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Palatal Rugae: A Tool for Sex Identification in Forensic Odontology.

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ABSTRACT

To record and compare the palatal rugae patterns between males and females population, using Discriminant Functional Analysis. The study comprised of 100 (51 males and 49 females) participants aged 17 to 28 years studying in Sumandeep Vidyapeeth University, Vadodara, Gujarat. The classification of rugae patterns was done using the classification given by Kapali et al, method of rugae recording used in this study was based on the classification given by Kapali et al, which included number, length, shape and unification of rugae. Unpaired t test and logistic regression analysis were used for statistical analysis. A total of 781(403 in females and 378 in males) rugae were counted in both males and females. Of these the mean number of rugae was found to be more in females than in males,781 (403 in females and 378 in males) number of rugae the mean was more in females (8.24±2.12) than males (7.44±1.70) but the difference was statistically insignificant ($p>0.05$). The count of rugae was higher on right (3.98±0.95) than left (3.86±0.95) side. Both genders showed predominance in wavy (females = 4.24±1.49 and males = 3.90±1.82) type of distribution pattern. The −2LL for logistic regression model for rugae type was 6.432, indicating high accuracy of fit. The findings showed a specific rugae pattern in this group of population. Palatal rugae patterns are definitely associated with regional variation and can aid as an additional tool in forensic identification procedures.

Keywords: forensic, mass disaster, palatal rugae.

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INTRODUCTION

Human being has come a long way from the early caveman age to the present day of covering, nothing less than astronomical heights to sea bed depths. His zeal to conquer new heights has created a world full of scientific advancement and technology. However, his intelligence has also led to a surge in crime rate, terrorism, wars, mass disasters, road traffic accidents and dreadful diseases. In all such incidents the identification of the diseased is a prime requisite for certification of death and for personal, social and legal reasons [1].

Human identification is one of the most challenging subjects that man has confronted with [2]. Forensic dental identification mainly comprises of determining the gender, age, ethnic background, community etc of an individual [3]. When traffic accidents, acts of terrorism or mass disasters occur in which it is difficult to identify a person according to fingerprints or dental records, palatine rugae may be an alternative method of identification [4,5].

Palatal rugae are irregular, asymmetric ridges of mucous membrane extending lateral from the incisive papilla and the anterior part of the median palatal raphe, which is just behind the maxillary central incisor teeth [6]**.** The characteristic uniqueness and genetic basis of the palatal rugae and the anatomical position inside mouth suggest their use in person's identification in forensic cases [7]. They are well protected from trauma and are insulated from heat by the lips, tongue and buccal fat of pads. Palatal Rugoscopy i.e study of palatal rugae is one of the simple techniques used by forensic odontologist in human identification [8]. Palatal rugae refer to the ridges on the anterior part of the palatal mucosa on each side of the medial palatal raphae and behind the incisive papilla [2]. Anatomically, the rugae consist of around 37 ridge and oblique ridges that radiate out tangentially from the incisive papillae. Histologically, the rugae are stratified squamous; mainly para keratinized epithelium on a connective tissue base, similar to the adjacent tissue of the palate [9].

In clinical dentistry due to the stable nature of the palatal rugae it aids as a landmark during orthodontic treatment [10], during cleft palate surgeries [11], palatal prosthesis [12] and medicolegal identification [2]. It is a well-established fact that the rugae pattern is as unique to a human as his or her fingerprints [12]. Rugal length and transverse palatal rugal region width increases with age in both genders and stops once the somatic growth stops [13]. Also, there seem to be a significant association between rugae forms and ethnicity as various authors reported the palatal rugae patterns unique to a particular community [4, 14, 15]. Palatal rugae pattern of an individual may be considered as a useful adjunct for sex determination for identification purposes [16]. The purpose of this study was to compare and record the palatal rugae patterns between males and females, using Discriminant functional analysis.

MATERIALS AND METHODS

The study comprised of 100 (51 males and 49 females) subjects aged 17 to 28 years affiliated with Sumandeep Vidyapeeth University, Vadodara, Gujarat. Healthy individuals free of congenital abnormalities, inflammation, trauma or orthodontic treatment were included in the study.

Ethical considerations

Our research was conducted in full accordance with the World Medical Association Declaration of Helsinki. An Institutional Ethics Committee approval was obtained before commencing the study. A written informed consent was obtained from all participants.

Training and Calibration

The counting of rugae and their patterns were done by three independent examiners who were trained and calibrated to ensure uniform interpretations and consistent recordings. The inter examiner reliability for assessment of palatal rugae using Kappa statistics was found to be 89%.

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Methodology

A maxillary arch impression of all participants was taken using an irreversible hydrocolloid impression material and a perforated metal tray. Casts were prepared using type III dental stone from these impressions, taking utmost care to prevent voids or air bubbles. The rugae were delineated using a sharp graphite pencil under adequate light and magnification The assessment of rugae was done using Kapali et al classification [4]. This classification includes number, length, shape and unification of rugae. Rugae length was recorded from the starting point of rugae at mid palatine raphe to the end point of rugae transversely and in case of circular rugae the maximum diameter was taken into consideration. All measurements were made under magnification using a slide calliper to an accuracy of 0.05mm. Having determined the length of all rugae, three patterns were formed:

- Primary rugae (5-10mm)
- Secondary rugae (3-5mm)
- Fragmentary rugae (less than 3mm)

Shape of individual rugae were classified as follows: (Figure 1)

Figure 1a-Showing different rugae patterns in femlaes

Figure 1b-Showing different rugae patterns in femlaes

Straight: Ran directly from the origin i.e mid-palatine raphe to termination.
Curvy: A simple crescent shape which was curved gently.
Circular: A definite continuous ring formation.

Wavy: In the form of serpentine.
Unification: When rugae have two arms which are joined either at their origin or termination which may be diverging and converging type. Diverging occurs when two arms of the rugae begin from the same origin and bifurcates transversely; similarly converging occurs when two arms of rugae arise with different origins and converge transversely.

Statistical Analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2007) and then exported to data editor of SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). Unpaired t test was used for comparison of mean and relationship between the attributes. Logistic regression analysis was applied for yielding a correct sex allocation rate. For all the tests, confidence interval and p-value were set at 95% and ≤0.05 respectively.

RESULTS

The total number of rugae in the study sample was 781 (403 in females and 378 in males). Mean number of rugae was more in females (8.24±2.12) than males (7.44±1.70) but the difference observed was statistically insignificant (p>0.05) [Table 1]. When compared with side of the arch, mean number of rugae was more on left side in females (4.15±1.15) and on right side in males (3.87±0.97). The difference was significant only on the left side (p<0.05). The overall mean number of rugae was 3.98±0.95 and 3.86±0.95 on right and left side respectively which showed predominance on right side.

Based on the shape of palatal rugae both genders showed wavy type (females = 4.24±1.49 and males = 3.90±1.82) followed with curved (females = 1.37±1.27 and males = 1.29±1.28) and straight (females = 1.12±1.36 and males = 0.84±1.15) type of distribution. Circular shapes were found to be negligible.

Gender-wise distribution of unification of the rugae showed predominance in males (0.80±0.87) than females (0.76±0.77). However, these observations were statistically insignificant (p>0.05) [Table 2].

The accuracy of sex prediction by LRA is depicted in the classification table [Table 3]. Application of LRA to all the rugae types yielded a correct sex allocation rate of 98%. This may indicate a high power of sex allocation using the rugae shapes. Table 4 shows the accuracy of the statistic: the lower the −2LL statistic, the better the fit of the model to the data. The −2LL for logistic regression model for rugae type was 6.432, indicating high accuracy of fit of the model to the obtained data.

Table 1: Distribution of study subjects according to the mean value of rugae in males and females.

Gender	Total individuals	Total no. of rugae	Mean no. of rugae		Total
			Right	Left	
Female	49	403	4.09±0.94	4.15±1.15	8.24±2.12
Male	51	378	3.87±0.97	3.57±0.75	7.44±1.70
Total	100	781	3.98±0.95	3.86±0.95	7.84±1.91
t value* p value**			-1.416 0.157	-4.002 0.000*	-1.836 0.066

Table 2: Mean distribution of the study subjects based on the number and shape of palatal rugae according to gender

Gender	Shape of palatal rugae					
	Straight Mean±SD	**Curved** Mean±SD	**Wavy** Mean±SD	**Circular** Mean±SD	**Unifaction** Mean±SD	**Fragmentary** Mean±SD
Females (n=403)	55 (1.12±1.36)	67 (1.37±1.27)	208 (4.24±1.49)	0	37 (0.76±0.77)	36 (0.73±1.11)
Males (n=378)	43 (0.84±1.15)	66 (1.29±1.28)	199 (3.90±1.82)	0	41 (0.80±0.87)	29 (0.57±0.75)
t-value* p-value**	-0.901 0.367	-0.372 0.710	-0.805 0.421	-	-0.123 0.902	-0.101 0.902

*Test applied: Unpaired t- test;
**Statistical significance is considered at p<0.05

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Table 3: Classification table of Logistic regression analysis (LRA)

	Female n (%)	Male n (%)	Σ n (%)
Rugae pattern	48/49 (98)	50/51 (98)	98/100 (98)

Table 4: Accuracy of fit statistic (-2LL)

	-2 Log likelihood
Rugae pattern	6.432

DISCUSSION

The present study was carried out to find out the number, pattern and side differences of palatal rugae in males and females, residing in and around Vadodara, Gujarat. Palatal rugoscopy is a tool employed successfully in identifying an individual based on the rugae pattern analysis as it is proved to be unique in shape, length, width, prominence, number and orientation considerably among individuals. Therefore, rugae patterns can be used in individual identification by comparing the postmortem rugae details with the antemortem records. The application of palatal rugae in gender determination could be attributed to low utilization cost, simplicity and reliability [17]. Thomas and Van Wyk in 1987 reported identification of a severely charred edentulous body with the help of plaster casts made from the dentures in the victims mouth and compared with another set found in that individual's home [18]. Muthusubramanian et al in 2005 performed an analysis of rugae in burn victims and cadavers to simulate rugae identification in cases of incineration and decomposition. They reported that 93 percent of palatine rugae were normal and 77 percent of palatine rugae showed no colour change among subjects with third degree panfacial burns when examined after 72 hours stored in a mortuary at 5 degrees with 30 to 40 percent relative humidity [19].

In our study the analysis of rugae patterns was done on casts made from the impressions of study subjects. Stone casts present an advantage of simulating the oral cavity in forensic laboratory, easy to handle, simple analysis, reduced cost and easy fabrication. Sognnaes advocated the use of casts made from jaws rather than from dentures for a more reliable result [20].

Various studies have shown the use of photographs taken by digital cameras, their transfer to the hard disk of the computer and analysis using a software programme [21, 22]. Neverthless, this process can conserve the physical space consumed in storing the stone casts, this process is complex as it involves specific photography skills in attaining the perfect photograph and includes complex data analysis and interpretation as the examiner must be well versed in photography and its software application and its execution.

Rugae pattern remains constant throughout life. They are two separate masses on right and left ranging from 3-5 rugae per side. Variation also exists in the right and left sides of the same person i.e no bilateral symmetry exists in the rugae pattern. Kashima et al did not find any difference in the rugae pattern in both the sexes in Japanese and Indian children [23].

Whatever may be the classification system employed in various population studies, a definite significant variation of palatal rugae among population and among ethnic group exists. Dohke and Osato reported that Japanese females had fewer rugae than males [24]. Kapali et al [4] in 1997 through their longitudinal and cross-sectional approaches aimed to investigate changes of rugae patterns with age in Australian Aborigines and compared the patterns between Australian Aborigines and Caucasians. They employed classification described by Lysell [25] and Thomas and Kotze [26 – 28]. Authors analysed the number, length, shape, direction and unification of rugae and concluded that mean number of primary rugae in Australian Aborigines was higher than that of Caucasians and the most common shapes in both the ethnic group were wavy and curved while straight and circular were least common [4]. Fahmi et al in 2001 studied the rugae patterns in Saudi males and females. Authors employed classification of Thomas and Kotze [25 – 28] and reported that females showed a significant difference in the converge type and males had a significant difference in the circular type and concluded that the rugae patterns can be an additional method of differentiation between Saudi males and females in conjunction with the other methods such as visual, fingerprints and dental characteristics in forensic sciences [29].

Nayak et al in 2007 examined the possible difference in rugae shape between Southern and Western Indians and also the effectiveness of rugae shape in identifying the populations using Discriminant function analysis. They reported low incidence of unifications and absence of circular rugae indicating that these two Indian populations were characterised by fewer types of rugae shape and also significant difference between two populations were observed in straight and curved rugae as they were seen in more number among Southern and Western Indians respectively. On Discriminant function analysis moderate differentiation of the populations were possible with an attributed accuracy of 70% and concluded that discrete variables such as rugae shape are better suited for the purpose of discrimination than continuous variables like rugae length [14].

Paliwal et al in 2010 determined the number and pattern of palatal rugae among Madhya Pradesh and Kerala populations of India and reported that straight rugae pattern on the right side of the palate among males were significantly predominant when compared to Madhya Pradesh population [15]. Kashima compared the palatine rugae and shape of the hard palate among Japanese and Indian children and reported that Japanese children had more primary rugae than Indian children and the palatal raphe of Japanese children were wider than those of the Indian children [22]. In a comparative study between Indians and Tibetan population by Shetty et al, it was reported that Indian males had more primary rugae on the left side as compared to females and vice versa for the Tibetan population. Also, Indian males had more number of curved rugae on both right and left sides than Tibetan males and Tibetan females had more wavy rugae on right and left sides than Indian females [30].

Shubha C in their study showed that North Indian Males had more number of rugae and South Indian females had more number of rugae than their counterparts The t-value and p-Value between male Vs female North Indians were 0.43 and 0.67 respectively, and 1.15 and 0.25 for male Vs female South Indians which is not significant [9].

In our analysis though the difference is not very high it is sufficient to differentiate the Gender if taken in conjunction with other findings. The ethnicity and genetic makeup is quite close as they were from neighbouring states, hence the lower but positive discrimination was observed in the two groups. Further research should be indicated with a larger sample size in order to validate our findings. Comparison with other geographical populations would give better understanding of Gender variations. Databank for storing the palatal rugae pattern must be established as these patterns may serve as ante-mortem record, which could be utilized in identification procedures of forensic odontology.

CONCLUSION

A specific rugae pattern was observed among male and female population. There was a significant difference in the average number of rugae, females showing increased number of rugae when compared to males. Unification pattern among males and females showed increased converging pattern in males and increased diverging pattern in females. Thus, this study highlights that palatal rugae pattern could be used as one of the adjunct in comparative identification process of forensic odontology.

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