal rugae and gender differences in rugae pattern in Maharashtra population thereby highlighting the importance of palatal rugae in establishing person's identity. The 600 dental casts of age 18 years and above were included in the study. The rugae were delineated using a sharp graphite pencil under adequate light and magnification and information was recorded about shape, number, size and direction of the palatal rugae. The most commonly noticed rugae among the total study participants primary and secondary. Among the patterns of rugae wavy (92.3%) was most common and significantly more among females. The point (9.8%) type of rugae was the only pattern found to be more in males. It may be concluded that the rugae pattern can be an additional method for post mortem identification in conjunction with the other methods such as visual, fingerprints and dental characteristics in forensic sciences.

Key words: forensic science, forensic odontology, palatine rugae, human identification, rugae patterns, criminal investigations.

INTRODUCTION

Identification is a mainstay of Human civilization and it has become fundamental in all aspects of human relationships, whether in living or dead. Especially when dealing with crimes or with mutilated bodies that have undergone damage beyond recognition, identification of unknown individuals is of paramount importance. When traffic accidents, acts of terrorism or mass disasters occur in which it is difficult to identify a person according to the fingerprints or dental records, palatine rugae may be alternative method of dental identification (1).

Palatal rugae are asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate, made from the lateral membrane of the incisive papilla, arranged in transverse direction from palatine raphe located in the midsagittal plane of oral cavity (2). Palatoscopy or palate rugoscopy, is the name given to the study of palatal rugae in order to establish a person's identity (3). According to Van der linden the anterior rugae do not increase in length after 10 years of age. The other characters such as shape, direction and unification remain stable throughout life (4). Even between twins, the patterns are similar but not identical. The palatal rugae, like finger prints, do not change during the life of the individual, are protected from trauma and high temperatures owing to its internal position in the oral cavity and protected by the lips, cheeks, tongue, teeth and bone, and prosthetic devices (5). Palatal rugae patterns are hence considered to be unique to an individual and they have the potential for identification (6). Thus, palatal rugae appear to possess the features of an ideal forensic identification parameter: uniqueness, postmortem resistance and stability. They can be used in postmortem identification when an antemortem record exists (7, 8).

In case of major disasters where bodies are often damaged beyond recognition Identification of sex is of major significance. On predicting sex it builds a biologic profile of unidentified human remains thereby excluding about half of the population in search operation (9). This study was carried out with

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the purpose to identify and compare the different morphological rugae patterns in males and females of central Indian population, which may be an additional method of identification in cases of crimes or aircraft accidents, thereby highlighting the importance of palatal rugae in establishing person's identity.

MATERIAL AND METHODS

An observational study was carried out among the patients of three different Dental Colleges of Central India namely: VSPM Dental College and Research centre Nagpur, VYWS Dental College and Hospital Amravati, Chhattisgarh Dental College and Research Institute, Rajnandgaon, Government Dental College, Indore. A pilot survey was carried out among 60 participants based on which sample size of 600 was decided. Ethical clearance was obtained from institutional ethical committee of Datta Meghe Intitute of Medical Sciences, Sawangi (Meghe) Wardha and respective college of central India.

Written Informed consent was obtained from each participant. Patients with age of 18 years and above with full maxillary teeth without considering third molar were taken for study. Cases with severe malocclusion and palatal asymmetries were not considered. Alginate impression of maxillary arch was made and cast was poured in dental plaster. A total of 600 dental casts were studied. The rugae were delineated using a sharp graphite pencil under adequate light and magnification. Subsequently, the information was recorded in a rugoscopy record or rugogram, including: shape, number, size and direction of the palatal rugae. The investigator was trained and calibrated in the department of Public health dentistry, Sharad Pawar Dental College & Hospital, Sawangi (M) Wardha, Maharashtra, India.

Shape analysis

The shape of the palatine rugae was analysed by classification of Trobo (Pueyo *et al.*, 1994). This classification also divides rugae into two groups: Simple rugae, classified as ABCDEF, where rugae shapes are well defined, and composed rugae, classified as type X, with a polymorphisms variety the union of two or more simple rugae.

Number analyses

Rugae were measured in a straight line between the origin and termination and were grouped into three categories:

1. Primary: 5 millimetres or more;
2. Secondary: 3 to 5 mm;
3. Fragmentary: 2 to 3 mm.

Rugae smaller than 2 mm are disregarded

Size analyses

Using a calliper, the maximum longitudinal diameter of all palatal rugae was measured.

Direction analyses

The direction of each primary rugae was determined by measuring the angle between the line joining its origin and termination and a line perpendicular to the median raphe. Forward-directed rugae were associated with positive angles, backward-directed rugae with negative angles, and perpendicular rugae with angles of zero degrees. Unification occurs when two rugae are joined at their origin or termination. Unifications in which two rugae began from the same origin but immediately diverged were classified as diverging. Rugae with different origins which joined on their lateral portions were classified as converging.

After completion of study the data was analyzed using Statistical Package for Social Science (SPSS) version 11.5 with Epi-info software. The p value was taken as significant when less than 0.05 (Confidence interval of 95% was taken). The Chi-square test was used to compare different rugae patterns among males and females study participants.

Table 1. Age and gender distribution of our study sample (n=336)

Characteristics of Rugae	Males	Females	Total	X2 (df)	P value
Primary	209 (34.8%)	283 (47.2%)	492 (82.0%)	0.811 (1)	0.368
Secondary	222 (37.0%)	299 (49.8%)	521 (86.8%)	0.842 (1)	0.359
Fragmented	119 (19.8%)	155 (25.8%)	274 (45.7%)	0.002 (1)	0.965
Point	32 (5.3%)	27 (4.5%)	59 (9.8%)	3.168 (1)	0.075
Wavy	247 (41.2%)	307 (51.2%)	554 (92.3%)	4.609 (1)	0.032*
Curved	90 (15.0%)	115 (19.2%)	205 (34.2%)	0.041 (1)	0.839
Angled	58 (9.7%)	67 (11.2%)	125 (20.9%)	0.577 (1)	0.448
Sinuous	53 (8.8%)	59 (9.8%)	112 (18.7%)	0.892 (1)	0.345
Circular	5 (0.8%)	10 (1.7%)	15 (2.5%)	0.627 (1)	0.429
Composed	31 (5.2%)	34 (5.7%)	65 (10.8%)	0.564 (1)	0.453
Forward	224 (37.3%)	280 (46.7%)	504 (84.0%)	1.584 (1)	0.208
Backward	40 (6.7%)	71 (11.8%)	111 (18.5%)	2.954 (1)	0.086
Unification	101 (16.8%)	134 (22.3%)	235 (39.2%)	0.020 (1)	0.888
Convergent	82 (13.7%)	90 (15.0%)	172 (28.7%)	1.850 (1)	0.174
Divergent	17 (2.8%)	40 (6.7%)	57 (9.5%)	4.780 (1)	0.029*

*Statistically significant if $p<0.05$.

RESULTS

The total number of persons who participated in the study were 600. Out of 600 study participants 260 (43.3%) were males and 340 (56.7%) were females. The prevalence of wavy type being highest 554 (92.3%) and it found to be significantly more in number among females 307 (51.2%) as compared to males 247 (41.2%) p<0.032. The most prevalent shapes of palatal rugae were the secondary (86.8%) followed by primary (82.0%) which were more in females, but the difference was not statistically significant. Though the Point type of pattern was more common in males (5.3%) the difference was not statistically significant. Unification occurs when two rugae are joined at their origin or termination. Conditions in which two rugae began from the same origin but immediately diverged were classified as diverging. It was seen in 57 (9.5%) study participants, significantly more number of females 40 (6.7%) had the presence of diverging rugae as compared to 17 (2.8%) males (p<0.029) (Table 1).

DISCUSSION

Crime in some form or the other has been existed since the beginning of the human race. Investigators involved in the identification of the human remains usually use fingerprints, blood group differentiation, anthropometry and dental records for confirming the identification of the diseased person. However in case like fire, major trauma, fracture of tooth or the teeth may not be present, then the identification of the dead may be difficult. The human palatal rugae can be used as an alternate method of identification as suggested by Harrison Allen. Also no two palates are alike in the Configuration and the palato-print does not change during growth (9). So the rugae patterns can be used as additional method for post mortem identification. In the present study, the most common palatal rugae was wavy, representing about 92.3% of the total population, followed by secondary 86.8% and then forward 84%. The morphological differences among the gender of the individual were found to be significant only with point type of rugae, which was higher in males than females. This finding is similar to the study done by Kapali *et al.* (4), Paliwal *et al.* (10), Gondivkar *et al.* (1), Sharma *et al.* (6). The incidence of forwardly directed rugae was more in the central Indian population as compared to backward directed rugae. This was similar to the study done by Govindwar *et al.* (1) and Sharma *et al.* (6). However there was no significant gender difference seen in the present study as concerned to the direction of rugae. This was in contrast to the studies done by Shetty *et al.* (11) and Govindwar *et al.* (1) which showed that forward direction was found to be more in females. Unification of rugae was found to be in 39.2% of the total study participants, and was found to be more in females as compared to males, difference was not statistically significant. This is in contrast to the study done by Govindwar *et al.* (1) in which males had higher percentage of unification as compared to females. The type of unification was classified as converging and diverging. The convergent type of unification was found to be more in relation to divergent. However the sexual dimorphism was not statistically significant in convergent type of rugae as it was in diverging type, which showed that divergent rugae was more in females as compared to males. This is in line with the study done by Bharath *et al.* (9) and contrast to the study done by Sharma *et al.* (6), where no gender difference was found in unification.

Pearson's correlation coefficients between gender and predictive morphological variables in the total sample population were significant and inversely correlated for point type of rugae and positively correlated for backward type of rugae (p<0.05). Hence Logistic regression analysis (LRA) was used to check the ability of palatal rugae pattern in determining sex. LRA enabled 39% of sex prediction when the rugae shapes were analyzed. This shows that using the observed rugae pattern, sex can be predicted

Table 2. Logistic regression analysis of all variables for prediction of Sex of an individual by type of rugae

Model	Regression coefficient	Standard error	Significance	
			T value	P value
Constant	1.341	0.194	6.900	0.000
Primary	0.088	0.061	1.455	0.146
Secondary	0.052	0.061	0.850	0.396
Fragmented	0.042	0.046	0.921	0.357
Point	-0.171	0.072	-2.370	0.018*
Wavy	-0.129	0.078	-1.659	0.098
Curved	-0.017	0.043	-0.384	0.701
Angled	-0.024	0.052	-0.469	0.639
Sinuous	-0.056	0.054	-1.028	0.304
Circular	0.153	0.132	1.159	0.247
Composed	-0.064	0.067	-0.961	0.337
Forward	0.236	0.145	1.628	0.104
Backward	0.285	0.141	2.030	0.043*
Unification	-0.126	0.227	-0.556	0.579
Convergent	0.071	0.228	0.313	0.754
Divergent	0.261	0.236	1.108	0.268

*Statistically significant if p<0.05.

correctly with a probability of 39% (Table 2). This indicates that palatal rugae shapes may be useful to predict sex.

CONCLUSION

In this study, the morphological characteristics of the palatal rugae have been studied in Central Indian population. Statistically significant differences between the males and females were observed in number, shape and unification of the rugae. Among the patterns of rugae the wavy was the most common palatal rugae with 92.3% followed by secondary which was 86.8%. Unification of rugae was found in 39.2% of total study participants. The divergent type of unification was more in females and statistically significant. Located in the anterior half of the roof of the mouth, palatal rugae serve as a reference landmark in various dental treatment modalities and could be used in the identification of submucosal clefts. Palatine rugae can be used to assess the amount of antero-posterior tooth movement, because they remain stable during a person's life. Moreover, the results of several studies show a significant association between rugae forms and different races. Palatine rugae are unique to individual can therefore be used for individual identification in forensic Odontology.

STATEMENT OF CONFLICTS OF INTEREST

The authors state no conflict of interest.

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