Evaluation of Palatal Rugae Pattern in Identification and Sex Determination in Indian Children

Prashant Babaji¹,², Siddik Abdul Jalal²,³, Shashibushan Kukkalli Kamalaksharappa¹,²

¹Professor, Department of Pedodontics, Sharavathi Dental College, Shimoga, Karnataka, India.
²Rajiv gandhi University of Health Sciences, Bangalore, Karnataka, India.
³Post-graduate Student, Department of Pedodontics, Sharavathi Dental College, Shimoga, Karnataka, India.

Author to whom correspondence should be addressed: Dr. Prashant babaji, Department of Pedodontics, Sharavathi Dental College, Sagar Road, Shimoga, Karnataka state, India. E-mail: babajipedo@rediffmail.com.

Academic Editors: Alessandro Leite Cavalcanti and Wilton Wilney Nascimento Padilha

Received: 05 January 2018 / Accepted: 16 March 2018/ Published: 23 March 2018

Abstract

Objective: To analyse the role of palatal rugoscopy in person identification and sex determination. Material and Methods: The study group consisted of 30 children having mixed dentition within the age range of 8-15 years. Based on the length of the rugae, it was classified as primary (>5mm), secondary (3-5mm) and fragmentary (<3mm) and according to shape, (straight, curve, circular and wavy). Association between rugae patterns and sexual dimorphism were tested and statistically analysed using Chi-square test and stepwise discriminant function analysis with statistical software SPSS version 17.0. Results: Results of the present study indicates that there was higher primary rugae patterns (p>0.05) among boys over girls (boys - 224 and girls - 213) and circular rugae pattern and secondary rugae were more among girls (88) over boys (56) (p<0.05). Converging unification pattern was more among boys (17) over girls (11), whereas diverging pattern was more among girls (19) over boys (13), but there was no difference for wavy and curved patterns between boys and girls. These results were confirmed with standardized canonical discriminant function coefficient test. Conclusion: The present study hypothesizes the uniqueness of the rugae pattern in person identification as no two palates showed similar type of rugae in either of the genders. Palatal rugae revealed a specific pattern in unification among boys and girls. Discriminant function analysis enabled sex determination of individuals.

Keywords: Forensic Anthropology; Forensic Dentistry; Sex Determination Analysis.
Introduction

Human identification is one of the major fields of study in forensic science because it deals with the human remains and aims at establishing the identity. Dental investigation in human identification remains one of the most reliable and frequently applied methods by forensic odontologist, predominantly by the comparison of antemortem and postmortem records. Forensic dental identification mainly involves determining gender, age, ethnic background, community etc of the individual [1].

Forensic odontology is a speciality in dentistry, which occupies a primary place within the total spectrum of methods applied to medico legal identification. DNA, fingerprint and dental record comparisons are the most commonly used scientific methods of forensic identification. Constraints to the use of fingerprints occur in situations where the hands are charred or mutilated. Though teeth are more durable, it is however not practical to employ them in identifying the edentulous persons. A useful method of human identification in these circumstances is by examining the palatal rugae pattern (palatal rugoscopy) [2].

Palatal rugoscopy i.e study of palatal rugae is one of the simple technique used by a forensic odontologist in human identification. Palatal rugae also called as rugaepalatinae or plicaepalatinaetransversae refers to a series of transverse ridges on the anterior part of the palatal mucosa on each side of the median palatal raphe and behind the incisive papillae. The anatomic position of these transverse ridges aid in oral swallowing, suction in children, taste perception and participate in speech specially ‘s’ and ‘sh’ phonemes. In clinical dentistry due to the stable nature of the palatal rugae it aids as a landmark during orthodontic treatment, during cleft palate surgeries, palatal prosthesis and medico legal identification [1].

Palatal rugae have been equated with fingerprints and are unique to an individual. It can be of special interest in edentulous cases and also in certain conditions where there are no fingers to be studied, such as burned bodies or bodies that underwent severe decomposition [3].

In addition, rugae pattern may be specific to racial groups, facilitating population identification, which is essential in mass-disasters. Even relatively similar population groups show differences in rugae pattern. Racial profiling using intraoral features other than the teeth may have relevance in odonto-stomatological identification in India where, credible dental anthropological data is negligible [4].

Rugae can resist the incidents of fire and high impact trauma and can also resist decomposition upto 7 days. Thus the objective of the present study was to record the distribution of the predominant rugae pattern in Shimoga population and to compare the distribution of these parameters between males and females to know if gender determination is possible.

Material and Methods

Sampling
Thirty school children comprising of 15 males and 15 females between the age group of 8-15 years were included for the present study from the Outpatient Department of Pedodontics, Sharavathi Dental College, Shimoga, India. All subjects were healthy individuals free of congenital anomalies, inflammation, trauma or orthodontic treatment. The purpose of this study was explained to the subjects and ethical clearance was obtained from institutional ethical committee.

The impression of their maxillary arch was recorded using alginate and models were prepared immediately by pouring dental stone in the impressions. The rugae were delineated using a sharp graphite pencil and recorded according to the classification given by Thomas and Kotze [5] (Figure 1).

Each rugae was measured on right and left side of mid-palatine raphe. Measurement was made with divider and then it was translated into millimetres using scale. Based on the length of the rugae, it was classified as primary (>5mm), secondary (3-5mm) and fragmentary (<3mm) and according to shape, (straight, curve, circular and wavy) (Figure 2).
Additionally, a specific pattern called unification occurs when two rugae have two arms, which are joined either at their origin or termination. A diverging pattern occurs when two rugae begin from the same origin but immediately diverge transversely. A converging pattern occurs when two rugae arise with different origins and converge transversely.

Statistical Analysis

Statistical analysis was performed using SPSS version 17.0 software IBM, Chicago, USA. Association between different sexes was analyzed with Chi-square test for comparison of rugae pattern between both genders. A stepwise discriminant function analysis is also performed between two different sexes for different types of rugae.

Ethical Aspects

The purpose of this study was explained to the subjects and ethical clearance was obtained from institutional ethical committee. Informed consent was obtained from all participants.

Results

Results of the present study indicates that there was significantly higher primary rugae patterns \( p>0.05 \) among boys over girls (boys - 224 and girls - 213) and circular rugae pattern and secondary rugae were more among girls (88) over boys (56) \( p<0.05 \) (Table 1 and Figure 1).

| Gender   | Number | Shape   |
|----------|--------|---------|
|          | Primary rugae | Secondary rugae | Straight | Wavy | Curved | Circular |
| Boys (N=15) | 224 | 83 | 117 | 145 | 46 | 56 |
| Girls (N=15) | 213 | 101 | 115 | 143 | 44 | 88 |

Converging unification pattern was more among boys (17) over girls (11), whereas diverging pattern was more among girls (19) over boys (13), but there was no difference for wavy and curved patterns between both the genders (Table 2). These results were confirmed with standardized canonical discriminant function coefficient test (Table 3).
Table 2. Distribution of unification pattern in boys and girls

| Gender | Unification Pattern | N  |
|--------|---------------------|----|
| Boys   | Converging          | 17 |
|        | Diverging           | 13 |
| Girls  | Converging          | 11 |
|        | Diverging           | 19 |

Table 3. Discriminant function analysis of different types of rugae.

| Standardized Canonical Discriminant Function Coefficients |
|---------------------------------------------------------|
| Function                                               |
| 1                                                      |
| PriRug                                                 | -0.078 |
| SecRug                                                 | 1.061 |
| Straight                                               | -1.305 |
| Wavy                                                   | -0.817 |
| Curved                                                 | 1.295 |
| Circular                                               | 1.18  |
| Conv                                                   | -0.401 |
| Diverg                                                 | 0.147 |

| Structure Matrix                                       |
|--------------------------------------------------------|
| Function                                               |
| 1                                                      |
| Circular                                               | 0.431 |
| SecRug                                                 | 0.324 |
| Conv                                                   | -0.178 |
| Diverg                                                 | 0.178 |
| PriRug                                                 | -0.115 |
| Straight                                               | -0.037 |
| Wavy                                                   | -0.055 |
| Curved                                                 | -0.029 |

Primary rugae pattern was predominant compared to secondary rugae and among shape, wavy (Boys 9.7 and Girls 9.5) was more followed by straight (Boys 7.8 and Girls 7.7) and less common for curved and circular type (Boys 3.1 and Girls 2.9)(Boys 3.7 and Girls 5.9). Mean unification pattern was found to be (1.1) for converging type and (0.9) for diverging type for boys (Table 4 and Figure 1).

Table 4. Comparison of rugae types between boys and girls.

| Rugae       | Males Mean  | Males SD | Males Range | Females Mean | Females SD | Females Range | Mean Diff t | p-value |
|-------------|-------------|----------|-------------|--------------|------------|---------------|-------------|---------|
| Number      |             |          |             |              |            |               |             |         |
| Primary rugae | 14.9       | 1.5      | 12 - 18     | 14.2         | 0.7        | 13 - 15       | 0.7         | 1.74    | 0.10   |
| Secondary rugae | 5.5       | 0.7      | 4 - 7       | 6.7          | 0.6        | 6 - 8         | -1.2        | 4.89    | 0.00** |
| Straight     | 7.8         | 0.6      | 6 - 8       | 7.7          | 0.7        | 7 - 9         | 0.1         | 0.56    | 0.58   |
| Wavy         | 9.7         | 0.8      | 9 - 12      | 9.5          | 0.5        | 9 - 10        | 0.1         | 0.53    | 0.60   |
| Curved       | 3.1         | 1.0      | 1 - 4       | 2.9          | 0.7        | 2 - 4         | 0.1         | 0.43    | 0.67   |
| Circular     | 3.7         | 0.7      | 3 - 5       | 5.9          | 1.1        | 4 - 7         | -2.1        | 6.49    | 0.00** |
| Shape        |             |          |             |              |            |               |             |         |        |
| Unification  |             |          |             |              |            |               |             |         |        |
| Converging   | 1.1         | 0.4      | 1 - 2       | 0.7          | 0.5        | 0 - 1         | 0.4         | 2.68    | 0.01*  |
| Diverging    | 0.9         | 0.4      | 0 - 1       | 1.3          | 0.5        | 1 - 2         | -0.4        | 2.68    | 0.01*  |

Unpaired t test: *p<0.05; **p<0.001.
Discussion

Since we entered the new millennium, our society is daily facing multiple challenges in every conceivable area. The most important role of a forensic dentist is the identification of diseased individuals with oro-dental remains in tragedies, disasters, and massacres. Human identification is the mainstay of civilization, whether in living or dead conditions, and the identification of unknown individual has always been of paramount importance to our society. Human identification is based on scientific principles, mainly involving dental records, fingerprints, and DNA typing. Sometimes, it becomes necessary to apply a lesser known and unusual technique like rugoscopy [6]. Nowadays the study of rugae pattern is gaining importance for various purposes such as in the field of anthropology, anatomy, genetics, orthodontics and prosthodontics [7].

Present study was done to evaluate the rugae pattern on 8-15 years old Indian school children. Results of our study indicates that there was higher primary rugae patterns (p>0.05) among boys over girls (boys - 224 and girls - 213) and circular rugae pattern and secondary rugae were more among girls (88) over boys (56) (p< 0.05) (Tables 1 to 4 and Figure 1). Our results are in accordance to previous study that found higher mean primary rugae pattern in males (7.48+4.5) while secondary (3.88+2.02) among female [1]. Previous researchers also found observation similar to our results [8]. Total rugae found to be more in girls over boys in our study, which is in consistent to previous results [2,9].

In the present study converging unification pattern was more among boys (17) over girls (11), whereas diverging pattern was more among girls (19) over boys (13) (Table 2). These results were confirmed with standardized canonical discriminant function coefficient test (Table 3). Similar results were found in the literature [1]. Some authors observed higher curved and diverging pattern among females while males had higher number of circular and converging type. They also found that arch length is more in males than females [10]. In contrast to our study, the dental literature shows that converging type common among females [11].

In our study primary rugae pattern was predominant compared to secondary rugae and among shape, wavy (Boys 9.7 and Girls 9.5) was more followed by straight (Boys 7.8 and Girls 7.7) and less common for curved and circular type (Boys 3.1 and Girls 2.9)(Boys 3.7 and Girls 5.9). There was no difference for wavy and curved patterns between both the genders (Tables 2 and 4). A previous study showed predominance in wavy (Males=4.82+_92, female=4.74+_1.98) [1]. This result is in correlation to several studies that observed predominance of wavy pattern followed by curved, straight and unification type [2-4,7]. Previous authors concluded that there is no difference in unification pattern among males and females and total number of rugae pattern was not significant. They stated that 78% of accuracy of rugoscopy in sex determination [12].

The literature shows a higher rugue pattern among North Indians compared to South Indians and rugae pattern and unification helps in differentiating the individuals [4]. However, some authors found significant difference in rugae pattern between western and northern Indians. Among
western Indian Wavy pattern was predominant in males and females had straight type whereas North Indian had curved among females [11].

One cross sectional study found that mean number of primary rugae was higher in Aborigines than Caucasians, and most common shape in both ethnic group was wavy and curved form [6]. Some authors studied the rugae pattern on genetically similar groups and found 61-87% accuracy respectively [5,13]. One dental literature observed statistically significant rise in unification pattern among females, whereas they found higher wavy pattern among males [7].

The fragmentary rugae were excluded from the present study since previous studies have shown that simple classification system could be successful and reliable and complex patterns induce more observer errors. There is a need for refining the rugae classification system so that they are reliable and simple to apply [10].

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. Many investigations dealing with aircracts and bomb explosions leads to loss of evidence, and human dentition become the prime method of determining the individuality. 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.

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 [7]. The application of palatal rugae in gender determination could be attributed to low utilization cost, simplicity and reliability [10].

Each individual irrespective of race, sex or identical twins or genetic identical had different rugue patterns type and unification. With use of rugae patterns in antemortam records person identification can be made easy.

The above-mentioned interpretations are precluded by limited sample size and therefore the preceding analysis should only be considered as preliminary. Further research work on larger sample size and application of advanced statistical methods is required to validate its use in forensic application.

**Conclusion**

The mean number and shape of rugae reveal significant differences between the two genders, which may be employed for gender determination. The present study showed that secondary rugae were more common in girls and primary rugae were more common in boys. Palatine rugae are highly unique to an individual similar to fingerprint patterns, and with provision of antemortem cast they can be used for person identification. The uniqueness of rugae pattern in individual is promising.
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