ASSESSMENT OF PALATAL RUGAE CONFIGURATIONS IN ETHNIC GROUPS OF MALAYSIAN POPULATION

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Abstract

Introduction: Palatal rugae patterns are one of the most dependable methods for human identification when valuable dental or other soft tissue information lack.

Method: The cross-sectional study included 120 Malaysian subjects comprising of 60 males and 60 females of Chinese, Malay and Indian groups of dentulous and edentulous state. Rugae were marked on the maxillary cast using lead pencil and were evaluated for the number, length and shape over the cast by the examiner. The collected data was sorted, tabulated and subjected to statistical analysis. The data was expressed in mean and standard deviation for number and length. A descriptive analysis was performed to assess the frequency of rugae pattern.

Results: The total number of rugae and the number of secondary rugae was higher in dentulous population. In Chinese population had the total number as well as primary rugae were more. Males had more total number of rugae whereas the secondary rugae number was more for females. The mean lengths of primary rugae for edentulous subjects were higher. Indian population had the longest mean length of primary rugae. The secondary rugae were longer for Malay population. Males had longer primary rugae whereas females had longer secondary rugae. The present study found that the incidence of wavy, divergence and convergence were more among males while straight, curved and circular were more among females than males.

Conclusions: Variations in number, length and shape of palatal rugae can be used as special characteristics that can distinguish individuals of one race from another.

New knowledge added by this study: Rugae patterns and number vary among races. Presence/absence of dentition does have an effect on the rugae configuration

Implications for clinical practice or policy: Rugae patterns may play role in forensics in sex identification and give a clue on race determination.

Keywords: Forensic Odontology, Palatal Rugae, Plica Palatinae, Rugoscopy, Rugae patterns.

I. Introduction

Perceiving the identity of a living or deceased individual is an ardous task in forensic sciences and forensic odontology contributes a prime role in the same. Certification of death for personal, social and legal reasons is possible only by revealing the identity of a person. Instances where hard tissues of the oral cavity are lost due to any reasons, non-mutilated palatal tissues can be visually examined for further investigations.[1] In an instance where fingerprint recording or connection using dental record is challenging, forensic dentistry has chosen palatal rugae as one of the reliable choice in identity determination.[2] The stability and uniqueness of rugae pattern has made rugae a standard parameter in human identification by forensic medicine. Palatal rugoscopy is dependable for dentulous as well as edentulous patients when post mortem dental identification is laborious. The palatoscopy is used as a necro identification technique as it can resist disintegration for upto seven days.[1]Palatal rugoscopy has low utilization cost and is expedient over other methods as they are highly unique, and persistent in shape throughout life.

Palatal rugae are anatomical folds or wrinkles that are located on the anterior third of the hard palate behind the incisive papillae. Palatal rugae were initially construed by Winslow in 1753 and the earliest illustration of was given in 1775. Influence of palatal rugae patterns in

personal identification was suggested by Allen in 1889. The term "Palatal rugoscopy" was first proposed by the Spanish investigator Trobo Hermosa.[3] Hauser and Roberts 1989 stated the importance of palatal rugae as a landmark during orthodontic treatment as they observed shifting of the lateral edges of the rugae one half the distance of migration of adjacent teeth, while the median rugae was not affected.[4]

Plica palatinae or palatal rugae are irregular, asymmetrical ridges of the mucous membrane extending lateral from the incisive papilla and the anterior part of the median palatal raphae. Palatal rugae appear in the 3rd month of intra-uterine life.[2] The palatal rugae will be intact even after third degree burns because of their anatomical position inside the mouth and is the prime reason for considering it as an identification tool.[1] Due to their anatomic loctaion, rugae are protected from thermic insults by the tongue and buccal pad of fat.

Various investigators have studied the anatomical pattern of palatal rugae to assess the racial differences, but very few have studied the distinctiveness of the same.[1,4-6] Many studies are based on systems devised by Lysell and Thomas and Kotze, although they may differ in details. The palatal rugae have been considered equivalent to the fingerprint and are unique for everyone. The present study used the morphologic classification by Thomas et al to assess the pattern of rugae (Table 1).[6] Number and length of rugae were also analysed in the present study to assess the individuality of the rugae in three ethnic races seen in Malaysia. The objectives were:

(a) to analyse and compare the number, length and pattern of rugae in dentulous and edentulous patients (b)to analyse and compare the number, length and pattern of rugae in Chinese, Malay and Indian races (c)to analyse and compare the number, length and pattern of rugae in males and females (d)to analyse whether palatal rugae can be used as a tool for identification of gender, region and race of a particular population.

Table 1: Thomas and Kotze classification (1983)

Classification Criteria		Description
BASED ON PATTERN		
A. Straight		Runs directly from origin to termination
B. Curvy		Simple Crescent shape that curves gently
C. Circular		Definite continuous ring form
D. Wavy		Serpentile form
Unification	E. Divergent	Two rugae begin from the same origin, but bifurcate transversely.
	F. Convergent	Rugae with different origins which are joined on their lateral positions and considered as converging.
BASED ON LENGTH		
Primary	A	5-10mm
	B	10mm or more
Secondary		3-5mm
Fragmentary		<3mm

II. Materials and Methods

This study comprised of 120 subjects comprising of 60 males and 60 females aged between 17 – 70 years old. The participants were further divided into Chinese, Malay and Indian group with 40

participants each including both the genders. Among the 60 males, 30 subjects were edentulous and 30 subjects were dentulous. Similarly 30 females were edentulous and another 30 were dentulous regardless of the races. All participants were healthy individuals free from congenital anomalies, inflammation, trauma, or orthodontic treatment. The purpose of the study was explained to the participants and the consent was obtained from them. A midline was drawn on the maxillary cast coinciding with that of the mid-palatine raphe extending from the incisive papillae to the posterior most extent of the rugae on the palate. This divided the rugae in two halves and the rugae in each half were highlighted using a lead pencil under spotlight by the examiner. The shape, number, and length of rugae pattern were studied over cast by the examiner and the mean value for length and numbers were calculated. The length of each rugae was measured using a Vernier caliper in millimeters (mm^2). The pattern of rugae was determined using Thomas and Kotze classification. The collected data was sorted, tabulated and subjected to statistical analysis. The data was expressed in mean and standard deviation. Statistical Package for Social Sciences (SPSS 16.0) version used for analysis. One way ANOVA (Post hoc) followed by Sheffe test and unpaired t test was applied to find the statistical significance. A p value less than 0.05 ($p<0.05$) was considered statistically significant at 95% confidence interval. A descriptive analysis was performed to analyze the distribution of rugae patterns.

III. Statistics and Results

The mean total number of rugae was evaluated (Table 2). The mean number was higher in dentulous population (8.76) as compared with edentulous population (6.26) and was statistically significant The number of rugae on right and left sides were statistically significant for dentulous patient compared to edentulous patients. The total mean number of rugae in Chinese population

(10.19) was higher followed by Indian (9.63) and Malay (6.23) population. There was statistical significance in the mean number of rugae among the groups. Females were found to have lesser mean total number(6.16) of rugae than males(9.90) and was statistically significant.

Table-2: Mean number of rugae in dentulous and edentulous/ three races in Malaysia/ Males and females.

Observation	Right (MEAN±SD)	Left (MEAN±SD)	Total (MEAN±SD)
Edentulous	3.12±0.99	3.14±1.06	6.26±1.02
Dentulous	4.32±1.21*	4.44±1.35*	8.76±1.48*
Malay	3.06±1.08	3.17±1.20	6.23±1.15
Indian	4.98±1.56*	4. 65±1.20*	9.63±1.25*
Chinese	5.17±0.96*,†	5.02±1.46*,†	10.19±1.23*,†
Females	3.02±1.14	3.14±1.31	6.16±1.22
Males	4.98±1.19*	4.92±1.33*	9.90±1.26*

(*,†p<0.05 significant)

The mean number of primary and secondary rugae was also analyzed to assess the gender and race variation (Table 3). The primary rugae for edentulous and edentulous patients did not show statistical significance. The secondary rugae (1.07) was more for dentulous subjects and was statistically significant with edentulous group(0.56). Chinese had more mean number of primary rugae (8.94) and was statistically significant with the other groups. Malay population had least mean number of primary rugae(6.46). Indians exhibited a mean number of 7.30 primary rugae. The mean number of secondary rugae was more for Chinese (1.41) and was statistically significant compared to Indian (0.81)and Malay(0.61) population. Males (7.69) had higher number of mean primary rugae than females(6.48) which was statistically significant. The mean number of secondary rugae was more for females(0.90) and statistically significant to male (0.65) group.

Table-3: Mean number of primary and secondary rugae in dentulous and edentulous / three races in Malaysia / Males and females.

Observation	Primary (MEAN±SD)	Secondary (MEAN±SD)	Total (MEAN±SD)
Edentulous	7.20±1.42	0.56±1.00	7.76±1.02
Dentulous	7.40±1.70	1.07±1.22*	8.47±1.48*
Malay	6.46±1.57*,†	0.61±1.02*,†	7.07±1.23*,†
Indian	7.30±1.29	0.81±1.09	8.11±1.15
Chinese	8.94±1.95*	1.41±1.30*	10.08±1.25*
Male	7.69±1.72	0.65±1.21*	7.13±1.26*
Female	6.48±1.58*	0.90±1.19	8.59±1.22

(*,†p<0.05 significant)

Length assessment (Table 4) showed that there is significant difference between primary and secondary rugae in all the categories. The mean length of primary rugae is for edentulous (10.09) patients is statistically significant with dentulous (8.46) patients. The secondary rugae of dentulous group (4.14) was statistically significant compared to edentulous group (3.12). Indian population had the longest mean length of primary rugae (10.12) followed by Malay population (9.66) and then the Chinese population (8.13). The results were statistically significant among the groups. The secondary rugae was longer for Malay population(5.03) and was statistically significant with Chinese (3.04) and Indian (4.22) group. Male population (9.70) had longer mean length of primary rugae than female population (9.56)) whereas female population (4.11) had longer mean length of secondary rugae than male population (3.87)and was statistically significant.

Table-4: Mean number of primary and secondary rugae in dentulous and edentulous / three races in Malaysia / Males and females.

Observation	Primary (MEAN±SD)	Secondary (MEAN±SD)
Edentulous	10.09±1.56	3.12±0.48
Dentulous	8.46±1.19*	4.14±0.42*
Malay	9.66±1.26	5.03±0.53*,†
Chinese	8.13±1.59*	3.04±0.37*
Indian	10.12±1.07*,†	4.22±0.43
Male	9.70±1.41	3.87±0.43*
Female	8.12±1.25*	4.11±0.44

(*,†p<0.05 significant)

Descriptive analysis showed that the wavy, curved and straight patterns are predominant in both dentulous and edentulous group, whereas divergent, convergent and circular were less common. Our study shows that divergent rugae pattern is more than convergent rugae pattern in dentulous group (Table 5). This study also showed that wavy, curved and straight were the most predominant rugae patterns in Malay, Chinese and Indian populations (Table 5). In our study, divergent is found more prevalent than convergent rugae pattern in all three races. Wavy rugae pattern was found to be the most predominant type in both males and females, followed by curved, straight, divergence, convergence and circular pattern (Table 5). In our study, comparison of different rugae pattern did not show much difference between males and females. The present study found that the incidence of wavy, divergence and convergence were more among males than females, while straight, curved and circular were more among females than males.

Table-5: Percentage of rugae pattern in dentulous and edentulous / three races in Malaysia / Males and females.

Type	Edentulous	Dentulous	Malay	Chinese	Indian	Male	Female
Straight	26.42	23.49	25.35	22.38	25.00	23.60	24.58
Curved	22.33	26.85	27.67	23.56	26.55	24.43	26.90
Wavy	35.85	34.42	30.93	42.58	29.65	36.56	33.33
Circular	0.93	0.37	0.23	0.59	0.66	0.33	0.64
Divergence	11.95	11.41	14.19	9.11	11.72	11.80	11.33
Convergence	2.52	3.46	1.63	1.78	6.42	3.28	3.22

IV. Discussion

Palatal rugae, also called plicae palatinate transverse and rugae palatina refer to the ridges on the anterior part of the palatal mucosa, each side of the median palatal raphe and behind the incisive papilla.[7] The palatal rugae originates from the covering connective tissue in the palatine process of maxillary bone, and its development and growth are mutually controlled by epithelial-mesenchymal interactions. Palatal rugae develop as localized regions of epithelial proliferation and thickening. Fibroblasts and collagen fibers then accumulate in the connective tissue beneath the thickened epithelium and assume distinct orientation.[2]

This study comprised of 120 subjects with 60 males and 60 females. The participants were further divided into Chinese, Malay and Indian group with 40 participants each including both the genders. Among the 60 males as well as females, 30 subjects were edentulous and 30 subjects were dentulous. The pattern of rugae was determined using Thomas and Kotze classification.

In our study, the number of rugae is significantly higher in dentulous population as compared with edentulous population. Similar result has been reported by Bhatt G who compared the rugae pattern between dentulous and edentulous population of Rajasthan state.[8] The study conducted by Jawad IA revealed that the total number of rugae in edentulous group was lesser than dentate

subjects.[9] Over time, even though in edentulous subjects ridges move towards the alveolar ridge, the forms persist but become less apparent often due to prosthetic pieces. The present study showed that Chinese population has higher number of palatal rugae, which is followed by Indian and Malay population. A study conducted by Hosmani J et al. showed that Indian population had significantly higher number of total rugae than the Tibetan population.[5] Another study conducted by Kommalapati RK et al found that the mean total number of rugae was found to be more in Andhra Pradesh, compared to Telangana population which represents two states in Indian subcontinent and the findings were statistically significant.[10] The above-mentioned studies denote that there is always racial or regional variation in the number of rugae present. This holds true for the present study and hence can be used as an important identification tool. The total number of rugae was more in males compared to females. The present study is in agreement with the studies conducted by Gadicherla P et al[11] and Kamala et al[12] which reported that the number of rugae in males was greater than that found in females. Our result was in contrast to the study reported by Babu et al[13] who reported that females were found to have greater number of rugae than males.

The number of primary rugae was similar in dentulous and edentulous groups whereas secondary rugae was more in dentulous population seen in Malaysia. The findings reported by Bhatt G who compared the rugae pattern between dentulous and edentulous population of Rajasthan State stated that the number of primary rugae is more in dentulous population.[8] Jawad IA has compared the rugae pattern between dentate and edentulous patients in Iraqi sample and has found that the primary rugae number in edentulous group were significantly lesser than those of dentate subjects.[9] Our study found that Chinese population has greater number of primary and secondary rugae than Malay and Indian populations. Kashima et al.[14] compared the palatine rugae and shape of the hard palate among the Japanese and Indian children and reported that Japanese children had more primary rugae than the Indian children and the palatal raphe of the Japanese

children were wider than those of the Indian children. Kapali et al reported that the Australian Aborigines had more primary rugae than the Caucasoids. According to this study, males had significantly higher number of primary rugae and females had higher number of secondary rugae than males.[15] This study is in contradiction with Thabitha et al who evaluated the palatal rugae pattern in establishing identification and sex determination in Nalgonda children.[16] They found that females had significantly higher number of primary rugae than males.

The mean length of primary rugae was more for edentulous patients whereas the secondary rugae was for dentulous population. The mean length of primary rugae was higher in Indian population and secondary rugae were higher in Malay population. Thus the study showed that there is difference between the comparative length of primary and secondary rugae in different races. This study is in contradiction with Basman RS et al who reported that the total number and mean length of primary, secondary and fragmentary rugae between the ethnic Javanese and non-Javanese groups were not statistically significant.[17] Research by Bansode and Kulkarni have shown that the shape of the rugae remain unaltered and changes in their length can occur due to orthodontic treatment or trauma.[18]

The most common rugae patterns were wavy, curved and straight in both dentulous and edentulous group, whereas divergent, convergent and circular were less common according to the present study. A study of the similar lines conducted by Jawad IA reveals that the most common rugae shapes were wavy and curved forms, whereas straight and circular types were least common.[9] Bhatt G found that the most common rugae shapes found among both the dentulous and edentulous groups were straight and curved followed by wavy and circular, which contrasts with our study.[8] Our study shows that divergent rugae pattern is more than convergent rugae pattern in dentulous and edentulous group. Similar results have been reported in the study

conducted by Jawad IA who compared the rugae pattern between dentate and edentulous patients in Iraqi sample.[9]

This study showed that wavy, curved and straight were the most predominant rugae patterns in Malay, Chinese and Indian populations. In the study conducted by Surekha et al on Manipur and Kerala populations, wavy pattern followed by curvy and straight was the most predominant type of rugae.[19] Furthermore, in the study by Savita et al curved, straight, and wavy rugae patterns were found to be the most common rugae patterns in both Kerala and Karnataka populations.[20] In a study by Nayak et al the most common rugae shape observed were wavy and curved forms, accounting for more than 65% in each population whereas wavy and curved forms accounted to 55% for each ethnic group in our study.[21] In the present study, it was found that divergent rugae are more prevalent than convergent rugae pattern in all three races. Azab SMS. et al found that presence of unification rugae pattern among Egyptian population with the converging form more prevalent than the diverging form.[22] Contrary to these findings are those found by previous studies on the Indian population as they found unification rugae pattern to be very rare.[7, 21] Also, comparison of rugae patterns in the African and European populations revealed that Africans had significantly greater numbers of unifications and circular rugae.[23] Thomas and Kotze studied the rugae patterns of six South African populations to analyze the interracial difference. They found that rugae were unique to each ethnic group and can be used successfully as a medium for genetic research.[6] It could be stated that the least commonly appearing patterns of rugae are seen in very specific races and hence can be used as an important tool in identification of a person's region or race.

In this study, wavy rugae pattern was found to be the most predominant type in both males and females, followed by curved, straight, divergence, convergence and circular pattern. The

study done by Sharma et al showed that predominant shape in males and females was wavy and curved, followed by the straight pattern which was in coincidence with our study.[24] In another study conducted by Selvamani et al, wavy pattern predominated in both males and females, followed by curved, straight, divergent, convergent, and circular pattern.[25] A study conducted by Azab SMS et al. found no significant differences between males and females in rugae pattern.[22] Another study conducted by Abdellatif A M. et al reported no significant differences between both sexes in the palatal rugae pattern among the adult Egyptian population.[26] Our study found that the incidence of wavy, divergence and convergence were more among males whereas straight, curved and circular were more among females than males. This is comparable to the study conducted by Shetty and Premalatha[27] and Manjunath et al[28] who found that the incidence of curved, straight and forwardly directed rugae was more among females than males, while wavy, perpendicular and backwardly directed rugae were more among males. Based on the various literatures and the current study, it could be stated that the commonly appearing patterns of rugae is more dependent on gender than the race.

The palatine rugae are unique to each patient and are reasonably stable during the patient's growth thus, they may serve as suitable reference points from which the clinician can derive the reference planes necessary for longitudinal cast analysis.[29] Bansode et al. analysed only some changes in the rugae pattern during orthodontic treatment by evaluating the preoperative and postoperative orthodontic casts of 60 patients. They also assessed that the morphology of palatal rugae remains stable throughout life and when carefully assessed, rugae pattern has definite role in forensic practice.[18]

V. Conclusion

Palatal rugae pattern is unique to an individual; hence, their use in forensic identification is of greater importance. The rugae are also considered to have population-specific configuration and can be successfully used in population identification. Within the limitation of the study, we found that there are differences in the palatal rugae number, length and pattern among the three ethnic groups in Malaysia. It also concluded that there is wide variation in individuality of rugae according to gender and also based on the presence of teeth in the oral cavity. Thus it can be concluded that rugae have great role in population differentiation along with gender identification. Larger sample size can be used for further studies to validate the findings and to establish palatal rugae as a definite tool for identification in forensic cases.

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