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Review Article

PALATOSCOPY-A PROGRESSIVE PERSPECTIVE OF FORENSIC SCIENCE

Sabarigirinathan C[1*], Venkatesh K[2], Meenatshi Muthiah[3], Balasiddharth S[3], Ishwarya B[4], Srinidhi L[4], Periyasamy S[4], Deepiha D[4]

[1]Professor and Vice-principal, Tamilnadu Government Dental College and Hospital, Chennai, Tamil Nadu - 600003, India.
[2]Director (Forensics) Shri JJT University, Rajasthan, India.
[3]Private Practitioner, Chennai, Tamil Nadu – 600003, India.
[4]Post graduate student, Tamilnadu Government Dental College and Hospital, Chennai, Tamil Nadu - 600003, India.

ABSTRACT

Identity is an invaluable entity for every individual. Forensic odontology is a burgeoning branch of forensic medicine which deals with the proper examination, handling, and presentation of dental evidence in a court of law and thus the establishment of individualism has been the prime importance of this relatively petite specialty of dentistry. Despite the development of recent advances in DNA technology, stomatognathic system still offers a rapid and cost-effective approach of identification of human remains. Hence useful information can still be gleaned from the study of palatoscopy, one of the dominant aspect of dental domain due to its distinctiveness of maintaining shape throughout life. This article reviews the significance of palatal rugae in the field of forensic odontology.

Key words:- Forensic Odontology, Individual Identification, Palatoscopy, Palatal Rugae.

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INTRODUCTION

Forensic dentistry requires an interdisciplinary knowledge encompassing all domains of dental science. This specialty plays a vital role in the detection of individuals and solution of crimes with the aid of accurate dental records. Visual identification, fingerprints, DNA comparisons, and the use of dental recognition are perhaps the most common techniques used in this context allowing fast and secure reliable identification.[1] Evident limitations such as postmortem changes, cost and time, make these former methods futile, and thus dental identification supercedes them.

Corresponding Author

Dr. C. Sabarigirinathan
Email : - sabarigirinathandr@yahoo.co.in

Palatoscopy (Rugoscopy) is the study of palatal rugae. Palatal rugae also called as ‘plica palatinae’ or ‘rugae palatine’ are the anatomical folds or wrinkles; irregular, asymmetric ridges of the mucous membrane extending laterally from incisive papilla and the anterior part of the median palatal raphe.[2]Rugoscopy finds application in the field of anthropology, comparative anatomy, genetics, forensic odontology, prosthodontics and orthodontics.[3,4]

Historical Background

Forensic Odontology, as a science, did not appear before 1897 when Dr. Oscar Amoedo wrote his doctoral thesis entitled “L’Art Dentaire en Medecine Legale”.[5] Palatal rugae were first described by

Winslow in 1753. 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 suggestion for the use of palatal rugae as a method of personal identification was suggested by Harrison Allen in 1889. [6] The term "Palatal rugoscopy" was proposed in 1932, by a Spanish investigator named Trobo Hermosa. [7]Studies have demonstrated that no two individuals' rugae patterns are alike in their arrangement and the characteristic rugae pattern of the palate does not change as a result of growth. Ritter.R (1943) in his study had stated that even between twins, patterns are similar but not identical.

Anatomical Aspect

Palatal rugae are formed in the 3rd month in utero from the hard connective tissue covering the bone. The rugae pattern and orientation is formed by about 12th to 14th week of prenatal life and remains stable until the oral mucosa degenerates after death. [8-10] The number of rugae on each side of the palate varies between three and five. The palatine rugae do not extend posteriorly beyond the anterior half of the hard palate and never cross the midline. The anterior rugae usually are more prominent than the posterior rugae. Two thirds of the rugae are curved, and the rest are angular. The last rugae frequently are divided into the medial and lateral parts are not connected and do not continue in their axial orientation. Fragmentary rugae frequently are present, particularly in the posterior half of the rugae territory. The shape, length, width, prominence, number and orientation of palatine rugae vary considerably among people. [11]

Once formed they do not experience any changes except in length, due to normal growth.[11] Investigations have been done on the thermal effect and decomposition changes on the palatal rugae of burnt victims which stated that most victims did not sustain any palatal rugae pattern changes. Furthermore, the capability of palatal rugae to resist decomposition changes for up to seven days after death was noted.[12] Palatal rugae, in addition to being unique to an individual, are protected from trauma by their natural position in the head and insulated from heat by tongue and buccal fat pads,[12] unlike fingerprints which can get destroyed. Despite being protected by their internal position within the head, some events can contribute to changes in rugae pattern, including trauma, extreme finger sucking in infancy and persistent pressure with dentures and orthodontic treatment. [13]

Physiologically, the rugae facilitate food transport through the oral cavity, prevent loss of food from the mouth, and participate in food crushing. Due to the presence of tactile and gustatory receptors, rugae contribute to perception of taste, mechanical food qualities, and tongue position and also participated in speech and in the function of suckling in infants. [14]

It is a well-established fact that anatomical position of rugae retains its shape throughout life and resist decomposition. This is in consistent with the study conducted by Sabet and Abdel. [9, 15] The core within the palatal rugae of humans contains elements that are believed to contribute to the maintenance of its shape. The main structural element contains glycosaminoglycan which by its hydrophilic nature causes the tissues to swell and contributes to the maintenance of the shape of rugae throughout life. Fibroblasts and collagen fibers beneath the thickened epithelium contribute to the stability of palatal rugae. Camargo et al. have referred that in gingival graft surgery, the selection of the palatal donor site should avoid the rugae areas because they may continue in the grafted tissues.

Types of Palatal rugae

1. The first system of classification was developed by Gloria (1911). The rugae pattern was divided into two types:

• Specifying the number of rugae
• Specifying the extent of rugae zone relative to the teeth
• Further distinguished rugae into 2 types:
  a) Simple or Primitive
  b) More developed

2. Lysell classification:

Lysell developed the first classification system for palatal rugae pairs in 1955.

Depending on length of palatal rugae [8], classified into: (Table 1, Figure 1)

- Primary rugae - length of more than 5 mm
- Secondary rugae - length between 3-5 mm,
- Fragmentary rugae -length between2-3 mm.

Smaller than 2mm in length are discarded.

3. Carrea Palatal Rugae Classification (1955)

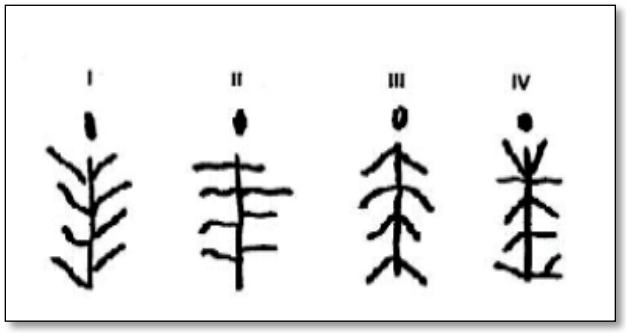

Figure 1: Carrea Classification

4. Trobo's Classification (1932)

Palatal rugae were divided into two groups [10]:

• Simple rugae: Where rugae shapes are well defined and divided further as Type A, B, C, D, E, F (Figure 2)

• 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	Shape
Type A	Point	
Type B	Line	
Type C	Curve	
Type D	Angle	
Type E	Sinuous	
Type F	Circle	

Figure 2: Different shapes of simple rugae

5. Lima classification (1968)
He classified rugae into 4 main types:

- Punctuate
- Straight
- Curved
- Composite

6. Da Silva classification (1938) (Figure 3)

In this classification, palatal rugae are divided into two groups: simple, from 1 to 6 and composed, resulting from two or more simple rugae. They are named according to each rugae number. It is possible to classify each rugae individually (describing its form), but also to describe all the palatal rugae system (describing each ruga type number), making this a difficult classification to use.

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

Figure 3: Da Silva Classification

7. Martins Dos Santos classification (1946) [3]

Based on the form and position of each palatal rugae, this classification indicates and characterizes the Table 2.

- 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 sub initial rugae; the most anterior one on the left side is represented by a capital letter.
- Several sub complementary rugae; the other left rugae are represented by numbers.

8. Basauri Classification (Table 3)

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

9. Kapali et al Classification

Rugae were divided into 4 types based on their shape as:

- Curved: They had a crescent shape and curved gently
- Wavy: If there was a slight curve at the origin or termination of curved rugae
- Straight: They run directly from their origin to termination
- Circular: Rugae that form a definite continuous ring

10. Thomas and kotze classification
a) Rugae dimension and prevalence

- Length - determined according to latest rugae dimension and is classified as primary, secondary or 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 the primary rugae.

b) Primary rugae details

Can be described as annular, papillary, crosslink, branches, unification, breaks, unification with non-primary rugae.

c) 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 the posterior border of last rugae

d) 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 primary or secondary rugae on one side of palate.

e) Dental arch and palate dimensions:

- Width- line joining the mesio-palatal cusp of permanent maxillary first molar or deciduous second molar is used to project a point below and perpendicular to it on the gingival margin to determine the width.
- Depth – point below and perpendicular to line joining the tips of mesiopalatal cusp of permanent maxillary first molar or deciduous second molar on the midpalatal raphe is used to determine the depth.
- Centre – perpendicular distance between the line joining the tips of mesiopalatal cusp of permanent maxillary first molar or deciduous second molar and the point on midpalatal raphe determines the centre.

Table 1. Carrea Palatal Rugae Classification

Classification of Palatal Rugae	Characteristics
Type I	Posterior-anterior directed rugae
Type II	Rugae perpendicular to the raphae
Type III	Anterior-posterior directed rugae
Type IV	Rugae directed in several directions

Table 2. Martin Dos Santos Classification

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

Table 3. Basuri Classification

Primary Rugae Classification	Accessory rugae classification	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

Palatal Rugae Analysis

Intraoral inspection utilizing palatal rugae is one of the most preferred method in forensic identification. Oral photography or oral impressions can be used to analyze the palatal rugae which pose a superlative means in terms of precision and comparison. Stereoscopy can obtain a three dimensional image of palatal rugae anatomy. It is based on examination of two pictures taken with the same camera, from two different points using special equipments. Calcorrugoscopy or overlay print can be used to perform comparative analysis. Stereo photogrammetry which by using special device called traster marker allows for correct determination of length and position of every single rugae.

Superimposition of various digital photographs for comparing rugae patterns can be performed using various computer software. E.g., RUGFP-ID, palatal rugae comparison software (PRCS version 2.0). Lorton (1988) describes in detail about CAPMI (computer assisted post-mortem identification system) software which has the advantages of simplification of data management, ease of learning the program, online help, physical characteristics and free availability of the program. Currently, the principal computer programs are CAPMI4 and WinID2. Limsons and Julian, who compared some points of the rugae patterns using computer software, reported that the percentage of accuracy in recognizing individuals ranged from 92 to 97% based on four computer operators. Though there are

a vast number of techniques; the study of maxillary dental cast is the highly desired one because of their low utilization, cost, simplicity and reliability.

A recent study by Obtam and coworkers states that high precision rates in postmortem identification from palatal rugae can be obtained by straight forward visual comparison of post and ante mortem rugae patterns obtained from dentures. [12]

Limitations of Palatoscopy

Forgery of palatal rugae pattern is possible in various circumstances. In a case report, Gitto et al described a method where palatal rugae were added to a complete denture in order to improve speech patterns in some patients. This process can lead to false identity exclusion due to misleading ante-mortem data. Another concern about palatal rugae voiced by many researchers is the possibility of ruga patterns changing with age and other outside influences. Form, layout, and characteristics are not affected by the eruption of the teeth or their loss, but sometimes palatal rugae adjacent to the alveolar arch slightly change their position after tooth extraction. Furthermore, it has been reported that extractions can produce a local effect on the direction of the palatal rugae and rugae count decreases significantly following cleft repair.

Few studies have stated that some events contributing to persistent pressure such as dentures and orthodontic treatment have led to changes in rugae pattern questioning the reliability of rugoscopy in such circumstances. Almeida et al noted that medial rugae were stable (the first medial ruga, in particular) and found no significant differences, whereas lateral rugae showed significant changes. Bailey et al noted statistically-significant changes in just the rugae of people in the extraction group. Correspondingly, these two studies highlight the discrepancies in the stability of palatal rugae after orthodontic treatment and extractions. Hence further studies are required to validate the use of rugae pattern in individual identification under all external influences.

In addition, we should propose uniform standards and procedures for palatal rugae pattern collection, recording and computer analysis, which is advantageous to the establishment of palatal rugae systems in forensic identifications.

CONCLUSION

Dental evidence plays a major role in establishing the identity of the unknown living victims and deceased individuals with oro-dental remains in tragedies, disasters, massacres, criminal or natural deaths and injuries etc. Palatal rugae have been equated with fingerprints, in that they are unique to each individual. They are of special interest in edentulous cases when teeth are absent as markers for identification purposes and also in certain conditions where fingers cannot be studied, such as in burned or severely decomposed bodies. Despite its drawbacks, palatoscopy presents as an auxiliary along with other discerning methods in establishing identity due to its uniqueness, internal position, and post-mortem resistance which makes it a noteworthy contribution to forensic odontology.

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