Original Article

Palatoscopy and odontometrics for sex identification and hereditary pattern analysis in a Navi Mumbai population: A cross-sectional study

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Abstract

Background: Identification of an individual is a challenging task in the field of forensic odontology. Sometimes, the identity of individuals by fingerprints is difficult; hence, the examination of palatal rugae and the human dentition is a viable option.

Aims and Objectives: The objective of the present study was to determine the sex of an individual and the hereditary pattern using three parameters are as follows: palatine rugae, dimensions of maxillary molar and maxillary canine.

Materials and Methods: A cross-sectional study involved a total of 200 participants which included 60 males, 60 females and 20 families with four members each. Maxillary impressions were made with elastomeric impression material, and dental stone was used to make the models. The parameters used were as follows: palatine rugae classified by Thomas and Kotze (1983), which included the shape, size, direction and unification pattern, mesiodistal (MD) width of canines and intercanine width and MD and buccolingual width of maxillary molars.

Statistical Analysis: Unpaired *t*-test and the median test were used to assess the sex differences in the number and unification pattern for the palatal rugae and to compare dimensions measured for males and females for the odontometric data. The data collected was statistically analyzed using the Statistical Package for Social Sciences 17.0 statistical program for windows. The statistical significance was fixed at 0.05.

Results: Males showed more number of converging rugae and females showed more number of diverging patterns of rugae. The number of primary and forward rugae was more in both the genders and females showed more wavy rugae while males showed more number of straight and curved rugae. The maxillary canine and maxillary molar dimensions both were more in males than the females and also none of these parameters showed a hereditary pattern.

Conclusion: Rugae pattern and the human dentition are both highly individualistic and can be used for personal identification and sex determination.

Keywords: Family, forensic odontology, human identification, odontometry, rugoscopy, sex determination

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INTRODUCTION

Human identification is the recognition of the physical characteristics that are unique to an individual. In case of violent crimes, child or elder abuse, missing persons and mass disasters, the forensic anthropologist is usually asked to assist or provide information that can determine the identity of the individual. Gender determination is usually the first step involved in an identification process in forensics. This not only cuts the possible matches to half but also helps for subsequent age and stature estimation.[1]

No two individuals are unique in their characteristics and this concept of uniqueness can be utilized in human identification. Finger prints, DNA profiling and dental records are standard methods. However, palatoscopy and odontometric measurements are also capable of giving reliable results and can be employed as ancillary methods if performed systematically.[2]

Palatal rugae are present in the maxillary portion of the oral cavity. The shape, position and characteristic layout of the rugae are not affected during eruption or loss of teeth. Rugae pattern are unique to an individual and hence are useful in identification. They are protected from any traumatic injury and can withstand high temperature due to their internal position in the oral cavity. They are surrounded and protected by the lips, cheeks, tongue, teeth and bones. The pattern of palatine rugae exhibits racial and gender variations and hence can facilitate population identification in mass disasters.[3]

Odontometric parameters also show ethnic, racial and to some extent geographic variations. Although pelvic and skull bones give more reliable results in exhibiting gender dimorphism, occasionally the only data available may be the teeth as they are more resistant to bacterial decomposition, fire and fracture.[4] Maxillary first molars being the first permanent teeth to erupt in the oral cavity are available for sex assessment at a much earlier age when compared to other permanent teeth. The canines have more chances of being impacted, while the incisors are more prone to trauma, show crowding and exhibit developmental anomalies which result in difficulty in odontometric analysis.[5]

Canines are the least frequently extracted teeth. They last longer in the oral cavity as they are least prone to caries, periodontal disease and can withstand vulnerable conditions.[6]

With this background in mind, the present study was undertaken to record the palatal rugae pattern with respect to the number, shape, length, position and unification pattern along with the mesiodistal (MD), buccolingual (BL) dimensions of maxillary first molars, MD width, intercanine width and maxillary canine index (MCI) and to determine the percentage of dimorphism as an aid in forensic odontology.

MATERIALS AND METHODS

The study sample consisted of 200participants, comprising 60 males, 60 females and 20 families of four members each. The participants were healthy and free of any congenital abnormalities, inflammation, bony or soft-tissue protuberances, allergy to impression materials and trauma related to the palate. Individuals with oral habits, teeth with orthodontic wires, attrition, abrasion or erosion, restored or carious adjacent teeth, malposed teeth and developmental anomalies were excluded from the study. Participants aged between 15 and 45 years having a fully erupted dentition up to the second permanent molars, caries and restoration free maxillary molars and canines with healthy periodontium were included in this study. All the participants belonged to the same geographical population, Navi Mumbai, Maharashtra, India. Written informed consent was obtained from the participants, and the present study was conducted after obtaining approval from the Institutional Ethics Committee.

Analysis of palatal rugae

A maxillary impression was made for each participant using addition silicon impression material, washed under running tap water and poured in Type III dental stone. The rugae pattern was traced on these casts using a 0.5-mm black graphite pencil. The principal investigator was blinded about the identity of the casts. A magnifying hand lens was used to visualize and analyze the characteristic rugae pattern using the Thomas and Kotz classification.[7]

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

The direction of each ruga was determined by measuring the angle between the line joining its origin and termination and a line perpendicular to the median raphe. They were classified as follows:

a. Forward-directed rugae – associated with positive angles
b. Backward-directed rugae – associated with negative angles

c. Perpendicular rugae – associated with zero-degree angles.

Further, the shapes of the individual rugae were classified into four major types as follows:

1. Straight – ran directly from their origin to termination
2. Curved – simple crescent-shaped with slight bend at the termination of the rugae
3. Circular – continuous ring formation
4. Wavy – serpentine in form.

When it was circular, the diameter from origin to termination was considered.

In addition, unification pattern was considered, which was subdivided into a diverging or converging type. A diverging pattern occurs when two rugae have a common origin but immediately diverge transversely while in converging pattern; two rugae having different origins converge transversely.

Odontometric measurements

BL and MD dimensions of maxillary first molar were measured using a digital vernier caliper (resolution of 0.01 mm). The MD crown diameter is the largest mesial-to-distal dimension, taken parallel to the occlusal surface. The BL crown dimension is the greatest distance between the buccal and lingual (palatal) surfaces perpendicular to the MD diameter.[8]

Similarly, the MD crown dimensions of the maxillary right and left canines were measured from the anatomical contact points using a digital caliper with the beaks inserted parallel to the long axis of the tooth (resolution 0.01 mm).[9] Intercanine width was measured from canine tip of one side to the canine tip on the other side with a digital caliper. MCI was calculated by dividing the MD width of the maxillary canine by the intercanine distance.[10-12]

Based on these values, the standard MCI was derived as follows:

Standard MCI =

$$\frac{\left(\text{mean male MCI} - \text{standard deviation} + \left[\text{mean female MCI} + \text{SD}\right]\right)}{2}$$

To obtain a reference point to differentiate males from females, the present study adapted the procedure used by Rao *et al.*[10] If the linear values of the BL and MD dimensions are higher than the respective reference points, the individual is considered to be a male otherwise the individual is a female.

$$\text{Reference point} = \frac{\left(\left[\text{mean male dimension} - \text{SD}\right] + \left[\text{mean female dimension} + \text{SD}\right]\right)}{2}$$

All measurements were performed by one person, and values were taken to two decimal points. Intraobserver error was assessed using digital caliper on the study casts at a different time by the same observer. The mean values of the MD and BL dimensions were then subjected to the following formula to calculate sexual dimorphism.[13]

$$\text{Percentage of sexual dimorphism} = ([Xm/Xf] - 1) \times 100$$

Where, Xm = mean male tooth dimension and Xf = mean female tooth dimension.

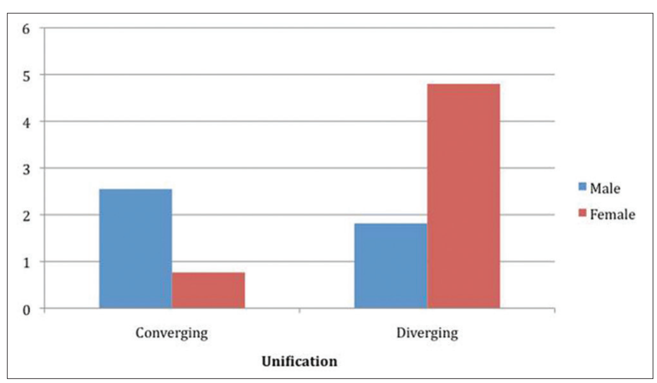
Statistical analysis

Unpaired *t*-test and the median test were used to assess the sex differences in the number and unification pattern for the palatal rugae and to compare dimensions measured for males and females for the odontometric data. The data collected was statistically analyzed using the SPSS (Statistical Package for Social Sciences) 17.0 Microsoft Corporation Inc., (Chicago, IL, USA) statistical program for windows. $P < 0.05$ was considered statistically significant.

RESULTS

Analysis of palatal rugae

Males showed more number of converging rugae whereas females showed more number of diverging rugae [Graph 1]. The most prevalent shape was wavy which was predominantly seen in females, followed by the straight and curved-shaped rugae seen more in males [Graph 2].



Graph 1: Analysis of unification pattern of rugae

Females showed more number of secondary and fragmentary rugae, whereas males showed more number of primary rugae [Graph 3].

The forward-directed and backward-directed rugae were predominantly seen in males while the perpendicular rugae were more prevalent in females [Graph 4].

When the mean, standard deviation, frequency and *P* value was calculated of different types of rugae, a significant correlation was observed in the unification pattern, wavy type of rugae, length of rugae and direction of the rugae.

A comparison of rugae patterns between the families was done using the Jonckheere–Terpstra test to see the varying trends of patterns in each family. It was observed that the diverging and straight rugae pattern showed a significant difference in each family.

We then used a logistic regression analysis method using the backward stepwise (Likelihood Ratio) and the Hosmer and Lemeshow test and developed an equation to determine the gender.

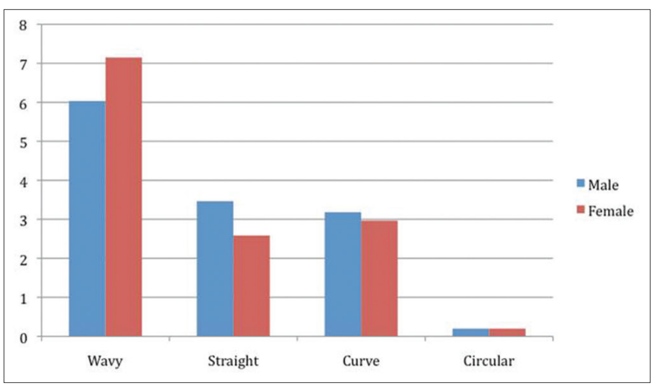
Gender = 0.769 (constant) − 0.789 converging + 0.790 diverging + 0.454 wavy + 0.489 circular − 0.353 primary + 0.165 secondary + 0.442 fragmentary + 0.316 forward + 0.20 backward + 0.142 perpendicular.

If the value of the gender is 0.5 and above the equation is determined as a female, otherwise it is a male. 90% accuracy was observed using this equation.

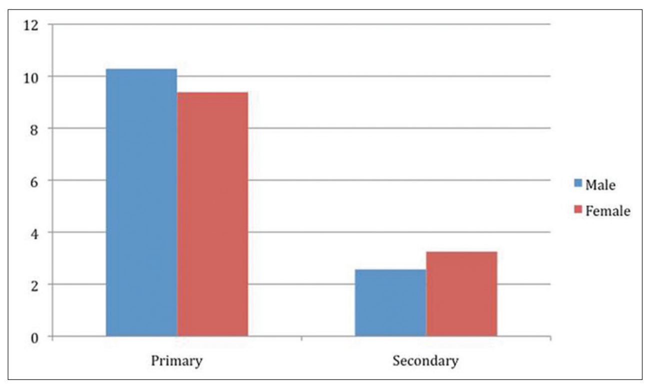
Odontometric analysis

BL and MD diameters of the right and left maxillary molars were measured on the study cast. The mean MD width was 10.35 mm (right side) and 9.97 mm (left side) in males, while it was 9.72 mm (right side) and 9.52 mm (left side) in females. The mean BL width was 9.70 mm (right side) and 9.68 mm (left side) in males, while it was 8.93 mm (right side) and 8.95 mm (left side) in females. The above values were higher in males as compared to females [Graph 5].

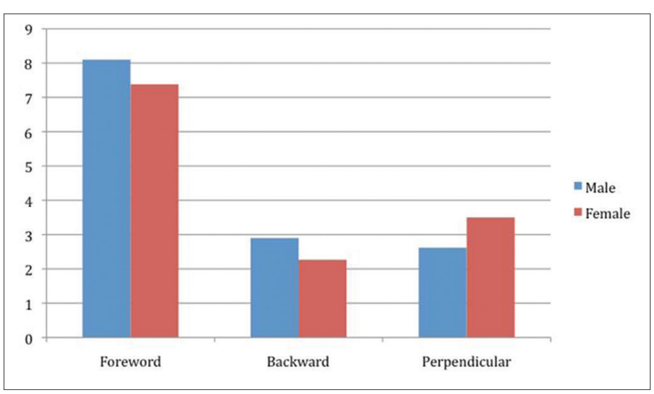
The MD width of canine was 7.35 mm (right) in males and 7.29 mm (left) and 6.85 mm (right and left) in females [Graph 6]. The mean values of these measurements were more in males as compared to females [Table 1]. When a comparative analysis of the odontometric data was done, it was observed that statistically significant difference was found with a $P < 0.05$, except for the left molar MD width.



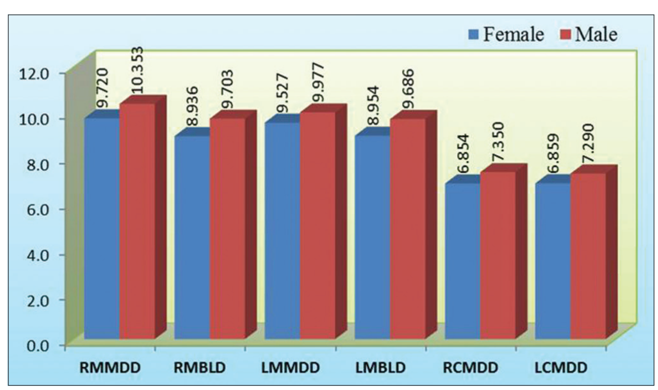
Graph 2: Analysis of shape of the rugae pattern



Graph 3: Analysis of length of the rugae pattern



Graph 4: Analysis of direction of the rugae pattern

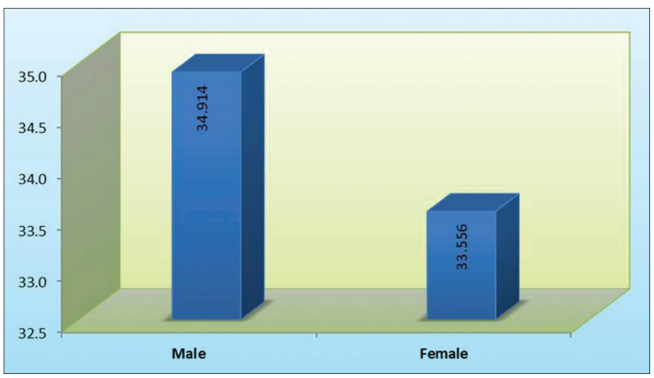


Graph 5: Comparison of maxillary crown dimension

Table 1: *T*-test for comparison of maxillary crown dimensions

	Mean	SD	SEM	*t*-statistics	*P*	Significance
Right molar MD dimension						
Female	9.7202	0.53689	0.06990	−6.437	<0.001	Significant
Male	10.3532	0.53574	0.06916			
Right molar BL dimension						
Female	8.9356	0.61746	0.08039	−7.107	<0.001	Significant
Male	9.7030	0.55953	0.07224			
Left molar MD dimension						
Female	9.5266	1.18852	0.15473	−1.610	0.110	Not significant
Male	9.9772	1.79716	0.23201			
Left molar BL dimension						
Female	8.9541	0.61371	0.08058	−6.894	<0.001	Significant
Male	9.6862	0.53845	0.06951			
Right canine MD dimension						
Female	6.8537	0.40601	0.05286	−6.105	0.000	Significant
Male	7.3495	0.47642	0.06151			
Left canine MD dimension						
Female	6.8590	0.36918	0.04806	−6.253	0.000	Significant
Male	7.2895	0.38165	0.04927			
Maxillary canine arch width						
Female	33.5559	2.13920	0.27850	−3.578	0.001	Significant
Male	34.9143	2.00102	0.25833			
MCI						
Female	0.2049	0.01358	0.00177	−1.756	0.082	Not significant
Male	0.2093	0.01325	0.00171			

MCI: Maxillary canine index, MD: Mesiodistal, BL: Buccolingual, SEM: Standard error of mean, SD: Standard deviation



Graph 6: Comparison of maxillary canine arch width

A high level of sexual dimorphism of 8.6% was found in the BL width of the right maxillary molar, followed by the BL width of the left maxillary molar (8.2%). The MD width of the right maxillary molar showed a sexual dimorphism of 6.5% while the left maxillary molar was 4.7%.

Sexual dimorphism for canines was higher in the right canine (7.2%) when compared to the left canine (6.3%). The canine arch width showed a dimorphism of 4% while the canine index was 2.14% [Table 2].

It was observed in the present study, that whenever the value of the right MD width is >10.03 mm, and the left MD width is >9.44 mm, the individual is likely to be a male. Furthermore, the right BL width was >9.34 mm, and the left BL width was >9.35 mm, the individual was likely to be a male.

It was observed that the MD width of maxillary left molar showed an accuracy of 96% for males while the MD width of maxillary right molar showed an accuracy of 80% for males.

For the canines, it was seen that if the MD width of the right and left canines was >7.06, the individual was more likely to be a male.

Based on the above parameters, the overall accuracy was calculated. The MD dimension of the right and left maxillary molars showed 73.5% and 61% accuracy, respectively, in assessment of gender. The BL dimension showed an accuracy of 72.5% (right side) and 69.5% (left side). The gender for the canine dimension was 71.5% (left side) and 54.5% (right side). It was 61% for the canine arch width [Table 3].

Similar formula was developed for odontometric data

Gender = −37.313 constant + 1.923 RC + 0.124 LMM + 1.567 RMB + 0.785 RMM

Where RC-MD dimension of right canine, LMM-MD dimension of left molar, RMB-BL dimension of right molar and RMM-MD dimension of right molar

When we substituted the value of each of the variable as per Pro forma, if the value of the gender was 0.5 and above then the equation determined a male; otherwise, it was a female. 90% accuracy was observed using this equation.

Table 2: Sexual dimorphism of molars and canines

Parameter	Sexual dimorphism (%)
Molar	
Maxillary MD-R	6.5
Maxillary BL-R	8.6
Maxillary MD-L	4.7
Maxillary BL-L	8.2
Canine	
Canine MD-R	7.2
Canine MD-L	6.3
Canine arch width	4
MCI	2.14

MD: Mesiodistal, BL: Buccolingual, L: Left, R: Right, MCI: Maxillary canine index

Table 3: Accuracy of sex assessment for molars and canines

Variable	Sex	*n* (%)			Overall accuracy (%)
		Total	Males	Females	
Molars					
Maxillary MD-R	Males	97 (100)	78 (80)	19 (20)	73.5
	Females	103 (100)	34 (33)	69 (67)	
Maxillary BL-R	Males	97 (100)	74 (76)	23 (24)	72.5
	Females	103 (100)	32 (31)	71 (69)	
Maxillary MD-L	Males	97 (100)	93 (96)	4 (4)	61
	Females	103 (100)	74 (72)	29 (28)	
Maxillary BL-L	Males	97 (100)	72 (74)	25 (26)	69.5
	Females	103 (100)	36 (35)	67 (65)	
Canine					
Canine MD-R	Males	97 (100)	38 (39)	59 (61)	54.5
	Females	103 (100)	32 (31)	71 (69)	
Canine MD-L	Males	97 (100)	72 (74)	25 (26)	71.5
	Females	103 (100)	32 (31)	71 (69)	
Canine arch width	Males	97 (100)	55 (57)	42 (43)	61
	Females	103 (100)	36 (35)	67 (65)	

MD: Mesiodistal, BL: Buccolingual, L: Left, R: Right

DISCUSSION

It has been observed that there are differences in the odontometric data and rugae pattern within the same population. Hence, it may be necessary to determine specific values for a specified population to make identification easier for measuring dental records.[14]

In case of dead, damaged and mutilated bodies, the gender determination is of prime importance for any medicolegal examination. Once the sex has been identified, the other investigative procedures are simplified.[15]

Although DNA profiling gives accurate results, the evaluation of odontometric data and rugae pattern for sex assessment of a large population sample is simple, inexpensive, reliable and easier to measure. Tooth development is completed before skeletal maturation which makes this parameter an important indicator.[16]

The BL and MD diameters of the right and left maxillary first molars were measured on the study casts. The values were observed to be higher in males as compared to females. All the results were statistically significant except for the left molar MD dimension. Similar statistical findings were also seen in a study by Eboh.[17] These results were similar to studies which were reported earlier,[18-20] where males had larger teeth than females. In a study done by Agnihotri and Sikri, the maxillary molar tooth dimensions were much larger than the present study.[21] These variations may be attributed to genetic, geographical, nutritional or dietary factors which may affect tooth size.

The MD width of the maxillary canines was significantly larger in males as compared to females, consistent with the previous study results.[22-24]

All the results were statistically significant which was in agreement with Sherfudhin *et al*.,[11] Parekh *et al*.[23] and Bakannavar *et al*.,[25] whereas Al-Rifaiy *et al*.[12] and Boaz and Gupta[22] found nonsignificant gender differences.

Studies were done by various researchers on various populations showed a varied percentage of dimorphism in maxillary teeth. The native South American population had a least dimorphism of 1.90%. The dimorphism increased in American Caucasoid (6.11), South African Caucasoid (4.83) and Australian Aboriginal (4.02) populations.[13]

When compared to the present study, the sexual dimorphism of maxillary left MD dimension showed a similar percentage (4.7%) as in a study done by Agnihotri and Sikri[21] and Narang *et al*.[5] The maxillary canines also showed a significant sexual dimorphism. Hashim and Murshid, who conducted a study on Saudi males and females (13–20 age group) found canines to be the only teeth to exhibit dimorphism and both left and right canines showing similar measurements. They inferred that in the absence of one canine the corresponding measurement could be a true representative of the value of the other canine.[26]

The percentage of dimorphism for canines was comparable with various studies. It was greater than Bakannavar *et al*.[25] which were 3.31% for right canine and 3.29% for left canine and less than Parekh *et al*.[23] which were 8.87% for right canine and 7.26% for left canine and 5.15% for intercanine width. It was greater than Paramkusam *et al*.[24] which were 4.4% for right canine and 4.1% for left canine.

Sexual dimorphism is different for different populations and groups. It can also differ from one another and also between generations. This magnitude of dimorphism could be due to an evolutionary change or genetic and environmental factors.[5] The Y chromosome is now known to contribute in the size of the teeth by controlling the thickness of the dentine, whereas the X chromosome helps modulate enamel thickness. Thus, sexual dimorphism in tooth morphology is attributed to the presence of more dentine in the crowns of male teeth.[27]

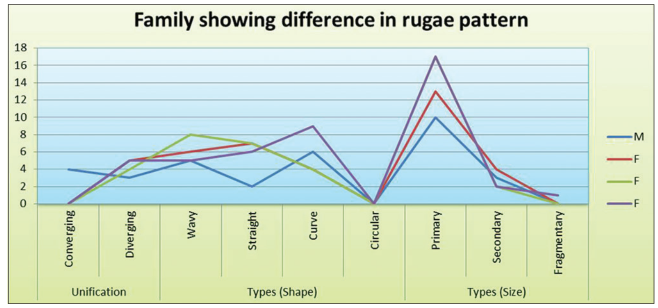
In the present study, the BL dimension of the right and left maxillary first molars showed 72.5% and 69.5% accuracy, respectively, in assessment of sex correctly. Narang *et al*.[5] and Rani *et al*.[13] reported 85.6% and 66.7% accuracy in determining sex in BL dimension of the left maxillary first molar. Macaluso Junior in his study predicted 60% of males and 67.6% of females. Rai *et al*. reported that whenever the BL width was >10.7 mm, the probability of gender being male is 100%. Comparatively, in the present study, if the BL width was >9.3 mm, the probability of the gender being male is 100%.[28]

The percentage of accuracy of gender determination using the standard MCI was more than 70%. The percentage of accuracy was 72.16% for males and 69.60% for females. Paramkusam *et al*.[24] in his study had an accuracy of 76.66% for males and 73.33% for females, respectively. Sherfudhin *et al*.[11] in his study had an accuracy of 88% for males and 86.8% for females. However, in the present study, the left maxillary MD dimension showed 96% accuracy in males while 80% accuracy was observed in the right maxillary MD dimension in males.

Palatal rugoscopy or palatoscopy was first proposed by Trobo Hermosa, a Spanish investigator in 1932. These are asymmetric, irregular ridges of mucous membrane which extend from incisive papilla.[29] Rugae are formed from the 3rd month *in utero* from the connective tissue that covers the palatine process of the maxillary bone. The rugae formed at birth have a typical orientation that changes only in its length during normal growth and stays in the same position throughout the life of a person.[30]

In the present study, females had more wavy-shaped rugae pattern, while males had more straight and curved palatal rugae. Circular rugae were least seen. Kapali *et al*., who conducted a study on Australian and Caucasian population found the straight and circular rugae patterns being the least common.[31] Similar observations were also made by Saraf *et al*.[32] and Mustafa *et al*.[33] on the Indian population. In a comparative study done by Shetty *et al*.,[34] it was reported that Indian males had more number of curved rugae that Tibetan males, while Tibetan females had more wavy rugae than Indian females.

Most of the palatal rugae in the present study were forward directed. Males had more forward-directed rugae than females. Diverging rugae were more in females, and converging type was more in males. Similar findings were observed by Jibi *et al*.[35] However, Shetty and Premalata[36] observed that the females had more forward-directed rugae as compared to males.



Graph 7: Rugae pattern in families

The equation which was used to determine the gender of the individual showed 90% accuracy. There has been no study in the literature which is used to assess the gender using rugoscopy and odontometrics.

The comparison of palatal rugae among the family members showed different patterns. Indira *et al*.[37] studied five pairs of dizygous twins and concluded that each twin showed different patterns. In the present study, it was observed that the diverging and straight rugae patterns showed a significant difference in each family [Graph 7].

CONCLUSION

Forensic odontology is an emerging field in a country like India. Identification of a living or a dead individual is a comprehensive work which involves the efforts of a multidisciplinary team using various methods such as palatoscopy and odontometry which shows variable patterns. Studies on a comparison of two methods for sex determination are minimal. The present study proves that palatal rugae and odontometric measurements have a good potential for gender determination and holds importance as an ancillary and supplemental tool for forensic investigation.

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Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Scheuer L. Application of osteology to forensic medicine. Clin Anat 2002;15:297-312.
2. Caldas IM, Magalhães T, Afonso A. Establishing identity using

cheiloscopy and palatoscopy. Forensic Sci Int 2007;165:1-9.
3. Nayak P, Acharya AB, Padmini AT, Kaveri H. Differences in the palatal rugae shape in two populations of India. Arch Oral Biol 2007;52:977-82.
4. Pratibha RR, Mahima VG, Patil K. Bucco-lingual dimension of teeth – An aid in sex determination. J Forensic Dent Sci 2009;1:88-92.
5. Narang RS, Manchanda AS, Singh B. Sex assessment by molar odontometrics in North Indian population. J Forensic Dent Sci 2015;7:54-8.
6. Kapila R, Nagesh KS, Iyengar AR, Mehkri S. Sexual dimorphism in human mandibular canines: A radiomorphometric study in South Indian population. J Dent Res Dent Clin Dent Prospects 2011;5:51-4.
7. Thomas CJ, Kotze TJ. The palatal rugae pattern: A new classification. J Dent Assoc S Afr 1983;38:153-7.
8. Hillson S, Fitzgerald C, Flinn H. Alternative dental measurements: Proposals and relationships with other measurements. Am J Phys Anthropol 2005;126:413-26.
9. Hunter WS, Priest WR. Errors and discrepancies in measurement of tooth size. J Dent Res 1960;39:405-14.
10. Rao NG, Rao NN, Pai ML, Kotian MS. Mandibular canine index – A clue for establishing sex identity. Forensic Sci Int 1989;42:249-54.
11. Sherfudhin H, Abdullah MA, Khan N. A cross-sectional study of canine dimorphism in establishing sex identity: Comparison of two statistical methods. J Oral Rehabil 1996;23:627-31.
12. Al-Rifaiy MQ, Abdullah MA, Ashraf I, Khan N. Dimorphism of mandibular and maxillary canine teeth in establishing sex identity. Saudi Dent J 1997;9:17-20.
13. Rani P, Mahima VG, Pati K. Bucco-lingual dimension of teeth – An aid in sex determination. J Forensic Dent Sci 2009;1:88-92.
14. Işcan MY, Kedici PS. Sexual variation in bucco-lingual dimensions in Turkish dentition. Forensic Sci Int 2003;137:160-4.
15. Dahberg AA. Dental traits as identification tools. Dent Prog 1963;3:155-60.
16. Lund H, Mörnstad H. Gender determination by odontometrics in a Swedish population. J Forensic Odontostomatol 1999;17:30-4.
17. Eboh D. A dimorphic study of maxillary first molar crown dimensions of Urhobos in Abraka, South – Southern Nigeria. J Morphol Sci 2012;29:96-100.
18. Stroud JL, Buschang PH, Goaz PW. Sexual dimorphism in mesiodistal dentin and enamel thickness. Dentomaxillofac Radiol 1994;23:169-71.
19. Rai B, Dhattarwal SK, Anand SC. Sex determination from tooth. Med Leg Update 2008;8;3-5.
20. Acharya AB, Mainali S. Sex discrimination potential of buccolingual and mesiodistal tooth dimensions. J Forensic Sci 2008;53:790-2.
21. Agnihotri G, Sikri V. Crown and cusp dimensions of the maxillary first molar. A study of sexual dimorphism in Indian Jat Sikhs. Dent Anthropol 2010;23:1-6.
22. Boaz K, Gupta C. Dimorphism in human maxillary and mandibular canines in establishment of gender. J Forensic Dent Sci 2009;1:42-4.
23. Parekh DH, Patel SV, Zalawadia AZ, Patel SM. Odontometric study of maxillary canine teeth to establish sexual dimorphism in Gujarat population. Int J Biol Med Res 2012;3:1935-7.
24. Paramkusam G, Nadendla LK, Devulapalli RV, Pokala A. Morphometric analysis of canine in gender determination: Revisited in India. Indian J Dent Res 2014;25:425-9.
25. Bakkannavar SM, Monteiro FN, Arun M, Pradeep Kumar G. Mesiodistal width of canines: A tool for sex determination. Med Sci Law 2012;52:22-6.
26. Hashim HA, Murshid ZA. Mesiodistal tooth width in a Saudi population sample comparing right and left sides. Part 2. Egypt Dent J 1993;39:347-50.
27. Townsend G, Alvesalo L. Tooth size in 47, XYY males: Evidence for a direct effect of the Y chromosome on growth. Aust Dent J 1985;30:268-72.
28. Rai B, Joun RK, Duban J, Dutta S, Dhattarwal S. Importance of maxillary first molar for sex determination. The Int J Dent Sci 2007;4:2.
29. Rai B, Anand SC. Palatal rugae in forensic examination. Int J Forensic Med Toxicol 2007;5:14-6.
30. Venegas VH, Valenzuela JS, Lopez MC, Galdames IC. Palatal rugae: Systematic analysis of its shape and dimensions for use in human identification. Int J Morphol 2009;27:819-25.
31. Kapali S, Townsend G, Richards L, Parish T. Palatal rugae patterns in Australian aborigines and caucasians. Aust Dent J 1997;42:129-33.
32. Saraf A, Bedia S, Indurkar A, Degwekar S, Bhowate R. Rugae patterns as an adjunct to sex differentiation in forensic identification. J Forensic Odontostomatol 2011;29:14-9.
33. Mustafa AG, Allouh M, Islam T, Raed A. Morphometric analysis of palatal rugae among Jordians. Further evidence of worldwide palatal rugae individuality. Aus J Forensic Sci 2013;46:53-63.
34. Shetty SK, Kalia S, Patil K, Mahima VG. Palatal rugae pattern in Mysorean and Tibetan populations. Indian J Dent Res 2005;16:51-5.
35. Jibi PM, Gautam KK, Basappa N, Raju OS. Morphological pattern of palatal rugae in children of davangere. J Forensic Sci 2011;56:1192-7.
36. Shetty M, Premalatha K. Study of palatal rugae pattern among the student population in Mangalore. J Indian Acad Forensic Med 2011;33:112-5.
37. Indira A, Gupta M, David MP. Usefullness of palatal rugae patterns in establishing identity: Preliminary results from Bengaluru city, India. J Forensic Dent Sci 2012;4:2-5.