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Palatal rugae patterns based on gender in Jember Indonesia

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Abstract

Introduction: Palatal rugae are anatomical structures located within the oral cavity. The teeth, buccal mucosa, and lips protect these structures from trauma. Palatal rugae have a unique individually characteristics. Therefore, palatal rugoscopy could determine sex differention in forensic odontology. The aim of this study was to identify the characteristics of palatal rugae patterns based on sex differention.

Materials and Methods: This study involved 200 maxillary cast samples consisting of 100 male and 100 female samples. We observed the palatal rugae patterns based on shape, unification, and length on the maxillary casts according to the Thomas and Kotze classification (1983). Then subsequently analyzed the differences in palatal rugae patterns between males and females using the Chi-square test with SPSS version 29.2, with level of significance $p < 0.05$.

Results and Discussion: Palatal rugae shape in males were predominantly wavy (41.92%), respectively followed by curved (30.45%), straight (25.85%), and circular patterns (1.79%) whereas in females were predominantly curved (33.52%), respectively followed by wavy (32.64%), straight (31.69%), and circular patterns (2.15%). Diverging represented the most common unification pattern in both sex (69.6%), followed by converging (30.4%). Primary rugae represented the dominant palatal rugae length category in male and female (74.3%), followed by secondary rugae (18.1%) and fragmented rugae (7.6%).

Conclusion: Palatal rugae patterns possess unique characteristics in every individual. However, there were no significance differences in male and female

Keywords: Palatal rugae pattern; Forensic odontology; Thomas and Kotze; Rugoscopy

1. Introduction

Disaster victim identification represents an essential process for determining victim identity, including sex, age, and race.[1] Investigators can determine the sex of a victim through the examination of structures within the oral cavity, including the anatomical structure of palatal rugae.[2] Palatal rugae are anatomical ridges or folds located in the anterior third of the palatal mucosa. These structures are generally located on the right and left sides of the palatine raphe and posterior to the incisive papilla.[3]

Palatal rugae are considered one of the oral anatomical structures that can assist forensic identification because the teeth, lips, and tongue surround these structures and protect them from trauma. In cases involving decomposed bodies or third-degree burns, investigators may use palatal rugae as an alternative identification method when fingerprints are unavailable investigators can perform this identification process by analyzing palatal rugae patterns through palatal rugoscopy.[4] Palatal rugae develop during the 12th to 14th week of prenatal life. The size and shape of palatal rugae

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remain stable after the age of 10 years until approximately 24 years of age, after which the size gradually decreases. However, qualitative characteristics such as pattern, shape, and direction remain stable throughout life without significant changes.[5] The uniqueness of palatal rugae resembles fingerprints because each individual possesses distinct characteristics.[3]

Palatal rugae analysis, also known as palatal rugoscopy, can be performed using maxillary casts of victims through a method commonly referred to as calcorrugoscopy, this method is simple, accurate, and cost-effective.[6] In addition to using maxillary casts or study models, rugoscopy can also be performed through direct intraoral examination, oral photography, and more advanced methods such as stereoscopy and stereophotogrammetry.

Several studies have investigated palatal rugae patterns. However, further studies remain necessary to expand scientific knowledge regarding palatal rugae patterns in sex determination.

2. Material and methods

This study was conducted after obtaining ethical approval from Ethics Committee of Faculty of Dentistry, University of Jember, and informed consent from all participants. The study was carried out at Dental Technology Laboratory, Faculty of Dentistry, University of Jember, and involved 200 maxillary cast samples obtained from residents in Jember Regency. The samples consisted of 100 male maxillary casts and 100 female maxillary casts. This study used primary data obtained through direct maxillary impressions from subjects. The impression procedure used alginate material, followed by casting the negative impressions with type IV gypsum in the rugae area and type III gypsum in the remaining areas. Palatal rugae on maxillary casts were outlined using a 2B pencil, as shown in Figure 1. This study used Thomas and Kotze classification (1983). Shape and unification patterns were observed using a magnifying glass, whereas rugae length was measured using a 0.1 mm diameter copper wire and a ruler. According to Thomas and Kotze classification (1983), palatal rugae length was categorized into three groups: primary rugae (≥5 mm), secondary rugae (3 – <5 mm), and fragmented rugae (<3 mm). In addition, palatal rugae shape was classified into four types: straight, wavy, curved, and circular. Unification patterns were classified into two types: converging and diverging. Data analysis was performed using SPSS version 29.2 and Chi-square test with a 95% confidence level and a significance value of $p < 0.05$.

Figure 1 Maxillary cast with outlined palatal rugae

3. Results and discussion

The collected data were analyzed using the Chi-square test to identify differences in palatal rugae patterns between males and females according to Thomas and Kotze classification (1983), which categorizes palatal rugae patterns based on shape, unification, and length. Figure 2 illustrates the classification of palatal rugae shapes according to Thomas and Kotze (1983).

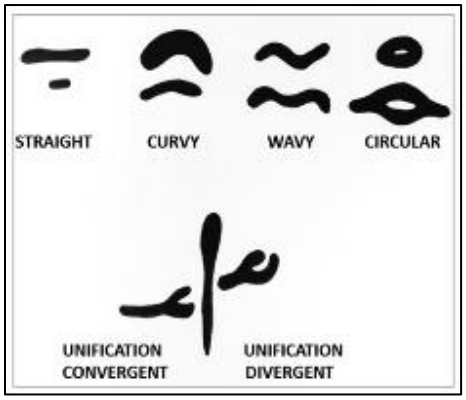

Figure 2 Thomas Kotze Classification (1983)[7]

Table 1 Analysis of palatal rugae shape patterns in males and females

Shape	Gender	Number	%	Mean	SD	Chi-square Value	P-value
Straight	Male	275	25.85%	2.75	1.87	21.993	0.005*
	Female	398	31.69%	3.98	1.95		
Curved	Male	324	30.45%	3.24	1.92	24.637	0.01*
	Female	421	33.52%	4.21	2.24		
Wavy	Male	446	41.92%	4.46	2.09	15.114	0.128
	Female	410	32.64%	4.1	1.71		
Circular	Male	19	1.79%	0.19	0.42	1.649	0.438
	Female	27	2.15%	0.27	0.51		

*) Statistically significant at $p < 0.05$

Based on the Table 1, straight and curved rugae shapes demonstrated significant differences between males and females because both categories showed p-values below 0.05. Male subjects showed 275 straight rugae patterns (25.85%), whereas female subjects showed 398 straight rugae patterns (31.69%) with a p-value of 0.005. Curved rugae patterns were identified in 324 males (30.45%) and 421 females (33.52%) with a p-value of 0.01.

In contrast, wavy and circular rugae patterns did not demonstrate statistically significant differences between males and females because both categories showed p-values above 0.05. Wavy rugae patterns were identified in 446 males (41.92%) and 410 females (32.64%) with a p-value of 0.128, whereas circular rugae patterns were identified in 19 males (1.79%) and 27 females (2.15%) with a p-value of 0.438. Based on these findings, wavy represented the predominant palatal rugae pattern in males, whereas curved represented the predominant pattern in females.

Table 2 Analysis of palatal rugae unification patterns in males and females

Unification	Gender	Number	%	Mean	SD	Chi-square Value	P-value
Diverging	Male	99	69.23%	0.99	0.93	3.667	0.453
	Female	80	70.18%	0.8	0.87		
Converging	Male	44	30.77%	0.44	0.69	2.37	0.499
	Female	34	29.82%	0.34	0.55		

Diverging and converging unification patterns did not demonstrate statistically significant differences between males and females ($p > 0.05$). Table 2 shows that the diverging unification pattern was more predominant than the converging unification pattern in both sexes.

Table 3 Analysis of palatal rugae length in males and females

Length	Gender	Number	%	Mean	SD	Chi-square Value	P-value
Primary Rugae	Male	945	78.29%	9.45	1.91	9.741	0.464
	Female	969	70.73%	9.69	2.11		
Secondary Rugae	Male	190	15.74%	1.9	1.81	30.553	0.001*
	Female	276	20.15%	2.76	1.69		
Fragmented Rugae	Male	72	5.97%	0.72	1.17	18.789	0.002*
	Female	125	9.12%	1.25	1.22		

*) Statistically significant at $p < 0.05$

Chi-square analysis of palatal rugae length demonstrated that primary rugae did not show statistically significant differences between males and females because the p-value was 0.464 ($p > 0.05$). However, secondary and fragmented rugae demonstrated statistically significant differences between both sexes ($p < 0.05$). Secondary rugae showed a p-value of 0.001, whereas fragmented rugae showed a p-value of 0.002. Based on Table 3, both males and females predominantly exhibited primary rugae.

Based on the overall Chi-square analysis, palatal rugae characteristics, including shape, unification, and length, did not demonstrate statistically significant differences between males and females. These findings may be influenced by multiple factors, one of which was the absence of racial or ethnic differentiation criteria during sample selection.

The findings of this study are consistent with those reported by Dahal et al. (2021), who stated that primary rugae represented the most predominant rugae length category in both sexes, and with the findings of Smriti et al. (2021) in the South Indian adult population, which demonstrated that the wavy pattern represented the most prevalent rugae shape, followed by curved and straight patterns.[8,9]

Observation of palatal rugae shapes between males and females without considering the right and left palatal regions demonstrated that straight rugae were more common identified in females (398) and showed statistically significant differences between both sexes ($p = 0.05$). These findings are consistent with the studies conducted by Gupta and Kaur (2021) and Selvamani et al. (2015), which reported statistically significant differences in straight rugae patterns between males and females.[10,11] In addition to the straight pattern, the curved pattern also demonstrated statistically significant differences between both sexes and was more frequently identified in females (421). These findings are supported by the study conducted by Azab et al. (2016) in the Egyptian population. However, the findings contradict those reported by Pakshir et al. (2019), who stated that curved patterns were more frequently identified in males.[12,13]

In the present study, the total number of wavy and circular palatal rugae patterns without differentiating the right and left palatal regions did not demonstrate statistically significant differences. Similar findings were reported by Pramanik et al. (2019), who stated that wavy and circular palatal rugae patterns did not show statistically significant differences.[14] The observations demonstrated that the wavy pattern was more frequently identified in males, whereas the circular pattern was more frequently identified in females. These findings are simmilar to the studies conducted by Dwivedi and Nagarajappa (2016) in the Central Indian population and Singh Oberoi et al. (2017) in students from the Jammu and Kashmir population.[15,16]

When categorized according to sex, males predominantly exhibited wavy patterns, whereas females predominantly exhibited curved palatal rugae patterns. These findings are consistent with those reported by Gadicherla et al. (2017).[17]

This study used Thomas and Kotze classification (1983), which categorizes palatal rugae based on shape, unification, and length. Overall, both diverging and converging unification patterns did not demonstrate statistically significant differences between males and females. Diverging unification patterns were more frequently identified than converging unification patterns in both sexes. These findings are supported by the studies conducted by Thabitha et al. (2015) in children from Nalgonda City, India, and Sherif et al. (2018) in Egyptian and Malaysian populations.[17,18]

Malekzadeh et al. (2018), Gezer et al. (2019), and Pratiwi et al. (2016) reported that the overall length of palatal rugae without differentiating the right and left palatal regions did not demonstrate statistically significant differences between males and females. These studies also reported that primary rugae represented the predominant category, followed by secondary rugae and fragmented rugae.[19,20,21] These findings are similar to the findings of the present study, which demonstrated that both males and females predominantly exhibited primary rugae. Based on length classification, substantial frequency differences were identified between males and females in secondary rugae patterns, indicating that males exhibited fewer secondary rugae than females. Similar findings were also observed in fragmented rugae patterns. Based on the presented data, differences in rugae length appeared more prominent than differences in shape and unification patterns.

Palatal rugae begin to develop during the 12th week of intrauterine and continue developing until the 14th week. During the initiation stage, palatal rugae appear as epithelial thickening, which gradually becomes more prominent and undergoes dimensional changes throughout fetal growth while maintaining a stable shape. This stability is associated with the hydrophilic glycosaminoglycans, which are abundantly present in palatal rugae connective tissue and contribute to the maintenance of rugae morphology throughout life. In addition to their stable morphology, palatal rugae are located within the oral cavity and are protected by the teeth, lips, and buccal mucosa, thereby reducing the likelihood of morphological changes caused by trauma, chemical exposure, or fire.[21]

Based on the findings of the present study, males and females demonstrated different predominant shapes, whereas the predominant unification and length patterns were similar in both sexes. Therefore, palatal rugae patterns cannot be used as an independent method for sex determination. Sheikhi et al. (2018) reported that genetic factors have a major role in determining palatal rugae patterns.[22] A similar study conducted by Ilma et al. (2017) in Minangkabau and Batak students demonstrated that palatal rugae patterns did not show substantial differences between different subraces within the same race.[3] These findings support the hypothesis that genetic factors influence differences in palatal rugae patterns among racial groups. During embryogenesis and postnatal growth, several genes regulate the orientation of collagen fibers within palatal rugae connective tissue, thereby influencing rugae patterns among different racial groups.

4. Conclusion

Palatal rugae patterns in males were predominantly wavy, respectively followed by curved, straight, and circular patterns, whereas the predominant unification pattern was diverging. Based on rugae length, primary rugae were the most frequently identified in males, followed by secondary and fragmented rugae.

Palatal rugae patterns in females were predominantly curved, respectively followed by straight, wavy, and circular patterns, whereas the predominant unification pattern was diverging. Based on rugae length, primary rugae were the most frequently identified in females, followed by secondary and fragmented rugae. Statistically, no significant differences were identified in the overall shape, unification, and length of palatal rugae patterns between males and females. However, palatal rugae patterns are unique characteristics because no two individuals show identical rugae patterns.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] De Boer, H. H., Blau, S., Delabarde, T., & Hackman, L. (2019). The role of forensic anthropology in disaster victim identification (DVI): recent developments and future prospects. In Forensic Sciences Research (Vol. 4, Issue 4, pp. 303–315). Taylor and Francis Ltd. https://doi.org/10.1080/20961790.2018.1480460

[2] Kumari, R., Kumar, S., & Sharma, V. (2021). Study Of Palatal Rugae For Forensic Identification. International Research Journal of Engineering and Technology. www.irjet.net

[3] Ilma, M. N., Murniati, N., & Ningsih, D. (2017). Pola rugae palatina pada mahasiswa suku Minangkabau dan suku Batak Palatal rugae pattern in Minangkabaunese and Bataknese students. Jurnal Kedokteran Gigi Universitas Padjadjaran, 29(1). https://doi.org/10.24198/jkg.v29i1.18599

[4] Jain, A., & Chowdhary, R. (2014). Palatal rugae and their role in forensic odontology. In Journal of investigative and clinical dentistry (Vol. 5, Issue 3, pp. 171–178). https://doi.org/10.1111/j.2041-1626.2013.00150.x

[5] Kasuma N. Rugae Palatina. Press Universitas Andalas. 2017

[6] Poojya, R., Shruthi, C. S., Rajashekar, V. M., & Kaimal, A. (2015). Palatal Rugae Patterns in Edentulous Cases, Are They A Reliable Forensic Marker? In InternatIonal journal of BIomedIcal scIence (Vol. 11, Issue 3). www.ijbs.org

[7] Gadicherla, P., Saini, D., & Bhaskar, M. (2017). Palatal rugae pattern: An aid for sex identification. Journal of Forensic Dental Sciences, 9(1), 48–53. https://doi.org/10.4103/jfo.jfds_108_15

[8] Dahal, S., Baral, R., Gupta, S. P., Dahal, S., & Sharma, R. (2021). Palatal rugae as an indicator of sexual dimorphism. Journal of Institute of Medicine Nepal, 43(3), 35–39. https://doi.org/10.59779/jiomnepal.1184

[9] Smriti, K., Gupta, R., Pentapati, K. C., Singh, A., Kapoor, I., Vineetha, R., & Gadicherla, S. (2021). Sex assessment by morphological analysis of palatal rugae patterns in a South Indian adult population. Clinical, Cosmetic and Investigational Dentistry, 13, 77–81. https://doi.org/10.2147/CCIDE.S304599

[10] Gupta, V., & Kaur, A. (2021). Palatal rugoscopy as an adjunct for sex determination in forensic odontology (Sri Ganganagar population): A cross-sectional study of 100 subjects. Journal of Oral and Maxillofacial Pathology, 25(3), 556. https://doi.org/10.4103/jomfp.jomfp_155_21

[11] Selvamani, M., Hosallimath, S., Madhushankari, Basandi, P. S., & Yamunadevi, A. (2015). Dimensional and morphological analysis of various rugae patterns in Kerala (South India) sample population: A cross-sectional study. Journal of Natural Science, Biology and Medicine, 6(2), 306–309. https://doi.org/10.4103/0976-9668.159985

[12] Azab, S. M. S., Magdy, R., & Sharaf El Deen, M. A. (2016). Patterns of palatal rugae in the adult Egyptian population. Egyptian Journal of Forensic Sciences, 6(2), 78–83. https://doi.org/10.1016/j.ejfs.2015.01.006

[13] Pakshir, F., Ajami, S., Pakshir, H. R., Malekzadeh, A. R., & Sh, A. (2019). Characteristics of Palatal Rugae Patterns as a Potential Tool for Sex Discrimination in a Sample of Iranian Children. J Dent Shiraz Univ Med Sci, 20(1), 1–9. https://doi.org/10.30476/DENTJODS.2019.44556

[14] Pramanik, A., Debnath, M., & Debnath, M. (2019). A Comparative Study of Gender Difference in Palatal Rugae Patterns among Bengali Subjects in Murshidabad. International Journal of Anatomy, Radiology, and Surgery, 8(1), AO06-AO10. https://doi.org/10.7860/IJARS/2019/36281:2449

[15] Dwivedi, N., & Nagarajappa, A. K. (2016). Morphological analysis of palatal rugae pattern in central Indian population. Journal of International Society of Preventive and Community Dentistry, 6(5), 417–422. https://doi.org/10.4103/2231-0762.192947

[16] Singh Oberoi, I., Hussain Chalkoo Professor, A., Dhingra Bds, K., Inderpreet Singh Oberoi, C., Hussain Chalkoo, A., & Dhingra, K. (2017). Evaluation of rugae pattern in individuals of a known population: A population based study. ~ 1 ~ International Journal of Applied Dental Sciences, 3(1), 1–4. www.oraljournal.com

[17] Thabitha, R., Reddy, R., Manjula, M., Sreelakshmi, N., Rajesh, A., & Kumar, V. (2015). Evaluation of palatal rugae pattern in establishing identification and sex determination in Nalgonda children. Journal of Forensic Dental Sciences, 7(3), 232. https://doi.org/10.4103/0975-1475.172447

[18] Sherif, A.F., Hashim, A.A., Al Hanafy, M.A. et al. A pilot- cross sectional study of palatal Rugae shape and direction among Egyptians and Malaysians. Egypt J Forensic Sci 8, 17 (2018). https://doi.org/10.1186/s41935-018-0050-1

[19] Malekzadeh, A. R., Hamid, ;, Pakshir, R., Ajami, S., Pakshir, F., & Pakshir, H. R. (2018). The Application of Palatal Rugae for Sex Discrimination in Forensic Medicine in a Selected Iranian Population. In Iran J Med Sci November (Vol. 43, Issue 6).

[20] Gezer, R., Deniz, M., & Uslu, A. I. (2019). Morphological Characteristics and Individual Differences of Palatal Rugae. Journal of Craniofacial Surgery, 30(6), 1906–1910. https://doi.org/10.1097/SCS.0000000000005599

[21] Pratiwi, D., Sumantri, D., & Lipoeto, N. (2016). PERBEDAAN POLA RUGAE PALATAL ANTARA LAKI-LAKI DAN PEREMPUAN SUKU MINANG. Andalas Dental Journal, 4(1), 8-17. https://doi.org/10.25077/adj.v4i1.44

[22] Sheikhi, M., Zandi, M., & Ghazizadeh, M. (2018). Dental Research Journal Assessment of palatal rugae pattern for sex and ethnicity identification in an iranian population. www.ncbi.nlm.nih.gov/pmc/journals/1480