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Forensic Odontological Study On Rugae Morphology African Racial Groups With Special Reference To The Dental Soft Tissue: Dimensional Variations In Rugae Patterns

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ABSTRACT

Forensic odontology is one of the fast growing subjects in both the forensic sciences and dentistry. It has a number of applications for the purpose of administration of the justice and also for the societal welfare. Though there are a number of studies available on age estimation and sex determination, there are a very few studies on the race determination. In case of major disasters the race could be easily identified with the least destructible palate of the intra oral cavity. The palatal rugae could be easily analysed for the determination of racial groups. This has been studied with the African population. It has been further compared with that of an Indian population (Gujarati in particular). On the basis of morphology and morphometry of the patterns of the palatal rugae it is easily identified about the individuality, a total number of 70 people have been considered for the study. 2 racial groups: Africans (male= 20, females= 15) and Indians population (Gujarat in particular- males= 17, females =18) between the age group of 18years to 28 years have been considered. 70 maxillary impressions were taken with alginate impression material and the casts are produced, 35 for African and 35 for Indian population. It was found that the Palatal rugae patterns in number, lengths and width showed significant differences between both the racial groups which serve as an important indicator for forensic identification especially in mass fatality incidents.

KEYWORDS: Rugae patterns, width, lengths, human identification.

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INTRODUCTION:

Postmortem human identification of the deceased in cases of mass disasters achieved by dental or any other means is one of the most challenging task. Forensic odontology is entirely a unique entity dealing with evidence related to dental and oral structures. Although various studies have been by the use of teeth in forensic investigations, use of other methods such as palatal rugae patterns, lip prints, and bite marks were also reported. Palatal rugae are considered to be equipotent with fingerprints and bite marks and a powerful tool for an individual identification in medico-legal investigations. Palatal rugae are anatomically transverse, asymmetrical, irregular, soft-tissue ridges present on the anterior part of the palatal mucosa, located posterior to the incisive papilla on each side of the mid palatine raphae.[1] They are also called 'plica palatine.' They are formed in the early intrauterine life during the period from 12th to 14th week and remain stable throughout the person's life, not undergoing any changes, except for increase in the length as a process of normal growth[2].These palatal rugae patterns are unique to each individual. They remain well protected by the lips, buccal pad of fat, mucosa, teeth and lips, and hence, survive postmortem insults. Palatal rugae were found to be stable in shape and structure during the life of an individual and remain unchanged by any disease, trauma, and chemicals or heat[3].Once formed, they remain in the same position and if destroyed, they are reproduced exactly on their original site[3].

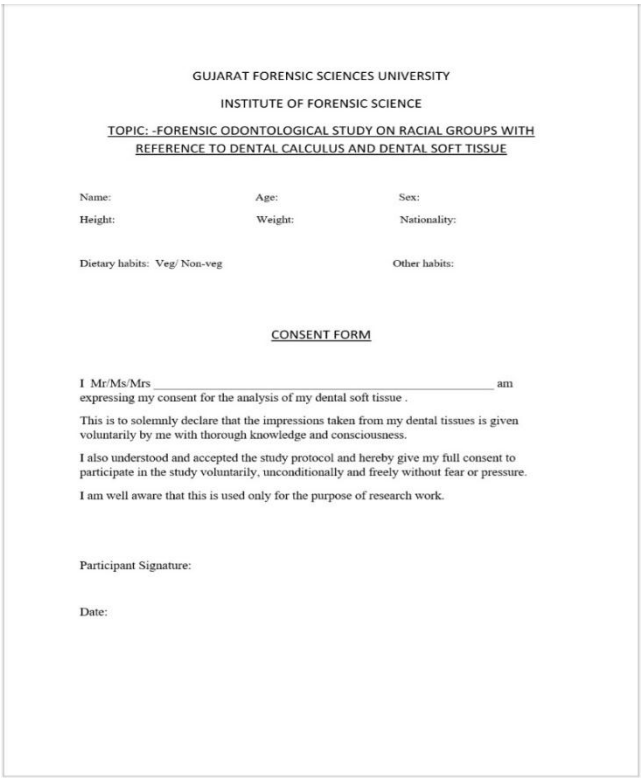
Studies done by Hauser et al. in 1989 have suggested that the mean recommended count changes fairly in adolescence, but the count increases markedly from the third to fourth decade onwards.[4] But, Lysell in 1955 concluded that the number of rugae decrease from the second decade onwards.[5] Peavy and Kendrick in their study identified that the palatal rugae do not change as a result of growth, but remain stable throughout life.[6]

A wide range of forensic science techniques help in positive identification of the deceased victims, some of these are visual identification, use of fingerprints, lip print, denture coding, DNA profiling and odontology. Just like fingerprints, palatal rugae are highly specific to each individual. Identification of the badly mutilated body has been done using rugae patterns on patient's denture in the past.[7] Also, rugae pattern are specific to different racial groups making it convenient for their identification in a mass disaster situation.[7] Several studies reported a significant association between rugae forms and ethnicity which may represent a valuable finding in forensic investigations especially in disasters.[3] Therefore this study is an attempt to differentiate between the various rugae patterns on the basis of their shapes, lengths and widths amongst the African and Indian population to see which rugae pattern is predominant in Africans and Indians population thereby highlighting the importance of palatal rugae pattern in establishing a person's identity and the need of maintaining

the antemortem record of the same in the form of photographs or digitalised casts which can be stored in the form of a secured database which later can be used for comparison purposes.

MATERIALS AND METHODS:

The study was conducted under Gujarat Forensic Sciences University. Informed consent was obtained was each individual before taking impressions [Figure 1]. 70 maxillary impressions were taken 35 each for Africans as well as Indians with the help alginate impression material and stainless steel impression trays and the casts were then obtained using dental stone. The age range was between 18-30 years. The casts obtained were free of any voids or bubbles. Patients with any congenital abnormality, pathology and orthodontic treatments were excluded from the study. The rugae were delineated using a sharp graphite pencil under adequate light and magnification shown in fig. 2, 3.



GUJARAT FORENSIC SCIENCES UNIVERSITY

INSTITUTE OF FORENSIC SCIENCE

TOPIC: -FORENSIC ODONTOLOGICAL STUDY ON RACIAL GROUPS WITH REFERENCE TO DENTAL CALCULUS AND DENTAL SOFT TISSUE

Name: Age: Sex:

Height: Weight: Nationality:

Dietary habits: Veg/ Non-veg Other habits:

CONSENT FORM

I Mr/Ms/Mrs _____ am expressing my consent for the analysis of my dental soft tissue .

This is to solemnly declare that the impressions taken from my dental tissues is given voluntarily by me with thorough knowledge and consciousness.

I also understood and accepted the study protocol and hereby give my full consent to participate in the study voluntarily, unconditionally and freely without fear or pressure.

I am well aware that this is used only for the purpose of research work.

Participant Signature:

Date:

Figure-1 Consent Form

Figure- 2 Indian Cast

Figure- 3 African cast

The pattern of rugae was determined using Thomas and Kotze classification (Figure-4).[11] Parameters included in the study were: number, shape, and unification patterns of rugae.

Also, lengths and widths of the rugae patterns were also measured.

The shapes of palatine rugae were classified into four major types:

- Straight type: The rugae patterns which ran directly from their origin to termination.
- Curved type: The rugae pattern which has a simple crescent shape, slightest bend at the termination origin of rugae.
- Wavy type: The basic shape of wavy was serpentine, however, if there was a slight curve at the origin or termination of the curved rugae, it was classified as wavy.
- Circular type: A rugae needed to display a definite continuous ring formation.

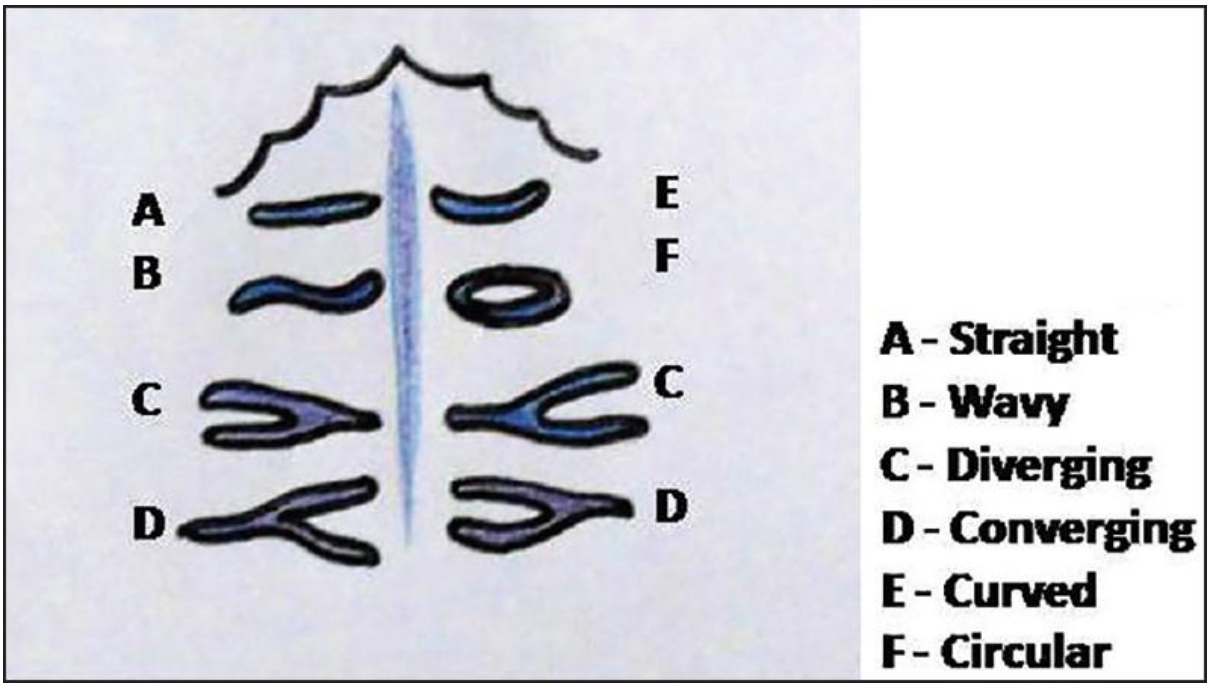


Figure- 4 Pictorial Representation of the Analysis of Various Shapes of Palatal Rugae (according to Thomas and Kotze) [11]

Length of Rugae. The length of rugae is classified as follows:

- Primary (>5 mm).
- Secondary (3–5 mm),
- Tertiary (<3 mm),

Measurement of the lengths and widths of the rugae was done manually with the help of a divider and the distance between the two end points between the rugae were measured with the help of a scale.

A simplified manner of a chart was prepared through this study to record all the findings for all the samples. This is easier for recording the findings shown in fig. 5.

Once the findings were recorded that data entry was done in Microsoft excel sheet.

S.No.	Position (Right/left)	Length in mm	P/S/T	Width in mm	Shape (straight, curved, wavy, circular)	Unification (convg/diverg)

Figure 5: Pictorial Representation of the Simplified Chart prepared for the Analysis of the Rugae Patterns (P: Primary, S: Secondary, T: Tertiary)

Exclusion Criteria:

- The subjects with congenital anomalies/malformations
- Subjects with any history of previous orthognathic surgery
- Bony and soft tissue protuberances in the palatal aspect
- Active lesions, and trauma of the palate were not selected
- Subjects who were wearing partial dentures and braces were excluded.

Inclusion Criteria:

Normal subjects within the age limit of 18-28 years.

RESULTS:

The data was then evaluated onto the SPSS software with independent t- test which showed high significance. Gender wise comparison of the patterns lengths as well as width for amongst African and Indians were evaluated for which width showed high significance for male straight patterns, female straight patterns, female curved patterns, male wavy patterns, female wavy patterns, male circular patterns for both the racial groups showed high significance with p value < 0.05, [table 1-2]

Width differences in both the population groups were found to be highly significant (Indians n=1.72, p=0.00 and Africans n= 2.67, p=0.00). The length measurements of primary rugae showed significance with p value=0.07ie. <0.05, secondary pattern did not show any significance with the independentt-test[table1&2

Differences in the number as well as measurements of length of rugae patterns classified on the basis of lengths were also seen according to which primary rugae were more in number in Africans whereas secondary rugae patterns were seen slightly more in Indians as compared to

Africans and tertiary patterns are very rarely seen or were found to be almost same for both the population groups and henceforth were not considered in statistical analysis shown in Table1 &2

Table-1: Gender wise analysis of mean of lengths of various patterns, including lengths of primary and secondary rugae along with the total width of the patterns. Group Statistics

	Country	N	Mean	Std. Deviation	Std. Error Mean
Male straight	**Indian**	95	1.53	.687	.071
	African	78	2.44	1.567	.177
Female straight	**Indian**	113	1.45	1.057	.099
	African	49	1.99	1.056	.151
Female wavy	**Indian**	39	1.62	.823	.132
	African	44	2.07	.720	.109
Male circular	**Indian**	11	2.32	1.601	.483
	African	35	4.23	2.889	.488
Female circular	**Indian**	6	2.08	1.530	.625
	African	9	2.28	.833	.278
Width	**Indian**	375	1.72	1.076	.056
	African	388	2.67	1.866	.095
Length Primary	**Indian**	341	10.18	2.953	.160
	African	343	10.61	5.873	.317
Length Secondary	**Indian**	32	4.41	.499	.088
	African	56	4.39	.562	.075

Table-2: Analysis of lengths of various patterns, including lengths of primary and secondary rugae along with the total width of the patterns with significance.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Male straight	Equal variances assumed	23.827	.000	-5.116	171	.000	-.913	.179	-1.266	-.561
	Equal variances not assumed			-4.784	101.181	.000	-.913	.191	-1.292	-.535
Female straight	Equal variances assumed	.952	.331	-3.026	160	.003	-.547	.181	-.904	-.190
	Equal variances not assumed			-3.028	91.422	.003	-.547	.181	-.906	-.188
Male curved	Equal variances assumed	.059	.809	-1.841	94	.069	-.620	.337	-1.290	.049
	Equal variances not assumed			-1.744	56.073	.087	-.620	.356	-1.333	.092
Female curve	Equal variances assumed	20.740	.000	-3.040	102	.003	-.735	.242	-1.214	-.255
	Equal variances not assumed			-2.826	65.465	.006	-.735	.260	-1.254	-.216
Male wavy	Equal variances assumed	11.128	.001	-4.330	102	.000	-1.013	.234	-1.477	-.549
	Equal variances not assumed			-5.818	82.991	.000	-1.013	.174	-1.359	-.667
Female wavy	Equal variances assumed	1.506	.223	-2.674	81	.009	-.453	.169	-.790	-.116
	Equal variances not assumed			-2.652	76.106	.010	-.453	.171	-.793	-.113
Male circular	Equal variances assumed	7.906	.007	-2.087	44	.043	-1.913	.917	-3.761	-.066
	Equal variances not assumed			-2.786	31.300	.009	-1.913	.687	-3.313	-.513
Female circular	Equal variances assumed	1.484	.245	-.320	13	.754	-.194	.607	-1.507	1.118

	Equal variances not assumed			-.284	7.001	.784	-.194	.684	-1.811	1.422
widths	**Equal variances assumed**	77.085	.000	-8.512	761	.000	-.943	.111	Lower	Upper
		77.085	.000	-8.512	761	.000	-.943	.111	-1.160	-.726
Length Primary	**Equal variances assumed**	7.213	.007	-1.233	682	.218	-.439	.356	-1.137	.260
	Equal variances not assumed			-1.235	505.207	.217	-.439	.355	-1.136	.259
Length second	**Equal variances assumed**	1.007	.318	.112	86	.911	.013	.120	-.224	.251
	Equal variances not assumed			.116	71.134	.908	.013	.116	-.218	.244

Lengths of the patterns showed the least significance with p values > 0.05 except the male wavy pattern length which showed high significance (p value = 0.00). [Table 3 and 4]

Table- 3 Gender wise mean of lengths of various shapes.

Group Statistics					
	Country Male Straight	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Male Straight	**Indian**	**96**	**9.51**	**5.186**	**.529**
	African	**78**	**9.26**	**3.742**	**.424**
Female Straight	**Indian**	**113**	**8.58**	**3.368**	**.317**
	African	**49**	**9.03**	**2.905**	**.415**
Male Curved	**Indian**	**33**	**7.85**	**2.852**	**.496**
	African	**63**	**8.30**	**3.331**	**.420**
Female Curved	**Indian**	**60**	**8.44**	**2.657**	**.343**
	African	**44**	**9.43**	**2.792**	**.421**
Male Wavy	**Indian**	**26**	**8.87**	**2.953**	**.579**
	African	**77**	**12.35**	**3.462**	**.395**
Female Wavy	**Indian**	**39**	**11.29**	**2.499**	**.400**
	African	**38**	**12.05**	**3.246**	**.527**
Male Circular	**Indian**	**11**	**6.26**	**2.778**	**.837**
	African	**35**	**7.31**	**4.162**	**.704**
Female Circular	**Indian**	**6**	**6.83**	**4.191**	**1.711**
	African	**9**	**7.02**	**1.979**	**.660**

Table- 4: Gender wise analysis of various shapes with significance.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Male straight	Equal variances assumed	.004	.951	.362	172	.718	.254	.701	-1.129	1.637
	Equal variances not assumed			.374	169.754	.709	.254	.678	-1.085	1.592
Female straight	Equal variances assumed	2.129	.146	-.820	160	.414	-.454	.553	-1.547	.639
	Equal variances not assumed			-.869	104.947	.387	-.454	.522	-1.489	.582
Male curved	Equal variances assumed	1.029	.313	-.664	94	.508	-.453	.682	-1.808	.902
	Equal variances not assumed			-.697	74.448	.488	-.453	.650	-1.748	.842
Female curved	Equal variances assumed	1.470	.228	-1.837	102	.069	-.990	.539	-2.059	.079
	Equal variances not assumed			-1.823	90.107	.072	-.990	.543	-2.069	.089
Male wavy	Equal variances assumed	.480	.490	-4.599	101	.000	-3.488	.758	-4.992	-1.984
	Equal variances not assumed			-4.978	50.053	.000	-3.488	.701	-4.895	-2.080
Female wavy	Equal variances assumed	3.356	.071	-1.150	75	.254	-.758	.659	-2.071	.555
	Equal variances not assumed			-1.146	69.506	.256	-.758	.661	-2.077	.562
Male circular	Equal variances assumed	5.954	.019	-.781	44	.439	-1.051	1.345	-3.761	1.660
	Equal variances not assumed			-.961	25.379	.346	-1.051	1.094	-3.302	1.200
Female circular	Equal variances assumed	6.421	.025	-.118	13	.908	-.189	1.596	-3.636	3.258
	Equal variances not assumed			-.103	6.507	.921	-.189	1.834	-4.593	4.215

Table 5 & 6 of statistical analysis shows that Africans have higher no. of curved, wavy and circular patterns which showed high significance (p >0.05) Among the Indians straight patterns are higher than the Africans in number (P=0.00, high significance with t-test).

Table- 5: Mean of number of different types of patterns

Group Statistics					
	Country	N	Mean	Std. Deviation	Std. Error Mean
Straight	Indian	35	5.89	2.285	.386
	African	35	3.74	2.105	.356
Curve	Indian	35	2.26	1.738	.294
	African	35	3.11	1.711	.289
Wavy	Indian	35	1.74	1.358	.230
	African	35	2.69	1.388	.235
Circular	Indian	35	.46	.701	.118
	African	35	1.34	1.571	.266
Converg	Indian	35	.14	.355	.060
	African	35	.20	.406	.069
Diverg	Indian	35	.74	.886	.150
	African	35	.37	.598	.101

Table- 6: Analysis of number of different types of patterns with significance.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
straight	Equal variances assumed	.137	.712	4.080	68	.000	2.143	.525	1.095	3.191
	Equal variances not assumed			4.080	67.548	.000	2.143	.525	1.095	3.191
curve	Equal variances assumed	.023	.880	-2.079	68	.041	-.857	.412	-1.680	-.035
	Equal variances not assumed			-2.079	67.984	.041	-.857	.412	-1.680	-.035
wavy	Equal variances assumed	1.023	.315	-2.872	68	.005	-.943	.328	-1.598	-.288
	Equal variances not assumed			-2.872	67.966	.005	-.943	.328	-1.598	-.288
circular	Equal variances assumed	7.152	.009	-3.047	68	.003	-.886	.291	-1.466	-.306
	Equal variances not assumed			-3.047	47.011	.004	-.886	.291	-1.471	-.301
converg	Equal variances assumed	1.597	.211	-.627	68	.533	-.057	.091	-.239	.125
	Equal variances not assumed			-.627	66.819	.533	-.057	.091	-.239	.125
diverg	Equal variances assumed	8.263	.005	2.055	68	.044	.371	.181	.011	.732
	Equal variances not assumed			2.055	59.674	.044	.371	.181	.010	.733

DISCUSSION:

Based on these results it can be concluded that there was a huge differences in the width of the patterns in African and Indian population which infers that Africans have very broad and thick patterns which was statistically too found out to be highly significant. African rugae patterns are quite elevated which was very well appreciated visually in fig -3. As far as the lengths are concerned

Africans have higher length measurements in wavy, straight and curved patterns. Number of Straight patterns are found to be more prevalent in Indian population as compared to Africans whereas curved, wavy and circular were found to be predominant in Africans as compared to Indians. For the number of patterns, this study shows that Africans have higher no. of curved, wavy and circular which are highly distinguishable and showed high significance Among the Indians straight patterns are higher than the Africans in number.

Rugae patterns are a convenient tool for human identification in a mass disaster situations because of their high specificity to different racial groups.[7] Several studies have been reported which infers that rugae patterns are significantly associated with the ethnicity thereby indicating a valuable finding in forensic investigations especially in disasters.[3]

Hauser et al., in 1989 performed a study to compare the rugae patterns of Swazi and Greek population and they found definite differences in the patterns between the two populations. This could be because of development of rugae and growth of the palate.[4] Several studies reported inter-racial differences in palatal rugae even in relatively similar population groups which may help to identify the population especially in disasters.[1, 9] But no study has been done to distinguish amongst the African and Indian on the basis of their rugae pattern. This study was aimed to analyse the differences in the number of patterns, their lengths and widths among the Indian and African population and highly significant results were obtained. Comparison was even seen amongst genders of both the population groups ie. Africans males and females compared with Indian males and females respectively and significant results were obtain in some of the patterns specially their widths which showed highly significant results whereas lengths were insignificant. Apart from these findings found by previous studies on the Indian population, they also found unification rugae pattern to be very rare.[10] Same was found in this study too for both the population groups as per sample size taken. This study has a limitation of less sample size gender wise. Further studies can be done with a larger sample size to establish much more significant differences amongst the sexes on a vast level.

CONCLUSION:

Palatal rugae patterns are unique to each individual as well as for the races too and so they can be used as population identification tool at the time of adversity. As per this study it can be concluded that rugae patterns are significantly different for Indian and African population based on the numbers, shapes, lengths and width and amongst the sexes too. Also, African patterns are remarkably unique on visual appraisal for they are very thick, elevated and broader in width which was even statistically proved with more number of curved wavy and circular patterns specifically

whereas Indian rugae pattern are very thin and slender mostly having the straight and wavy patterns more. Further studies can definitely be done with larger samples to obtain much more significant differences among various other aspects too. Finally we conclude that rugae can be used as consistent tool in forensic identification and even serve as a dental biometric tool too.

REFERENCES:

1. Kapali S, Townsend G, Richards L, Parish,T. *Palatal rugae patterns in Australian Aborigines and Caucasians*, Australian Dental Journal.1997; 42(2):129-133.
2. Byatnal A, Byatnal A, Kiran A R, Samata Y, Guruprasad Y, & Telagi N. *Palatoscopy: An adjunct to forensic odontology: A comparative study among five different populations of India*, Journal of natural science, biology, and medicine. 2014; 5(1): 52-5.
3. Janardhanam D, Nalliappan G, Thukanaykanpalayam RY, Vadivel I, Arumugasamy N, Akbarsait, R. *Palatal rugae patterens in individuals identification: A forensic study'*, International Journal of Current Advanced Research. 2017; 6(1): 1723-1725.
4. Hauser G, Daponte A, & Roberts MJ. *Palatal rugae*, Journal of anatomy.1989; 165:237-49.
5. Lysel L. and Brayton V. '*Plicae palatinae transversae and papilla incisiva in man: A morphologic and genetic study'*, Acta Odontologica Scandinavica. 1955; 13(18):135-137.
6. Peavy DC Jr, Kendrick GS. '*The effects of tooth movement on the palatine rugae'*, Journal of Prosthetic Dentistry.1967; 18(5): 36-42.
7. Deeksha, KS, Sheetal M, Hegde DD, Patil A, Edake D, Unadkat H. '*Palatal Rugae Patterns as a Bioindicator for Forensic Identification in Kodava and Tibetan Populations of India'*, Journal of International Oral Health and International Society of Preventive and Community Dentistry, 2015; 7(2): 57–59.
8. Ghanta SB, T. Sreenivasa B, N Govindraj, K. '*Characteristics of Palatal Rugae Patterns in West Godavari Population of India'*, Journal of Clinical Diagnosis and Research, 2013; 7(10): 2356–2359.
9. Muthusubramanian M, Limson K S, Julian R. '*Analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition'*, Journal of Forensic Odonto-Stomatology, 2005; 23(1):26-29
10. Byatnal, A., Byatnal, A., Kiran, A. R., Samata, Y, Guruprasad, Y, Telagi, N. '*Palatoscopy: An adjunct to forensic odontology: A comparative study among five different populations of India',* Journal of natural science, biology, and medicine, 2014; 5(1): 52-5.
11. Thomas, C.J and Kotze, T.J. '*Palatal rugae pattern: A new classification*', Journal of Dental Association of South Africa 1983; 38(3): 153-7.