Section: Forensic Medicine

Original Research Article

A DESCRIPTIVE ANALYSIS OF PATTERNS OF PALATAL IMPRINTS

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ABSTRACT

Background: Palatal rugae, the distinct ridge patterns on the anterior palate, are unique to each individual, making them valuable in forensic dentistry due to their permanence. While their uniqueness is well-established, factors like sex, palate side, and familial traits are still under investigation. This study aimed to analyze the frequency and distribution of palatal rugae patterns in a South Kerala population to assess their forensic potential. **Materials and Methods:** A cross-sectional study was conducted on 100 individuals (50 males and 50 females), aged 18 to 80, from Government Medical College, Thiruvananthapuram, Kerala. Participants were selected based on inclusion and exclusion criteria, excluding those with congenital defects, previous surgeries, or dental appliances. Alginate impressions of the palate were made, and dental stone casts were created for digital analysis. Rugae patterns were classified using the Thomas and Kotze system. Statistical analysis compared the distribution of patterns by gender and palate side, with significance set at $p < 0.05$. **Findings:** The most common rugae pattern was wavy, followed by curved. However, patterns were not entirely unique to individuals, which may be due to the limited sample size. No significant differences were found in rugae patterns between genders or palate sides, but unique combinations were observed. **Conclusion:** While the study found no significant gender or side-based differences, the observation of unique rugae combinations suggests that further research with a larger sample size and additional parameters could improve the forensic utility of palatal rugae analysis.

INTRODUCTION

Palatal rugae, the unique and permanent ridges on the anterior portion of the hard palate, have been a longstanding focus of research in forensic science due to their stability and individuality. These patterns are formed during the early stages of fetal development and remain largely unchanged throughout an individual's lifetime, making them highly reliable anatomical markers for identification purposes. Given that other common identifiers such as fingerprints and dental structures can be compromised by environmental factors or post-mortem changes, palatal rugae offer a resilient alternative in forensic investigations. Various studies have noted the distinctive nature of rugae patterns, suggesting that they may be as unique,[1] to an individual as fingerprints; however, research also indicates that these patterns may exhibit variations influenced by factors such as age, gender, and genetic heritage, underscoring the need for a more comprehensive understanding of these factors.

In the context of forensic dentistry, accurate and reliable identification methods are crucial, especially in scenarios involving unidentified remains or disputed identities. In regions where access to advanced forensic resources is limited, palatal rugae analysis could serve as an accessible and cost-effective technique for identification. Studies from different populations have shown that the shape, direction, and length of palatal rugae can vary significantly across individuals, with classification

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systems such as Thomas and Kotze's categorizing these patterns into distinct types,[2] including wavy, curved, straight, circular, divergent, convergent, and non-specific. However, there is limited data on these variations in specific populations, and few studies have systematically explored the differences in rugae patterns between sexes or across different sides of the palate. Moreover, while the uniqueness of rugae patterns has been documented in some studies, the extent of this individuality and the practical applicability of rugae patterns for identification purposes require further empirical support.

This study aims to address these gaps by analyzing the palatal rugae patterns of a specific population from South Kerala. By examining a sample of both male and female participants and comparing the frequency and distribution of various rugae patterns, this research seeks to provide insights into the individuality of these structures and their potential application in forensic investigations. Understanding the distribution of rugae types within this population and their variations between genders and the left and right halves of the palate could offer valuable data for forensic casework. Additionally, findings from this study could contribute to building a database of palatal rugae characteristics, aiding identification efforts in regional forensic contexts and potentially guiding future research,[3,4] on the heritability and environmental influences on palatal rugae patterns.

MATERIALS AND METHODS

Study Design

A descriptive study was conducted to analyze the patterns of palatal imprints among the male and female populations of South Kerala.

Study Population

A total of 100 individuals, comprising 50 males and 50 females, were included in the study. Participants were recruited from the Department of Forensic Medicine, Government Medical College, Thiruvananthapuram, Kerala. Data Collection Palatal Impression: Alginate impressions were taken from the palates of each participant. Data Recording: The patterns of palatal rugae were recorded using a digital camera and analyzed using specialized software.

Data Analysis Classification

The palatal rugae patterns were classified according to the Thomas and Kotze classification system.

Frequency Analysis

The frequency of occurrence of each pattern was calculated. **Statistical Analysis:** Statistical analysis was performed to determine the significance of any differences in pattern distribution between genders and between the left and right sides of the palate.

Ethical Considerations

The study adhered to ethical guidelines, and informed consent was obtained from all participants. The ethical clearance was obtained from the Human Ethics Committee medical college, Thiruvananthapuram-(03/05/2017/MCT).

After getting informed written consent, patients were made to sit in a chair with the head in resting position. Measurement of the maxillary jaw was taken by inserting a dental tray of appropriate size for the person. After confirming the size, a negative impression of the palate was taken by the impression material (Alginate) which is an irreversible hydrocolloid consisting of gelatinous particles in water. It is supplied in powder form which is mixed with water and when set, the material is a flexible gel resembling rubber. Its most important characteristic is its ability to rebound to its original form. After the negative imprints were obtained, dental stone is poured onto it to make a positive impression. When the stone plaster was set after the prescribed time, the dental casts were removed from the tray and the palatal rugae were observed using the magnifying hand lens and classified according to Thomas and Kotze classification. Those rugae which are not morphologically identifiable with the Thomas and Kotze classification are classified as non-specific rugae.

RESULTS

Pattern of palatal rugae in all subjects In the 100 cases studied, wavy pattern was seen in all subjects, followed by curved (99%), straight(94%), divergent (49%), convergent(26%), non specific (15%) and circular pattern(14%).

Pattern of palatal rugae on left and right halves of palate

Patterns of palatal rugae on the left and right halves of the palate were studied and in the study it was observed that wavy, curved, convergent and non-specific rugae were more on the left side and straight, divergent and circular patterns were more on the right side. Wavy pattern was found in 95% of total rugae on right side and 98% on left side, followed by curved pattern 91% on right side and 95% on left side, straight pattern 85% on right side and 78% on left side, divergent pattern 35% on right side and 32% on left side, convergent pattern 12% on right side and 18% on left side, circular pattern 9% on the right side and 4% on left side and non-specific pattern 7% on right side and 8% left side, Table:1.

Pattern of palatal rugae in males and females

Wavy pattern was present in all males and all females, curved pattern was found in all males and in 98% females, followed by straight pattern 94% in males and females. Divergent rugae was found more in females (54%) compared to males (44%). Convergent rugae was more in males (32%) compared to females (20%). Circular pattern was more in females (16%) compared to males (12%). Non-specific pattern was more in males (16%) compared to females (14%), Table: 2.

Combination of palatal rugae patterns

Combinations of different patterns of rugae were also seen in the study group. For the better and easy description different combinations were grouped as

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group 1 to group 18. Groups 1, 2, 4, 5, 6, 10,18 were present in only 1% of the study subjects, that is only one person had a particular type of these groups of combination. Group 14 was the least reliable one observed in 30% of study subjects, followed by group 7 in 22%, group 8,15, 17 in 5% of study subjects, group 9, 13 in 4% study subjects, group 12, 16 in 3% study subjects, Table 3.

Palatal rugae pattern in family members

In the study we have found that, group 1, 2, 4, 5, 6, 10, 18 were present with only 1% of the study patients, that is only one person had a particular type of these groups of combination. Group 14 was the least reliable one observed in 30% of study subjects, followed by group 7 in 22%, group 8,15, 17 in 5% of study patients, group 9, 13 in 4% study patient, group 12, 16 in 3% study patient, Table:4. We have found that siblings showed the same number of rugae in total and on both halves of the palate. Both parents and older offspring showed more numbers of straight rugae followed by a wavy pattern. The younger offspring showed more curved rugae followed by a wavy pattern. Wavy patterns in the father and the offspring were interrupted.

Table 1: Distribution of Palatal Rugae Patterns On Left and Right Halves of the Palate

Pattern Of Rugae	Right	Left
Straight	85	78
Curved	91	95
Wavy	95	98
Divergent	35	32
Convergent	12	18
Circular	9	4
Non-Specific	7	8

Abbreviations: S – Straight; C – Curved; W – Wavy; D – Divergent; Co – Convergent; Cr – Circular; NS – Non-specific

Table 2: Comparison of Palatal Rugae Patterns Between Male and Female Participants

Pattern	Male (N)	Male (%)	Female (N)	Female (%)	Total (N)	Total (%)
Straight	47	94	47	94	94	94
Curved	50	100	49	98	99	99
Wavy	50	100	50	100	100	100
Divergent	22	44	27	54	49	49
Convergent	16	32	10	20	26	26
Circular	6	12	8	16	14	14
Nonspecific	8	16	7	14	15	15
Total	50	100	50	100	100	100

Abbreviations: N – Number of individuals; % – Percentage; S – Straight; C – Curved; W – Wavy; D – Divergent; Co – Convergent; Cr – Circular; NS – Non-specific

Table 3: Frequency and Distribution of Palatal Rugae Pattern Combinations in Study Subjects

S.NO	Group	Frequency	Percent	S.NO	Group	Frequency	Percent
1	C+W+Co	1	1	10	S+C+W+Cr+NS	1	1
2	C+W+Co+Cr	1	1	11	S+C+W+Co	10	10
3	C+W+D	2	2	12	S+C+W+Co+NS	3	3
4	C+W+D+NS	1	1	13	S+C+W+Co+Cr	4	4
5	C+W+D+Co	1	1	14	S+C+W+D	30	30
6	S+W+D	1	1	15	S+C+W+D+NS	5	5
7	S+C+W	22	22	16	S+C+W+D+Cr	3	3
8	S+C+W+NS	5	5	17	S+C+W+D+Co	5	5
9	S+C+W+Cr	4	4	18	S+C+W+D+Co+Cr	1	1
TOTAL						100	100

Abbreviations: S – Straight; C – Curved; W – Wavy; D – Divergent; Co – Convergent; Cr – Circular; NS – Non-specific

Table 4: Comparison of Palatal Rugae Patterns Among Family Members

Pattern of Rugae	Mother	Father	First Child	Second Child
Straight	10	6	4	1
Curved	4	4	3	7
Wavy	5	5	4	5
Divergent	0	0	1	0
Convergent	0	0	0	0
Circular	0	0	1	0
Nonspecific	0	1	0	0
Total No. of Rugae	19	16	13	13

Abbreviations: S – Straight; C – Curved; W – Wavy; D – Divergent; Co – Convergent; Cr – Circular; NS – Non-specific

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DISCUSSION

This study evaluated palatal rugae patterns among 100 subjects to explore the hypothesis that these patterns are uniquely individualized. Contrary to the widely held view of rugae uniqueness, our findings showed no significant individual specificity based solely on the Thomas and Kotze classification.[5] This result suggests that adding parameters, such as the direction of rugae from the median raphe, the length of individual rugae, and the distance between them, could provide a more detailed analysis, as observed in similar studies by Jibi PM et al,[6] Thabitha et al,[7] Mutalik et al,[8] and Kamala et al.[9]

All rugae types-wavy, curved, straight, divergent, convergent, non-specific, and circular-were observed on both halves of the palate, with the wavy pattern being the most common (100%), followed by curved (99%), straight (94%), divergent (49%), convergent (26%), non-specific (15%), and circular (14%). The circular pattern, observed least frequently, aligns with findings by Shetty et al.[10] The study also noted a sidespecific distribution, with wavy, curved, convergent, and non-specific rugae more frequently found on the left side, while straight, divergent, and circular patterns were more common on the right. These observations were not previously reported in similar studies, suggesting that examining rugae patterns separately on each side of the palate in larger populations might yield statistically significant results.

Regarding gender distribution, no statistically significant differences were noted between males and females. Wavy and curved patterns were dominant across both groups, but slight variations were observed for divergent and convergent types. Divergent rugae were more common in females (54%) than males (46%), while convergent rugae were more frequent in males (32%) compared to females (20%). These findings are consistent with prior research by Manickam Selvamani et al,[11] and N Dwivedi et al. Divergent rugae showed no significant differences between genders, and non-specific patterns appeared slightly more in males (16%) than females (14%).

The study also indicated no statistical significance in the distribution of rugae patterns between the left and right sides of the palate. Specifically, wavy, curved, convergent, and non-specific rugae patterns were more prevalent on the left side, while straight, divergent, and circular patterns were more common on the right. For example, wavy rugae accounted for 95% of total rugae on the right and 98% on the left, while straight rugae appeared in 85% on the right and 78% on the left. No previous studies have yet explored the significance of different combinations of rugae patterns. Although combinations were observed among study subjects, they were statistically insignificant. Expanding the sample size and including other parameters, such as the left and right halves of the palate and the distance from central incisors or first molars, might yield statistically significant results.

Due to factors like migration, tooth loss, use of dentures, and lack of willing participants, family studies were limited to one family, with only minor similarities observed. These similarities were insufficient to suggest a hereditary component. Future studies with larger, more diverse samples, and a broader range of variables may enhance our understanding of palatal rugae patterns' individual specificity and potential genetic influence.

Limitations

The main limitations of this study include its small sample size of 100 individuals[12-14], which restricts the generalizability of the findings, and its population specificity to South Kerala, limiting applicability to broader or more diverse populations. The study also focused solely on pattern classification using the Thomas and Kotze system without considering additional characteristics, such as rugae orientation or distances from anatomical landmarks, which could provide a more detailed analysis of rugae uniqueness. Additionally, the reliance on traditional alginate impressions and manual observation introduces potential observer bias; advanced imaging techniques like 3D scanning could enhance accuracy. Finally, the study did not consider environmental or lifestyle factors that might influence rugae patterns, such as diet or oral health habits, which could be explored in future research for a more comprehensive understanding of rugae variability.

CONCLUSION

No study was conducted yet on the significance of different combinations of patterns of palatal rugae. In our study, we have found different combinations though statistically insignificant. Thus we conclude that, if the study can be arranged with a huge size of sample, statistical significance may be observed along with considering other parameters like left and right halves of palate and distance from central incisor or first molar teeth.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. Human ethics committee medical college, Thiruvananthapuram issued approval 03/05/2017/mct. recommended to conduct the study.

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work.

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REFERENCES

1. Kapali S, Townsend G, Richards L, Parish T: Palatal rugae patterns in Australian Aborigines and Caucasians. Australian dental journal. 1997, 42:129-33. 10.1111/j.1834-7819.1997.tb00110.x
2. Sassouni V: Palatoprint, Physioprint, and Roentgenographic Cephalometry, as New Methods in Human Identification: Preliminary Report. Callaghan. 1957. https://search.worldcat.org/title/Palatoprintphysioprint-and-roentgenographic-cephalometry-as-new-methods-in-human-i
3. Surekha R, Anila K, Reddy V, Hunasgi S, Ravikumar S, Ramesh N: Assessment of palatal rugae patterns in Manipuri and Kerala population. Journal of forensic dental sciences. 2012, 1:93-6. 10.4103/0975- 1475.109896
4. Caldas IM, Magalhaes T, Afonso A: Establishing identity using cheiloscopy and palatoscopy. Forensic science international. 2007, 5:1-9. 10.1016/j.forsciint.2006.04.010
5. Thomas, C.J. and Kotze, T.J. (1983: The palatal rugaepattern: A new classification . Journal of the Dental Association of South Africa. 38:153-157.
6. Thabitha RS, Reddy RE, Manjula M, Sreelakshmi N, Rajesh A, Kumar VL: Evaluation of palatal rugae pattern in establishing identification and sex determination in Nalgonda children. Journal of forensic dental sciences. 2015, 7:232. 10.4103/0975-1475.172447
7. Mutalik VS, Menon A, Jayalakshmi N, Kamath A, Raghu AR: Utility of cheiloscopy, rugoscopy, and dactyloscopy for human identification in a defined cohort. Journal of forensic dental sciences. 2013, 5:2. 10.4103/0975-1475.114535
8. Kamala R, Gupta N, Bansal A, Sinha A: Palatal rugae pattern as an aid for personal identification: a forensic study. Journal of Indian Academy of Oral Medicine and Radiology. 20111, 23:173. 10.5005/jp-journals 10011-1122
9. Selvamani M, Hosallimath S, Basandi PS, Yamunadevi A: 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. 2015, 6:306.
10. Dwivedi N, Nagarajappa AK: Morphological analysis of palatal rugae pattern in central Indian population . Journal of International Society of Preventive & Community Dentistry. 2016, 6:417.
11. Indira AP, Gupta M, David MP: Usefulness of palatal rugae patterns in establishing identity: Preliminary results from Bengaluru city, India. Journal of forensic dental sciences. 2012, 4:2.
12. Natarajan, Iswarya1; Rajendran, Kathiravan2; Narayanan, Seetharaman3; Shanmugam, Jeevithan3. Swachh Bharat Mission Gramin: Uptake and challenges in rural Coimbatore. Journal of Family Medicine and Primary Care 13(10):p 4539-4544, October 2024. | DOI: 10.4103/jfmpc.jfmpc_91_24
13. Charles J, Rajendran K, Osborn J. An Internal Audit on Patient Safety and Quality of services in a Rural Health Training Center, Coimbatore.. *Digital Journal of Clinical Medicine*. 2024; 6(1): -. doi: https://doi.org/10.55691/2582-3868.1175
14. Balasundararaj D, Prabhu MS, Thilagarajan S, Rajendran K.Analysis of Preanalytical Errors in Clinical Biochemistry Laboratory of a Tertiary Care Hospital: A Retrospective StudyJ Clin of Diagn Res.2024; 18(12):BC06-BC09. https://www.doi.org/10.7860/JCDR/2024/73364/20384

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