

Correlation of Palatal Rugoscopy with Gender, Palatal Vault Height and ABO Blood Groups in Three Different Indian Populations

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Abstract

Background: Palatal rugae (PR) are asymmetrical irregular elevations, recorded during maxillary cast fabrication, that can be used for identification purpose if previous comparative sources are available. **Aim:** This study investigated uniqueness of PR patterns in relation to gender, palatal vault forms, and ABO blood groups in three (North-East [N-E], Northern and Western) populations of India. **Subjects and Methods:** The study was conducted on randomly selected 90 students, 30 from each sub population. Design - The palatal vault was recorded as Types I, II, and III. The maxillary casts were analyzed for each subject. The blood group of each subject was also recorded. Pearson's correlation coefficient tests were performed on cross-tabulations to evaluate significant relationship among different variables. **Results:** The PR number was more among females with an insignificant correlation among gender and mean rugae size on both sides. Types I and II hard palate vaults were seen associated with straight forwardly directed PR pattern, while Type III with curved forwardly directed PR. On the right side, straight rugae shape was most common type. On the left side, straight rugae shape was most common in Northern population while in N-E and Western populations curved rugae was the dominating type. A highly significant correlation was found between ABO blood groups and different PR patterns. **Conclusions:** PR possesses unique characteristics and can be used along with palatal vault forms as well as ABO blood groups for racial and individualistic soft tissue oral print in forensic cases.

Keywords: Blood groups, Forensics, Palate

Introduction

Palatal rugae (PR) or transverse palatine folds are asymmetrical irregular elevations of the mucosa, which are located in the anterior third of the hard palate. These are made from lateral membrane of the incisive papilla and are arranged in the transverse direction from palatine raphe in the mid-sagittal plane.^[1] The PR was first described by Winslow in 1753^[2] and Allen in 1889^[3] discussed their role as an identification method.

These appear toward the 3rd month of intrauterine life, from the connective tissue covering in the palatine process of maxillary bone. Its development and growth is mutually controlled by epithelial-mesenchymal interactions, where specific extracellular matrix molecules are spatiotemporally expressed during development.^[4] The first rugae is distinguished next to incisive papilla in the human embryo of 32 mm crown-rump length, with prominence in prenatal age.^[5] PR at birth have a typical orientation pattern, once formed; only changed in its length due to normal growth staying in the same position throughout the life of a person.^[4] Physiologically, PR aid in the swallow and tend to improve the taste reception on the dorsal surface of the tongue.^[5]

As PR are surrounded by cheeks, lips, tongue, and buccal pad of fat, these are protected in case of trauma or incineration. When recognition of an individual is convoluted by other forensic methods, PR are considered as an alternative source.

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Being specific to the racial groups, they facilitate population identification in mass disasters.^[6,7]

Based upon the height of palatal vault at the deepest point, palatal shapes are classified as medium (Type I), high/steep (Type II) or low/flat (Type III).^[8] The palatal shapes recorded during maxillary cast fabrication can be used for identification purpose if previous comparative sources are available. Thus, a dental surgeon can play an important role in personal identification and criminal investigations in our law and justice.

As the epithelium of the primary palate is of ectodermal origin and embryogenesis has a genetic basis; so does the determination of blood group of an individual. Hence, this study was undertaken to find out the association between the PR pattern and blood group of an individual.^[9] The study aims to investigate the uniqueness of the PR patterns in relation to gender, palatal vault forms, and ABO blood groups in three different (North-East [N-E], Northern and Western) populations of India.

Subjects and Methods

The study was conducted on randomly selected 90 students, 30 from each N-E, Northern and Western population zones of India in Surendera Dental College and Research Institute, Sriganganagar, Rajasthan, from April to July 2013. The study sample included subjects aged between 18 and 25 years, of which 56 subjects were females and 34 were males. All the subjects were briefed about the purpose of study and a written informed consent was obtained after their racial confirmation. The study approval was obtained from the Institutional Ethical Approval.

Exclusion criteria

The subjects with parafunctional oral habits, orthodontic interventions, congenital anomalies/malformations, previous orthognathic surgery, allergic to impression materials, bony and soft tissue protuberances, active lesions, deformity or scars and trauma to the palate, were excluded from the study.

Study materials

Mouth mirror, tongue depressor, addition silicone impression material, perforated metal trays, Type III dental stone, 0.5 mm black graphite pencil, electronic digital calipers, metallic scale, anti-A sera, anti-B sera, and anti-Rh sera for ABO blood group testing.

Method

The subjects were clinically examined using mouth mirror and a tongue depressor under artificial illumination for palatal vault height evaluation at the deepest point. Following the visual inspection, the palatal vault form was recorded as Types I, II, or III.

The maxillary impression of each subject was made in appropriate perforated impression trays using addition silicone impression material due to its higher tear strength and better accuracy. The impression was washed under running tap water and the casts were poured in Type III dental stone. The PR patterns were highlighted using 0.5 mm black graphite pencil on the cast and were then analyzed macroscopically [Figure 1].

The number of PR on left as well as right sides of the median palatine raphe was recorded. The size of each ruga was traced by measuring the distance from one end to the other end using an electronic digital caliper and a metallic scale. Based on the length, rugae were classified as: Primary (≥ 5 mm); secondary (3-5 mm); and fragmentary (< 2 mm).

The rugae shapes on both sides were analyzed according to Kapali *et al.* classification:^[10]

- Straight type ran directly from their origin to termination in a straight line
- Curved type had a simple crescent shape which curved gently, either at the termination or origin of a ruga
- Wavy type was recorded with a serpentine shape
- Circular type with ruga displaying the definite continuous ring formation.

In addition, if a ruga had two arms, it was categorized as unification, which can be converging or diverging type.^[11] Unifications in which two rugae began from the same origin, but immediately diverged were classified as diverging and in those which converged were classified as converging. The ruga shape that did not fall in any of the six shapes was named nonspecific type.

The direction of each ruga was determined by measuring the angle between the line joining its origin and termination and a line perpendicular to median palatine raphe. Forward - directed rugae were associated with positive angles, backward - directed



Figure 1: Maxillary casts showing different rugae patterns and types of palate in three different populations

rugae were associated with negative angles and *perpendicular* rugae were associated with zero degrees angulations.

The blood group of the subjects were identified by placing a drop of blood on the slide and treated with anti-A, anti-B and then on anti-Rh sera. Positive agglutination of the blood on treating with anti-A was considered as blood group A, positive reaction with anti-B was considered as blood group B, if no agglutination was produced then the blood group was O and if agglutination was seen with both antisera then blood group AB was considered. Similarly, positive agglutination reaction with Rh antigen was considered Rh⁺ or otherwise Rh⁻.

Results

The collected data were statistically analyzed using SPSS, Version 20.0 (Microsoft Corporation Inc., Chicago, IL, USA). The cross-tabulations were made for comparing the constituents between the groups. Pearson's correlation coefficient tests were performed on cross-tabulations to evaluate significant relationship among different variables.

A total of 790 PR were observed in 90 subjects, almost equally divided on left and right side of the median palatine raphe. The number of rugae was found more among females with statistically no significant difference with males ($P = 0.06$) in all the three populations [Table 1].

The mean PR size was noted largest among N-E population in both genders on right and left sides. A statistically highly significant correlation ($P < 0.001$) was found among both genders and mean rugae size on both sides in all the three Indian populations [Table 2].

The primary PR length was the predominating type among all the three populations, with the maximum number recorded in males of N-E population and females of Northern population. The fragmentary rugae were completely missing among both genders in N-E population [Table 1].

Regarding the PR shape on the right and left sides, straight shape was most commonly found followed by curved, wavy and circular in Northern population, whereas in N-E and Western populations, curved rugae were most common followed by straight, wavy and circular patterns [Table 3].

In Northern population, Types I and II forms of the hard palate were associated with straight forwardly directed PR while Type III was dominantly related to curve forwardly directed rugae pattern. In N-E population, Type I palatal form was seen maximum in curved forwardly directed rugae pattern, while Type II was associated with straight backwardly directed and Type III with wavy forwardly directed PR pattern. The Western population had Types I and III palatal forms predominantly allied with curved forwardly and backwardly directed rugae pattern while Type II coupled with straight forwardly directed pattern [Table 4].

Table 1: Gender wise distribution of palatal rugae number and rugae length in different populations

	Male						Female						Total
	North zone	North-East zone	West zone	Total	t	P value	North zone	North-East zone	West zone	Total	t	P value	
Rugae number													
Right side	29	58	61	148	3.9	0.06*	116	54	82	252	3.9	0.06*	400
Left side	31	58	63	152	4.0	0.06*	102	55	81	238	3.9	0.06*	390
Total	60	116	124	300	3.9	0.06*	218	109	163	490	4.0	0.06*	790
Rugae length													
Primary	58	115	118	291	1.1	0.40*	212	108	146	466	1.0	0.41*	757
Secondary	1	1	2	4	1.0	0.42*	4	1	14	19	1.0	0.42*	23
Fragmentary	1	0	4	5	1.2	0.39*	2	0	3	5	1.2	0.36*	10
Total	60	116	124	300			218	109	163	490			790

*Correlation is insignificant with $P > 0.05$ levels (2-tailed)

Table 2: Gender wise distribution of mean rugae size in different populations

Mean rugae size	North zone	North-East zone	West zone	Total	t	P value	95% confidence interval of the difference	
							Lower	Upper
Male								
Right side	9.8	10.9	10.1	10.3	379.4	<0.001**	9.7	9.9
Left side	9.9	10.9	10.3	10.4	631.0	<0.001**	10.8	11.0
Total	9.9 (0.0)	10.9 (0.0)	10.2 (0.1)	10.3	176.2	<0.001**	9.9	10.4
Female								
Right side	9.6	10.4	9.3	9.8	52.9	<0.001**	9.1	10.7
Left side	10.3	10.9	10.9	10.7	73.7	<0.001**	10.0	11.3
Total	9.9 (0.3)	10.7 (0.3)	10.1 (0.8)	10.2	23.0	<0.01*	8.2	11.9

*Correlation is significant with $P \leq 0.05$, **Highly significant with $P \leq 0.001$ level

Table 3: Right and left side PR distribution in male and female of different populations

Rugae shapes	North zone				North-East zone				West zone			
	Right side		Left side		Right side		Left side		Right side		Left side	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Straight	5	45	15	29	13	15	11	10	20	21	22	16
Curved	10	28	8	32	16	13	17	17	26	34	24	31
Circular	0	1	0	2	0	0	0	0	1	0	1	0
Wavy	2	10	6	27	5	10	15	18	5	6	11	20
Unilaterally convergent	1	3	1	6	1	3	6	6	4	2	1	3
Unilaterally divergent	2	10	2	6	5	10	10	4	5	6	4	6
Nonspecific	0	0	0	0	0	0	0	0	0	0	0	0
Forwardly directed	10	39	17	50	20	22	32	33	35	25	42	48
Backwardly directed	14	32	5	16	22	19	10	7	9	32	13	17
Perpendicular	5	32	9	17	13	13	7	15	16	25	8	16
Correlation coefficient (<i>r</i>)	1	0.8	1	0.9	1	0.9	1	0.9	1	0.8	1	0.9
<i>P</i> value	<0.001**	0.01*	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	<0.01*	<0.001**	<0.001**

*Correlation is significant with $P \leq 0.05$, **Correlation is highly significant with $P \leq 0.001$. PR: Palatal rugae**Table 4: Distribution of PR in different types of palate forms in different populations**

Rugae shapes	Types of palate								
	North zone			North-East zone			West zone		
	I	II	III	I	II	III	I	II	III
Straight	52	31	11	39	4	6	50	26	1
Curved	47	25	13	55	3	5	89	18	3
Circular	0	2	4	0	0	0	4	0	0
Wavy	33	29	6	44	0	24	40	9	1
Unilaterally convergent	6	1	4	8	3	5	8	2	0
Unilaterally divergent	9	4	7	21	5	3	14	4	2
Nonspecific	0	0	0	0	0	0	0	0	0
Forwardly directed	54	48	14	89	2	16	108	39	3
Backwardly directed	30	27	10	42	3	13	53	6	4
Perpendicular	42	15	5	32	2	14	46	14	0
Correlation coefficient (<i>r</i>)	1.0	0.9	0.8	1.0	0.2	0.6	1.0	0.9	0.7
<i>P</i> value	<0.001***	<0.001***	<0.01**	<0.001***	0.56*	0.05**	<0.001***	<0.01**	0.03**

*Correlation is insignificant with $P > 0.05$ levels (2-tailed), **Correlation is significant with $P > 0.05$, ***Highly significant with $P \leq 0.001$ level. PR: Palatal rugae

The study showed absence of A⁻ blood group in N-E. No case was recorded with B⁻ and O⁻ blood groups in N-E as well as Western population; whereas complete absence of AB⁻ blood group was recorded in all the three populations. The prevalence of B⁺ blood group was found to be maximum in all the three populations, with associated dominating straight pattern in north, wavy in N-E and curved rugae pattern in west population.

The Pearson correlation statistical analysis was done to check the relationship between rugae shapes and blood groups. The results indicated a highly significant correlation of rugae shapes with B⁺ and significant correlation with O⁺ blood groups in all the three populations. The correlation was found to be highly significant with AB⁺ blood group in North and significant in West, whereas it was recorded to be insignificant in N-E population. A highly significant correlation was also found with A⁺ blood group in North, whereas correlation was insignificant in N-E and significant in west populations. Correlation with A⁻, B⁻ and O⁻ blood groups was highly significant for North population [Table 5].

Table 6 shows the distribution of different blood groups among three population groups. The Pearson correlation statistical analysis indicated a highly significant correlation among all the blood groups in West and N-E populations.

Discussion

The use of PR patterns in postmortem identification has gained giant strides over several years. It is an established fact that no two hard palates are alike in their configuration and once formed does not undergo any changes except in length due to normal growth.

This study was undertaken to evaluate the qualitative and quantitative characteristics of rugae in three different Indian populations. The subjects of 18-25 years were selected as this age represents the growth completion. The maxillary dental casts were selected for the study as they are exact reproduction of the fleshy palates, showing all the details that could be measured accurately. The recording of measurements was

Table 5: Distribution of PR in ABO blood groups in different populations																								
Rugae shapes	A -ve			A +ve			B -ve			B +ve			AB -ve			AB +ve			O -ve			O +ve		
	North	North- West	West	North	North- West	West	North	North- West	West	North	North- West	West	North	North- West	West	North	North- West	West	North	North- West	West	North	North- West	West
	Ease			Ease			Ease			Ease			Ease			Ease			Ease			Ease		
Straight	5	0	3	16	12	9	2	0	0	36	15	52	0	0	0	10	12	3	6	0	0	19	10	12
Curved	1	0	1	8	16	19	0	0	0	33	27	53	0	0	0	6	5	5	4	0	0	26	15	27
Circular	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	2	0	0
Wavy	3	0	3	20	13	4	5	0	0	27	28	28	0	0	0	5	7	2	1	0	0	7	20	20
Uni convergent	0	0	2	3	6	4	0	0	0	6	6	7	0	0	0	1	1	2	0	0	0	1	3	6
Uni divergent	1	0	0	2	8	2	2	0	0	9	12	4	0	0	0	2	6	1	0	0	0	4	3	3
Nonspecific	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forwardly directed	6	0	3	28	24	16	3	0	0	42	43	93	0	0	0	8	5	10	4	0	0	25	35	33
Backwardly directed	1	0	5	8	14	16	4	0	0	34	29	27	0	0	0	5	6	2	3	0	0	12	9	21
Perpend	3	0	1	5	9	9	2	0	0	30	19	38	0	0	0	11	6	2	4	0	0	8	14	15
Correlation coefficient (r)	1	0.5	-	1	0.5	0.8	1	-	-	1	0.9	0.9	-	-	-	1	0.5	0.8	1	-	-	1	0.8	0.7
P value	<0.001***	0.18*	-	<0.001***	0.14**	<0.01**	<0.001***	-	-	<0.001***	<0.01**	<0.01**	-	-	-	<0.001***	0.14*	<0.01**	<0.001***	-	-	<0.001***	<0.01**	0.02**

PR: Palatal rugae. *Correlation is insignificant with P>0.05 levels (2-tailed), **Correlation is significant with P≤0.05, ***Highly significant with P≤0.001 level

Table 6: Distribution of ABO blood groups in different populations

Blood groups	North	West	North-East
A ⁺	6	4	9
A ⁻	1	1	0
B ⁺	12	15	12
B ⁻	1	0	0
AB ⁺	2	2	3
AB ⁻	0	0	0
O ⁺	7	8	6
O ⁻	1	0	0
Correlation coefficient (r)	1.0	0.9	0.9
P value	-	<0.01*	<0.01*

*Correlation is highly significant with P≤0.001 level (2-tailed), ABO: ABO Blood grouping system

easily performed with low errors; however, eyestrain was a problem and rest intervals were required.

The total number of rugae in the three racial populations of Northern, N-E and Western Indian zones was noted more on the right side of palate, which is in accordance with the results of Dhoke and Osato^[12] It was explained that this was due to the phenomenon of regressive evolution, dominating the right side of the palate. However, Shetty *et al.*^[2] in their study on the population in Tibet and Mysore found no statistical difference in the total number of rugae between the races or the side of the palate.

The most common rugae shape is straight followed by curved in the Northern zone while in N-E and Western zone, curved rugae were the dominating shapes as observed by Ohtani *et al.*^[13] and Indira *et al.*^[14] in their studies. Moreover, in this study we have found that unifications were moderate in number. The circular rugae were absent in N-E population and they constitute only 0.6% of the total rugae shapes in the other two populations, similar to the results of this study conducted on West and South-Indian populations by Pretty *et al.*^[15]

The forward, backward and perpendicular was the descending manner of rugae direction in all populations. This may be attributed to the significant changes occurring in the rugae position, especially at their lateral ends, which were believed to follow the direction of tooth migration. The results of our study coincided with that of Jawad.^[16] This study did not shown any significant difference of rugae length between male and female in all the populations, as observed by Fahmi *et al.*^[17] and Kapali *et al.*^[10] in their studies. The average size of PR was observed more among males on the left side, irrespective of population, similar to the findings of Kamala *et al.* studies.^[18]

Type I (medium) palatal vault was seen most commonly in all the populations followed by Type II (high) in Northern and Western Indian population, while in N-E population, it was Type III (low) palatal form. The results were in accordance with Kim^[8] regarding the anatomical form of the hard palate.

A highly significant correlation was found between ABO blood groups and different PR patterns in three different Indian sub-populations. The results were highly significant regarding the intergroup comparison of blood groups and three populations. The findings obtained from our study were in accordance with the study conducted by Gulati *et al.*,^[9] which revealed a significant correlation between blood group and dermatoglyphic pattern. They discussed the use of these parameters for personal identification, as both are controlled by a genetic mechanism.

Palatal rugae are permanent, prominent and unique for individuals and thus can be used as identification for forensic purposes widely in edentulous patients where dental identification is not possible. Furthermore, there is a gender and region wise variations in PR pattern as studied by Byatnal *et al.*^[19]

Hence, this study indicates that this significant correlation of palatoscopy with blood group can also be utilized as personal identification marker in forensic odontology. As this study was conducted using only three Indian subpopulations with a small sample size, so further large sample studies are required to substantiate the results.

Conclusion

In view of the significant findings found in this study, the correlation of Palatal Rugoscopy along with palatal vault forms and ABO blood group can be used as a reliable guide in personal identification in forensic odontology. Thus, it will help us to reach one step closer to the truth.

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