

Oral Fingerprint: Identification of Individuals using Palatal Rugae

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ABSTRACT

Objectives: To record the characteristic number, shape, length, direction and position of the palatal rugae. To analyse if palatal rugoscopy can be used for sex determination and determine if the rugae pattern which belonged to families with twins are identical in their characteristics.

Materials and Methods: A cross-sectional study was conducted on a sample of 120 subjects. This included 40 males, 40 females and 10 families who had either identical or dizygous twins in the age range of 20 to 60 years. Maxillary impressions were made with elastomeric impression material. The number, shape, length and direction of palatal rugae were analysed using Thomas and Kotze classification (1983).

Results: The main distinguishing feature between male and female palatal rugae was the unification pattern wherein males showed more number of converging patterns and females showed more diverging patterns. When the families with identical and dizygous twins were compared, each member showed a distinct rugae pattern.

Conclusion: Rugae pattern are individualistic which can be used for identification and sex determination.

Keywords: Rugoscopy, forensic odontology, sex determination, human identification, twins.

INTRODUCTION

Establishing one's identity can be a very difficult process in forensic identification. Fingerprints, dental records and DNA comparisons are the most commonly used techniques. However, since these cannot always be used; simpler techniques such as "Palatal rugoscopy" which is the study of palatal rugae can be used. [1] Winslow was probably the first to describe them in 1753. [2]

Palatal rugae are present in the maxillary portion of the oral cavity. They are also termed as plicae palatinae transversae or rugae palatina. They are present on both sides of the median palatal raphe, behind the incisive papilla, which is present just behind the maxillary central incisor teeth. The

rugae anatomically consist of about three to seven rigid oblique ridges which radiate tangentially from the incisive papilla. [3] The shape, position and characteristic layout of the rugae are not affected during eruption or loss of teeth. Palatal rugae pattern are unique to an individual and hence are useful in identification. Rugae play an important role in forensic science since they are protected from any traumatic injury and can withstand high temperature due to their internal position in the oral cavity. Moreover, they are surrounded and protected by the lips, cheeks, tongue, teeth and bone. Being specific to racial groups, they facilitate population identification in mass disasters. [4] Also, their use is preferred because of the low cost, simplicity and reliability. Even after any traumatic

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destruction, they can be reproduced exactly on the same site. [5] Thus, considering the above facts palatal rugae may act as evidence in post mortem analysis that is present in all victims. It is resistant to changes with age or trauma and hence can be used as an important tool in forensic odontology.

With this background in mind, the present study was undertaken to record the palatal rugae pattern with respect to the number, shape, length and unification pattern in a cross section of the population in Navi Mumbai, India.

MATERIALS AND METHODS

This cross-sectional study sample consisted of 120 subjects, comprising of 40 males, 40 females and 10 families who had either identical or dizygous twins. The subjects were healthy and free of any congenital abnormalities, inflammation, bony or soft tissue protuberances, allergy to impression materials and trauma related to the palate. In addition, the subjects did not have any fixed or removable prosthesis and had not undergone previous orthodontic treatment. The casts which were selected were free of air bubbles or voids. Subjects aged between 20 and 60 years and belonged to the same geographical population, Navi Mumbai, Maharashtra, India. Written informed consent was obtained from the subjects and study was conducted after obtaining approval from the Institutional Ethics Committee. The study was carried out over a period of six months.

A maxillary impression was made for each individual using addition silicon impression material, washed under running tap water and poured in Type III dental stone. The rugae pattern was traced on these casts using a 0.5mm black graphite pencil. The principal investigator was blinded about the identity of the casts. A magnifying hand lens was used to visualize and analyse the characteristic rugae pattern using the Thomas and Kotz classification (1983). [3]

The number of rugae on the right and the left sides of the median palatine raphe were recorded. The size of each rugae was traced by measuring the distance from one end to the other end using a digital calliper and a metallic scale. Based on the length, rugae were classified as: Primary ($\geq 5\text{mm}$);

Secondary (3-5mm); and fragmentary ($\leq 2\text{mm}$) (Figure. 1).

The direction of each rugae was determined by measuring the angle between the line joining its origin and termination and a line perpendicular to the median raphe. They are classified as follows:-

- a) Forward-directed rugae: associated with positive angles.
- b) Backward-directed rugae: associated with negative angles.
- c) Perpendicular rugae: associated with zero degree angles.

Further, the shapes of the individual rugae are classified into four major types.

- 1) Straight type: runs directly from their origin to the termination.
- 2) Curved type: simple crescent shaped and slightly bent at the termination of the rugae.
- 3) Circular type: displays a continuous ring formation.
- 4) Wavy type: serpentine in form.

When it was a circular form, the diameter from the origin to termination was considered.

In addition to the above parameters, a unification pattern was also considered, which is subdivided into a diverging or converging type. A diverging pattern occurs when two rugae have a common origin but immediately diverge transversely, while in converging pattern two rugae having different origins converge transversely. [6, 7]

Statistical analysis

Unpaired 't' test and median test were used to assess sex differences in the number and unification pattern. The data collected was statistically analyzed using the SPSS (Statistical package for Social Sciences) 17.0 statistical program for Windows.

RESULTS

Number

Total number of rugae on the right and left side of the median palatal raphe was counted. The average number of rugae was slightly more in females than in males. (Table 1)

Table 1: Distribution According to Identification.

Gender	Frequency	Percent
Female	64	52.0%
Male	59	48.0%
Total	123	100.0%

Table 2: Sample of Rugae in both genders.

Identification	total Female	total Male	total	%
Converging	49	160	209	9.4%
Diverging	259	77	336	15.1%
Wavy	415	338	753	33.8%
Straight	247	252	499	22.4%
Curve	201	210	411	18.4%
Circular	11	11	22	1.0%
Total	1182	1048	2230	100.0%

Table 3: Direction of Rugae in both the genders.

Direction	Gender			
	Female		Male	
	rugae, n=863	%	rugae, n=837	%
Forward	467	54.1%	483	57.7%
Backward	164	19.0%	154	18.4%
Perpendicular	232	26.9%	200	23.9%

Table 4: Rugae in both genders according to type (size).

Types (Size)	Female		Male	
	n	%	n	%
Primary	634	74.5%	587	73.8%
Secondary	185	21.7%	177	22.3%

Fragmentary	32	3.8%	31	3.9%
Total	851	100.0%	795	100.0%

Table 5: Descriptive statistics of different types of Rugae patterns categorized by Sex and comparison between genders.

Type of Rugae	Sex	N	Mean	SD	t-stat	df	p-value
Converging	Female	62	.790	1.461	-7.624	117	.000**
	Male	57	2.807	1.420			
Diverging	Female	61	4.246	2.087	8.422	114	.000**
	Male	55	1.400	1.461			
Wavy	Female	64	6.484	1.877	2.201	121	.030*
	Male	59	5.729	1.928			
Straight	Female	64	3.859	4.309	-0.527	121	.599
	Male	59	4.271	4.350			
Curve	Female	64	3.141	1.612	-1.375	121	.172
	Male	59	3.559	1.764			
Circular	Female	55	.200	.487	0.000	108	1.000
	Male	55	.200	.678			

******: Significant at 0.01 level, *****: Significant at 0.05 level

SD: Standard Deviation, df: degree of freedom

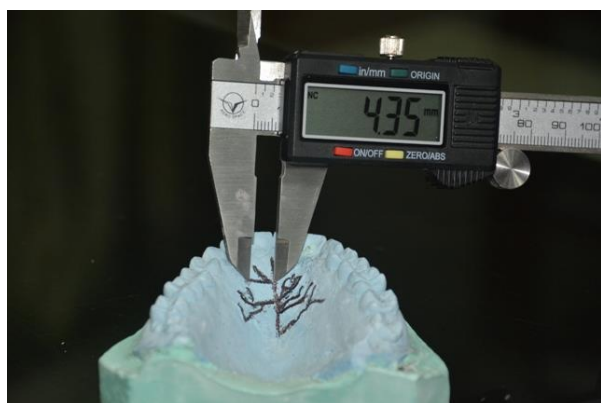


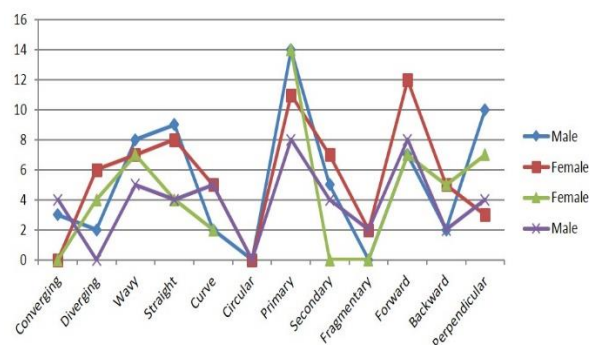
Fig 1: Measurement of the length of the palatal rugae.

Length

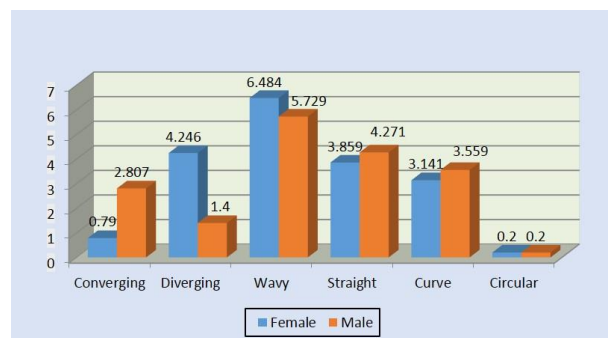
In males, the mean average length was 9.5mm while in females the average length was 8.2 mm.

Shape

The most prevalent shape was wavy (33.8%), followed by straight (22.4%), curved (18.4%) and circular (1.0%). In addition, the converging rugae (9.4%) were less in comparison to the diverging rugae (15.1%). The details of the gender wise distribution of the rugae patterns are in Table 2.



Graph 1: Rugae pattern in families of identical and dizygous twins.



Graph 2: Average number of rugae according to the sex.

Unification Pattern

The forward directed rugae were predominantly seen in males while the backward directed rugae and perpendicular rugae were more prevalent in females (Table 3). On observing the number of rugae, females showed more number of primary rugae as compared to males while secondary rugae was more common in males (Table 4). When the family members of identical and dizygous twins were compared, each member showed a distinct rugae pattern including the twins (Graph 1).

The mean number of converging rugae was higher in the males (2.807 ± 1.420) than the females (0.79 ± 1.461) while the mean number of diverging rugae was more in females (4.246 ± 2.087) than the males (1.4 ± 1.461) which was statistically significant. Mean value of the wavy rugae was higher in females (6.484 ± 1.877) than that in males (5.729 ± 1.928) and this was statistically significant. However, the difference between the mean values in straight, curved and circular rugae was not statistically significant between the two genders. (Table 5, Graph 2).

DISCUSSION

The palatine rugae appear towards the 3rd month of intrauterine life. They arise from the connective tissue that covers the palatine process of the maxillary bone. Its development and growth is controlled by the epithelial – mesenchymal interaction. The rugae at birth have a typical orientation pattern that once formed only changes in its length which occurs during normal growth and stays in the same position throughout the life of the person. The palatal rugae aid in swallowing, taste perception, participate in speech, suction in

children and in medico-legal identification process. [8]

Routinely, bones and teeth may be used for sex determination in forensics but in cases where these structures are absent, mucosal tissues can provide an interesting data. The key factors which make palatal rugae one of the interesting tools in forensics are its internal position and stability. [9] Some investigators have assessed its feasibility with the help of a computer aided software programme. [10]

The present study was undertaken to establish the individuality of palatal rugae patterns by their characteristic shape, size, direction, and number and to compare the rugae patterns among males and females and families with identical and dizygous twins, in order to analyse its usefulness as an adjunct in human identification and sex determination.

Rugae pattern varies among different racial groups. In a study conducted by Sapte E et al. [11] and Sekhon HK et al., [12] the maximum number of palatal rugae was 18 and 16 while the minimum number was 6 in both studies. In the present study, the maximum number of rugae was 17 and the minimum was 7.

The rugae pattern was studied according to the classification put forth by Thomas and Kotz. The palatine rugae pattern was analysed in 120 individuals. Each individual showed a different rugae pattern indicating that the patterns are highly individualistic. This finding was similar to studies conducted by Dhoke M and Osato S, [13] Venegas VH et al. [8] and Sekhon HK et al. [12] The average number of rugae pattern was slightly more in females than in males and this was not statistically significant. This finding showed a positive correlation with the studies carried out by Saraf A et al. [14] and Shetty M and Premalatha K. [15] However Dhoke M and Osato S [13] reported that females had fewer rugae than males.

In the present study, the wavy shaped rugae were the predominant rugae pattern, followed by the straight and curved palatal rugae. The circular rugae were the least frequent. In a study done on Australians, Aborigines and Caucasians by Kapali S et al. (1997), [6] the straight and circular rugae pattern were least common. This was also observed

in a study by Saraf A et al. ^[14] and Mustafa AG et al. ^[16] on an Indian population.

The curved and straight rugae pattern was slightly more in males while the wavy rugae were more predominantly seen in females. In a comparative study done by Shetty SK et al., ^[17] it was reported that Indian males had more number of curved rugae than Tibetan males, while Tibetan females had more wavy rugae than the Indian females.

The comparison of palatal rugae among the family members (father, mother, child A and child B) also showed different patterns. The rugae patterns in both the identical and dizygous twins showed different patterns thereby suggesting that the role of heredity is uncertain for determination of the rugae pattern. Similar studies were done by Ritter and Chae (cited in English WR et al.)^[18] who suggested the uniqueness of palatal rugae pattern and that genetic influencing was questionable for determining rugae patterns in twins. Indira AP et al. ^[19] also studied five pairs of dizygous twins and concluded that each pair of twins showed different patterns. Very few studies in the review of literature have investigated this parameter.

Most of the palatal rugae in the present study were forward directed. The males had more forward directed rugae than females. Diverging rugae were more in females and converging type were more in males. This was similar to the findings by Jibi PM et al. ^[20] However, Shetty M and Premalatha K ^[15] observed that the females had more forward directed rugae as compared to males.

The average length of palatal rugae was 9.75 mm. In a study done by Venegas VH et al. ^[8] and Sekhon HK et al. ^[12] the average size was 9.58 mm and 9.221 mm respectively. In an Indian population, the shape, number and direction of the palatal rugae have usually been identified. Few studies have investigated the length of the rugae pattern.

CONCLUSION

The advantage of studying the palatal rugae pattern is its low cost, simplicity and reliability. The rugae pattern being highly individualistic can be used as a supplemental aid for personal identification and sex determination. No two individuals have their palates that are alike in their rugae configuration.

Hence, palatal rugae can be used as one of the tools for personal identification in forensic odontology in the Indian context. The observations in the present study seem to indicate the possible use of palatal rugae as an adjunct with other methods for sex determination. However, further studies on individuals of different races, family members with a larger sample size are needed to validate this observation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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