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To analyze differences in the palatal Rugae patterns and maxillary arch length of adult male and female patients

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Abstract

The aim of the present study is to analyse differences in the palatal rugae patterns and maxillary arch length of adult male and female patients. To study the individuality of palatal rugae pattern like shape, direction and unification among the study population and to compare the rugae pattern among the males and females and its usefulness in gender determination.

The study group comprised of 500 subjects which included 250 males and 250 females in the age group of 20-35 years from the Department of Oral Medicine & Radiology of the Vananchal dental college & hospital, Garhwa, Jharkhand. All individuals selected for the study comprises of the same geographical population i.e resident of Jharkhand, healthy, free of any diagnosed congenital abnormalities, inflammation, trauma or orthodontic treatment. After the institutional ethical committee clearance & a written consent from patient, a detailed history of all the patients were recorded and maxillary alginate impression was made.

The use of palatal rugae in forensic identification is advantageous because of their low utilization cost, simplicity and reliability. Palatal rugae have been shown to be highly individualistic and have consistency in shape throughout the life and can be used successfully for human identification. Palatal rugae play an important role in medico legal identification. In addition, the rugae pattern appears to be specific to the racial groups facilitating population identification. Based on our study, it is sufficiently a characteristic to discriminate between individuals because no two palates are alike in their rugae configuration. Hence, palatal rugae can be one of the tools for personal identification in forensic odontological identification in the Indian context. In view of these findings, palatal rugae could be used as a personal print for identification. This study has indeed demonstrated a clear evidence of the individualistic nature of palatal rugae as have been reported by several authors. This is the study done by using discriminant analysis on arch length and rugae pattern combination. In this study, rugae pattern and arch length on discrimination analysis yielded moderate discriminatory ability between gender and when combination was used discriminatory ability was increased. Hence, the palatal rugae pattern and maxillary arch length can be used as an additional method in differentiating gender between human population groups.

Keywords: palatal Rugae patterns, maxillary arch length, forensic identification, etc

1. Introduction

Identifying an individual had become a difficult task for forensic, social, legal and humanitarian reasons. Most commonly employed techniques for human identification include dental, fingerprint and DNA comparison methods. In situations, when identification of an individual is difficult, palatal rugae patterns may be considered as an alternative methods of identifying a deceased person based on comparison of ante mortem and postmortem reports. Rugoscopy, study of palatal rugae is used for individual identification. The palatal rugae appear toward the third month of intrauterine life. They are asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate. They are formed from the lateral membrane of the incisive papilla, arranged in transverse direction from the palatine raphe located in the midsagittal plane. Development and growth of rugae are controlled by epithelial mesenchymal interactions during intrauterine life [1].

They are also called “plica palatinae” or “rugae palatine [2]. Palatoscopy or palatal rugoscopy is the name given to the study of palatal rugae in order to establish a person’s identity [3]. In human embryos, rugae are relatively prominent and occupy most of the length of the palatal shelves at the time of their elevation [4].

At the 550 mm stage of embryonic development, there are five to seven rather symmetrically disposed ridges, with the anterior ones beginning at the raphe, the others more laterally [4]. Towards the end of intra-uterine life, the pattern of rugae becomes less regular, posterior ones disappearing and those anterior become considerably more pronounced and compressed [1]. The development and differentiation of rugae are more advanced in rats than humans and while they are probably involved in oral function in animals, rugae seem to be attenuating in humans [5].

Every palatal rugae are unique once they are formed and remain unchanged during lifetime. They do not undergo any changes except in their length, which halts at puberty. They are also usually specific in racial groups aiding the identification of various races [5].

Hausser E. ZurBedeutung (1951) suggested with the increase in size of the anterior part of the palate in the early years of life, the length of the rugae and the distance between them increases. The pattern of orientation of the rugae remains unchanged throughout life. The number of rugae on each side of the palate varies between three and

five. The palatine rugae do not extend posteriorly beyond the anterior half of the hard palate and never cross the midline. The anterior rugae usually are more prominent than the posterior rugae [5].

Palatal rugae have been shown to be highly individualistic and have consistency in shape throughout the life and can be used successfully for human identification. Palatal rugae play an important role in medico legal identification. In addition, the rugae pattern appears to be specific to the racial groups facilitating population identification [1].

Applications of palatal rugae patterns for personal identification was first done by Allen in 1889. Palatal rugoscopy was first proposed by 1932 by Trobo Hermosa. Sassouni stated that no two plates were alike in their configuration and that the print does not change during growth. Kapali *et al* observed denture wear, tooth malposition and palatal pathology could have cause an alterations in rugae patterns. Thomas *et al* stated that rugae are genetically determined. English *et al* used manual methods to compare the rugae patterns. Thomas and VanKyn successfully identified a severely burned edentulous body by comparing the rugae to the pattern on the victim's old denture. Carrea indicated that a rugae patterns is formed by the 12th so 14th week of parental life and it remains stable throughout the person's life [1].

Forensic identification by its nature is a multidisciplinary approach relying on positive identification methodology as well as presumptive or exclusionary methodologies which deals with proper handling and examination of dental findings [1].

Physiologically the palatal rugae are involved in the oral swallowing and help to improve the relationship between food and the taste receptors in the dorsal surface of the tongue (Buchtová *et al*.), also participated in speech and in the suction in children [6].

The palatal rugae form elevations more or less prominent and take various configurations. Its design and structure are unchanged and are not altered by chemicals, heat, disease or trauma, or, if palatal rugae are destroyed, are reproduced exactly on the same site that had. Form, layout and characteristics are not affected by the eruption of the teeth or their loss, but sometimes palatal rugae adjacent to the alveolar arch slightly change their position after tooth extraction. However, some events may contribute to changes in the pattern of palatal rugae, such as finger sucking in childhood and persistent pressure due to orthodontic treatment. Furthermore, it has been reported that extractions can produce a local effect on the direction of the Palatal rugae [7].

It is the most valuable technique in aeronautical accidents in order to ensure identification of pilots making use of ante mortem data. Many of the studies have been reported to determine gender using arch length and rugae as individual parameters but few studies found in the literature have considered them together [8]. Palatal rugae are well protected from trauma by their internal position in the oral cavity and they are insulated from heat by lips, tongue, and buccal fat pads [9].

It is well established fact that rugae retains its shape throughout life and resist decomposition. Personal identification is based on the rugae pattern since the palate would remain intact when most other anatomical structures are destroyed, burned or dehydrated and also in situations where there are no finger prints [9].

Palatal Rugae remains fairly stable in number and do not undergo any change due to growth, ageing tooth extraction and disease, morphological changes may occur due to trauma, surgery persistent pressure and proliferative benign and malignant lesion [10].

Hence a study was carried out to investigate differences in the palatal rugae patterns and maxillary arch length in male and female patient. Caldas *et al*. have reported that palatal rugae were first described by Winslow in 1753; however, Kuppler, in 1897, was the first person to study palatal anatomy to identify racial anatomic features. They have also cited in their article that palatal rugosscopy was first proposed in 1932 by a Spanish investigator named Trobo Hermisa. In 1937, Carrea developed a detailed study and established a way to classify palatal rugae [11].

Lysell developed the first classification system for palatal rugae pairs. Lysell as well as Sassouni (1957), believed that, in general, the palatal rugae are unchanged throughout life, but found that this does not apply in every aspect. In older subjects there is an evident reduction in the number of rugae. Lysell (1955) therefore, was unsure if the rugae could be used for identification purposes. Sassouni (1957) stated that it is possible to derive a classification based on the symmetry, number and shape of papillae. When Sassouni (1957) tested the classification, he was able to identify a person without difficulty. The palatal rugae can be used in the same way as fingerprints; however, as the rugae are composed only of soft tissue, they are not present in skeletons. Fiene (1958) discovered that the palatal rugae could be helpful in anthropological paternity investigations [11].

The aim of the present study is to analyse differences in the palatal rugae patterns and maxillary arch length of adult male and female patients. To study the individuality of palatal rugae pattern like shape, direction and unification among the study population and to compare the rugae pattern among the males and females and its usefulness in gender determination.

Methodology

The study group comprised of 500 subjects which included 250 males and 250 females in the age group of 20-35 years from the Department of Oral Medicine & Radiology of the Vananchal dental college & hospital, Garhwa, Jharkhand. All individuals selected for the study comprises of the same geographical population i.e resident of Jharkhand, healthy, free of any diagnosed congenital abnormalities, inflammation, trauma or orthodontic treatment. After the institutional ethical committee clearance & a written consent from patient, a detailed history of all the patients were recorded and maxillary alginate impression was made.

Inclusion criteria

1. Study subjects was of age group of 20-35 years with full set of maxillary teeth from first permanent molar to molar on either sides.
2. Study subjects were resident of Jharkhand.
3. Study subjects were healthy individuals free of congenital abnormalities, inflammation, trauma, or orthodontic treatment.

Exclusion criteria

1. Study subjects having any systemic disease.
2. Study subjects having any congenital developmental

anomaly of jaw. Eg. cleft palate
3. Study subjects having history of trauma in the palatal region of upper jaw. Study subjects having habit of chewing betel nuts.
4. Study subjects not willing to participate in the study.
5. Study subjects allergic to irreversible hydrocolloid alginate impression material.
6. Study subjects with severe malocclusions.

An irreversible hydrocolloid Alginate was be used as an impression material and ideal cast was prepared with dental stone and plaster of Paris base for interpretation of maxillary arch. Maxillary impression trays were selected according to the shape and size of the patient's arches. Two levels of alginate impression material were taken in the scoop and mixed with 40ml of water in a flexible rubber bowl with a mixing spatula.

The mix was immediately transferred to the impression tray for insertion into the patient's mouth. The tray was held passively and motionless during the setting of impression material. After about 2 minutes the tray was separated quickly from the teeth to avoid the rocking and possible deformation of the fine areas of the impression. Excess material is drained out as as fast as possible. Dental stone was mixed and poured on alginate impression tray, The cast was separated from the impression in about 60 minutes. Base for the study casts was made using the base former and dental stone. Base for the study casts were numbered for easy identification. All the measurements were taken by a one observer. Before delineation all bubbles on the palatal aspect of dental cast was removed with lecron instrument. The rugae were highlighted by a sharp graphite pencil on the cast. Measurement was done using Yamavo Vernier Caliper of 0.01 calibrations.

The outline of the rugae was traced on these casts using a sharp graphite pencil. Using a magnification lens the pattern of palatal rugae was analyzed separately for right and left side on these casts by a single observer. The rugae pattern was assessed using Thomas and Kotze (1983), classification which is based on their length, shape, direction and unification including the arch length. Lavelle *et al*. method was be used for dental arch length measurement. The measurement will be performed on maxillary casts using Yamavo Vernier Caliper of 0.01 calibrations. The dimensions of dental arch length will be measured between the most mesial aspect of anterior teeth and the most distal aspect of posterior teeth. The dimensions of 11-13 and 11-16 was measured.

The rugae were delineated using sharp graphite pencil and recorded according to classification given by Thomas and Kotze. The rugae was measured with the help of Yamavo Vernier Caliper (0.01 calibration) Digital vernier Caliper and were classified as primary (>5 mm), secondary (3-5 mm) and fragmentary (2-3 mm). Based on the shape rugae were classified into four major types: Curved, wavy, straight, and circular. Based on unification rugae can be classified as converging and diverging. All the identification and measurements were done by one examiner. The readings were reported for each study cast and observation was tabulated.

In the statistical analysis the comparison of arch length and rugae pattern was tested using parametric test 'unpaired t test' and nonparametric test was applied which do not follow Gaussian distribution using Mann Whitney test. Data was entered in Microsoft excel and analyzed using

Graphpad (version 6).'p' value of less than 0.05 was accepted as indicating statistical significance.

Results and Discussion

A total of 500 subjects were included in the study, which had equal distribution of males and females. The mean values of arch length of subjects. It was found out that the males had higher arch length than those of the females at all dimensions, which were found to be statistically significant. The frequency of circular rugae was least, however, it showed a statistically significant difference in their mean. This study revealed that no two palates are alike in their configuration, with each presenting an organized pattern of rugae specific to the individual. The wavy, curve and straight patterns were predominantly common while circular and unification of rugae were less common.

Table 1: The mean arch lengths of males and females

Gender	Arch length			
	11-13	11-16	21-23	21-26
Male	23.83±1.206	45.28±1.93	23.83±1.206	45.28±1.93
Female	22.34±0.5641	41.55±5.133	22.34±0.5641	41.55±5.133
P value	0.001 (S)	0.004 (S)	0.001 (S)	0.004 (S)

Table 2: Different types of rugae based on size of male and female

Gender	Size		
	Primary	Secondary	Fragments
Male	7.55±1.395	1.6±1.231	0.35±0.6708
Female	7.1±1.252	1.65±3.345	0.85±0.8127
P value	0.289	0.950	0.040 (S)

Unpaired test (P<0.05, Significant (S))

Table 3: Different types of rugae based on shape of male and female

Gender	Shape			
	Curved	Wavy	Straight	Circular
Male	2.1±1.683	3.6±2.303	1.95±2.212	0.3±0.5712
Female	1.85±1.387	4.6±2.21	2.05±2.328	0.2±0.4104
P value	0.611	0.169	0.890	0.528

Unpaired t test (P<0.05, Significant (S))

Table 4: Different types of rugae based on Unification of male and female

Gender	Unification	
	Converging	Diverging
Male	1.05±0.89	0.50±0.76
Female	0.15±0.37	1.00±1.124
P value	0.042 (S)	0.003 (S)

Unpaired t test (P<0.05, Significant (S))

Table 5: Gender wise comparison of primary rugae

Gender	Right	Left	P value
Male	3.75±0.85	3.80±0.83	0.84
female	3.50±0.76	3.60±0.68	0.964
P value	0.477	0.357	

Mann Whitney test (P<0.05, Significant (S))

Table 6: Gender wise comparison of secondary rugae

Gender	Right	Left	P value
Male	1.25±0.45	1.55±1.04	0.749
female	2.40±2.07	2.10±2.47	0.541
P value	0.149	0.674	

Mann Whitney test (P<0.05, Significant(S))

Length of rugae patterns: The rugae were basically primary rugae (>5mm) with few secondary rugae (3-5mm), while the fragmentary rugae (<3mm) was obviously insignificant. The males had more primary rugae than females while the females had more secondary rugae than males.

Table 7: Gender wise comparison of fragmented rugae

Gender	Right	Left	P value
Male	2.00±0.00	1.00±0.00	0.095
female	1.50±0.58	1.22±0.44	0.386
P value	0.403	0.4755	

Mann Whitney test (P<0.05, Significant(S))

Table 8: Gender wise comparison of curved rugae

Gender	Right	Left	P value
Male	1.39±0.51	2.00±0.74	0.034 (S)
female	1.43±0.53	1.80±1.01	0.53
P value	0.888	0.317	

Mann Whitney test (P<0.05, Significant(S))

Right and left distribution of palatal rugae patterns: The predominant patterns, wavy, curve and straight were found to be more on the left than the right while the less predominant patterns, circular and unification of rugae were more on the right than the left. The males had more curve pattern on the left than the right while the female had more number of wavy patterns on the left than the right.

Table 9: Gender wise comparison of wavy rugae

Gender	Right	Left	P value
Male	2.35±0.86	2.46±0.78	0.515
female	2.50±1.34	2.47±0.90	0.805
P value	1	0.679	

Mann Whitney test (P<0.05, Significant (S))

Table 10: Gender wise comparison of straight rugae

Gender	Right	Left	P value
Male	1.92±1.04	2.00±1.29	0.965
female	2.33±1.23	1.82±1.25	0.212
P value	0.441	0.841	

Mann Whitney test (P<0.05, Significant(S))

Table 11: Gender wise comparison of circular rugae

Gender	Right	Left	P value
Male	1.00±0.00	1.33±0.58	NA
female	1.00±0.00	1.00±0.00	NA
P value	NA	NA	

Mann Whitney test (P<0.05, Significant) NA: Not applicable

Table 12: Gender wise comparison of coverging rugae

Gender	Right	Left	P value
Male	1.08±0.29	1.14±0.38	0.75
female	1.00±0.00	1.00±0.00	NA
P value	NA	NA	

Table 13: Gender wise comparison of diverging rugae

Gender	Right	Left	P value
Male	1.00±0.00	1.00±0.00	0.75
female	1.11±0.33	1.11±0.33	NA
P value	NA	NA	

Right and left distribution of palatal rugae patterns: The predominant patterns, wavy, curve and straight were found to be more on the left than the right while the less predominant patterns, circular and unification of rugae were more on the right than the left. The males had more curve pattern on the left than the right while the female had more number of wavy patterns on the left than the right

Length of rugae patterns: The rugae were basically primary rugae (>5mm) with few secondary rugae (3-5mm), while the fragmentary rugae (<3mm) was obviously insignificant. The males had more primary rugae than females while the females had more secondary rugae than males.

The most common rugae shape observed in the present study were wavy and curved forms in males, wavy and straight forms in females. These findings were consistent with the study done by Kapili *et al* in Australian Aborgines and Cacusians and Nayak *et al* in South and West Indian Population and Paliwal *et al* in Madhya Pradesh and Kerela Population. Unlike in the present study, Saraf *et al* reported unification was greater in females and circular rugae were more in males in his study in North Indian population [1].

The females has more wavy, straight and converging while the males had more curve curve, circular and diverging than their counterpart. The incidence of higher converging in females and highly diverging males has been also reported by Saraf*et al* and Faisal *et al*. [12]

The present study revealed that arch lengths of the males were greater than those of the females which were in agreement with the findings of Shrestha and Bhattarai, Barrett *et al*., and Huang *et al*. [3]. The predominant shape of palatal rugae seen was curved and wavy rugae followed by straight rugae. However, only circular type of rugae was found to be statistically higher in males than in females, which were similar to the findings by Fahmi *et al*. and Jibi *et al*. [3].

In this comparative study in which the discriminant function analysis has been used for arch length and rugae pattern in combination. The predicatye accuracy was found to be higher, i.e., 75% for combination when compared to 72% and 71% for arch length and rugae pattern individually [3].

Various classifications were introduced to access palatal rugae. Most of the studies were done using the Silve, Caarrea etal methods. Thomas and kotze highlithed the difficulties in observing, classifying, and amnalyzing the minute vibrations of the palatal rugae and emphasized on the need to standardize the procedures in recording rugae. However, they observed that it was difficult to formulate a universally acceptable classification and convinced that a single operator alones and considering his own classification can successfully apply to his comparative project, and the results derived from the comparisons are great value than the comparisons itself.

The characteristic pattern of the palatal rugae does not change as per the result of growth and remains stable from time of development until the oral mucosa degenerates at death. Events as trauma, extreme finger sucking in infancy and persistent pressure from orthodontic treatment can contribute to the change in the rugae patterns. The palatal rugae have the ability to resist decomposition for up to seven days after death.

The positive identification of living or deceased persons using the unique traits and characteristics of the teeth and jaws is a corner stone of forensic science. The theory of uniqueness is a strong point used in the analysis of fingerprints and bite marks to convince the court of law. Likewise, even lip prints and palatal rugae patterns are considered to be unique to an individual and hence hold the potential for identification of an individual [12].

Conclusion

The use of palatal rugae in forensic identification is advantageous because of their low utilization cost, simplicity and reliability. Palatal rugae have been shown to be highly individualistic and have consistency in shape throughout the life and can be used successfully for human identification. Palatal rugae play an important role in medico legal identification. In addition, the rugae pattern appears to be specific to the racial groups facilitating population identification. Based on our study, it is sufficiently a characteristic to discriminate between individuals because no two palates are alike in their rugae configuration. Hence, palatal rugae can be one of the tools for personal identification in forensic odontological identification in the Indian context. In view of these findings, palatal rugae could be used as a personal print for identification. This study has indeed demonstrated a clear evidence of the individualistic nature of palatal rugae as have been reported by several authors. This is the study done by using discriminant analysis on arch length and rugae pattern combination. In this study, rugae pattern and arch length on discrimination analysis yielded moderate discriminatory ability between gender and when combination was used discriminatory ability was increased. Hence, the palatal rugae pattern and maxillary arch length can be used as an additional method in differentiating gender between human population groups.

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