

Rugae Palatal as a Human-Identification Tool: A Systematic Review

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Abstract:

Objective: This review was intended to look at the accuracy of the palatal rugae in the procces of human identification. **Material and Methods :** Data collection in this paper was done by gathering various scientific literatures in the last ten years. **Results:** The methode used in human identification consist of visual identification, fingerprint, DNA and dental analysis. However, these methods had limitations in certain conditions, especially when mass disasters occur. Visual identification and fingerprint were limited by post-mortem changes related to time, temperature and humidity. DNA identification was less efficient if it was used in mass disaster cases because it required a long identification time and a large amount of cost. Dental analisis became more limited to victims who were found to be fully edentulous or had poor dental records. Rescarchers had found another method namely rugoscopy, was a palatal rugae examination, as one method that could be used in the process of human identification because the uniqueness of the individual morphology consists of patterns that were not the same for each person and its resistance to chemicals, heat, disease and trauma, made the rugae stable and unchanged throughout life. It was known that the palatal rugae pattern does not change after adolescence. **Conclusion :** The process of human identification still one of the biggest challenges in the forensic world, yet the rugoscopy could be one of methods that simplify the human identication.

Keywords: *Palatal rugae, Forensic, Rugoscopy, Human identification*

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Introduction:

Determining human identity is still a difficult challenge in the forensic world, especially in cases of traffic accidents, terrorism, or mass disaster situations. The human identification process is based on comparisons between ante-mortem and post-mortem data from the person. Visual identification, fingerprints, DNA comparisons, and the use of dental records are the most commonly used techniques because they allow fast and reliable identification. However, these techniques have limitations in various situations. Visual identification and use of fingerprints is limited by postmortem changes related to time, temperature, and humidity. DNA comparison tests that have no doubt in giving accurate results, require large costs and take a lot of time if done for many victims. Identification through dental records is usually another effective alternative and does



not require a lot of costs, but has limitations in such situations as if the recording of the condition of the teeth and the treatment is incomplete or even non-existent, or the victim is in full edentulous condition. Researchers have found another method namely rugoscopy, is a palatal rugae examination, as one method that can be used in the process of human identification because the uniqueness of the individual morphology consists of patterns that are not the same for each person and its resistance to chemicals, heat, disease, and trauma, making the rugae stable and unchanged throughout life. It is known that the palatal rugae pattern does not change after adolescence.^{1,2,3}

Historical Review

The application of palatal rugae patterns to personal identification was first suggested by Allen in 1889. Palatal rugae (rugae palatinae or plicae palatinae transversae) are asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate, made from the lateral membrane of the incisive papilla and arranged in a transverse direction from the palatine raphe located in the midsagittal plane. The rugae are anatomical grooves, folds, or wrinkles with irregular, asymmetric ridges extending laterally from the incisive papilla (IP) and the anterior part of the median palatal raphe. Their number, shape, length, width, prominence, and orientation vary on each side of the midline and among different individuals. The palatal rugae never cross the midline and are numbered separately from anterior to posterior on each side of the palate.^{4,5,6}

Palatal rugae appear to possess the features of an ideal forensic identification parameter, that is, uniqueness, postmortem resistance, and stability. Their design and structure are unchanged. It has been shown that the total number of rugae does not change throughout early childhood and adolescence, and changes that occur in rugae are only related to their length. Palatal rugae are also not altered by chemicals, heat, disease, or trauma. If palatal rugae are destroyed, they are reproduced exactly on the same site. Clinical removal of palatal rugae is not permanent, and that when removed, the rugae returned several months later.^{4,8}

Human rugae are formed during the third month or about 12 to 14 weeks of intrauterine life from connective tissue that covers the palatine ridge on the maxillary bone, with development and growth mutually controlled by epithelial-mesenchymal interaction by specific extracellular matrix molecules that are spatiotemporally expressed during development. The rugae will grow during the palatal development, but change less in shape and pattern and are rather well maintained after adolescence. Physiologically the palatal rugae contribute to oral swallowing, food crushing and preventing loss of food from the mouth, perception of taste and tongue position, and to speech and suction in children. Many population-specific studies have been carried out on the rugae patterns in various parts of the world, and is apparently particularly popular in India. Such studies have demonstrated that palatal rugae show unique characteristics even between family members.

Classification of Palatal Rugae^{5,8}

In 1897, Kuppler was the first to study palatal anatomy to identify the appearance of racial anatomy. In 1937, Carrea developed a more detailed and mature study of how to classify palatal rugae. In 1946, Martins dos Santos presented a practical classification



based on rugae location. In 1983, Brinon followed Carrea's study, dividing the palatal rugae into two groups (basic and specific) in a manner similar to that done on fingerprints. Studies have shown that there are no similar rugae patterns between two individuals and that the palatal rugae patterns do not change even due to growth.

Carrea classification:

Depend on the direction, Carrea classified palatal rugae into 4 main types.

- a. Type I: Posterior–anterior directed rugae
- b. Type II : Rugae perpendicular to raphe
- c. Type III: Anterior–posterior directed rugae
- d. TypeIV: Rugae directed in several direction

Lysell classification:

Depend on the length, palatal rugae classified into

- a. Primary rugae: length of more than 5 mm
- b. Secondary rugae: length between 3-5 mm,
- c. Fragmentary rugae: length between 2-3 mm.
- d. Smaller than 2 mm in length are discarded

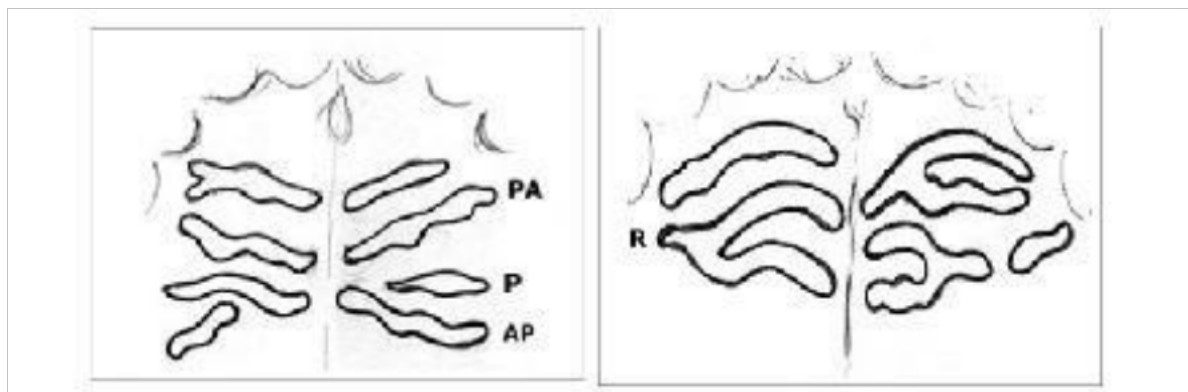


Figure 1 Lysell classification

Lima classification:

He classified rugae into 4 main types:

- a. Punctuate
- b. Straight
- c. Curved
- d. Composite

Trobo classification:

He classified rugae into 2 types:

- a. Simple : Rugae shapes are well defined, and further subdivided into A,B,C,D,E,F
- b. Compound : Rugae were formed by union of two or more simple rugae and classified as type X





Figure 2 trobo classification

Methods

The aim of this systematic review is to look at the accuracy of the palatal rugae in the process of human identification. The objectives of the review were to:

1. Identify the uniqueness of the palatal rugae pattern in each individual
2. Identify epidemiological differences in each palatal rugae pattern
3. Identifying the ease of use of the palatal rugae pattern as a tools of human identification

This study is a systematic review of previously published data and as such did not require ethical approval, as we used no human subjects in the preparation of this manuscript. A comprehensive search was undertaken to identify published reports of studies which discusses the use of palatal rugae in the forensic world. Studies of all designs including descriptive, observational, and experimental methodologies were included in the review.

The inclusion criteria of the literature is in the form of (1) literature published from 2014 to 2019 which examines the uniqueness of palatal rugae in every individual who is at least an adolescence, (2) being, ever or never received dental treatment, (3) research with a different population samples, (4) research that discusses the different patterns of palatal rugae in gender terms.

Result

The initial search identified 657 published studies. These were then divided equally between four authors who screened the abstracts based on the inclusion criteria above. The 251 papers identified in the initial screening were discussed by the authors with the options of rejection, or possible inclusion into the review. At this point, 231 papers were rejected, with 19 for possible inclusion and further qualitative analysis. After further analysis and meetings with the author team, only 9 of the studies were found to fit the inclusion criteria. The search for unpublished works (grey literature) did not yield any studies suitable for inclusion in this review.

The uniqueness morphology of the palatal rugae is proven by Suhartono et al⁴ in 2015 by analyzing 100 dental casts of population in Indonesia with the result that there were no similar palatal rugae patterns between one person and another. Another study was conducted by Syadatullah et al³ in 2019 by analyzing 154 dental casts from King Khalid University College of Dentistry Dental Clinic in Saudi Arabia and found no similarity in the pattern of palatal rugae between one dental cast and another dental cast. The uniqueness between male and female genders was examined by Pangestu et al⁸ in 2016 using 18 male rugae samples and 26 female rugae samples and by Oberoi et al⁹ 2017 with a much larger sample of 1414 dental casts. Both studies have received consistent results in the form of significant differences in male and female palatal rugae patterns. Different results obtained by Kommalapati et al¹⁰ who also conducted

research in 2017 with 200 research subjects consisting of 100 subjects from the Coasta Andhra population and 100 subjects from the Telangana population. This study revealed that there were no significant differences between male and female palatal rugae patterns in both the Andhra population and the Telangana population, but the results obtained were in the form of significant pattern differences between the two populations.

Adisa et al² in 2014 conducted a study using 150 dental casts, which consisted of 50 pairs of dental casts and 50 others were single dental casts, to be identified by 5 dentists. The results of this study in the form of successful identification is various, from 72-96%, depending on the knowledge and experience of the evaluator.

To ascertain concerns about changes in the pattern of palatal rugae as a result of dental treatment, Taneva et al⁶ in 2015 and Gibelli et al¹¹ in 2017 conducted a study using orthodontic patients as research subjects. Each study by Taneva and Gibelli used 69 and 62 dental models, which both obtained results in the absence of significant changes in the pattern of palatal rugae before and after treatment, so the limitations regarding changes in the pattern of palatal rugae along with the dental treatment have been indisputable. Abdalla et al¹² in 2017 also conducted a study with prostodontic patients as subjects, 128 dental casts were used and the results were obtained that the palatal rugae pattern was very unique so that there was no similar pattern and did not change after prosthodontic treatment was performed.

Discussion

Palatal rugae has been widely regarded as unique to the individual in terms of combined patterns of shape, length, width, elevation, number, and orientation. Many studies that are specific to several populations have been conducted to look at patterns of palatal rugae in various parts of the world. These studies have proven that rugae has unique characteristics even among family members. Even among twins, the study found that the pattern of the palatal rugae was similar but not identical.^{4,7}

The use of rugae patterns to identify individuals was first proposed by Allen in 1989. Rugae palatinus appears to have an ideal forensic identification parameter feature, which is unique, resistant to postmortem changes, and stable. The pattern and structure do not change. It has been learned that the number of rugae has not changed throughout early childhood and adolescence, and the changes that occur in rugae only include changes in length. Palatal rugae also does not change due to chemicals, heat, disease, or trauma. If the palatal rugae is damaged, they will regenerate in the exact same place. Clinical removal of the palatal rugae is also not permanent, and the rugae that is removed will re-form several months later.^{5,7}

Concerns about possible changes in the pattern of palatal rugae as a result of growth, orthodontic treatment, palatal expansion, and extraction of adjacent teeth have been widely discussed in previous studies. However, different studies have found that the medial and lateral points of the third rugae are stable in both orthodontic and non-extraction orthodontic cases. Thus, this point can be used as an anatomical reference in the analysis of dental impressions. As for the case of palatal expansion, the pattern of palatal rugae remains the same before or after the expansion is carried out, there are no signs of morphological changes.⁷

Over time, several studies have developed different approaches to assess the unique



anatomy of the palatal rugae. Some researchers consider the classification of rugae morphology through determining the shape and coding system. The accuracy of the procedures reported by different researchers is similar, ranging between 72-96% by Adisa et al., And 76-97.7% by Bansode and Kulkarni. Another method takes the superimposition of palatal rugae silhouettes into other considerations to verify the possibility of correspondence. The percentage of correct identification seems to be higher than the results given by mere comparison, the accuracy reaches 100%. Observers' experience proves to be an important factor in the accuracy of identification, because more experienced operators have a higher level of identification accuracy.^{2,11}

The literature also shows that a research protocol is being developed to determine whether there are statistically significant differences in the use of digital photographs of the palatal rugae for identification purposes. Palatal rugae can be photographed digitally and stored in a data bank as used for digital fingerprint analysis. Identification can be done by matching digital photos of the victim's rugae with photos in the data bank. In fact, unlike lip prints, this rugae data is more likely to obtain ante mortem data, such as data stored in dentist's practice in different forms (dental prints, intraoral photographs, and dentures).^{1,6}

Conclusion

Rugae palatinus is a very important structure in the practice of dentistry and forensics. Palatal rugae has unique characteristics in each person that is stable throughout life. This method needs to be socialized more so that each individual has a jaw print that can be used as ante-mortem data. It has been proven that there is no similar pattern of palatal rugae between one person and another. Therefore, the palatal rugae can be used as reliable guide to the forensic identification.

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