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Role of Palatal Rugoscopy to Establish Sexual Dimorphism as an Adjunct in Personal Identification: A Forensic Study

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Abstract

Objectives: The forensic discipline is concerned with the application of science and technology to the detection and investigation of crime and the administration of justice, requiring the coordinated efforts of a multidisciplinary team. Human identification is one of the most challenging tasks in this process. However, when a victim is edentulous, methods for personal identification available in forensic odontology are much more limited than in the case of dentate victims. In such cases, additional/supplemental aids like palatal rugoscopy hold promise. **Materials and Methods:** Two hundred subjects were included in the study, they were divided into 4 groups, each of the four groups included 50 participants, consisting of 25 males and 25 females. Maxillary impression was made for all the included subjects and casts were poured and analysed. **Results:** A total of 2104 palatal rugae were observed in 200 subjects. When types of rugae based on length were compared between males and females on each side of the palate, primary type, secondary type and fragmentary type were observed in a mean number of 4.19, 0.78 & 0.18 in males and 4.20, 0.81 and 0.16 in females respectively on the right side. Whereas on the left side, primary type, secondary type and fragmentary type were found in a mean number of 4.59, 0.83 & 0.09 in males and 4.40, 0.78 & 0.07 in females respectively. **Conclusion:** It may be concluded that the rugae pattern may be an additional method of differentiation, which may help narrow the process for identification and give results in conjunction with other methods such as finger prints and dental characteristics in forensic sciences. Palatal rugoscopy may thus be used successfully as an adjunct in the process of forensic identification.

Keywords: Forensic Odontology, Gender determination, Palatal Rugae, Personal Identification

Introduction

The forensic discipline is concerned with the application of science and technology to the detection and investigation of crime and administration of justice, requiring the coordinated efforts of a multidisciplinary team[1]. Human identification is one of the most challenging tasks in this process. The process of identification has three types or stages. The first is a general identification which an anthropologist usually provides when the remains are completely or mostly skeletonized. This type is a general description of the individual, what the person's sex, age, race, and stature were at the time of death. The information provided by anthropologists can lead police investigators to the possible identities of an unknown individual. Comparisons between possible identities and the unknown individual can direct investigators to a presumptive or positive identification. Presumptive identification may also be made based on tattoos, circumstantial evidence, personal effects, or facial reconstruction. This type of identification is not scientifically confirmed but can be accepted as final when foul play is not suspected and no other reason for doubt exists. Corpus identification, in which a relative or close friend identifies the individual by viewing the body, is also accepted as positive identification. However, corpus identification is not beyond human error and is not possible when the body is in advanced stages of decomposition or severely damaged by trauma such as fire or mutilation. Positive identification is scientifically proven, usually through DNA matching, fingerprinting or dental comparison[2].

Dental identification takes three main forms. Firstly, the most frequently performed examination is a comparative identification that is used to establish (to a higher degree of certainty) that the remains of a decedent

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and a person represented by antemortem dental records are of the same individual. Secondly, in those cases where antemortem records are not available and no clues to the possible identity exist, a post-mortem dental profile is completed by the forensic dentist suggesting characteristics of the individual likely to narrow the search for the antemortem resources, this is referred to as dental profiling. Thirdly, forensic odontologists also play a vital role in the identification of victims of mass disasters[3]. The various identification methods employed in forensic odontology include bitemarks, radiographs, photographs, molecular methods, cheiloscopy and palatal rugoscopy[4–6].

However, when a victim is edentulous, methods for personal identification available in forensic odontology are much more limited than in the case of dentate victims. In such cases, additional/supplemental aids like palatal rugoscopy hold promise[7].

Many studies have been carried out on rugae patterns and it is an established fact that no two palates are alike in their configuration and once formed, they do not undergo any changes except in length due to normal growth, remaining in the same position throughout a person's entire life. Even diseases, chemical aggression or trauma do not seem to be able to change the palatal rugae form[7]. Thus, palatal rugoscopy appears to possess the features of an ideal forensic identification parameter namely uniqueness, postmortem resistance and stability. Hence, they can be used in postmortem identification provided an antemortem record exists. Previous studies have focused on the use of palatal rugoscopy for personal identification, but shed little light on sexual dimorphism in the biometric features of the palatal rugae. It was proposed that there may occur certain, as yet unidentified, genes influence the orientation of collagen fibres during embryogenesis and postnatal growth pattern in different populations[9].

Therefore, the present study was undertaken to identify the pattern of palatal rugae in terms of number, size and shape in individuals of the region and to compare the patterns among males and females of different age groups.

Materials and Method

Sample Selection

The study participants were selected based on the following inclusion and exclusion criteria:

Inclusion Criteria

- Healthy subjects within the age group of 21 to 40 years.
- Subjects belonging to P CITY region.

Exclusion criteria

- Subjects are allergic to impression material.
- Subjects with severe malocclusions.
- Subjects with developmental anomalies of the palate like the cleft palate.
- Subjects who were wearing partial dentures and braces.
- Subjects with surgeries such as orthognathic or surgical correction of cleft palate, bony and soft-tissue protuberance, active lesions, deformity of scars and trauma to the palate.
- Subjects not willing to participate.
- Ethical clearance was obtained from the institutional ethical committee and informed consent was taken from the participants.

Sample Size

Two hundred subjects were included in the study, they were divided into 4 groups as follows:

- Group I: 21 to 25 years
- Group II: 26 to 30 years
- Group III: 31 to 35 years

- Group IV: 36 to 40 years

Each of the four groups included 50 participants, consisting of 25 males and 25 females.

Procedure

The study subjects were clinically examined. Maxillary impression was made for all the included subjects and casts were poured and analysed. The rugae pattern was delineated using a sharp graphite pencil under adequate light and magnification with a Digital Vernier calliper (Digiset) to an accuracy of 0.05 mm following the descriptions of Thomas and Kotze for the assessment of the length of rugae[8].

Determination of Length of Rugae

The rugae were categorized into three groups based on their length as follows:

1. Primary rugae: 5 mm or more
2. Secondary rugae: 3-5 mm
3. Fragmentary rugae: less than 3 mm.

The number of Primary, secondary and fragmentary rugae was noted on the specially designed proforma and the shape of only the primary and secondary rugae was assessed. The numbering of the rugae was done according to the method given by Kapali*et al*as shown in Figure 1[4].

Determination of shape and Classification of Rugae

The term, *origin* of the rugae was considered to be the end of the ruga near the mid-palatine raphe and *termination* was considered to end away from the mid-palatine raphe[4]. The shapes of individual rugae were classified according to Kapali *et al* into four major types as straight, curved, wavy and circular (Figure 2)[4].

The shapes of the rugae were defined as follows

1. Straight types were those rugae that ran directly from their origin to termination ('c' in Figure 2).
2. Curved types were those rugae with a simple crescent shape which curved gently. Rugae exhibiting even the slightest bend at the origin or termination were classified as curved ('a' in Figure 2).
3. Wavy rugae were serpentine in form. Curved rugae exhibiting a slight curve at the origin or termination are also classified as wavy ('b' in Figure 2).

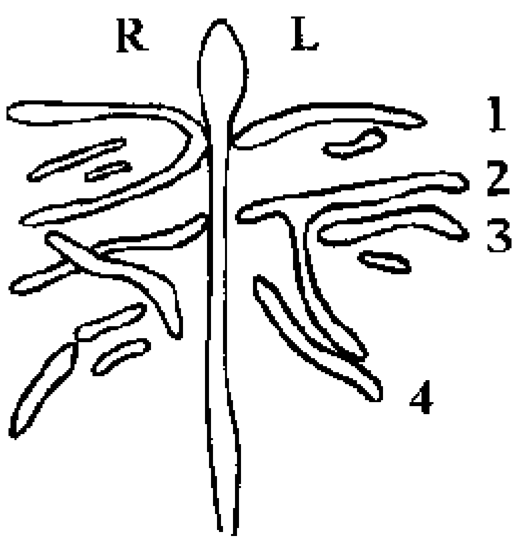

Figure 1. Numbering of palatal rugae.

4. Circular rugae were those rugae with definite continuous ring formation('d' in Figure 2).
5. Nonspecific: The rugae which did not fit into any of the above patterns were classified as non-specific.

The term Unification was used when two rugae joined at their origin or termination. Unifications in which two rugae began from the same origin but immediately diverged were classified as *diverging*. Rugae with different origins which joined on their lateral portions were classified as *converging*.

Results

A total of 2104 palatal rugae were observed in 200 subjects, almost equally divided on the left and the right side of the median palatine raphe (1075 and 1029 respectively). (Table 1)

Different Shapes of Rugae in Males and Females

It was found that males had a higher mean proportion of curved, straight, circular, unification diverging and nonspecific shapes of rugae as compared with females. Females had a significantly higher mean proportion of unification convergent type and wavy type as compared with males, in our study. (Table 2) However, when the different shapes of rugae were compared among males and females by unpaired t-test, there were no statistically significant differences observed with any of the shapes, ($p > 0.05$) as shown in Table 2.

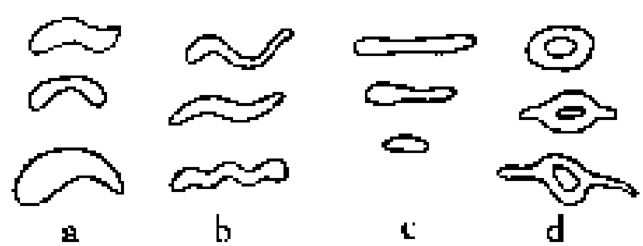

Figure 2. Shape of rugae.

Length of Rugae in Males and Females

Males had a higher mean proportion of primary and fragmentary rugae as compared to that females, whereas females had a higher mean proportion of secondary rugae

Table 1. Number of rugae in males and females

Gender	Total Patients (n)	Total Rugae	Mean no. of Rugae	Standard Deviation
Males	100	1065	10.65	1.96
Females	100	1039	10.39	1.79
Total	200	2104	10.52	1.87

p = 0.072

Table 2. Comparison of different shapes of rugae in males and females

Type	Percentage	Total			Males			Females			t Test	p Value
		Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation		
Straight	27.94	588	2.94	1.814625	301	3.01	1.789390732	287	2.87	1.845853	0.545	0.587
Curved	46.63	981	4.905	1.831049	505	5.05	1.777383163	476	4.76	1.880898	1.121	0.264
Wavy	15.26	321	1.605	1.23556	157	1.57	1.208179196	164	1.64	1.267464	-0.400	0.690
Circular	0.90	19	0.095	0.326355	10	0.1	0.362371538	9	0.09	0.287623	0.216	0.829
Non Specific	0.43	9	0.045	0.230741	5	0.05	0.261116484	4	0.04	0.196946	0.306	0.760
Divergent	6.23	131	0.655	0.78681	66	0.66	0.819213715	65	0.65	0.757121	0.929	0.929
Convergent	2.61	55	0.275	0.490487	21	0.21	0.456048022	34	0.34	0.516789	-1.886	0.061

The ratio of observed difference between the two means of small samples to the SE of difference is denoted by t

Table 3. Type of rugae according to length in males and females

Type	Total			Males			Females			t Test	p Value
	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation		
Primary	1738	8.69	1.397737	881	8.81	1.440363	857	8.57	1.350309	1.216	0.629
Secondary	316	1.58	1.386801	156	1.56	1.38768	160	1.60	1.392621	-0.203	0.839
Fragmentary	50	0.25	0.537535788	28	0.28	0.58741	22	0.22	0.483673	0.789	0.431

Table 4. Mean of length of rugae in males and females

	Total	Males	Females
Primary	9.50	9.50	9.51
Secondary	4.10	4.26	3.94
Fragmentary	2.43	2.34	2.51

Table 5. Number of rugae in right and left side

Side	Total Rugae	Mean no. of Rugae	Standard Deviation
Right	1029	5.145	1.166524279
Left	1075	5.375	1.144958361
Total	2104	10.52	1.872734813

p- 0.017

Distribution of Rugae among Right and Left Sides of Palate

There were more rugae found on the left side, and when analysed by unpaired t-test, the results were found to be statistically significant (p= 0.017) as shown in Table 5.

Type of Rugae based on Length on Right and Left Sides of Palate

The number of primary rugae was less on the right side of the palate (839 with a mean number of 4.20) when compared to the left sides of the palate (899 with a mean number of 4.50). The secondary type (mean proportion on right 0.80 compared to 0.79 on the left side) and fragmentary type (mean proportion on right 0.17

compared to 0.08 on the left side) of rugae were found to be more on the right side of the palate. The results were analysed using an unpaired t-test. The primary rugae pattern showed a statistically significant difference (p = 0.001) when compared between the right and left sides, as shown in Table 8.

Frequency and Gender Differences of Different Shapes of Rugae on Right and Left side of Palate

The results were analysed using an unpaired t-test. The curved rugal pattern showed a significant statistical difference (p = 0.009) when compared between the right and left sides, while the unification divergent pattern had a highly significant statistical difference (p = 0.001) between the sides, as shown in Table 6.

When types of rugae based on length were compared between males and females on each side of the palate, primary type, secondary type and fragmentary type were observed in a mean number of 4.19, 0.78 and 0.18 in males and 4.20, 0.81 and 0.16 in females respectively on the right side. Whereas on the left side, primary type, secondary type and fragmentary type were found in a mean number of 4.59, 0.83 and 0.09 in males and 4.40, 0.78 and 0.07 in females respectively. The results were analysed using an unpaired t-test and the value was not found to be statistically significant (p > 0.05) between the sides, for males and females as shown in Table 7 (A and B).

Age Wise Distribution of Rugae

There was a statistically significant difference between different age groups as determined by one way- ANOVA for wavy [F (3, 196) = 3.368, p = 0.02] and primary rugae [F (3,196) = 6.201, and p = 0.00]. (Table 10)

Intraobserver Variability

Intraobserver variation of length comes out to be 0% for primary, secondary and fragmentary rugae pattern. Variation in total no. of rugae in different shapes was 0% for wavy, circular, nonspecific, convergent and divergent types, whereas for straight and curved shapes, it comes out to be 0.95%.

Table 6. Type of rugae according to shape in right and left side

Type	Total			Right			Left			t Test	p Value
	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation		
Straight	588	2.94	1.814625	286	1.43	1.175589235	302	1.51	1.181898651	-0.752	0.453
Curved	981	4.905	1.831049	459	2.295	1.255330344	522	2.61	1.22695849	-2.658	0.009
Wavy	321	1.605	1.23556	166	0.83	0.79641155	155	0.775	0.804744099	0.764	0.446
Circular	19	0.095	0.326355	6	0.03	0.171015295	13	0.065	0.247144496	-1.818	0.071
Non Specific	9	0.045	0.230741	6	0.03	0.171015295	3	0.015	0.121857483	1.135	0.258
Divergent	131	0.655	0.78681	81	0.405	0.559050703	50	0.25	0.456664772	3.370	0.001
Convergent	55	0.275	0.490487	25	0.125	0.331548825	30	0.15	0.37174044	-0.699	0.485

Table 7A. Variation of rugae according to length on right and left side in males and females

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
P RT	Male	100	4.1900	.96080	.09608
	female	100	4.2000	.92113	.09211
S RT	male	100	.7800	.78599	.07860
	female	100	.8100	.84918	.08492
F RT	male	100	.1800	.50010	.05001
	female	100	.1600	.39492	.03949

Table 7A. to be continued...

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
T RT	male	100	5.1500	1.18386	.11839
	female	100	5.1700	1.16389	.11639
P LT	male	100	4.5900	.98571	.09857
	female	100	4.4000	.96400	.09640
S LT	male	100	.8300	.96457	.09646
	female	100	.7800	.89420	.08942
F LT	male	100	.0900	.32083	.03208
	female	100	.0700	.32582	.03258
T LT	male	100	5.5100	1.21850	.12185
	female	100	5.2500	1.07661	.10766

Table 7B. Variation of rugae according to length on right and left side in males and females

F		Levene's Test for Equality of Variances		t-test for Equality of Means						
		Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
P RT	Equal variances assumed	.574	.449	-.075	198	.940	-.01000	.13310	-.27248	.25248
	Equal variances not assumed			-.075	197.649	.940	-.01000	.13310	-.27248	.25248
S RT	Equal variances assumed	.018	.895	-.259	198	.796	-.03000	.11571	-.25818	.19818
	Equal variances not assumed			-.259	196.828	.796	-.03000	.11571	-.25819	.19819
F RT	Equal variances assumed	.603	.438	.314	198	.754	.02000	.06372	-.10566	.14566
	Equal variances not assumed			.314	187.900	.754	.02000	.06372	-.10570	.14570
T RT	Equal variances assumed	.194	.660	-.120	198	.904	-.02000	.16602	-.34739	.30739
	Equal variances not assumed			-.120	197.943	.904	-.02000	.16602	-.34739	.30739
P LT	Equal variances assumed	.047	.828	1.378	198	.170	.19000	.13787	-.08189	.46189
	Equal variances not assumed			1.378	197.902	.170	.19000	.13787	-.08189	.46189
S LT	Equal variances assumed	.116	.733	.380	198	.704	.05000	.13153	-.20938	.30938
	Equal variances not assumed			.380	196.874	.704	.05000	.13153	-.20939	.30939

Table 7B. to be continued...

F		Levene's Test for Equality of Variances		t-test for Equality of Means						
		Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
F LT	Equal variances assumed	.650	.421	.437	198	.662	.02000	.04573	-.07017	.11017
	Equal variances not assumed			.437	197.953	.662	.02000	.04573	-.07017	.11017
T LT	Equal variances assumed	2.336	.128	1.599	198	.111	.26000	.16260	-.06065	.58065
	Equal variances not assumed			1.599	195.041	.111	.26000	.16260	-.06068	.58068

Table 8. Type of rugae according to length in right and left

Type	Total			Right			Left			t Test	p Value
	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation	Total	Mean	Standard Deviation		
Primary	1738	8.69	1.397737	839	4.195	0.938819423	899	4.495	0.977112452	-3.255	0.001
Secondary	316	1.58	1.386801	159	0.795	0.816276015	157	0.785	0.928052481	-0.138	0.891
Fragmentary	50	0.25	0.537535788	34	0.17	0.449567073	16	0.08	0.322677243	2.238	0.026

Table 8A. Age wise distribution of Rugae

Serial No.	Age Group	Total No. of Patients	Total No. of Rugae	Mean	Standard Deviation
1	21-25	50	530	10.6	1.958758457
2	26-30	50	553	11.06	1.420117845
3	31-35	50	535	10.7	1.940439672
4	36-40	50	486	9.72	1.906380265

Table 8B. Age and Gender wise distribution of rugae on the basis of shape

Age Group	Gender	Total Patient	Straight	Curved	Wavy	Circular	Non specific	Divergent	Convergent
21-25	Male	25	3.12	5	1.76	0.08	0.12	0.64	0.36
21-25	Female	25	2.96	4.6	1.48	0.04	0	0.6	0.44
26-30	Male	25	2.8	5.68	1.96	0.04	0.04	0.56	0.12
26-30	Female	25	3.04	5.16	2.12	0	0	0.44	0.2
31-35	Male	25	3.56	5.16	1.24	0.16	0.04	0.52	0.12
31-35	Female	25	3.04	4.48	1.64	0.2	0.12	0.8	0.32
36-40	Male	25	2.56	4.36	1.32	0.12	0	0.92	0.24
36-40	Female	25	2.44	4.80	1.32	0.12	0.04	0.76	0.4

Table 8C. Age and Gender wise distribution of rugae on the basis of length

Age Group	Gender	Total Patient	Primary	Secondary	Fragmentary
21-25	Male	25	8.68	2.04	0.36
21-25	Female	25	8.44	1.4	0.28
26-30	Male	25	9.56	1.32	0.32
26-30	Female	25	9.08	1.6	0.24
31-35	Male	25	8.84	1.6	0.36
31-35	Female	25	8.56	1.76	0.28
36-40	Male	25	8.16	1.28	0.08
36-40	Female	25	8.2	1.64	0.08

Table 8D. Mann-Whitney Test for different shapes of the rugae

	Total	Straight	Curved	Wavy	Circular	Non specific	Divergent	Convergent	Primary	Secondary	Fragmentary
Mann-Whitney U	4676.500	4741.000	4560.500	4852.500	4959.000	4949.500	4954.000	4363.000	4558.500	4904.000	4834.000
Wilcoxon W	9726.500	9791.000	9610.500	9902.500	10009.000	9999.500	10004.000	9413.000	9608.500	9954.000	9884.000
Z	-.802	-.644	-1.091	-.371	-.207	-.586	-.124	-2.055	-1.104	-.242	-.578
Asymp. Sig. (2-tailed)	.423	.520	.275	.711	.836	.558	.901	.040	.269	.809	.563

Table 9. Descriptive Analysis ANOVA

Descriptive Analysis ANOVA									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Straight	21-25	50	3.04	1.749	.247	2.54	3.54	1	9
	26-30	50	2.92	1.614	.228	2.46	3.38	0	6
	31-35	50	3.30	2.003	.283	2.73	3.87	0	9
	36-40	50	2.50	1.832	.259	1.98	3.02	0	7
	Total	200	2.94	1.815	.128	2.69	3.19	0	9
Curved	21-25	50	4.80	1.604	.227	4.34	5.26	1	7
	26-30	50	5.42	1.928	.273	4.87	5.97	1	10
	31-35	50	4.82	1.758	.249	4.32	5.32	1	9
	36-40	50	4.58	1.960	.277	4.02	5.14	0	9
	Total	200	4.91	1.831	.129	4.65	5.16	0	10
Wavy	21-25	50	1.62	1.105	.156	1.31	1.93	0	5
	26-30	50	2.04	1.370	.194	1.65	2.43	0	5
	31-35	50	1.44	1.091	.154	1.13	1.75	0	4
	36-40	50	1.32	1.269	.179	.96	1.68	0	4
	Total	200	1.61	1.236	.087	1.43	1.78	0	5

Table 9. to be continued...

Descriptive Analysis ANOVA									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Circular	21-25	50	.06	.240	.034	-.01	.13	0	1
	26-30	50	.02	.141	.020	-.02	.06	0	1
	31-35	50	.18	.438	.062	.06	.30	0	2
	36-40	50	.12	.385	.055	.01	.23	0	2
	Total	200	.10	.326	.023	.05	.14	0	2
Non specific	21-25	50	.06	.314	.044	-.03	.15	0	2
	26-30	50	.02	.141	.020	-.02	.06	0	1
	31-35	50	.08	.274	.039	.00	.16	0	1
	36-40	50	.02	.141	.020	-.02	.06	0	1
	Total	200	.05	.231	.016	.01	.08	0	2
Divergent	21-25	50	.62	.667	.094	.43	.81	0	2
	26-30	50	.50	.735	.104	.29	.71	0	2
	31-35	50	.66	.745	.105	.45	.87	0	2
	36-40	50	.84	.955	.135	.57	1.11	0	3
	Total	200	.66	.787	.056	.55	.76	0	3
Convergent	21-25	50	.40	.571	.081	.24	.56	0	2
	26-30	50	.16	.370	.052	.05	.27	0	1
	31-35	50	.22	.465	.066	.09	.35	0	2
	36-40	50	.32	.513	.073	.17	.47	0	2
	Total	200	.28	.490	.035	.21	.34	0	2
Primary	21-25	50	8.56	1.280	.181	8.20	8.92	7	12
	26-30	50	9.32	1.220	.172	8.97	9.67	7	12
	31-35	50	8.70	1.403	.198	8.30	9.10	6	12
	36-40	50	8.18	1.466	.207	7.76	8.60	6	13
	Total	200	8.69	1.398	.099	8.50	8.88	6	13
Secondary	21-25	50	1.72	1.552	.220	1.28	2.16	0	7
	26-30	50	1.46	1.313	.186	1.09	1.83	0	6
	31-35	50	1.68	1.518	.215	1.25	2.11	0	6
	36-40	50	1.46	1.147	.162	1.13	1.79	0	4
	Total	200	1.58	1.387	.098	1.39	1.77	0	7
Fragmentary	21-25	50	.32	.587	.083	.15	.49	0	2
	26-30	50	.28	.497	.070	.14	.42	0	2
	31-35	50	.32	.683	.097	.13	.51	0	3
	36-40	50	.08	.274	.039	.00	.16	0	1
	Total	200	.25	.538	.038	.18	.32	0	3

Table 10. ANOVA test

ANOVA Test						
		Sum of Squares	df	Mean Square	F	Sig.
straight	Between Groups	16.680	3	5.560	1.706	.167
	Within Groups	638.600	196	3.258		
	Total	655.280	199			
curved	Between Groups	19.455	3	6.485	1.962	.121
	Within Groups	647.740	196	3.305		
	Total	667.195	199			
Wavy	Between Groups	14.895	3	4.965	3.368	.020
	Within Groups	288.900	196	1.474		
	Total	303.795	199			
circular	Between Groups	.735	3	.245	2.347	.074
	Within Groups	20.460	196	.104		
	Total	21.195	199			
non specific	Between Groups	.135	3	.045	.843	.472
	Within Groups	10.460	196	.053		
	Total	10.595	199			
divergent	Between Groups	2.975	3	.992	1.617	.187
	Within Groups	120.220	196	.613		
	Total	123.195	199			
convergent	Between Groups	1.695	3	.565	2.398	.069
	Within Groups	46.180	196	.236		
	Total	47.875	199			
primary	Between Groups	33.700	3	11.233	6.201	.000
	Within Groups	355.080	196	1.812		
	Total	388.780	199			
secondary	Between Groups	2.920	3	.973	.502	.681
	Within Groups	379.800	196	1.938		
	Total	382.720	199			
fragmentary	Between Groups	1.980	3	.660	2.330	.076
	Within Groups	55.520	196	.283		
	Total	57.500	199			

Discussion

An extensive search confirmed the paucity of literature on palatal rugal patterns in the region of the State. Palatoscopy may have relevance in odontostomatological identification in India, where data regarding dental anthropology and odontology is negligible[11]. Hence the present study was undertaken to evaluate and identify the rugal pattern of palatal rugae in terms of number, size and shape in individuals of region. Gender differences in the patterns among different age groups were also analysed.

The present study found that the rugae pattern of 200 subjects, did not comprise one form alone, but appeared as a mixture of varying forms. Though the total and mean number of palatal rugae was more in males when compared to females, the result was not statistically significant. A greater number of rugae in men was also found in studies done by Kamala R *et al.*,[15] and Venegas

VH *et al*[10]. This observation is in contrast to that of Paliwal A *et al.*,[12] in Kerala population, who found a greater number of rugal patterns in females. The reason for this difference could probably be explained due to regional variations[4,9,11,12,20,23].

The palatal rugae pattern in all 200 subjects was distinct and unique. In the study population, the predominant rugae pattern in both genders was curved type followed by the straight type and wavy type rugae pattern. Unification diverging and unification converging types had a very low proportion, while circular and nonspecific types of rugae were found to be negligible. The curved type was the most predominant pattern found in Lucknow city population according to studies done by Kamala R *et al.*,[15] and in Chennai population according to study done by Rajguru JP *et al.*[18] Straight type was the most predominant pattern in Odisha and Andhra population according to study done by Rath R and Reginald BA[23]. Wavy type was the most predominant pattern in Manipuri, Kerala populations according to study done by Surekha R *et al.*,[19] and the population around Coorg according to study done by Shetty DK *et al*[20]. The variations could be due to the genetic variation among different geographic regions[9,11,12,13]. Most of the Indian populations found a low prevalence of unification diverging and converging and negligible circular rugae, as noted in our study[15,22]. It may be concluded that certain rugae patterns are specific to a particular population and may also have utility in population differentiation[17].

Comparisons of the unification of rugae (converging and diverging) among females and males did not show a statistically significant association. However, the number of diverging rugae was slightly more in males whereas converging rugae were more common in females. This was in agreement with the observations made by Faisal et al., who observed that Saudi females had more converging rugae than males[24]. The low incidence of unifications and circular rugae in our study indicates that the P CITY population is characterized by fewer types of rugae shapes when compared to other racial groups.

The present study population showed a higher proportion of the primary type of rugae followed by the secondary type and fragmentary type. The observation was similar to most of the studies conducted on the Indian population of different states, by Bharath ST *et al.*,[13] Gondivkar SM *et al.*,[14] and Byatnak S *et al*[22]. The present study revealed no statistically significant differences in the type of rugae based on lengths, between the two sexes, similar to the findings of Saraf A *et al.*[16]

Comparing the mean lengths of rugae, it was observed that the mean length of secondary rugae was longer for males than females, whereas the mean length of fragmentary rugae was longer for females when compared with males. The observations are similar to the results of the study conducted by Bhagwath S *et al.*[21]

The present study revealed more number of rugae on the left side compared to the right side of the palate. This observation was found to be statistically significant when analysed by unpaired t-test. The observation was in contrast to the results of the earlier study by Paliwal A *et al.*,[12] in Madhya Pradesh and Kerala population. The results of the present study were in accordance with the study conducted by Surekha R *et al*,[19] who found more rugae on the left side than the right side in Manipuri and Kerala population. The total number of rugae in the sample showed more rugae on the left side when compared to the right, suggesting intraoral environmental factors contributing to it[17].

Comparing the right and left sides, mean proportion for the wavy type, nonspecific type and diverging type of unification of rugae were more on the right side compared to that on left side. Whereas mean proportion for curved type, straight type, circular type and converging type of unification of rugae were more on the left side compared to that on the right side of the palate. The curved rugae pattern showed a statistically significant difference ($p = 0.009$) when compared between the right and left sides, while the unification divergent pattern had a highly statistically significant difference ($p = 0.001$) between the sides. The results are in contrast to the study conducted by Paliwal A *et al.*,[12] in Madhya Pradesh and Kerala population where straight type, curved type and unification type of rugae were found to be more common on the right side of the palate; circular and nonspecific type more common on the left side of the palate, however, the wavy type was found to be equal on both sides of the palate. This variation could be due to the apparent lack of systemic trends and needs more comprehensive evaluation by further studies[12].

The mean number of rugae in the age groups 21-25, 26-30, 31-35 and 36-40 years were 10.6, 11.06, 10.7, 9.72 respectively. Except for the age group of 21-25 years, the mean number of rugae showed a decreasing trend with increasing age. This observation was similar to a study conducted by Kamala P *et al.*[15]

In all the age groups, the shape of rugae in decreasing order of frequency was curved, straight, wavy, divergent, convergent, and circular followed by nonspecific patterns. There was no alteration in the shape of the rugae patterns observed in the study suggesting that the shape of palatal rugae does not change with age. This is in accordance with a study done by Kamala R *et al.*, in the Lucknow population[15]. When the length of rugae patterns for different age groups was evaluated age-wise, the primary type was found to be the most common followed by the secondary type and fragmentary type in all four groups. This observation was similar to various studies done on rugae patterns, which state that the number of primary rugae was greater than secondary and fragmentary rugae. Thus, the most common rugal patterns observed in the P CITY population were curved, straight and wavy forms in primary rugae in all age groups in both genders.

There was no intra-observer variability with respect to length and wavy, circular, nonspecific, convergent and divergent shape of rugae. However, negligible variability (0.95%) existed for straight and curved rugae, which may lead to erroneous results in the identification of patterns when applied to cases with forensic post-mortem identification.

It may be concluded that the rugae pattern may be an additional method of differentiation, which may help narrow the process for identification and give results in conjunction with other methods such as fingerprints and dental characteristics in forensic sciences. Palatal rugoscopy may thus be used successfully as an adjunct in the process of forensic identification. However, studies with large sample sizes, done in wider age ranges may be needed to confirm the findings of this preliminary study in the P CITY population.

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