

Review Article

Palatal Rugoscopy: Implementation in Forensic Odontology- A Review

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Abstract:

The aim of this paper is to provide an overview of palatal rugae classification, methods of rugae analysis, and a brief review on its application in forensic odontology & dentistry. Background: The analysis of the teeth, fingerprints and DNA comparison, are probably the most commonly used techniques, allowing fast and secure identification processes. However, these techniques cannot always be applied, in some cases, e.g Burn, trauma, edentulous cases etc, it is necessary to apply different and less known techniques. We conclude that the palatal rugae are very important in dental and forensic practice and can be used to evaluate the dental movements, as they remain stable over a person's life. In addition, show a significant association between shapes and ethnicity.

Key words: Palatal rugae, Personal identification, forensic odontology, Orthodontic movement.

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Introduction

Human identification is of paramount importance and it is indeed challenging considering the fact that every individual has distinctive trait. This requires a combination of different procedures to individualize a person or an object. "Identity" is a set of physical characteristics, functional or psychic, normal or pathological, that define an individual.¹ In forensic medicine, the main methods of identifications used are the DNA test, retina, fingerprints and dental characteristics. DNA testing is the gold standard in forensic science but it is very

costly and cannot be conducted for everybody. In many instances, one or all of these methods may not be totally effective or conclusive. Many criminal investigations and victims of aircraft accidents have been identified by their dentition. Thus the use of human palatal rugae has also been suggested as an alternative method of identification. Forensic odontology involves participation of a dental surgeon in assisting legal and criminal issues.² Rugae are not damaged from trauma due to their internal position in the oral cavity and are insulated from heat by tongue and buccal fat pads.³ In one study, it was reported that no two palates

are alike in their configuration and that the palatal print did not change.⁴ In twins also, the studies indicated that the patterns may be similar but not identical.² So the aim of this paper is to provide an overview of palatal rugae classification, methods of rugae analysis, and a brief review on its application in forensic odontology & dentistry.

Events contributing to changes in Rugae pattern^{5,6}

- Finger sucking in childhood
- Persistent pressure due to orthodontic treatment
- Local effect on lateral rugae after tooth extraction (mainly effects the lateral part of rugae)
- Changes in the lateral edge of the rugae with orthodontic tooth movement

Historical Background

Rugae were first described by Winslow in 1732. The earliest illustration of Palatal rugae was probably by Santorini in 1775, wherein he put a drawing depicting 3 wavy lines crossing the midline of palate. The first palatal classification system was put forth by Gorla in 1911. The first suggestion for the use of palatal rugae as a method of personal identification was suggested by Harrison Allen in 1889.⁷ The term "Palatal rugoscopy" was proposed in 1932, by a Spanish investigator named Trobo Hermosa.⁸ Embryologically, Palatal rugae appears around the 3rd month of intrauterine life from the covering of connective tissue in the palatal process of maxillary bone. Once formed they may experience changes in their size due to growth of the palate, but its shape is generally maintained.⁵

Relevance of Palatal Rugae in Forensic Odontology:

Palatal rugae analysis may serve as an important aid in forensic odontology as

they remain consistent in shape, pattern, direction & unification throughout the life of an individual except change in their size with growth of the palate. They are well protected from heat, chemicals & trauma due to their internal position. In a study conducted by Muthusubramanian et al. it was found that among the subjects with third-degree panfacial burns, 93 percent of the palatine rugae were normal. The authors observed no changes in the color or surface anatomy of the palatine rugae in 77 percent of the human cadavers. They concluded that the palatine rugae could be used as a reference landmark during forensic identification of an individual.⁹

Relevance of Palatal Rugae in Dentistry¹⁰

- **Landmark in Orthodontic treatment:** Serve as suitable reference points from which the clinician can derive the reference planes necessary for longitudinal cast analysis. Positional changes of posterior teeth in the anteroposterior direction are relevant to the diagnosis and correction of sagittal occlusal abnormalities and arch length discrepancies.
- **Palatine rugae in speech and palatal prostheses:** Pronunciation of certain letters e.g, "S", "Sh" requires contact of the tongue to palatal rugae. Palatography frequently has served as the basis for determining the shape of the anterior palatal vault most conducive to satisfactory sound articulation.
- **Palatal vault shape:** Patients whose speech is sensitive to a changed relationship of the tongue to a palatal prosthesis may require surface texture to orient the tongue. The palatine rugae often can serve as a cue. Because the lack of texture on the palatal portion

of a complete denture can impede proper articulation, one solution is to add palatine rugae. Unfortunately, the addition of rugae to a prosthesis is not a foolproof method of eliminating speech problems. Landa reported that rugae in dentures are ineffectual or sometimes detrimental to speech if they add unnecessary thickness to the anterior palatal region.

• **Antero-posterior tooth movement:** Hoggan and Sadowsky investigated the use of the palatine rugae as reference points for measuring tooth movement in a manner comparable with cephalometric superimpositions and concluded that palatine rugae could be used reliably to assess anteroposterior tooth movements.¹¹

• **Palatine rugae in cleft palate patients:** Early diagnosis of submucosal cleft palate is important. In children too young to tolerate nasendoscopy and videofluoroscopy, the diagnosis depends on the patient's clinical history and intraoral examination findings. Kratzsch and Opitz investigated the relationship of palatine rugae to points (landmarks) and distances on the cleft palate during the period from birth to the time of early mixed dentition. The results of their study indicated that a comparison of distances from the palatine rugae with distances between equivalent points revealed the changes that occurred in the anterior palate during various stages of orthodontic therapy and growth.¹²

Classification:

1. The first system of classification was developed by Gorla (1911).¹³ The rugae pattern was divided into two types-

- Specifying the number of rugae
- Specifying the extent of rugal zone relative to the teeth
- Further distinguished rugae into 2 types-
- Simple or Primitive
- More developed

2. By Trobo (1932)¹⁴

Palatine rugae were divided into two groups:

- **Simple rugae:** Where rugae shapes are well defined and divided further as Type A, B, C, D, E, F (Figure 1)

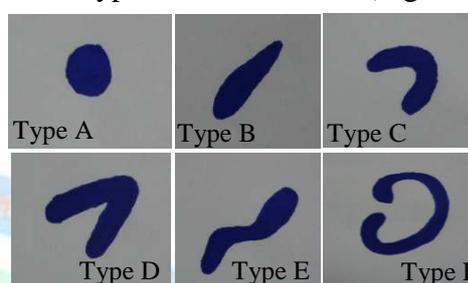


Figure 1: Different shapes of simple rugae

- **Compound rugae:** Rugae are formed by the union of two or more simple rugae and were classified as "Type X" or Polymorphic type.

Classification Rugae type

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

3. According to Lysell (1955):¹⁵ Palatal rugae were classified depending on its length

- Primary: 5mm or more
- Secondary: 3-5mm
- Fragmentary: 2-3mm
- Rugae smaller than 2mm are disregarded

4. By Kapali et al(1997):¹⁶ Based on shape of Palatal rugae (Fig. 2)

- Curved
- Wavy
- Straight
- Circular

5. Modification of Kapali's classification (Figure 2)¹⁸

- Converging
- Curved
- Wavy
- Straight
- Circular
- Furcated

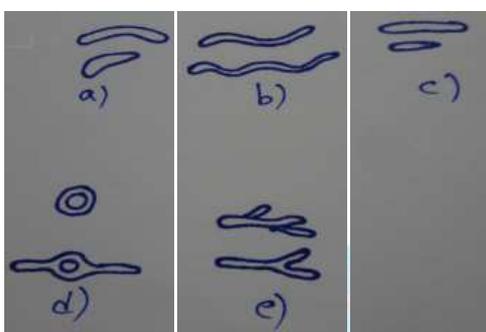


Figure 2: a) Curved; b) Wavy; c) Straight; d) Circular; e) Furcated

6. Carrea classification:¹⁷ based on form of the palatal rugae

- Type I: Posterior-Anterior directed rugae
- Type II: Rugae perpendicular to raphe
- Type III: Anterior-Posterior directed rugae
- Type IV: Rugae directed in several directions

7. Martins dos santos classification:¹⁷ Based on form and Position of each palatal rugae

One initial rugae; the most anterior one on the right side is represented by a capital letter

Several complementary rugae; the other right rugae are represented by numbers

One subinitial rugae; the most anterior one on the left side is represented by a capital letter

Several subcomplementary rugae; the other left rugae are represented by numbers

Rugae type	Anterior position	Other positions
Point	P	0
Line	L	1
Curve	C	2
Angle	A	3
Circle	C	4
Sinuuous	S	5
Bifurcated	B	6
Trifurcated	T	7
Interrupt	I	8
Anomaly	An	9

8. Da Silva Classification:¹⁷ Based on shape

Palatal rugae classified into two types-

- Simple: Numbered from 1-6
- Composed: Resulting from combination of 2 or more rugae patterns

Classification Rugae type

Classification	Rugae type
1	Line
2	Curve
3	Angle
4	Circle
5	Wavy
6	Point

9. Basauri Classification:¹⁷

It differentiates between the principal rugae, which is the more anterior one (Labelled with letters) and the accessory rugae, which consists of all the remaining rugae (Labelled with numbers). The rugogram is elaborated beginning from the right side of the palate.

10. Thomas and Kotze classification (Most accepted classification) (1983)¹³: Proposed detailed classification consisting of the following--

- Rugae dimension and Prevalence-
 - Length- determined according to the latest rugal dimension and is classified as Primary, Secondary and Fragmentary rugae.
 - Prevalence- Rugae is determined by counting and recording the number in each category (Primary, Secondary and fragmentary) and not the total number on each side.
 - Area- determination of the surface area of primary rugae
- Primary rugae details-
 - These can be described as annular, papillary, crosslink, branches, unification, breaks, unification with non-primary rugae
- Rugae pattern dimensions-
 - Distance between most anterior point on incisive papilla and most anterior point on rugae pattern regardless of the side.
 - Distance between incisive papilla to posterior border of last primary or secondary rugae.
 - Distance between incisive papilla to posterior border of last rugae (including fragmentary).
- Angle of Divergence-
 - Measured in degree between the line formed by the medial palatal raphe and line joining incisive papilla with the origin of most posterior primary or secondary rugae on one side of the palate.
- Dental arch and palate dimensions-
 - Width- Line joining the tips of mesiopalatal cusp of permanent maxillary first molar or the deciduous second molar is used to project a point below and perpendicular to it on the

Principal rugae	Accessory rugae	Rugae anatomy
A	1	Point
B	2	Line
C	3	Angle
D	4	Sinuous
E	5	Curve
F	6	Circle
X	7	Polymorphic

gingival margin to determine the width.

- Depth- point below and perpendicular to line joining the tips of mesiopalatal cusp of maxillary permanent first molar or the deciduous second molar on the mid-palatal raphe is used to determine the depth.
- Centre- Perpendicular distance between the line joining the tips of mesiopalatal cusp of maxillary permanent first molar or the deciduous second molar and the point on the mid-palatal raphe determines the center.

11. Rugae unification pattern classification (Figure 3):¹⁹

- Converging
- Diverging

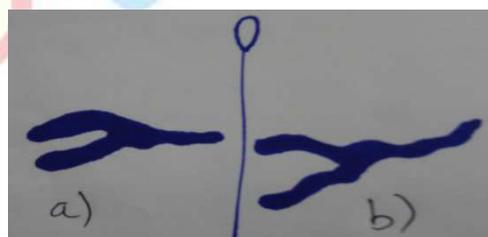


Figure 3: a) Diverging; b) Converging

12. Classification based on orientation of rugae in relation to mid palatal raphe (Figure 4):²⁰

- Forward
- Right angle
- Backward
- **Intra-oral examination:** Most commonly used technique
- Advantages: Easy to perform and cost-effective

- Disadvantages: No records exist with this method which makes future comparison difficult.

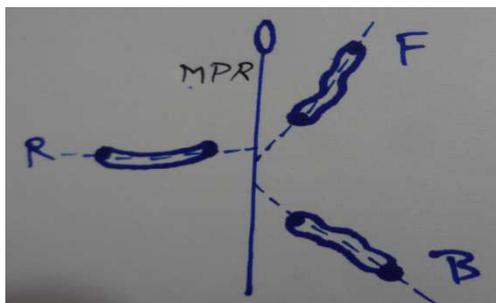


Figure 4: F- forward, R- right angle, B- backward, MPR-Mid palatal Raphe

➤ **Photographs and Impression of maxillary arch:**

- Advantages: Futures comparisons can be made, easy to perform and cost-effective

➤ **Computer software programs:**

- Superimposition of various digital photographs for comparing rugae pattern can be Performed using various computer softwares e.g, RUGFP-ID, Palatal Rugae Comparison Software (PRCS Version 2.0).

➤ **Calcorrugoscopy or Overlay print:**

- Can be used to perform comparative analysis

➤ **Stereoscopy:**

- Can be used to obtain the 3-dimensional image of palatal rugae anatomy.

➤ **Stereophotogrammetry:**

- Allows for an accurate determination of length and position of every single Palatal rugae.

Conclusion and Future Research:

Palatal rugae are very important in forensic and dental practice. Various studies show that palatal rugae can be used for personal identification, gender determination, has got wide range of importance in Orthodontics and prosthodontics. Thus the Palatal rugae possess the features of an ideal identification parameter because of its uniqueness, internal position, post-

mortem resistance and stability. Antemortem records of palatal rugae can be obtained in dental practice in various forms (dental casts, Intra-oral photographs, dental prosthesis). So, it is the sole responsibility of dentist and government to maintain these records for future comparisons.

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