Sexual Dimorphism On The Basis Of Palatine Rugae In Kashhmiri Population- An In Vitro Study

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Abstract
AIM: *The study was aimed at establishing sexual dimorphism on the basis of variation in number and shape of palatine rugae in male and female sexes in Kashmiri population.*

MATERIALS & METHODS: *A cross sectional, descriptive, in vitro type of study was carried out on old maxillary casts of patients visiting registered dental clinics in Kashmir. Maxillary dental casts made up of plaster of Paris, were obtained and were examined to fit into inclusion criteria. The sample included 65 male and 65 female casts. Casts from both the groups were given unique identification numbers and demographic data was hidden except for the sex of the person. Palatine rugae were marked using sharp graphite pencil. The rugae were analyzed for length and shape. For classifying the rugae on the basis of length, Lysell's classification was implemented. Framentary rugae were also taken into consideration in addition to primary and secondary rugae. For classifying on the basis of shape of the rugae, Thomas & Kotze classification was implemented. Both male and female categories of casts were compared for differences.*

RESULTS: *Number of Primary rugae, secondary rugae and total number of rugae were found to be higher in males as compared to females. Fragmentary rugae were found to be higher in females than in males. All the values of difference were found to be statistically insignificant. Although it was found that studying each palate reveals that each palate is unique in number, distribution and pattern of rugae.*

CONCLUSION: *Studying palatal rugae in Kashmiri population suggested that sexual dimorphism was insignificant on the basis of palatine rugae in the study population.*
More studies with larger sample need to be done to validate the results of this study.

Keywords:*Palatine rugae, sexual dimorphism, kashmiri population.*

I.   Introduction

Forensic anthropology is the field of study that deals with the analysis of human skeletal remains resulting from unexplained deaths. Experts in this discipline, because of their understanding of skeletal biology and associated subjects examine human bones with the goal of extracting as much information as possible about persons represented by skeletal remains and about the circumstances surrounding their deaths. Forensic anthropology is applied science that embraces both anthropological and forensic studies. Forensic anthropologists attempt to accomplish five main objectives in their work which includes firstly, the determination of ancestry, sex, age and living height from the skeleton of the person whose soft tissues are decomposed. Secondly the attempt to identify the nature of trauma and cause behind it(e g bullet injury etc).Thirdly, determination of postmortem interval by studying the decomposition pattern of individual. Fourthly, they assist in locating and recovering buried or surface remains because they are trained in archaeology. Fifthly, they use unique features found in all skeletons to identify the skeletal remains of deceased.[1]

Forensic odontology is an offshoot of forensic science which has made great strides and has evolved as a very helpful speciality in the field of forensic science in the last half of century.It relies on sound knowledge of teeth and jaws possessed by dentists. It helps in establishment of person`s individuality by making use of multiple parameters like morphology of teeth, Craniofacial structures, palatine rugae, developmental anomalies etc. Proper identification of dead is required both for legal and humanitarian reasons.

Palatine rugae,also known as Plicae palatinae transversae or Rugae palatina, are asymmetric and irregular ridges on the anterior part of the palatal mucosa on each side of the mid-palatine raphe, behind the incisive papilla.Palatine rugae have been studied in various fields including Anthropology, Forensic Odontology and Genetics. In the field of forensic odontology, study of palatine rugae is useful method of identification in both dentate as well as edentate individuals. Rugae vary in terms of shape, size and number. The rugae pattern

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on the deceased`s maxilla or maxillary denture may be compared to old dentures that may be recovered from decedent`s residence or plaster models that may be available with the treating dentist.

Since, palatal rugae are unique to an individual like teeth, finger prints and DNA, they seldom change shape with age and reappear after trauma or surgical procedures and are used for establishing identity of a person especially when fingerprints and DNA are not available due to Amputation, Decomposition or severe burns.[2]This variation can be used to identify the sex of an individual in mass disaster cases and crime investigations.[3]

Various studies have been carried out that point out association between rugae patterns and gender. Some of these studies show that significant differences exist in different genders in rugae patternwhile some others do not show any significant differences. Different populations have been studied across different regions of India and other countries but till date as per best of knowledge of authors of this study, no such studies have been done on Kashmiri population.

II. Brief Review

2.1. A study carried out by Kamala et al(2011)[4] in Lucknow Uttar Pradesh, was aimed to compare the rugae pattern in males and females of Lucknow city. Effects of different treatments on rugae were also assessed. The number and shape of rugae were recorded and compared according to classification given by Kapali et al, [1997]asWave, Straight, Circular, Uniform converging,Uniform diverging. Comparison between males and females was made in terms of number of rugae, shape of rugae, and size of rugae. The conclusion of the study was that palates are unique for an individual, they do not undergo any changes except in length due to normal growth.Position remains same throughout life. Thus palatal rugae possess the features of an ideal forensic parameter i,e uniqueness and post mortem resistance.

2.2. Another study was carried out by Fahmi et al(2001)[5], in Saudi males and females,in post graduate department of Prosthodontics, King Saud university Riyadh, KSA.The aim of the study was to establish uniqueness of palatal rugae in males and females to aid in identification in case of crimes and aircraft accidents.Rugae were studied according to classification given by THOMAS et al [1983] which includes number, shape and unification of rugae.Diverge,Converge, Curve, Wavy, Straight,Circular. The conclusion of the study was that there is no significant difference in males and females in terms of number, while as there is significant difference in shape, converge type being most predominant shape in females and circular was found to be most predominant in males.

2.3. A study, conducted by Sunita kapali et al(1997)[6] in Australian Aborigines and Caucasians. The purpose of study was to determine whether rugae patterns change with age and to compare the number and pattern of rugae in Australian Aborigines with those of Caucasians.It was a cross-sectional as well as longitudinal type of study.For the longitudinal part of study, serial dental casts of ten Aborigines, 5 males and 5 females, from 6 to 20 years of age, were examined and rugae patterns were recorded.For cross sectional part of the study, 100 dental casts of Australian Aborigines, 50 males and 50 females and 220 casts of Caucasians, 110 males and 110 females were studied, ranging in age from 13 to 17 years. Characteristics observed were number, length, shape, direction and unification of rugae.The rugae on dental casts were marked by sharp pencil and measurements were made using vernier caliper.The classification followed was Thomas and Kotze classification, according to which, On the basis of length, there are three categories of rugae : Primary, Secondary, and Fragmentary.On the basis of shape, there are six categories of rugae.The conclusion of study was, length of rugae increased significantly with age but total no of rugae remained constant, rugae that displayed a change in shape [32%], rugae that displayed a change in orientation [28%], majority of Aboriginal rugae moved posteriorly, primary rugae in Caucasians exceeded 10mm in length as compared to Aborigines. The mean number of primary rugae in Aborigines was found to be higher than in Caucasians.G] Wavy and curved forms were most common in both the groups while as circular and straight forms were least common.

2.4. Another study was carried out by Afaf, Ghada et al(2017)[7]in Assiut university in Egypt aimed at analyzing palatal rugae characteristics of a population sample from upper Egypt, and to compare age and gender effects on rugae pattern. TROBOS classification was implemented. Palate was divided into quadrants A to E, for ease and accuracy in observation.The conclusion of the study was, sinuous pattern of rugae were more prevalent and circular type were least prevalent, males had higher proportion of angle and point patterns than females, rugae length and number did not differ in relation to gender and age and in different age groups, no of rugae varied in different quadrants.

2.5. A systematic analysis was conducted by Valeria H V et al(2009)[8] in a Japanese population to analyse the shape and dimensions of the palatal rugae. The shape, size, number and position of the palatal rugae were determined. The most prevalent palatal rugae shape was sinuous (43%) followed by curve (27%), line (15%), point (11%), and polymorphic varieties (4%). The average number was 12.27, being higher in male than female. The palatal rugae that were larger were the sinuous (mean 9.58 mm). 40% of the rugae were found in the E quadrant, followed by D (30%), the rest were distributed among the other regions. The study concluded

that the analysis of the palatal rugae and their features can be used as a reliable guide to the forensicidentification.

A study was carried out by Indira A et al[9]to establish, individual identity using palatal rugae patterns. The study group consisted of 100 study models all of whom were subjects above 14 years old. Martin dos Santos' classification was followed based on form and position to assess the individuality of rugae pattern. It was found thateach individual had different rugae patterns including dizygous twins and the rugae patterns were not symmetrical, both in number and in its distribution. The study undertaken concluded no two palates are alike in terms of their rugae pattern. Palatal rugae possess unique characteristics as they are absolutely individualistic and therefore, can be used as a personal soft-tissue 'oral' print for identification in forensic cases.

III.Materials And Methods

3.1 **Study design:** Cross sectional, descriptive type, in vitro study.

3.2 **Sample size:** 130 (60/60) Convenience sampling method

3.3 **Armamentarium:** Maxillary dental casts of Plaster of Paris, Metallic scale, Pointed divider, Sharp graphite pencil, Ordinary Magnifying glass(4X)

3.4 **METHODOLOGY:** The study was conducted on old maxillary dental casts collected from dental clinics of Kashmir Province of Jammu & Kashmir state of India. Fully dentulous maxillary casts made up of plaster of Paris of male as well as female patients above 20 years of age were included in the study.

Casts of the patients having Cleft lip or/and palate, previous history of surgical procedure in maxillo-facial region, those undergoing orthodontic or maxillo-facial orthopaedic treatment, edentulous patients, below 20 years of age and casts having bubbles or distortions were excluded from the study.

After obtaining the ethical clearance for the study, two registered dental clinics were visited in Kashmir province and old maxillary casts were collected from the records of previous patients with proper permission from the authorities of clinics in written format, without exposing personal data of the patients except for the sex of the patient. The casts were properly examinedto fit into inclusion criteria and 65 male and 65 female casts were selected for the study. The selected casts were divided into two groups, Male group and Female group.Unique identification codes were assigned to casts of both the groups as MC1, MC2, MC3, MC4………MCn for casts in male group [MC1=Male,cast number 1] and FC1, FC2, FC3, FC4……..FCn for casts in female group [FC1=Female,cast number 1].Landmarks on the palate i,e palatal raphae and palatal rugae were marked using 0.3 mm graphite pencil under adequate light and magnification Macroscopically.[Calcorugoscopy]

The marked Rugae were measured using vernier caliper & values were cross checked using a scale. The details were entered in proforma corresponding to each cast. On the basis of classification given by Lysell[10] taking "length of rugae" as a parameter of classification, we measured rugae in a straight line ,from origin on the medial side to terminus on lateral side, the rugae were classified intoPrimary [length a]5-10 mm or 10 mm or more],Secondary [length 3-5mm] and Fragmentary [2-3mm] for each cast and were counted and recorded corresponding to each cast. Rugae less than 2mm are not categorizedas per Lysell's claasification. After counting the number of each type of rugae, the primary rugae were analyzed for Variation in shapes and were categorized as per classification given by Thomas & Kotze et al(1983)[11] with four basic types and two types describing unification of rugae

1. Straight: runs directly from origin to termination(origin being towards mid palatine raphe running to termination laterally).

2. Circular: definite, continuous ring formation,diameter from origin to termination is considered.

3. Curved: simple crescent shape,curving gently.

4. Wavy: serpentine form.

5.Unification converging form

6.Unification diverging form
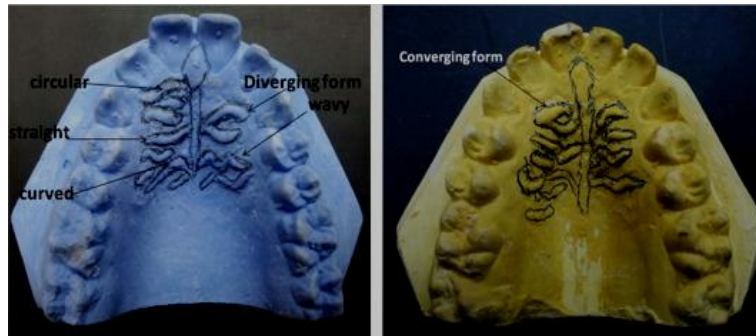
These values were recorded in separate proforma.

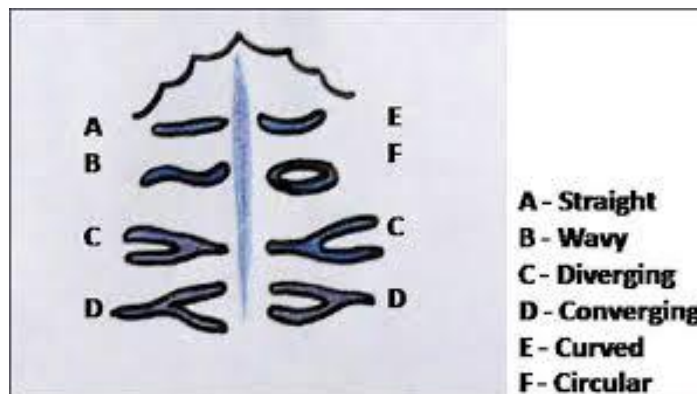**Fig. 1: Palatine rugae marked using grahite pencil(color print needed)**

Fig 2: Types of rugae on the basis of shape(color print not needed)

Fig 3: Armamentarium used(color print needed).

IV.Results

Independent samples t-test (student t test) was used for determination of statistical evidence among two groups that whether dimorphism based on palatal rugae pattern , exists in Kashmiri population or not.

Table 1 showing p-value, mean difference and standard deviation for different variables used in the study

	t-test for Equality of Means					95% Confidence Interval of the Difference	
	t	df	p-value	Mean Difference	Std. Error Difference	Lower	Upper
P.Rugae	-1.735	128	.085	-.508	.293	-1.087	.071
S.Rugae	-.472	128	.638	-.123	.261	-.639	.393

F. rugae	.633	128	.528	.169	.267	-.360	.698
Total rugae	-1.002	128	.318	-.462	.461	-1.373	.450

V. Observations

5.1: Rugae Number:

A total of 673 rugae(table 2) were observed in 65 female casts out of which 117 were primary rugae (length=5-10mm or >10mm), 153 were secondary rugae(length= 3-5mm) and 103 were fragmentary rugae (length=2-3 mm). Total number of rugae in 65 male casts was 703, being higher than in females, out of which 150 were primary rugae, 161 were secondary rugae and 92 were fragmentary rugae.

Using t-test for equality of means, mean value of primary rugae in each individual in males was 6.92 ± 1.753(mean$\pm$SD) and in females was 6.42 ± 1.580 (p=0.085). Mean value for secondary rugae in males was 2.48 ± 1.582 and in females was 2.35 ± 1.386(p=0.638). Mean value for fragmentary rugae in males was $1.42 \pm1.56$and in females was 1.58 ± 1.48(0.528).

Statistically, no significant differences were observed in number of rugae among males and females(using independent T Test). When total number of rugae in males were compared with females, the number in males was found to be insignificantly higher in males as compared to females.

Table 2 Showing number of primary, secondary, fragmentary and total number of rugae in males and females.

	Primary Rugae	Secondary Rugae	Fragmentary rugae	Total rugae
FEMALE	417	153	103	673
MALE	450	161	92	703

5.2 Rugae shape:

Rugae shapes in each cast were unique as no two identical patterns were observed. The most prevalent shape of palatal rugae in both groups of samples were straight type(table 3).

Most common shape of primary rugae was found to be straight type(males=159, and females=204)followedby curved(male=100,females=71),wavy(males=91,females=69), circular (males=40,females=34). The unification converging type being least common in females(males=35,females=20) while as unification diverging being least common in males(males=22,females=21).

Most of the shapes are insignificantly differentiated between males and females but females had higher total number of straight type rugae than males.

Table 3 showing numbers of different patterns of rugae in males and females..

Shape of Primary Rugae	N	Female	Male	
straight	65	204	159	
wavy	65	69	91	
curved	65	71	100	
circular	65	34	40	
U.converg	65	20	35	
U.diverg	65	21	22	

VI.Discussion

The aim of present study was to find out difference in palatine rugae in different sexes in Kashmiri population.The variation in number and shape of primary rugae and the variation in total number of rugae (Primary,secondary and fragmentary Rugae) were studied and sexual dimorphism was evaluated on the basis of these findings.

Dental casts have the advantage of simple analysis, easy availability in each dental setting and reduced cost, so the study of maxillary dental casts is the most commonly used technique in study of palatine rugae analysis. In the present study the method used to study was Calcorugoscopy using Lysell[10] classification on the basis of length of rugae and classification given by Thomas et al[11] describing the shapes of rugae.

The study was carried on Kashmiri population to find out unique features which will aid in sex differentiation in Kashmiri population.

The results obtained highlighted that each palate had a unique pattern of rugae, no two palates showed resemblance.Total number of rugae(primary+secondary+fragmentary) were higher in males than in females with both primary as well as secondary rugae being higher in males than in females but the difference was found

to be statistically insignificant. In contrast to this, fragmentary rugae were found to be higher in number in female group than in male group. The mean number of total rugae did not show any statistically significant difference in males and females. These findings are consistent with that of study undertaken in Upper Egyptian population by Afaf et al[7] and a study on Saudi population by Fahmi et al [5]. The results were consistent with another study done on a population of Uttar pradesh by Kamala et al[4] showing that palates were unique to individual.The result of our study was in contradiction with another study carried out on Japanese population by Valeria H V et al[8] where females had fewer rugae than males. In the present study, the number of fragmentary rugae was given special consideration. The fragmentary rugae also were counted and a difference was found to be present in number of fragmentary rugae among different sexes in Kashmiri population while as most of the other researchers have not included the fragmentary rugae in their studies.

In regard to shape of the rugae, the most common type of primary rugae in both males and females was found to be straight, and the least common type in case of females was unification converging type and in case of males was unification diverging type. Converge and diverge types being few in number. This was in contradiction to results of the study done on upper Egyptian population[7] where sinous type was found to be most common type in both males and females but the classification used in this study was Trobo`s classification[10].The study done by Indira et al[9] in Indian sub populations showed that curved form was most predominant. In the same study carried out by Indira et al[9] it was found that palates are unique to individual, no two palates being identical. This finding is consistent with the result of present study in which each palate is found to have different number and pattern of rugae. Unlike the studies discussed above, in present study, taking individual female and male groups into consideration, the straight type in females was higher in number than in males. Curved form was higher in males than in females. The difference in results may be attributed to different types of classifications used in different studies. This difference can also be attributed to the fact that different populations vary in palatal rugae patterns.

On the basis of findings of this study, sexual dimorphism was statistically insignificant based on mean number and shape of rugae.

VII. Conclusion

Studying the palatal rugae pattern in Kashmiri population revealed that rugae number and shape could not discriminate between males and females although examining each palate individually revealed that no two palates are same. Total number of fragmentary rugae was higher in females than in males with a difference of 10.

It can be determined that palatal rugae pattern being unique to each individual in terms of number and shapes of each type of rugae can be person and population specific with good capability for forensic applications specially in disaster victim identification especially applicable if ante mortem casts or computer stored images are available for comparison with post mortem records. Further studies from different areas of Kashmir and studies with larger sample size are needed to validate and supplement the findings of this study. Moreover studies on orthodontically treated individuals need to be done to determine the impact of orthodontic treatment in palatal rugae pattern and longitudinal studies to determine the age related changes on palatine rugae pattern need to be carried out in Kashmiri population.

LIMITATIONS OF THE STUDY
1. Study done on Kashmiri regional population, the values may not be generalized for other populations.
2. The study does not consider variations in different age groups.
3. Casts from edentulous patients are not considered.
4. Study is done on casts rather than subjects in vivo.
5. Orthodontically treated cases are not considered.

Conflicts of interest: No conflict of interest.

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