

PALATAL RUGOSCOPY AS A METHOD OF SEX DETERMINATION IN FORENSIC SCIENCE

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Received: 15 November 2014, Revised and Accepted: 23 December 2014

ABSTRACT

Objective: The role of forensic science in establishing the personal identity is based on DNA analysis, finger print and dental analysis. When the forensic remains are decomposed making all these sources, unavailable palatal rugae served as an important aid as it is resistant to heat and placed deep inside the oral cavity in a secure environment. Thus, palatal rugae can be used as an adjunct in the gender determination. This study was performed to determine the length, number and the patterns of palatal rugae in males and females on right and left side and thereby determine the gender difference.

Methods: A total of 50 subjects were included in the study comprising of 25 males and 25 females. An impression of the maxillary arch was made using the hydrocolloid impression material (alginate). The palatal rugae were highlighted using a graphite pencil and the length, number and pattern of the rugae were determined using Thomas and Kotze classification. Statistical analysis was performed to determine the two-tailed significance test to determine the significance between the two genders.

Results: The wavy pattern was found to be highest, followed by curved, straight, circular and unification pattern. The females showed a statistically significant rise in the unification pattern, whereas males demonstrated higher amount of wavy and straight pattern based on descriptive statistics. There was no statistical difference in the length and number of the rugae in males and females.

Conclusion: No two palatal rugae are alike and this forms the basis of rugoscopy. The uniqueness, overall stability and feasibility make palatal rugae an ideal forensic identification marker.

Keywords: Rugoscopy, Personal identification, Gender, Marker.

INTRODUCTION

Identification of deceased and establishing the individual identity forms the basis of Forensic odontology. There are various positive identification methods as well as exclusionary methods that aid in personal identification. DNA analysis, fingerprints, and comparison of ante-mortem and post-mortem dental records are by far the most commonly used methods for identification [1,2]. However, these methods cannot be applied in forensic identification at times when the body is burnt or decomposed making the fingerprints unavailable [3]. Palatal rugae come into place at such instances in establishing personal identity. It also applies serves as a tool for identification in edentulous patients, when teeth cannot be used for identification.

A more recent method of establishing identity of a person is rugoscopy or the study of palatal rugae. Palatal rugae also called as plicae palatinae are the transverse ridges in the mucous membrane that run laterally behind the incisive papilla in the anterior part of the palate [4].

Rugae pattern is unique to every individual, and every palatal rugae are unique once they are formed and remain unchanged during lifetime [3,5,6]. They do not undergo any changes except in their length, which halts at puberty [6]. They are also usually specific in racial groups aiding the identification of various races. Thus, the uniqueness of the rugae pattern, post-mortem resistance and overall stability, and additionally low utilization cost makes palatal rugae an ideal forensic identification parameter [5].

A review of previous research shows numerous studies done on rugoscopy. However, the pattern of fragmented rugae and the length and number were lacking. The present study was performed to assess the gender difference in the palatal rugae patterns, the length and the number of primary rugae, secondary and fragmented rugae.

METHODS

Patient sampling

The study consisted of 50 subjects, comprising of 25 males and 25 females. The patients were distributed in both the age groups in the age range of 18-23. Individuals with congenital anomalies, previous history of orthognathic surgery, bony and soft tissue protuberances, active lesions, deformity and scars were not included in this study. An informed consent was obtained from the patients before the start of the study.

Impression making and rugae analysis

After obtaining informed consent, an irreversible hydrocolloid (alginate) impression was made of the maxillary arch. The impression was disinfected, and a study cast was poured using dental stone. The rugae were delineated using a sharp graphite pencil to make it prominent, and the number of rugae on either side of the midline was counted and the length measured (Fig. 1).

Classification of palatal rugae

The shape of the rugae was recorded according to the classification given by Thomas and Kotze (1983) [7]. Based on the length of the rugae, it was classified under three categories: Primary rugae (more than 5 mm in length), secondary rugae (3-5 mm in length) and fragmented rugae (<2 mm in length). The pattern of the rugae was classified into curved, wavy, straight and circular types (Fig. 2). The straight pattern had a direct course from the point of origin to their insertion in a straight line. The curved pattern had a crescent shaped pattern with a mild curvature. A slightest curvature at the termination or origin of the led to the classification as curved type. Wavy rugae were serpentine in shape. Rugae with specific continuous ring type morphology were classified as circular. Unified rugae were united either in their origin or in their insertion giving a forked appearance.



Fig. 1: Marking of palatal rugae on a maxillary cast with a graphite pencil

PATTERN	REPRESENTATION
STRAIGHT PATTERN	
WAVY PATTERN	
CURVED PATTERN	
CIRCULAR PATTERN	
UNIFICATION PATTERN	

Fig. 2: The patterns of palatal rugae

Statistical analysis

The two-sample t-test and Chi-square tests were used for comparison of means and relationship between the attributes. A significance level of 5% was considered as a critical value.

RESULTS

The total numbers of rugae in both the genders were about 256 in females and 243 in males (Table 1). The number of rugae on the right and left side was found to be almost the same, and it did not show a statistical difference. However, the fragmented rugae were found to be significantly increased in females as compared with males ($p=0.0142$) (Table 2).

Table 1: Number of rugae in males and females on right and left side

Gender	Total number	Total number of rugae	Mean	SD
Females	25	256	10.65	1.65
Males	25	243	10.15	0.96
Total	50	499	10.41	2.61

The analysis on the length of the rugae demonstrated a higher number of primary rugae followed by secondary and fragmented rugae. There was also a gender difference in the length of the rugae in males and females. However, it was not statistically significant (Table 3).

The distribution of rugae pattern also showed a difference in both the genders. There was a higher incidence of wavy pattern followed by curve pattern in both the genders. However, wavy and unification pattern was more predominant in females, and there was a statistical difference in the unified type of rugae with females showing a higher prevalence compared to males. The prevalence of the circular pattern was almost significantly increased in females as compared to males. The wavy and straight rugae had a greater predominance in males thus showing a marked variation in the distribution of rugae in males and females. However, there was significance statistically in these groups in both the genders (Table 4).

DISCUSSION

The role of palatal rugae have recently been studied for various purposes mainly in the field of anthropology, comparative anatomy, genetics, prosthodontics and orthodontics [8,9]. Palatal rugae were first described by Winslow in 1753 [6,10]. After a year in 1983, the palatal rugae were divided into the fundamental group and specific group having common principles with dactyloscopy. Palatal rugoscopy was first proposed by a Spanish investigator Troban Hermaso in the year 1932. Various classifications have been proposed from then. However, most of the studies are based on the Thomass and Kotze classification and hence, we used the same method for differentiating the patterns of the rugae. The method was found to be the most practical and easiest to apply compared with other methods [7].

There are several studies done in the literature on rugoscopy to analyze the patterns of the rugae. However, there is scarcity in the analysis of fragmented rugae as they also occupy a predominant portion of the palate. Hence, this study was performed with an objective to assess the length number and pattern of the primary secondary and fragmented rugae in males and females and to determine if there is any statistical difference amongst them.

This study was done in an Indian sample within the age group of 18-23 years to avoid racial and gender difference in the rugae patterns. The present study did not show much difference in the rugae lengths between the genders and it was statistically insignificant. This correlates with the results done by Nayak *et al.* [11]. However, the results in Dohke *et al.* showed an increase in the rugae in females [12]. This could probably be due to the secondary and fragmented rugae not included in the study design. Our results also show correlation with A Saraf *et al.* wherein the rugae number was same in both males and females [12,13]. Our study also demonstrated a significant rise in the number of fragmented rugae in females as compared to males.

The rugae did not show a statistical difference in the number of rugae in both males and females. The number of primary rugae was found to be increased in both the genders followed by secondary rugae. Fragmented rugae constituted a smaller proportion of the rugae patterns. This correlates with the previous literature done by Indira *et al.*, which demonstrated that the length remained the same in both the genders [14].

The assessment of rugae pattern in both the groups showed that wavy pattern was predominant, followed by curved and straight patterns. The

Table 2: Number of primary, secondary and fragmented rugae on right and left side of males and females

	Primary rugae		Secondary rugae		Fragmented rugae	
	Right	Left	Right	Left	Right	Left
Males n=30	4.4±0.8	0.45±0.76	3.34±0.47	1.34±0.64	0.25±0.17	0.32±0.05
Females n=30	4.68±0.47	0.98±0.54	4.11±0.56	1.43±0.21	1.22±0.21	0.8±0.34

Table 3: Length of the rugae in males and females on right and left side

Sex	>10 mm	5-10 mm	2-5 mm	Total
Male	98	129	16	243
Female	93	134	29	256
Chi-square test	0.241			
p	0.254			

Table 4: Difference in the pattern of rugae in males and females

Patterns	Gender	N	Mean	SD	P value
Wavy	Male	25	25.32	6.11	0.124
	Female	25	22.12	8.2	
Curved	Male	25	13.02	8.20	0.4236
	Female	25	11.53	4.24	
Straight	Male	25	6.25	4.24	0.2205
	Female	25	7.45	2.46	
Circular	Male	25	3.2	1.55	0.0100
	Female	25	1.1	2.57	
Unification type (diverging and converging)	Male	25	4.2	6.34	0.0010
	Female	25	11.2	9.83	

SD: Standard deviation

circular pattern was few in number and unification pattern were present in four casts among 60 patients. This correlates with the previous studies study done by Kapali *et al.* on the assessment of pattern [15]. Few studies demonstrated that wavy pattern is predominant in females. His could be due to the interobserver variations in the analysis of ruggae patterns.

The three main methods used in the field of forensic are the visual, fingerprints and dental characteristics. In numerous instances, these methods may not be totally effective or conclusive [16]. Many investigations dealing with aircrafts and bomb explosions leads to loss of evidence, and human dentition become the prime method of determining the individuality [8,9,17,18]. The use of palatal rugae serves as an important aid in forensic identification as they are placed in a much internal position and are insulated from heat by the tongue and buccal mucosa [19]. The uniqueness and individuality of the palatal configuration furthers support rugoscopy as a useful tool in forensic science. The rugae remain stable thought the life of an individual in terms of number and morphology except in the case of orthodontic tooth movement, trauma, extreme finger sucking, persistent pressure, which may modify the alignment.

In the light of these results, there is no statistical significance in the number of rugae in males and females. However, the unification pattern

was much higher in females and males demonstrated a significantly higher wavy patter. Thus, palatal rugae pattern are definitely a sufficient characteristic to discriminate between the genders supporting the hypothesis on the uniqueness of the palatal rugae, which could serve as a tool in forensic identification. Further studies with larger samples may be indicated to substantiate the results of this study.

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