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Dietary and Gender Variations in Palatal Rugae Morphology: A Comparative Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Palatal rugae, the complex and asymmetric ridges formed by connected tissues located behind the incisive papilla on the front section of the maxillary palate, have been subjects of numerous studies exploring their morphology and its variations with factors such as gender, age, and orthodontic

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treatments. According to the studies, the stability of palatal rugae remains a debated and investigated topic. This pilot study aims to investigate palatal rugae morphology in relation to dietary habits and gender in India. A comprehensive analysis was conducted using data from diverse regions of India, examining the intricate relationship between dietary habits, gender, and palatal rugae morphology. The study employed the elements of purposive sampling, to ensure representation from various geographic locations and populations encompassing 200 diagnostic study models evenly distributed between 100 male and 100 female samples. Utilizing established classification methods, the study rigorously assessed rugae morphology, considering factors such as length, shape, and direction. Statistical analysis was performed using unpaired t-tests in Microsoft Excel to examine the correlation between palatal rugae shapes, gender, and dietary habits. The findings revealed that neither gender nor dietary habits significantly influenced the total number or primary count of palatal rugae. Although slight variations were observed in rugae counts between dietary groups, the overall patterns remained consistent, challenging prior assumptions, and emphasizing the complexity of rugae development. While offering valuable insights, the study acknowledges limitations such as sample size and cross-sectional design, emphasizing the necessity for further research. Future studies, incorporating longitudinal studies and advanced imaging techniques, are recommended to gain a deeper understanding of the complex mechanisms underlying dietary influences on palatal rugae morphology.

Keywords: Palatal rugae morphology; dietary habits; gender; classification methods; future studies etc.

1. INTRODUCTION

Palatal rugae are the complex and asymmetric ridges that develop from interconnected tissues, found behind the incisive papilla toward the front of the upper palate. These ridges stretch from the anterior part of the hard palate to the inner side of the first permanent molars, without traversing the midline [1,2]. Palatal rugae, made up of keratinized stratified squamous epithelium and containing many Merkel cells, help in positioning the tongue during chewing and swallowing. These ridges start forming during the third month of fetal development and keep their shape because they are rich in glycosaminoglycans, which is hydrophilic [3,1,4]. Specific pattern of rugae is determined by the connective tissues composed of fibroblast and collagen [2]. The development of palatal rugae comprises various stages, such as the multiplication of mesenchymal cells, the growth, lifting, merging of the palatal shelves, and finally, the vanishing of the midline epithelial line [5,2]. In practical terms, palatal rugae serve as stable landmarks for assessing tooth movement in orthodontics. Additionally, they are useful for forensic identification, aiding in establishing an individual's identity [6]. Several studies have conducted on the morphology of palatal rugae, examining how it varies with factors such as gender, age, and orthodontic treatments [7,1,8]. However, the stability of palatal rugae remains a topic of debate and investigation. It is a pilot study focusing on palatal rugae morphology based on dietary habits with respect to gender in India.

1.1 Literature studies related to examination of palatal rugae morphology with respect to different variables

Palatal rugae have emphasized significant attention in forensic science for their potential in individual identification, as highlighted by Ujjainia & Mahna [2], Barbo et al. [9], and Babaji et al. [10], who explored various aspects of rugae anatomy and variation using modern and traditional techniques. However, the stability of palatal rugae, particularly after orthodontic expansion, remains debated, as indicated by Tey et al. [11], whose review signified inconclusive results regarding rugae morphology post-expansion. While studies by Sherif et al. [12], Amjad et al. [13], and Ali et al. [14] compare rugae patterns among different populations and genders, Moran et al. [15] suggest connections between rugae patterns and dental conditions. Subramanian & Jagannathan [16] and Rajan et al. [8] underscore the stability and gender-specific characteristics of rugae, supporting the findings by Indira et al. [17] on the uniqueness of rugae like fingerprints. Recent studies by Trizzino et al. [18], Gadicherla et al. [19], and Pappu et al. [20] further explore gender determination using rugae patterns. Despite this specific research studies, there is a notable gap in understanding how rugae morphology varies with factors like

gender and dietary habits, as seen in studies by Gezer et al. [21], Armstrong et al. [22], and Saadeh et al. [23], which examine rugae characteristics in different populations but do not explore dietary influences. Moreover, while some studies like Ahmed & Hamid [24] and Jibi et al. [25] discuss gender dimorphism in rugae patterns, there's limited exploration of dietary effects on rugae morphology. Therefore, there is a need for research investigating the influence of dietary habits on palatal rugae morphology, which could enhance our understanding of individual variations and contribute to forensic applications.

1.2 Objective

The primary objective of this research study is to examine the significant variations in palatal rugae morphology due to dietary habits within vegetarian and non-vegetarian populations with respect to their genders. The null hypothesis for the study is there will be no significant changes in the palatal rugae morphology due to dietary habits among 2 genders. The alternative hypothesis for this research will be contradictory to the null hypothesis, i.e. whether there will be any significant changes in the palatal ruage morphology due to dietary habits among two genders (male and female).

2. MATERIALS AND METHODS

2.1 Sample

The sampling technique utilized in this study involved obtaining 200 diagnostic study models, with 100 male and 100 female samples, from multiple dental clinics across different regions of India. Specifically, the models were acquired from Shine and Smile Multispecialty Dental Clinic in Vasundhara, Ghaziabad; a Dental Clinic in Jammu; Swasti Dental Clinic in Radhagobindapolly, Kolkata; and Shree Ram Dental Care Clinic in Delhi. This approach utilized elements of purposive sampling, as the researchers aimed to ensure representation from diverse geographic locations and populations.

2.2 Instruments Utilized

The analysis employed various instruments including magnifying glasses, study models, marking pencils, dividers, metal scales, and other necessary tools.

2.3 Methods

The analysis of palatal rugae morphology was conducted following the Thomas & Kotze classification from 1983. Rugae were classified based on their length as follows: Primary (> 5 mm), Secondary (3-5 mm), and Fragmentary (< 3 mm), with rugae less than 2 mm being disregarded. Rugae were categorized into six types based on their shape: Wave, Straight, Curve, Divergent, Convergent, and Circular.

Fig. 1. Representative sample frame of 200 palatal rugae samples collected from different states across India

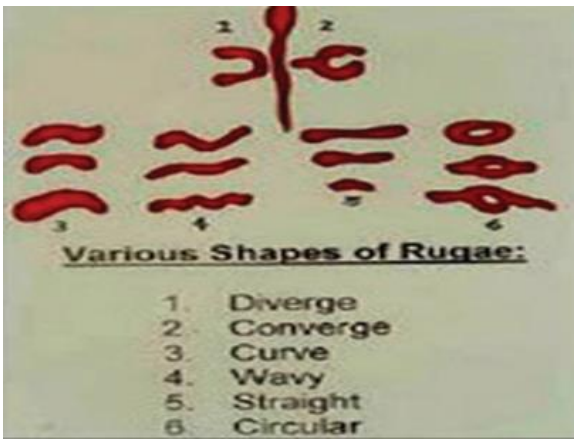

Fig. 2. Thomas and Kotze classification

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 raphe. Based on direction, rugae were classified as forwardly directed (associated with positive angles), backwardly directed

(associated with negative angles), or perpendicular (associated with zero angles).

Unification was identified when two rugae joined at their origin or termination, categorized as either diverging (if two rugae had the same origin from the midline but immediately branched) or converging (if rugae had different origins from the midline but joined on their lateral portions).

2.4 Statistical Analysis

Details from every dental model were carefully recorded. The correlation between the shapes of the palatal rugae, gender and dietary habits has been examined using unpaired t-tests in Microsoft Excel.

2.5 Limitations

It is very important to acknowledge potential limitations in this study, such as the sample size and the variability of rugae morphology within individuals. Additionally, the study's reliance on data from specific dental clinics may introduce bias, and extrapolating findings to broader populations should be done cautiously.

3. RESULTS

In Table 1, the analysis of gender-based differences in palatal rugae morphology yielded noteworthy results. It is found that the null hypothesis, suggesting no significant variations in the total number of rugae between males and females ($p > 0.05$), was supported. This indicates that there are no pronounced differences in the overall number of rugae between the two genders. It appears that the overall shape and structure of palatal rugae remain relatively consistent regardless of gender. Additionally, in Table 2, the mean values for different rugae shapes (wave, straight, curve, divergent, convergent, circular) were alike between males and females, further supporting the absence of substantial gender-related differences in palatal rugae morphology.

In Table 3, the null hypothesis was again accepted, indicating no significant disparity in total rugae count between males and females ($p > 0.05$). The mean number of total rugae for males was 3.63, while for females, it was 3.62, reaffirming the negligible gender-related differences in palatal rugae morphology.

In Table 4, the null hypothesis was accepted, suggesting no significant divergence in total rugae count between individuals following vegetarian and non-vegetarian diets ($p > 0.05$). However, a closer examination reveals a marginally lower mean total rugae count for vegetarians (3.52) compared to non-vegetarians (3.724). This slight variation may warrant further exploration to ascertain if dietary preferences exert any subtle influence on palatal rugae morphology.

In Table 5, analyzing the mean values of different rugae shapes between vegetarians and non-vegetarians, comparable trends were observed across both groups. While minor differences exist in the mean values for rugae shapes, the overall pattern remains consistent. These findings suggest that dietary habits may not significantly impact the shape or distribution of palata l rugae.

Table 6 and 7 depicts the correlation between gender, diet, and the total count of rugae. In both vegetarians and non-vegetarians, the null hypothesis was supported, indicating that there were no significant variations in the total rugae count between males and females ($p > 0.05$). This implies that neither gender nor dietary preferences seem to have a considerable impact on the overall number of rugae present on the palate.

Table 1. Gender based variation in the number of primary palatal rugae

Gender	Total number of Samples	Number of primary rugae	Mean	SD
Male	100	317	3.17	0.95
Female	100	326	3.26	0.93

Table 2. Gender specific variation in palatal rugae morphology

Gender	Wave	Straight	Curve	Divergent	Convergent	Circular
Male (Mean)	0.76	0.83	0.88	0.26	0.35	0.09
Female (Mean)	0.75	0.8	0.86	0.34	0.32	0.19

Table 3. Gender based variation in the number of total rugae

Gender	Total Number	Total rugae	Mean	SD
Male	100	363	3.63	1.151
Female	100	362	3.62	1.022

Table 4. Dietary variation in the total number of rugae

Diet	Total number of samples	Total number of rugae	Mean	SD
Veg	102	359	3.52	1.14
Non	98	365	3.724	1.01

Table 5. Dietary variation in the palatal rugae shapes

Veg	Wave	Straight	Curve	Divergent	Convergent	Circular
Mean	0.745	0.804	0.882	0.275	0.314	0.137
Non	**Wave**	**Straight**	**Curve**	**Divergent**	**Convergent**	**Circular**
Mean	0.765	0.816	0.857	0.327	0.357	0.143

Table 6. Dietary variation in total rugae count with respect to gender in the case of vegetarians

Gender	Number of Vegetarians	Total Rugae	Mean	SD
Male	46	158	3.43	1.24
Female	56	202	3.607	1.07

Table 7. Dietary variation in total rugae count with respect to gender in the case of non-vegetarians

Gender	Number of non-vegetarians	Total Rugae	Mean	SD
Male	54	205	3.79	1.05
Female	44	160	3.63	0.966

Table 8. Dietary variation in primary rugae count with respect to gender in the case of vegetarians

Gender	Number of Vegetarians	Total Primary Rugae	Mean	SD
Male	46	140	3.043	1.03
Female	56	183	3.267	0.92

Table 9 Dietary variation in primary rugae count with respect to gender in the case of non-vegetarians

Gender	Number of non-vegetarians	Total Primary Rugae	Mean	SD
Male	54	177	3.27	0.877
Female	44	143	3.25	0.967

In Table 8 and 9, when assessing the total number of primary rugae, the null hypothesis was upheld for both vegetarians and non-vegetarians. This suggests that there were no significant differences in the total count of primary rugae between males and females within each dietary group ($p > 0.05$). Despite differences observed in average values, the overall trend indicates that neither gender nor dietary habits exert a significant influence on the number of primary rugae present.

4. DISCUSSION

The findings of this study contribute to the growing body of literature on palatal rugae morphology and its potential implications for forensic science. The analysis of gender-based differences in rugae morphology aligns with previous research, as highlighted by Ujjainia & Mahna [2], Barbo et al. [9], and Babaji et al. [10], who emphasized the importance of rugae in individual identification. Consistent with these

studies, this research study indicates that there are no significant variations in the total number and shape of rugae between males and females. This supports the notion that palatal rugae exhibit stable characteristics regardless of gender, as suggested by Tey et al. [11] in their review on rugae stability post-orthodontic expansion.

Furthermore, the findings of this study regarding dietary influences on rugae morphology align with existing literature, albeit with some nuanced differences. While Gezer et al. [21], Armstrong et al. [22], and Saadeh et al. [23] have explored rugae characteristics in different populations, including Mediterranean cohorts like the Lebanese population in our study, none have specifically investigated the impact of dietary habits on rugae morphology. This study fills the gap by examining the relationship between diet and rugae morphology, finding no significant disparities in rugae count or shape between vegetarians and non-vegetarians.

Moreover, this analysis of gender, diet, and rugae count correlation supports previous research of Trizzino et al. [18], Gadicherla et al. [19], and Pappu et al. [20], which explored only the gender determination using rugae patterns. This finding indicates that neither gender nor dietary preferences seem to have a considerable impact on the overall number of rugae present on the palate, reaffirming the stable nature of rugae characteristics across different demographic groups for their whole life span [26,27].

These findings contribute to the broader understanding of rugae characteristics and their potential applications in forensic science. However, further research is warranted to explore additional factors that may influence rugae morphology and to validate the findings across diverse populations [28].

5. CONCLUSION

In conclusion, it can be stated that, this research article provides valuable insights to the complex patterns of palatal rugae and their potential correlations with dietary habits and gender. Through rigorous analysis of gender and dietary specific palatal rugae samples gathered from different regions of India, this research endeavors to unravel the nuanced interplay between biological factors and environmental influences on palatal rugae morphology. The findings of this study, as evidenced by the acceptance of the null hypothesis across multiple analyses, suggest that neither gender nor dietary habits exert a significant influence on the total number of rugae or primary rugae count. This study represents a pioneering attempt to elucidate the potential impact of dietary habits on palatal rugae morphology. While this study provides comprehensive insights, it is essential to acknowledge its limitations. The sample size and demographic representation may not fully capture the diversity of dietary habits across different regions of India. Additionally, the study's cross-sectional design limits it is ability to establish causality between dietary habits and palatal rugae morphology. Future research could benefit from longitudinal studies with larger and more diverse participant groups, along with advanced imaging techniques to better understand how dietary choices influence rugae formation.

CONSENT

While conducting the study, care was taken to ensure patient privacy and confidentiality. Written consent was obtained from all participants, and efforts were made to minimize any discomfort or inconvenience during data collection. Additionally, the research adhered to principles of scientific integrity and transparency throughout the study process.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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