



## Updated insights into the role of palatal rugae in gender determination - A systematic review

<sup>1</sup>Dr. Bidyut Chakraborty, <sup>2</sup>Dr. Sonal Saigal, <sup>3</sup>Dr. Ankur Bhargava, <sup>4</sup>Dr. Amit Agarwal, <sup>5</sup>Dr. Vivek Singh, <sup>6</sup>Dr. Ranjeeta Mehta

<sup>1</sup>Associate Professor, Department of Oral Pathology & Microbiology, North Bengal Dental College & Hospital, West Bengal, India

<sup>2</sup>Associate Professor, Department of Oral Pathology, Microbiology and Forensic Odontology, Dental College, Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India

<sup>3</sup>Professor & Head, Department of Oral Pathology & Microbiology, Hazaribagh College of Dental Sciences & Hospital, Hazaribagh, Jharkhand, India

<sup>4</sup>Professor & Head, Department of Oral Maxillofacial Surgery, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

<sup>5</sup>Lecturer, Department of Public Health Dentistry, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

<sup>6</sup>Reader, Department of Oral Medicine & Radiology, Seema Dental College and Hospital, Rishikesh, Uttarakhand, India

**Corresponding Author: Dr. Ankur Bhargava**

### ABSTRACT

**Background:** The distinctiveness of palatal rugae can serve as a means of identifying individuals, much like fingerprints, and can be useful even when variations exist in different populations. However, despite its effectiveness in identification, it is not a reliable tool for determining gender. This investigation examines the controversial use of palatal rugae in gender discrimination.

**Materials and Methods:** The search terms related to palatal rugae and sex determination were utilized to search through several databases, including PubMed Central, SCOPUS, EBSCOhost, and Google Scholar, spanning from 2018 to 2023. After analyzing the abstracts of 102 articles, 5 articles were ultimately included in the study.

**Results:** In this study, 1,248 participants took part, including 638 females and 610 males. Significant variations were detected between the genders in terms of the quantity, length, and configuration of palatal rugae patterns across different studies.

**Conclusion:** During our analysis, we noted that the patterns of rugae on the palate differed between females and males, with males exhibiting a predominant pattern compared to females. However, it should be noted that palatal rugae should not be relied upon solely as a method of gender discrimination.

**Keywords:**

### INTRODUCTION

Palatal rugae are the asymmetrical and irregular elevations on the anterior third of the palate that form transverse folds. These folds consist of approximately 3-7 dense ridges that radiate tangentially from the incisive papilla.<sup>1, 2</sup> Assessment of palatal rugae is considered a reliable method for personal identification when other methods such as DNA analysis, fingerprints, and comparison of ante mortem and post mortem records are unavailable. This method is particularly useful in cases where the body is burnt or decomposed, as well as in edentulous conditions.<sup>2, 3</sup>

The palatal rugae pattern is regarded as a distinctive feature in every individual due to its stability throughout life and resistance to post mortem changes, except for length during puberty. Therefore, palatal rugae have been proposed as an ideal parameter for forensic identification purposes.<sup>3, 4</sup> The use of palatal rugae for identification was first suggested by Allen in 1889, and various studies have since been conducted in this area. However, conflicting results have been reported, with some studies indicating that males exhibit a particular pattern more prominently than females, while others suggest that males and females display a varied pattern and unification, making the use of palatal rugae for sex determination in forensic odontology questionable.<sup>5-7</sup>

Against this backdrop, we conducted a systematic review to assess the role of palatal rugae in gender discrimination for identification purposes in forensic odontology.

## MATERIALS AND METHOD

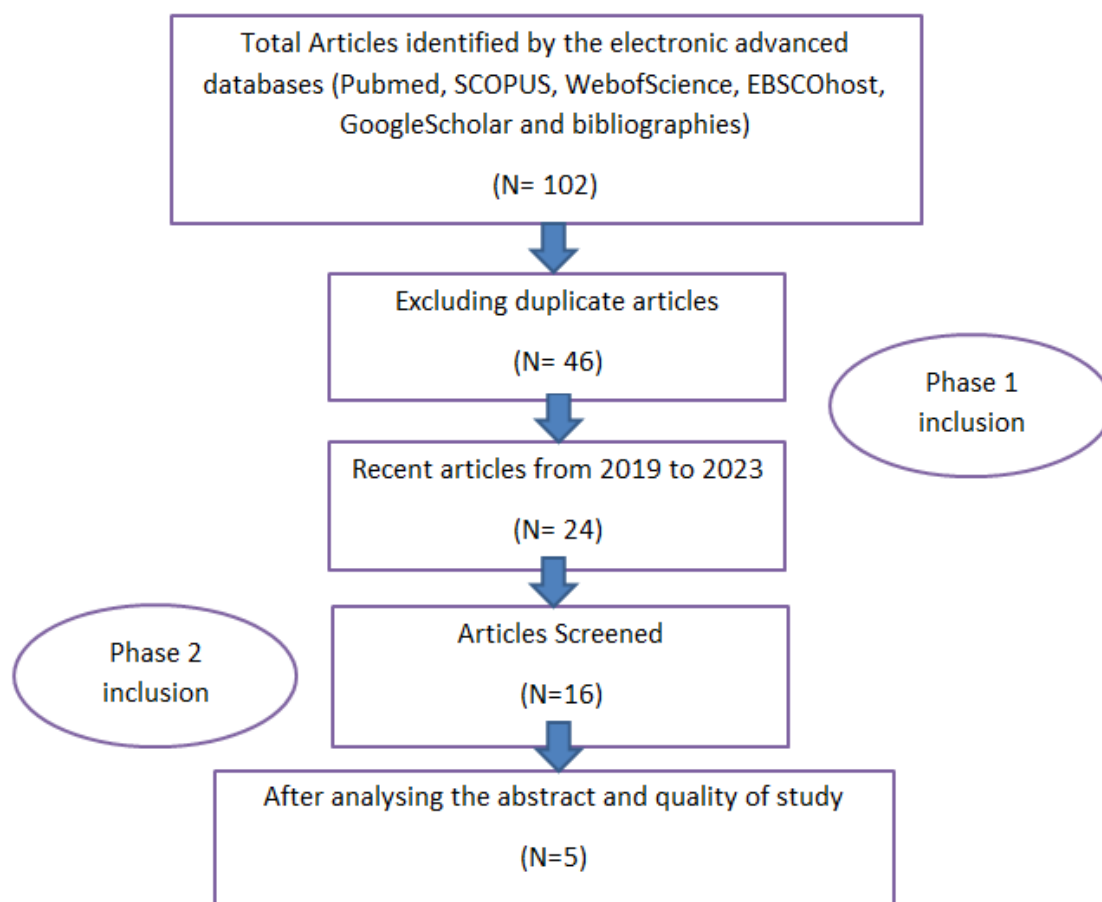
We conducted a comprehensive search of the PubMed Central, EMBASE, EBSCOHOST, and Cochrane databases using the search terms "palatal rugae" and "sex determination" to retrieve relevant studies published from 2019 to 2023. (Table 1) Additionally, we reviewed the reference lists of retrieved articles to identify any other relevant studies.

**Table 1: Keyword Search**

<b>Search Method for all databases</b>	
<b>Search group</b>	<b>Keywords</b>
1	Palatal Rugae OR Rugae palatinae OR Rugae palate OR Palatine rugae OR Palatine ridges OR Palatine folds OR Transverse palatine ridges OR Transverse palatine folds
2	Gender discrimination OR Gender determination OR Sex discrimination OR Gender identification OR Sexual differentiation OR Sex identification OR Gender diagnosis OR Sex diagnosis OR Sexual determination
3	1 AND 2

### **The following eligibility criteria were used for selecting studies:**

Inclusion criteria consisted of human studies conducted from 2018 to 2023 on healthy individuals who had no congenital or palatal abnormality, history of trauma, inflammation, orthodontic treatment, denture use, or surgical procedures in the rugae area. Exclusion criteria consisted of pilot studies, systematic reviews, narrative reviews, editorials, opinions, studies not published in a peer-reviewed journal, studies available only as abstracts, studies published in languages other than english, and comparative observations of palatal rugae. The article selection process is presented in Figure 1.



**Figure 1: Flow chart**

## RESULTS

After reviewing the available literature, it can be concluded that studies examining palatal rugae have found varying patterns in both males and females, with differences in the proportion of wavy, curvy, circular, and straight rugae, as categorized by the Thomas and Kotze classification<sup>3</sup>. However, there were also significant discrepancies in the number, length, and shape of the rugae patterns observed between different studies, indicating limitations in the use of palatal rugae as a reliable tool for identification. In contrast, some studies have reported similar rugae patterns between males and females. A total of five articles were included in this study, and a summary of each article can be found in Table 2.<sup>8-12</sup>

**Table 2: Characteristics of included study**

Author & year	Jadoon OK et al, 2018 <sup>8</sup>	Pereira T et al, 2018 <sup>9</sup>	Gezer R et al, 2019 <sup>10</sup>	Smriti K et al, 2021 <sup>11</sup>	Alshammari A et al, 2022 <sup>12</sup>
<b>Study Design</b>	Cross sectional study	Cross sectional study	Cross sectional study	Cross sectional study	Cross sectional study
<b>Sample Size</b>	102 maxillary study models inclusive of 52 males & 50 females	60 males & 60 females	230 (108 female and 122 male)	300 maxillary study models inclusive of 150 males & 150 females	496 maxillary study models inclusive of 226 males & 270 females
<b>Age group</b>	>20 years	15-45 years	16-57 years	18-40 years	>6 years
<b>Ethnicity</b>	Pakistan	India	Turkey	India	Saudi Arabian

Classification system used	Thomas and Kotze	Thomas and Kotze	Thomas and Kotze	Thomas and Kotze	Thomas and Kotze
<b>Inclusion &amp; exclusion criteria</b>	The study excluded individuals who had issues with their palate, such as cleft palate, soft tissue protrusions, palate trauma, as well as those who were wearing braces.	The study excluded individuals with oral habits, developmental anomalies, malposed teeth, orthodontic treated, attrition, abrasion or erosion, restored or carious adjacent teeth, as well as those who had any congenital abnormalities, inflammation, bony or soft-tissue protuberances, allergy to impression materials, or trauma related to the palate. Only participants who were healthy and did not have any of these conditions were included in the study.	The study included individuals who did not have any issues with their palate such as abnormalities, asymmetry, or tissue damage, and who had never received any tooth restoration treatments.	Casts with palatal pathologies, edentulous, history of any previous trauma or palatal surgeries or cleft palate, and those undergoing fixed orthodontic treatment were excluded	Eligibility criteria included full maxillary dentition (except for third molars). Exclusion criteria were: records with a history of the disease, trauma, or surgery of the palate or tuberosity, severe palatal congenital malocclusion disorders or asymmetries, any dental appliances in the upper teeth, previous orthodontic treatment, medication that would affect the periodontal soft tissue, and malposition or malalignment of the posterior maxillary teeth.
<b>Methodology</b>	The analysis of palatal rugae was conducted considering their number, shape & unification pattern..	palatal rugae pattern with respect to the number, shape, length, position and unification pattern	The shapes, lengths, and directions of rugae measured on these casts.	The rugae patterns were classified based on the total number of rugae, shape, predominant direction of rugae, and unification of rugae.	palatal rugae length, orientation, & shape
<b>Result</b>	NUMBER: Primary rugae- males>females	NUMBER: Primary rugae-	NUMBER: Females>males	SHAPE: Males-	PATTERN- Females-

	Fragmentary rugae- females>males SHAPE: curves>straight>circular & wavy Distribution: left>right	males>females Fragmentary rugae- females>males UNIFICATION: males- converging & females diverging SHAPE: Females- wavy>straight Males- Curved	Distribution: Males- right>left Females- left>right SHAPE: Males & Females- wavy & forwardly directed	Females- circular rugae DIRECTION: Males- forward directed Females- backward directed	backward Males- Curved UNIFICATION: Diverging > converging Distribution: left>right
<b>Conclusion</b>	Palatal rugae pattern give unique method for individual identification.	Rugae pattern is highly individualistic and can be used for personal identification and sex determination	Each individual exhibits unique shapes, lengths, and directions of palatal rugae, which serve as distinctive features that differentiate them from other populations.	Certain palatal rugae patterns can be used for the assessment of sex with limited accuracy	In a Saudi Arabian ethnic group, the direction and shape can be used to determine gender, although with limited accuracy.

## DISCUSSION

Palatal rugae, located in the oral cavity, are distinct to each person, making them a potential identifier. However, relying on them for gender discrimination may not be reliable as there are variations observed in different populations and a lack of effective means to differentiate between males and females.<sup>13,14</sup> Therefore, it is recommended that other methods should also be considered for gender discrimination.

The rugae are situated within the oral cavity, surrounded by various structures including the cheeks, lips, tongue, buccal fat pad, teeth, and bone, providing protection to the rugae. However, their use as a reliable criterion for identification has limitations. Jacob and Shalla<sup>15</sup> reported an accuracy of 79% with equivocation when rugae were used for identification, with low identification due to rugae obliteration in denture fabrication. Thus, palatal rugae tracings derived from dentures are not recommended for forensic analysis.<sup>15</sup> Furthermore, certain factors such as orthodontic treatment, cleft palate surgery, forced eruption of impacted canines, thumb sucking, and extractions can influence the pattern of palatal rugae.<sup>16</sup> Therefore, caution should be exercised when using palatal rugae as a means of identification, and additional methods should be employed for increased accuracy in forensic analysis.

The reliability of palatal rugae as a marker for gender determination has been called into question due to the possibility of falsification of the rugae pattern in edentulous cases and the observed significant changes in lateral rugae over time.<sup>16,17</sup> Discrepancies have also been observed between studies, further undermining the reliability of palatal rugae as a tool for gender discrimination. In a review of 5 articles meeting inclusion criteria, it was concluded

that palatal rugae can only be used as an adjuvant and not as a primary tool for gender determination.

## CONCLUSION

While some studies suggest that palatal rugae can be used to assist in determining the sex of an individual in forensics, we have observed a range of discrepancies in these patterns across different populations. As a result, we conclude that palatal rugae cannot be relied upon as a precise supplementary tool for gender discrimination.

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