

## Palatal Rugae: An Overview in Forensic Odontology

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### Abstract

The available literature of palatoscopy is vast and extensive, but this review was considered to throw some light on history, different classifications of palatal rugae patterns and various studies done on palatoscopy. Palatal rugae were first described by Winslow in 1732. The earliest illustration of palatal rugae is by Santorini in 1775. The palatal rugae has been considered relevant for human identification due to its stable, being equivalent to the fingerprint, unique for each individual and study on the identification of persons is called palatoscopy or palatal rugoscopy. Several studies done in the past have revealed and statistically proved that the rugae patterns are highly individualistic and there are differences between genders and populations. Lysell's classification in 1955 is the most important, and it has been used widely in research involving rugae. Finally, palatal rugae can be used as a reliable guide to the forensic identification.

**Key words:** Forensic; Odontology; Palatal rugae.

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### Introduction

Identification of an individual is a prerequisite for certification of death and for personal, social and legal reasons. Human identification is a mainstay of civilization, whether in living or dead, and the

identification of unknown individual has always been of paramount importance to our society.[1]

Personal identification forms an integral part of forensic science especially, when they are dealing with any crime or with mutilated bodies that have undergone damage beyond recognition. Nature has made each and every individual different in his or her own way and personal identification is the proof.[2]

Personal identification is based on scientific principles, mainly involving dental records, fingerprints and DNA comparisons. Sometimes, it becomes necessary to apply a

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lesser known and unusual technique like palatoscopy.[1]

Palatoscopy or Rugoscopy is the name given to the study of palatal rugae in order to establish a person's identity.[2] Palatoscopy can be of special interest in those cases when no fingers are available to be studied such as burnt bodies or bodies in severe decomposition.[3]

Palatal rugae form a pattern in the anterior part of the palate that is considered unique to an individual, analogous to finger prints. Rugoscopy finds application in the field of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics.[3]

In the field of forensic odontology, rugoscopy is still in its infancy. Despite the ongoing problem of describing palatal rugae pattern, quantitatively and qualitatively, their uniqueness to individuals has been recognized as providing a potentially reliable source of identification.[1,4]

The available literature of palatoscopy is vast and extensive, but this review was considered to throw some light on history, different classifications of palatal rugae patterns and various studies done on palatoscopy.

### *History*

Palatal rugae were first described by Winslow in 1732. The earliest illustration of palatal rugae is by Santorini in 1775: a drawing depicting three continuous wavy lines that cross the midline of the palate.[2,5]

The application of palatal rugae patterns for personal identification was first suggested by Harrison Allen in 1889. Palatal rugoscopy was first proposed in 1932, by a Spanish investigator named Trobo Hermosa. Carrea in 1937 published a system of classification and stated that rugae are unique to each individual, of constant shape, and permanent.[6]

Ritter in 1943 studied the rugae of twins and found that the pattern was similar but not

**Figure 1: Palatal rugae seen as asymmetrical and irregular elevations of the mucosa located in the anterior third of the palate**



identical. Hausser in 1950 studied children from birth to nine years old and found that the characteristic picture of the palate does not change as a result of growth. Sassouni in 1957 stated that, no two palates are alike in their configuration and the palate-print did not change during growth.[5]

Leontsinis in 1952 ascertained that rugae do not change from the time they develop until the oral mucosa degenerates at death. Lysell in 1955 found that rugae are, in general, unchanged throughout life and can thus be used to help in the identification of an individual. Aufiero and Cesati 1940 used Carrea's classification and found that systems of classification have no legal value but may be useful in limiting the searches of the archives in identifications.[5]

### *Development of Palatal rugae*

Transverse palatine folds or palatal rugae, 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, arranged in transverse direction from palatine raphe located in the mid-sagittal plane (Figure 1).[1]

The palatal rugae appear towards the third month of intrauterine life, from the covering connective tissue in the palatine process of

maxillary bone, and its development and growth is mutually controlled by epithelial-mesenchymal interactions, where specific extracellular matrix molecules are spatiotemporally expressed during development.[7,8]

The first rugae are distinguished in human embryos of 32 mm CRL (Crown rump length) next to the incisive papilla. Then, in the prenatal stage are relatively prominent, the palatal rugae at birth are well trained with a typical orientation pattern and adolescence acquire the final feature shape of each individual. Once they are formed may experience changes in their size due to growth of the palate, but its shape is maintained.[5,7]

Physiologically the palatal rugae are involved in the oral swallowing and help to improve the relationship between food and the taste receptors in the dorsal surface of the tongue, also participated in speech and in the suction in children.[7]

#### *Palatal rugae as an ideal method of human identification*

The palatal rugae have been considered relevant for human identification due to its stable, being equivalent to the fingerprint and unique for each individual. The study on the identification of persons is called palatoscopy or palatal rugoscopy.[7]

The characteristic uniqueness and genetic basis of the palatal rugae suggest their use in person's identification. Palatoscopy may be used as a necro-identification technique. Palatoscopy can be of special interest in those cases where there are no fingerprints available like decomposed bodies, burned bodies.[2,3]

It is the most valuable technique in aeronautical accidents in order to ensure identification of pilots making use of ante mortem data.[2]

#### *Advantages of palatal rugae in forensic identification*

1. It is preferred because of their low utilization cost, simplicity and reliability,

the study of maxillary dental cast is the most used technique.[2]

2. It is sufficiently characteristic to discriminate between individuals because no two palates are alike in their configuration. Studies of rugae pattern of twins have showed that they are similar, but not identical.[2,3]
3. The palatal rugae do not change during the life of the individual, are protected from trauma and high temperatures for its internal position in the oral cavity, surrounded and protected by lips, cheeks, tongue, teeth and bone, also prosthetic devices are not affected.[1]
4. Once formed, only change is in its length, due to normal growth, staying in the same position throughout the life of a person and even disease, trauma or chemical attacks do not seem to change the shape of the palatal rugae.[1,2]

#### *Gender-wise comparison of palatal rugae patterns*

Several studies done in the past have revealed and statistically proved that the rugae patterns are highly individualistic and there are differences between genders.[2,4,8]

#### *Comparison in total number of palatal rugae in males and females*

Various studies showed that the total number of rugae in males was slightly more than in females. The total numbers of rugae were more on the right side when compared to the left, suggesting intraoral environmental factors contributing to it.

#### *Comparison in different shapes of palatal rugae in males and females*

The predominant shape of the rugae was curved, straight and circular shapes in the females and wavy among the males.

*Comparison in size, predominant direction and unification of palatal rugae in males and females*

Males show more number of primary rugae than the female counterparts. The incidence of forwardly directed rugae were more among the females whereas the backward and perpendicularly directed rugae were more among the males. Comparisons of the unification of rugae both converging and diverging reported that males had more diverging rugae than females.

*Population-wise comparison of palatal rugae patterns*

It has been proven that rugae maintain a constant shape throughout life and may be specific to racial groups facilitating population identification. Hauser *et al.* (1989) compared the rugae pattern of Swazi and Greek populations and found definite difference in the rugae pattern between the two populations.[9] English *et al.* (1988) reported that palatal rugae pattern is sufficiently characteristic to discriminate between individuals and distinctive enough for population based comparison.[5]

*Various classifications for palatal rugae patterns*

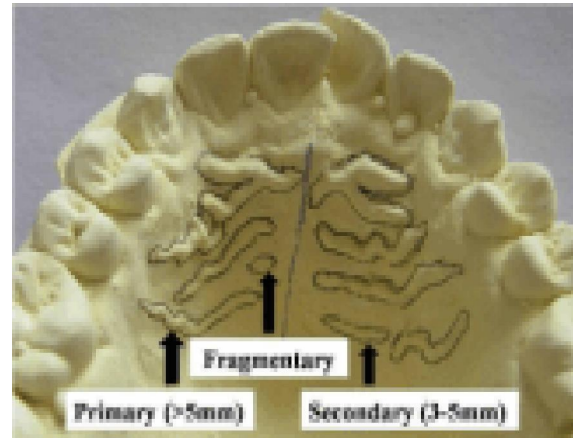
The first system of classification was developed by C. Gorla in 1911. The rugae pattern was categorized into two ways:

1. Specifying the number of rugae
2. Specifying the extent of rugal zone relative to the teeth. Gorla further distinguished two types: simple or primitive and more developed.[10]

Lysell's classification in 1955 is the most important, and it has been used widely in research involving rugae. Rugae are measured in a straight line between the origin and termination and grouped into three categories.[11]

1. Primary:  $\geq 5$  mm
2. Secondary: 3-5 mm
3. Fragmentary: 2-3 mm

**Figure 2: Based on length, rugae are classified into primary, secondary and fragmentary**



Thomas and Kotze in 1983 further detailed the various patterns of primary rugae. The rugae pattern was classified based on their length, shape, direction, and unification.

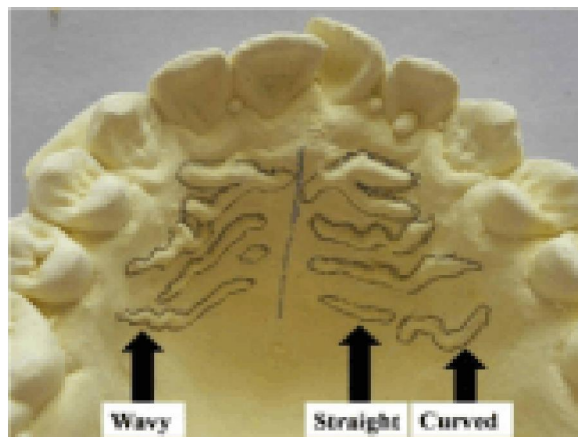
A. Based on the length of rugae (Figure 2):

1. Primary rugae:  $>5$  mm
2. Secondary rugae: 3-5 mm
3. Fragmentary (2-3 mm) and Rugae  $< 2$  mm were disregarded

B. Based on the shapes of individual rugae, classified into four major types (Figure 3):

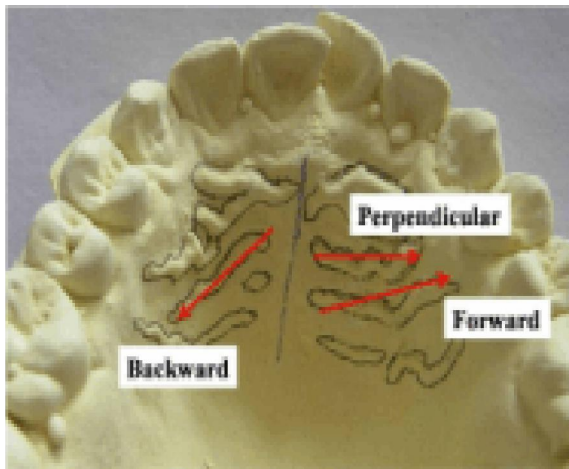
1. *Curved*: They had a crescent shape and curved gently Evidence of even the slightest bend at origin or termination of rugae led to it being classified as curved rugae.

**Figure 3: Based on the shape, rugae are classified into wavy, straight and curved**





**Figure 4: Based on direction, rugae are classified into forwardly directed, backwardly directed and perpendicular rugae**

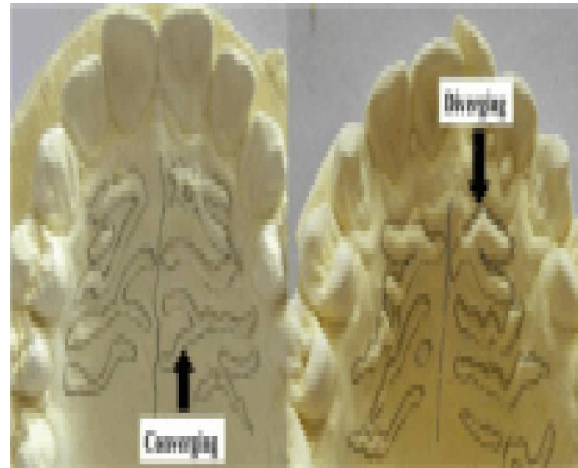


2. *Wavy*: If there was a slight curve at the origin or termination of curved rugae, it was classified as wavy.
  3. *Straight*: They ran directly from their origin to termination.
  4. *Circular*: Rugae that formed from a definite continuous ring were classified as circular.
- C. The direction of the rugae was determined by measuring the angle formed by the line joining its origin and termination and the line perpendicular to the median rugae. Forwardly directed rugae were associated with positive angles, backwardly directed rugae were associated with negative angles, and perpendicular rugae were associated with zero angles (Figure 4).
- D. Unification occurs when two rugae are joined at their origin or termination. Rugae are considered diverging if two rugae had the same origin but immediately branched, whereas rugae with different origins that joined on their lateral portions are considered converging (Figure 5).[12]

The Cormoy system of classification (Pueyo *et al* 1994) is based on the length of the palatal rugae.[13]

1. Principal rugae: > 5 mm
2. Accessory rugae: 3-4 mm

**Figure 5: Based on unification, rugae are classified into converging and diverging**



3. Fragmental rugae: <3 mm

Martins dos Santos classification (Perrella *et al* 2000) is based on the form and position of each palatal rugae. This classification indicates and characterizes the following.[14]

1. One initial rugae; the most anterior one on the right side is represented by a capital letter;
2. Several complementary rugae; the other right rugae are represented by numbers;
3. One subinitial rugae; the most anterior one on the left side is represented by a capital letter;
4. Several sub-complementary rugae; the other left rugae are represented by numbers.

The shape of the palatine rugae was registered according to the classification of Trobo (Pueyo *et al* 1994). This classification also divides rugae into two groups.[10]

1. Simple rugae, classified as ABCDEF, where rugae's shapes are well defined, and
2. Composed rugae, classified as type X, with a polymorphisms variety (these composed rugae is the result of union of two or more simple rugae).

Finally, the Basauri classification is a very easy classification to use. It discriminates between the principal ruga, which is the more anterior one (labeled with letters), and the

accessory rugae, which concern all the remaining rugae (labeled with numbers).[10]

### Conclusion

In recent years analysis of palatal rugae pattern is an important complementary technique for human identification, providing a significant contribution in cases of criminal investigation. Various studies have shown a significant association between shapes and gender; shapes and ethnicity. Thus the palatal rugae can be used as a reliable guide to the forensic identification.

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