The medicolegal importance of establishing human identity by using dactyloscopy and rugoscopy: A comparative study

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Abstract

Background: Palatal rugae are irregular and asymmetric mesenchymal ridges that extend in a lateral direction away from the incisive papilla and mid-palatine raphe. Their unique characteristics and environmental stability justify their inclusion in forensic investigations. Dermatoglyphics or fingerprint patterns are epidermal ridges, which are genetically controlled and are specific to an individual. Hence they are used as a forensic tool. Objectives: The study aimed to assess the reliability of Rugoscopic and Dermatoglyphic patterns for gender identification. Materials and Methods: A total of 200 subjects were recruited in this prospective study. All subjects were between the age range of 18 and 55 years. The subjects were categorized into 100 males and 100 females. Fingerprint dermatoglyphic patterns were recorded using stamp pad, ink, and A4 size white sheets. A subject’s fingers were pressed onto the stamped ink pad and lightly pressed over a sheet of paper. Obtained patterns were coded and analyzed as per Galton’s criteria into arch, loop, and whorl patterns. Palatal rugae patterns were obtained by making alginate impression material and impression trays. Obtained casts were analyzed for rugae pattern analysis using Kapali’s classification. An unpaired t test was used as a statistical tool. Results: On analyzing dermatoglyphic patterns, the arch pattern was most common among male subjects, whereas loop pattern was found to be most common among females. On rugoscopic pattern analysis, Straight pattern was most frequent among males, whereas the circular pattern was common among females. Conclusion: A statistically significant difference was noted between gender and rugoscopic patterns (P = 0.02) and dermatoglyphic patterns (P = 0.03).

Keywords: Dermatoglyphics, forensic, gender, rugoscopy, tool

Introduction

The word “Forensic” is derived from Latin, Forensis which means forum. On the contrary, Forensic Dentistry is defined as “a branch in Dentistry which for the purpose of solving a case and providing justice deals with proper handling followed by proper evaluation of gathered evidence followed by the final presentation of the obtained findings.” Forum in ancient Rome was a designated place where meetings used to be conducted for discussion of amount along with legal issues. “Comparative identification” is performed to compare both antemortem and postmortem records, whereas profiling is done, in the absence of

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antemortem records to establish age and gender. Thus, profiling is done for probable identification.[9]

Rugoscopy and Dermatoglyphics are forensic identification tools useful in homicides, suicides, or mass disasters. It is also useful in criminal identification and lost persons’ cases. “Dermatoglyphics” is constituted by a study of fingerprints.[2]

“Identity” can be defined as “physical characteristics of a person which may be normal/pathological or functional/psychological.”[9]

Palatal rugae were first identified in 1732 by Winslow. The first identifiable illustration of palatal rugae was done by Santorini (1775). Harrison Allen (1889) was the first person to suggest the use of palatal rugae for the identification of persons. The term “Palatal Rugoscopy” was proposed by Trobo Hermosa in 1932. During embryological development, rugae develop at third months of intrauterine life. They may change in size with age and palatal growth however, its shape remains the same 93% of palatal rugae remain preserved/retained in individuals with third-degree facial burns.[8]

Rugae are important tools in forensic identification that can be used even after an individual’s death due to their intraoral location which even after an individual’s death due to their intraoral location protects them from exposure of excessive heat. Rugae patterns differ between various subjects also, between twin siblings.[9]

Classification of rugae patterns:
1. Gloria et al. (1911) classified rugae patterns into two types: (a) Number of rugae and (b) Extent of rugae in relation to teeth. These were further subclassified into (a) Simple and (b) Developed.[4]

2. Trobo et al. (1932) identified two rugal patterns: (a) Simple type: These were further classified into types A (Point-shaped), B (Line-shaped), C (curve-shaped), D (Angulated), E (Sinuous-shaped) and F (Circle-shaped) and (b) Compound type: In this pattern, two or more simple rugae patterns coexist and are classified as polymorphic or X type.[9]

3. Lysell’s classification (1955): This classification is based on rugae length: (a) Primary (less than and equal to 5 mm), (b) Secondary (measuring between 3 to 5 mm), (c) Fragmentary (measuring between 2 to 3 mm) and (d) Rugae measuring less than 2 mm.[9]

4. Kapali's classification (1997): This classification is based on the shape of rugae as (a) Curved; (b) Wavy; (c) Straight and (d) Circular.[9]

5. Modified Kapali’s classification: According to this classification, rugae patterns are classified into (a) Converging, (b) Curved; (c) Wavy; (d) Straight; (e) Circular and (f) Furcated.[7]

6. The classification proposed by Corea: This classification system is based upon rugae forms: (a) Type I: Posterior-anteriorly directed palatal rugae; (b) Type II: Rugae in a perpendicular position to palatine raphe; (c) Type III: Anterior-posteriorly directed rugae patterns and (d) Type IV: Rugae in different directions.[9]

7. Da Silva classification: This classification system is based on shapes: (a) Simple (numbered from one to six) and (b) compound (the combination of two or more patterns).[8]

8. Classification based on unification patterns of rugae: These are classified into (a) Converging and (b) Diverging.[9]

Various techniques used for palatal rugae identification include the following:

a. Intraoral examination: The advantage of this technique is its ease and cost feasibility, whereas its disadvantage is no evidence or records for further reference.

b. Photographs and impressions: Advantages of this may be- ease in making comparisons on a later date, low cost, and easy method.

c. Computerized analysis: There are various software, for example, RUGFP-ID (Palatal rugae comparison software) for using comparison using superimposing digital images.

d. Overlay print method or Calcorrugoscopy: This method is used for comparisons of images.

e. Stereoscopy: This technique is used for obtaining three-dimensional images of palatal rugae.

f. Stereophotogrammetry: This method aids in accurately determining the position and length of palatal rugae.

Fingerprint patterns develop as epidermal ridges up till twelfth to thirteenth weeks of intrauterine life.[10] The term “Dermatoglyphics” was introduced by Harold Cummins in 1926. It is derived from Greek words Dermato meaning “skin” and Glyphics meaning “carving.”[9]

Fingerprint patterns are unique for each case and these have been considered to be highly sensitive indicators such as intrauterine abnormalities and pathological diseases like oral submucous fibrosis, cleft lip, and palate, malocclusion, and dental caries.[11] Fingerprints have been divided into three groups by Galton (1892): arches, whorls, and loops. FBI classified fingerprint patterns into (a) Arch (subclassified into plain and tented arch) pattern, (b) Loop (subclassified into double-loop, radial, and ulnar) pattern and (c) Whorl (subclassified into plain and accidental) patterns.[11]

According to Michael Kucknas, fingerprints are of three types: (1) Loop; (2) Arch and (3) Whorl pattern.[12]

“Sexual dimorphism” is be defined as “differences in sizes, shapes, and appearances of males and females.” These variations are also applicable to the oral cavity and its surrounding structures. These characteristics can be made useful by comparing antemortem and post-mortem findings and data.[3,4] Palatal rugae patterns are considered to be equivalent to fingerprint patterns in forensics.

These are population-specific and have customization, resistance to post-mortem, stability, and distinctiveness.[3-4]
The study aimed to evaluate the reliability of rugoscopy and dermatoglyphics for gender predilection.

**Materials and Methods**

This prospective study comprised 200 subjects ($n = 100$ males and $100$ females, each). These study participants were randomly selected from the general population aged between 18 and 55 years. The study design was approved by the institutional ethical committee of Hi-Tech dental college and Hospital, Odhisa (Reg No. EIC/513/OD/2018).

**Fingerprint recording method**

Inclusion criteria for the dermatoglyphic pattern were (a) no hereditary diseases, (b) no motor neuron diseases, and (c) no trauma on any of the digits.

Fingerprint patterns were recorded by pressing fingertips on the ink pad and lightly pressing on plain A4 size white paper sheet. Dermatoglyphic patterns were analyzed as per Galton’s criteria into arch, whorl, and loop patterns.

**Method for studying palatal rugae patterns**

Inclusion criteria for the rugoscopic study were (a) presence of incisors, (b) presence of canines, and (c) no history of orthodontic treatment.

Impressions were made by using alginate impression material and impression trays. Obtained casts were analyzed for rugae patterns as per Kapali’s classification into (a) curved, (b) wavy, (c) straight, and (d) circular.

All casts and fingerprint patterns were coded to maintain subject secrecy and individuality.

All obtained data were entered into Microsoft Excel Worksheets and statistical analysis was done using unpaired $t$ test. A $P$ value of $\leq 0.05$ was considered statistically significant.

**Results**

**Dermatoglyphic patterns**

Predominant patterns in decreasing order of frequency in males were an arch pattern followed by whorl and loop patterns, whereas among females were loop pattern followed by whorl and arch pattern [Table 1, Graph 1]. An unpaired $t$ test was applied. Significant differences were observed with a statistically significant $P$ value of 0.03.

**Palatal rugae patterns**

On analyzing palatal rugae patterns, most predominant patterns in decreasing order of frequency were straight (78), wavy (67), curved (54), and circular (25), whereas among females the circular pattern was most frequent (75) followed by curved (46), wavy (33), and straight (22) patterns [Table 2, Graph 2]. On the application of the unpaired $t$ test, a statistically significant $P$ value of 0.02 was obtained.

**Discussion**

Dental professionals play an important role in process of identifying an individual due to unique morphological features of extraoral as well as intraoral structures such as lip print patterns, and rugae patterns. This has prompted the use of methods like analysis of bite marks, Cheiloscopy, rugoscopy for forensic purposes. Development of dermatoglyphic patterns (include hands and feet) takes place by mesenchymal elevations (volar pads) which are responsible for ridge patterns. These are genetically governed structures similar to rugae found on the hard palate. The two important characteristics of fingerprints that describe the identification patterns include; their uniqueness and persistence of the friction ridge skin. The feature of the uniqueness of fingerprint has been incorporated during the development of the skin in the fetus.

Palatal rugae are also known as rugae palatine and plica palatinae transverse. These are found on anterior hard palate lateral to median raphe posterior to incisive papilla. These are prominent even in embryos and are present in a large area on palatal shelves. Analysis of cheiloscopic patterns, rugoscopy, and dermatoglyphics is inexpensive, noninvasive, and effective forensic tools in resource-restricted countries. Hence, their cost-effectiveness along with diagnostic sensitivity proves as useful techniques in forensic odontology.

Keerthi et al. (2018) showed a predominant loop pattern (49.9% cases) which was followed by whorl and arch patterns (40.1% and 10.1%, respectively) in both the genders. However, the soft tissue-based identification process does not work in the case of decomposed bodies. In such cases, the availability of hard tissue structures like rugae serves as useful identification tools.

Buddhika TB (2013) Wijerathne et al conducted a study to evaluate gender-wise diversity of digital dermatoglyphic traits in a sample of Sinhalese people in Sri Lanka. It was observed

| Table 1: Dermatoglyphic patterns (gender-wise distribution) |
|-----------------|----------------|----------------|
| **Patterns**    | **Males**     | **Females**    |
| Arch            | 74            | 26             |
| Loop            | 52            | 48             |
| Whorl           | 58            | 42             |

| Table 2: Palatal rugae patterns (gender-wise distribution) |
|-----------------|----------------|----------------|
| **Patterns**    | **Males**     | **Females**    |
| Curved          | 54            | 46             |
| Wavy            | 67            | 33             |
| Straight        | 78            | 22             |
| Circular        | 25            | 75             |
that the loop pattern was more frequent (59.72%) compared to whorl (35.53%) and arch (4.75%) in the Sinhalese population.[17] Bhardwaja et al. (2004) found that the loop pattern was more predominant than whorls and arches by 35.83%.[18]

Talib Saddam Mohsin et al. (2020) conducted a study on 315 individuals to evaluate the association between dermatoglyphics, blood group, and gender. It was concluded that a significant association between blood group types and gender was present. The nonsignificant association among fingerprint patterns and gender, as well as dermatoglyphic patterns and blood group types, was present.[19]

In this study, on analyzing dermatoglyphic patterns among males and female subjects, it was observed that among males, the most common pattern was the Arch pattern. This was followed by loop and whoor patterns, whereas among female subjects the loop pattern was most frequent which was followed by whoor and arch patterns.

Cheeli et al. (2017) in their study on 800 children age between 8 and 16 years found that forward-directed rugae were the most predominantly found pattern. Rugoscopy has also been found to be an indicator of dental caries along with malocclusion. These investigators found that the curved pattern of rugae shows the early diagnostic indicator for prediction of future caries and development of malocclusion.[20]

Pramanik et al. (2019) in their study on 68 study participants (34 each of males and females) found that curved and forwardly-directed rugae patterns among female subjects (mean = 3.706 ± 0.676 and 2.471 ± 0.992, respectively). However, the perpendicular pattern was most frequently found among male subjects (P = 0.824 ± 0.387).[21]

Babaji et al. (2018) in their study on 50 children in Karnataka (n = 5 males and females each) found high primary rugae patterns in boys compared to girls, whereas the circular and secondary rugae patterns were more predominantly found in females.[22]

Sara Gardezi et al. showed the reliability of the rugae pattern for identification of gender in 456 individuals and concluded that in males wavy pattern of rugae was more common. However, females predominately had curved patterns followed by wavy, straight, divergent, convergent, and circular rugae. Significant dimorphism of gender was observed while comparing the different shapes of rugae and the reliability of gender prediction by rugoscopy was 45.6%.[23]

Oberoi et al. (2017) in their study on 120 children belonging to Jammu and Kashmir population concluded that primary rugae pattern was more in males (mean = 7.62 ± 2.67) than among females (mean = 6.43 ± 1.91).[24] Khajuria et al. (2017) in their study in the Jammu population found that the straight rugae pattern is the most prevalent type in both the genders.[25]

Kalyani et al. (2016) in their study on the Andhra population found that the divergent and wavy rugae pattern was more frequent among male subjects.[26] Goncalves et al. (2015) in their study concluded that changes in palatal rugae patterns occur following orthodontic treatment as was evident by a significant reduction in palatal rugae area after completion of therapy.[27]

Asdullah et al. (2014) in their study on Lucknow based population comprising of 100 study participants comprised of 50 male and female participants. They fell within the age group of 18 to 40 years. They found that the curved and straight palatal rugae patterns were more frequently found among female subjects.[28] Mutilak et al. (2013) in their study among 100 female subjects found palatal rugae patterns observed in decreasing order were wavy (52%), curved (18.6%), straight (10.9%) and undetermined (5.4%). However, no circular patterns were found.[29]

Paliwal et al. (2010) in their comparative study between two population groups belonging to Kerala and Madhya Pradesh found that the wavy rugae pattern was most predominant and was closely followed by curved, straight, united, circular and nonspecific patterns. The straight pattern was found to be most predominant among males belonging to Madhya Pradesh, whereas the wavy form was the predominant pattern in the Kerala population. No significant difference was observed among females of the studied population groups.[30]
In this study, on comparing rugoscopic patterns, it was observed that the straight pattern was most frequent which were followed by wavy, curved, and circular patterns. On comparison, the circular pattern was most frequent among females which were followed by curved, wavy, and straight palatal rugae patterns.

Relevance to primary care
This study was conducted to evaluate the reliability of fingerprints and palatal rugae patterns of individuals in gender identification. Forensic science has an important role in crime resolution and detection and person identification. Information related to gender identification of an individual plays a pivotal role during crime investigation in judicial and legal procedures. Increasing demands for justice and quick action on law enforcement agencies for providing adequate physical evidence linked to crime, has made it necessary for the use of any physical evidence available. The use of dermatoglyphics in conjunction with palatal rugae analysis narrows the field for the identification process and gives better results for gender evaluation. Dermatoglyphic pattern analysis along with Cheiloscopy and Palatal Rugae analysis (Rugoscopy) is the least invasive and cost-effective method that can be used in Forensic Science.[29,30]

Conclusion and Summary
Statistically significant associations were observed between genders and dermatoglyphics and rugoscopy in this study, thus adding to the fact that these can be used as reliable forensic evidence which can be produced in the court of law and can help in aiding justice. However, a larger sample would further help in substantiating and corroborating the study findings.

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Conflicts of interest
There are no conflicts of interest.

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