Review Article

Indian Journal of Forensic Odontology
Volume 13 Number 2, July–December 2020
DOI: http://dx.doi.org/10.21088/ijfo.0974.505X.13220.2

Palatal Rugae – An Identification Marker in Forensic Dentistry

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How to cite this article: Pankaj Datta, Shivam Katyal / Palatal Rugae – An Identification Marker in Forensic Dentistry – A Review. Indian Journal of Forensic Odontology. 2020;13(2):5 –11

Abstract

Establishing a person's identity is one of the primary objectives of forensic sciences and can involve a very complex procedure. The records collected from the deceased for identification should be accurate and totally inclusive of objective findings. These records can be obtained in the form of finger prints, DNA profiling and dental records. When a victim is edentulous, information for use in personal identification based on methods available in forensic odontology is much more limited than in the case of dentate victims. Palatal rugae have been considered relevant for human identification due to its stability and individuality, which is comparable to fingerprints. Hence, this article will provide a review on palatal rugae and its applications in forensic dentistry.

Keywords: Palatal rugae; Palatoscopy; Dentures; Calcorrugoscopy.

Introduction

Establishing a person's identity can be a difficult task in cases of traffic accidents, acts of terrorism or in mass disaster situations[1].Visual identification of fingerprints, DNA comparisons and use of dental records are perhaps the most widely used techniques used for rapid, secure and reliable identification. However, visual identification of fingerprints has limitations due to post-mortem changes associated with time, temperature and humidity[2]. The use of DNA profiling is accurate but is expensive and time consuming.

Identification of a deceased person can also be made using various anatomic dental structures. It is based on the comparison of ante-mortem (before death) and post-mortem (after death) records. Although teeth are more durable when compared to other parts of the body but still identification via dental records may prove to be inconclusive because,if any dental treatment is performed after registration of dental records, the models obtained in futuremight vary from previously registered record and identification using these records will not be possible[3].

If the deceased person is edentulous, various identification methods are available, such as comparing the anatomy of the paranasal sinuses and comparing bony patterns seen on radiographs[4]. Furthermore, the victim's dentures themselves, which are usually found inside their mouth or within their homes can provide with more personal information with regard to denture making, denture materials and their unique shapes, for use as post-mortem evidence[5].

Palatal rugae have been considered relevant for human identification due to its stability and is also considered equivalent to the fingerprint as it is unique for each individual. The study of rugae is known as palatoscopy or palate rugoscopy[6]. Rugae patterns have been studied for various purposes such as in the fields of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics, orthodontics and the most important of all for personal identification in the field of forensic odontology[7].

The palatal rugae are the folds of mucosa situated

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in the anterior part of hard palate on each side of the medial palatal raphae and behind the incisive papilla. The pattern of orientation is typical for every individual and is formed by the 12th to 14th week of intrauterine life and remains stable from this time throughout the life until the oral mucosa degenerates at death, with exceptions for those patients who have undergone orthodontic treatment[8].

The application of palatal rugae patterns to personal identification was first suggested by Allen in 1889[9]. Their design and structure remains unchanged and are also not altered by chemicals, heat, disease, or trauma. If palatal rugae are destroyed in case of any injury or surgery, they are re-developed exactly on the same site[10].

In a case report, the identification of a badly burned body was found with a set of dentures close to the site of crime. These dentures were compared to a set of dentures found in thesuspect's house. Plaster casts for both of these maxillary dentures were made and the rugae and mid-palatal raphe were traced on acetate paper and were further superimposed on photographs of the other models. The lateral and frontal tracings matched in both of the plaster casts and the suspect was later arrested[11]. Thus, palatal rugae appear to possess the features of an ideal forensic identification parameter, that is, uniqueness, post-mortem resistance and stability. 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[12].

Development and Anatomy

The rugae was first described in year 1955, where three continuous wavy lines were depicted that cross the midline of the palate[13]. Palatal rugae is also known as plicae palatinae transversae and rugae palatine. Anatomically, in the hard mucosal palate, an anteroposterior thin central groove can be identified, bordered on each side by a crest, known as the palatal raphae.From this crest, three to seven smaller crests emerge which are called palatal rugae(fig. 1)[14].

Fig. 1: Patterns of palatal rugae.

The occurrence, number and arrangement of palatal rugae in mammals are species specific[15]. In humans, they are asymmetrical, which is an differentiating feature of all human beings[16].

The palatal rugae appear in the third month of intrauterine life, from the covering connective tissue in the palatine process of maxillary bone and its development and growth are mutually controlled by epithelial–mesenchymal interactions, where specific extracellular matrix molecules are spatiotemporally expressed during development[17]. In the human embryo, they are relatively prominent, occupying much of the length of the palatal shelves at the time of their elevation, but become less prominent during foetal growth and from the new-born stage onwards are confined to the anterior part of the secondary palate[18].

Palatine rugae do not extend posteriorly beyond the anterior half of the hard palate and they never cross the midline. Anterior rugae are usually more prominent than posterior rugae. The shape, length, width, prominence, number and orientation of palatine rugae vary considerably among individuals. Variation also exists, although to a lesser extent, in the left and right sides of same individual as well.It has been found that there are slightly more rugae in males also the left side of the palate has more number of rugae than the right side[19].

Classification of Rugae

1. Lysell's classification[20]

Depends on length palatal rugaeclassified into;

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

2. Lima's classification[21]

Classified rugae into 4 main types;

- Punctuate
- Straight
- Curved
- Composite

3. Carrea's classification[22]

Depending on direction, classified palatal rugae into 4 main types;

- Type I - Posterior – Anterior direction rugae
- Type II - Rugae perpendicular to raphae
- Type III - Anterior – posterior direction rugae
- Type-IV - Rugae directed in several direction

4. Trobo's classification[23]

1. Simple - Rugae shapes are well defined, and further subdivided into A, B, C, D, E & F(Table 1).
2. Compound-Rugae were formed by union of two or more simple rugae and classified as type X.

Table 1. Palatal rugae classified into 2 types;

Classification	Rugae type	Shape
TYPE A	Point	
TYPE B	Line	
TYPE C	Curve	
TYPE D	Angle	
TYPE E	Sinuous	
TYPE F	Circle	

5. Basauri classification[24]

It distinguishes between all primary rugae, which is more anterior one (labelled as letters) and accessory rugae (labeled as numbers) (Table 2) (Fig. 2).

Table 2.Basauri's classification

Primary rugae Classi? cation	Accessory rugae classi? cation	Rugae anatomy
Type A	1	Point
Type B	2	Line
Type C	3	Curve
Type D	4	Angle
Type E	5	Sinuous
Type F	6	Circle
Type X	7	Polymorphic

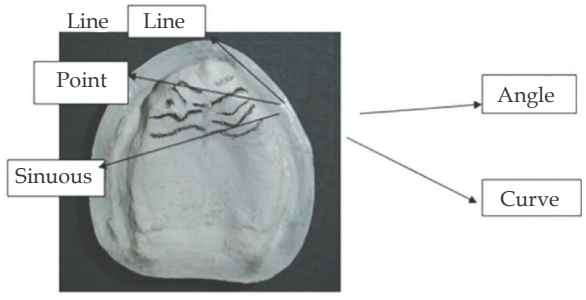

Fig. 2: Anatomy of palatal rugae.

Rugae Pattern Analysis

For rugae pattern analysis, intraoral inspection is mostly useddue to its ease of accessibility. However, it can create difficulties when a future comparative evaluation is required[25]. For more detailed and accurate study as well as the need to preserve evidence, the use of oral photography and oral impressions is increased[26].

Calcorrugoscopy or the overlay print of palatal rugae in a maxillary cast can be used to study the patterns. Previously, the ruga patterns from the dentures were transfered onto clear acetate and then these tracings were superimposed over the photographs of plaster models[5].

Recently, a computer software program was developed, that makes use of the principle that is commonly employed for fingerprint analysis. The method uses digitized images of the palatal rugae on which certain characteristic points are plotted on the medial and lateral extremities

of all rugae. The plotted points were assessed by the software program and information was stored sequentially. This software obtained up to 97% accuracy in identifying individuals in a mock ante-mortem and post-mortem comparison of the palatal rugae[6].

A recent study suggested that rugae patterns are also useful in identifying an individual's race or ethnicity. According to the study, the rugae was examined as straight, curved, wavy and circular in shapes in populations belonging to southern and western India.Straight rugae were more frequently found among southern Indians, curved rugae had a greater incidence among western Indians. Based on rugae shape, they were able to correctly identify an individual's origin in 70% of cases[27]. However, these studies failed to observe any significance of sex determination in rugae pattern.

Stereoscopy has also been used successfully to observe and compare the rugae patterns. By this method, one can obtain a 3D image of palatal rugae anatomy. This is based on an analysis of two pictures taken with the same camera, from two different points, using special equipment.

Another technique is stereophotogrammetry, which by using a special device called "Traster marker", allows for an accurate determination of the length and position of every palatal rugae. Due to its simplicity, price and reliability, it is mostly used in the field of forensics[25].

Limitations Of Palatoscopy

Forensic dentists should be aware that forgery of

rugae patterns can easily be accomplished. A study was conducted which showed, when the rugae were used as the only criterion for identification, only 79% accuracy was demonstrated. It was found that the low level of identification was caused by rugae obliteration during the fabrication of the dentures. This may have occurred during denture adjustment in the palatal region[28]. Rugae variation may occur due to trauma or disease. Therefore, palatal rugae tracings, derived from dentures, do not give the desired accuracy needed for a forensic dental identification.

Dental treatments such as orthodontic tooth movement,extractions,cleft palate surgeries,periodontal surgeries and extraction of impacted canines are some of the concerns that may change the patterns of rugae[29]. The layout and characteristics of rugae are not affected by the eruption or loss of teeth but sometimes may show a slight change in position.30It has also been reported that extractions can produce a local effect on the direction of the palatal rugae[6].

Some events might also contribute to changes in the pattern of rugae, such as thumb sucking in childhood and persistent pressure due to orthodontic treatment.It has been documented that rugae count decreases significantly following cleft repair surgery[31].

Conclusion

Palatal rugae have been equated with fingerprints, in that they are unique to each individual. These can not be used as definitive investigative procedure alone but can be used in conjuction with other anatomic landmarks. The use of palatoscopy is beneficial in cases where fingers or other definitive landmarks for identification cannot be studied, such as in cases of burned or severely decomposed bodies.

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