

## Rugoscopy – An Emerging Aid For Personal Identification - A Review

### Abstract

Palatal rugoscopy, or palatoscopy, is the process by which human identification can be obtained by inspecting the transverse palatal rugae inside the mouth. The palatal rugae are unique, unchanging, perennial and subject to classification. It appears in the third month of the embryonic period, remaining for the entire life of the individual and for several days after his/her death. When identification cannot be established by fingerprinting or by analysis of dental arches (dental records data), the palatal rugae can be considered as a source of comparative material. This paper reviews the development of rugae, the different classifications and significance of palatoscopy.

### Key Words

Forensic Odontology, Palatoscopy, Rugoscopy Calcorrugoscopy

### Introduction

Forensic odontology can be defined as a branch of dentistry which deals with the appropriate handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of justice.<sup>[1]</sup> In forensic identification, the mouth allows for a myriad of possibilities. Due to the distinctive features of teeth, dental identification is one of the most popular ways to positively identify somebody. In fact, teeth are known to have singular features and possess extraordinary resistance to extreme conditions. These properties enable fast and secure identification processes.<sup>[2]</sup> However at times identification using dental records may prove to be inconclusive, since many antemortem dental records may be inaccurate or incomplete.<sup>[3]</sup> Also, additional dental treatment might have been performed in the time interval between the creation of a dental record and death of the individual.<sup>[4]</sup> In such cases data collected from lips & palate can help in person's identification. The study of lip prints is known as cheiloscopy; and the study of hard palate anatomy to establish someone's identity is called palatoscopy.<sup>[2]</sup> Palatal rugae (PR) also called plicae palatinae transversae and rugae palatine 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.<sup>[5],[6]</sup>

### Historical Overview

The earliest reference to rugae was in an anatomy text by Winslow in 1732 and was first illustrated by Santorini in 1775.<sup>[7]</sup> The use of human palatal rugae was suggested as an alternate method of identification in 1889 by Harrison Allen.<sup>[8]</sup> Many researchers have studied the morphology and the racial differences of palatal rugae.<sup>[7]</sup> Kuppler, in 1897, was the first person to study palatal anatomy to identify racial anatomic features. In 1932, a Spanish investigator called Trobo Hermosa first proposed palatal rugoscopy.<sup>[2]</sup>

### Anatomy & Development of Rugae

Palatal rugae in mammals are transversally running crests, which are exclusively formed by the mucosa of the hard palate except where an ossified base can be distinguished. The occurrence, number and arrangement of palatal rugae in mammals are species-specific.<sup>[9]</sup> Studies conducted on mice has shown that they develop as localized regions of epithelial proliferation and thickening even before the elevation of the palatal shelves. Later fibroblasts and collagen fibres accumulate in the connective tissue below the thickened epithelium and then assume a distinctive orientation. The collagen fibres determine the orientation of the rugae Individual variations in the number and morphology of palatal rugae in man were described in detail by C a r u

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s o (1969). In human embryos, rugae are relatively prominent and occupy most of the length of the palatal shelves at the time of their elevation.<sup>[10]</sup> At the 550 mm stage of embryonic development, there are five to seven rather symmetrically disposed ridges, with the anterior ones beginning at the raphe, the others more laterally. Towards the end of intra-uterine life, the pattern of rugae becomes less regular, posterior ones disappearing and those anterior become considerably more pronounced and compressed. Several studies conducted on children & adults have shown a reduction in mean palatal ridge number with age.<sup>[11]</sup>

Peterková et al. (1987) also defined six stages of individual development of palatal rugae as follows: 1) thickening of epithelium, dipping into mesenchyme – the rugal anlage; 2) levelling of basement membrane and protrusion of epithelium above the surface – the primitive ruga; 3) condensation of mesenchymal cells beneath the top of rugae; 4) formation of bulged fibrous stroma beneath the rugae – the rugal core - covered by thinning epithelium; 5) epithelium of uniform

thickness similar to that covering the interrugal areas – definitive ruga, initial keratinization; 6) the ruga as in adults.<sup>[9]</sup> Controversy still exists about the stability of quantitative and qualitative characteristics of rugae during growth, and the extent of differences between ethnic groups and sexes.<sup>[10]</sup> Hauser et al. have suggested that mean ruga count changes moderately in adolescence, then increases markedly from the age of 35 to 40 years.<sup>[11]</sup> In contrast, Lysell considered that the number of rugae decreased from 23 years of age onwards.<sup>[12]</sup> English et al. noted that the characteristic pattern of the palatal rugae did not change as a result of growth, remaining stable from time of development until the oral mucosa degenerated at death.<sup>[13]</sup> However, some events can contribute to changes in rugae pattern, including trauma, extreme finger sucking in infancy, and persistent pressure with orthodontic treatment and dentures.<sup>[10]</sup>

### Palatal Rugae Classifications

Researchers have found the task of classification a difficult aspect of rugae studies. The subjective nature of observation and interpretation within and between observers poses a problem. Nowadays, there are several known palatal rugae classifications.<sup>[2]</sup> The first system of classification was developed by Gorla in 1911 and was rudimentary. The rugae pattern was categorized in two ways: specifying the number of rugae and specifying the extent of the rugal zone relative to the teeth. In this system, compound rugae of two or more branches were counted as one, whether they were V- or Y-shaped. Gorla further distinguished two types: simple or primitive and more developed.<sup>[14]</sup> However, according to several authors Lysell, in 1955, developed the first classification system for palatal rugae pairs.<sup>[2]</sup> His classification is the most important, and it has been used widely in research involving rugae. In this classification rugae are measured in a straight line between the origin and termination and are grouped into three categories:

Primary: 5 millimeters or more;

Secondary: 3 to 5 mm;

Fragmentary: 2 to 3 mm;

Rugae smaller than 2 mm are

disregarded. This is rather simplified picture of the intricate form that rugae usually present.<sup>[2]</sup>

Several other classifications have been proposed but none have been able to fill all the criteria. The various classifications are those given by Thomas and Kotze. They classified rugae as branched, unified, crosslinked, annular, and papillary, among others. Carrea classified them based on directions.<sup>[14]</sup> Martins dos Santos based it on the form and position of each palatal rugae. Lo'pez de Le'on proposed the existence of a link between a person's personality and palatal rugae morphology. In this manner, there were four known types of palatal rugae: B—bilious personality rugae; N—nervous personality rugae; S—sanguinary personality rugae; L—lymphatic personality rugae. The letters B, N, L, and S, stand for the different personalities. The letters l and r stand for the left and right side of the palate, and are followed by a number, which specifies the palatal rugae number on each side. For instances, a possible rugogram would be Br6; Bl8. It has only historic relevance.<sup>[2]</sup>

Basauri proposed a very easy classification. It distinguishes between the principal rugae, which is the more anterior one (labelled with letters) and the accessory rugae, which concerns all the remaining rugae (labelled with numbers).<sup>[15]</sup> Cormoy classifies palatal rugae according to their size. The form (line, curve, and angle), origin (medial extremity) and direction of each rugae are also described. Possible ramifications are also pointed out. It is a very complete system. However, its use does not lead to rugogram elaboration, which makes the managing and processing of data difficult.<sup>[15]</sup>

### Analysing and recording palatal rugae

There are several ways to analyse palatal rugae. Intraoral inspection is probably the most used and also the easiest and the cheapest. However, it can create difficulties if a future comparative exam is required.<sup>[15]</sup> A more detailed and exact study, as well as the need to preserve evidence may justify oral photography or oral impressions.<sup>[16]</sup> Calcorrugoscopy, or the overlay print of palatal rugae in a maxillary cast, can be used in order to perform comparative analysis.<sup>[2]</sup> Other more complex techniques are also available. By using stereoscopy, for

example, one can obtain a three dimensional image of palatal rugae anatomy. It is based on the analysis of two pictures taken with the same camera, from two different points, using special equipment. Another technique is the stereophotogrammetry which, by using a special device called Traster Marker, allows for an accurate determination of the length and position of every single palatal ruga.<sup>[15]</sup> However, due to its simplicity, price and reliability, the study of maxillary dental casts is the most used technique.<sup>[2]</sup>

### Forensic identification:

Human identification has become fundamental in all aspects of human relationships, at both social and legal levels. Establishment of person's identity can be a difficult task in cases of traffic accidents or acts of terrorism or in mass disaster situations.<sup>[2]</sup> According to Arbenz (1988), the identification requires demonstrating that a person or one of his or her characteristics being examined is the same as observed in a previous situation. An important aspect refers to the distinction between recognition and identification. In Forensic Medicine or Dentistry, it is usually visually conducted by relatives and friends of the victim, thus making this practice highly susceptible to mistakes and failures. The identification is characterized by the utilization of proper techniques and means to find the identity. It may be performed by experienced technicians (law professionals or policemen) or by professionals with differentiated and specific knowledge in biology (forensic medical or forensic dental), with utilization of a nearly unlimited series of techniques and means to determine the human identity. Five elementary technical requirements should be met to assure the applicability of an identification process: unicity, individuality or variability, immutability, perennity (persistence), practicability and possibility of classification. In some patients, a prominent exostosis, the torus palatinus, is found in the palatal midline. Its presence is sometimes recorded in dental notes and, therefore, it can be used as an identification mark. According to Arbenz (1988), dactyloscopy is the only method currently available that meets all these requirements; however, it lacks the quality of perennity, since it disappears after skeletization.<sup>[17]</sup> In forensic identification, use of dental records,

visual identification and fingerprints and DNA comparisons probably are the most common techniques used allowing fast and secure reliable identification. When identification cannot be established by fingerprinting or by analysis of dental arches (dental records data), the palatal rugae can be considered as a source of comparative material<sup>[18]</sup> because they are able to individualize a person, legitimizing an identification process,<sup>[6]</sup> even in extreme circumstances.<sup>[19]</sup> Illnesses, chemical injury or trauma do not seem to modify the palatal rugae structure.<sup>[18]</sup>

### Significance Of Palatal Rugae

Uniqueness of Rugoscopy for personal identification

It is a well-established fact that the rugae pattern is as unique to a human as are his or her fingerprints and it retains its shape throughout life. The anatomical position of the rugae inside the mouth - surrounded by cheeks, lips, tongue, buccal pad of fat, teeth and bone - keeps them well-protected from trauma and high temperatures. Thus, they can be used reliably as a reference landmark during forensic identification.<sup>[14]</sup> Sassouni stated that no two palates are alike in their configuration and that the palatoprint did not change during growth.<sup>[20]</sup> Ritter studied the rugae of twins and found that the pattern was similar but not identical. Hausser 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. Leontsinis ascertained that rugae do not change from the time they develop until the oral mucosa degenerates at death.<sup>[6]</sup> Peavy et al. have shown that slight morphologic alterations occur in the relationship of rugae to teeth during orthodontic tooth movement, but no major alteration in the rugae shape occurs.<sup>[21]</sup>

### Variation of rugae pattern in different ethnic groups:

There seems to be a significant association between rugae forms and ethnicity. Kapali and colleagues studied the palatal rugae pattern in Australian Aborigines and whites. They observed the number, length, shape, direction and unification of rugae. The authors concluded that the mean number of primary rugae in Australian Aborigines was higher than that in whites, although whites had more primary rugae that

exceeded 10 mm in length. The most common shapes in both ethnic groups were wavy and curved forms, while straight and circular forms were least common.<sup>[10]</sup> Shetty and colleagues compared the palatine rugae patterns in Indians with those in a Tibetan population. The results of their study showed that males had more rugae on the right side than on the left side in both populations, Indian males had more primary rugae on the left side than did females and vice versa for the Tibetan population, and Indian males had more curved rugae than did Tibetan males.<sup>[22]</sup>

### Rugae patterns as an adjunct to sex differentiation in forensic identification

Palatal rugae pattern of an individual may be considered as a useful adjunct for sex determination for identification purposes. Many studies have been carried out on the rugae patterns in the populations of Australia, South Africa and Japan.<sup>[4]</sup> Kapali et al in their study did not reveal any significant differences in the number of primary rugae between Australian Aboriginal males and females.<sup>[10]</sup> Saraf A et al in their study found that in terms of the different types of rugae shape, the converging type of rugae were statistically greater in number in females whilst the circular type of rugae were statistically greater in number in males, which contrasts with earlier studies. The use of logistic regression analysis (LRA) enabled highly accurate sex prediction (>99%) when all the rugae shapes were analyzed. It may be concluded that rugae pattern through the use of LRA can be an additional method of differentiation between the Indian male and female and assist with the identification process in conjunction with other methods such as visual, fingerprints and dental characteristics in forensic sciences.<sup>[4]</sup>

### Rugae patterns as identification tool in burn cases

Muthusubramanian et al. did a study to examine the extent of palatine rugae preservation for use as an identification tool in burn victims and cadavers, thus simulating forensic cases of incineration and decomposition. The study results showed that among the subjects with third-degree panfacial burns, 93 percent of the palatine rugae were normal. They concluded that the palatine rugae could be used as a reference landmark during

forensic identification of individual.<sup>[23]</sup> Many victims of natural disasters such as fires and floods, have also been identified by dental means. Many criminal investigations have included the use of dental evidence. Unfortunately, the dentition is not always available for identification. Teeth may be lost due to trauma, heat fracture, or may not be present if the victim was edentulous at the time of the accident.<sup>[7]</sup>

### Problems With Palatoscopy

Palatoscopy is a technique that can be of great interest in human identification. In fact, contrary to lip prints, it is possible to have antemortem data established such as records found in dental practice in different forms (dental casts, old prosthetic maxillary devices and intraoral photographs). However, palatoscopy might not be so useful in crime scene investigations in the linking of suspects to crime scenes. In fact, this kind of evidence is not expected to be found in such circumstances. Another aspect of palatoscopy that one must consider is the possibility of rugae pattern forgery.<sup>[2]</sup>

### Conclusion

Nowadays, palatal rugae patterns are considered a viable alternative for identification purposes. Some investigators aim to assess its feasibility with the aid of a computer and a software program. The results so far are good, but expected to be better. Few studies using palatal rugae as a means of forensic identification are found in literature. However, the idea of rugae being unique to an individual is promising and deserves further investigation.

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