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Palatal rugae morphology as an early indicator of malocclusion in primary dentition

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Abstract:
Palatal rugae are stable anatomical structures, but their association with terminal plane relationships in primary dentition remains inadequately understood. Therefore, it is of interest to evaluate the correlation between palatal rugae patterns and terminal planes in 1200 children aged 3–6 years using the Thomas and Kotze classification system. Children were categorized into flush terminal plane, distal step plane and mesial step plane groups and palatal rugae characteristics were statistically analyzed. No significant differences were observed in the number, orientation or unification of palatal rugae, whereas wavy rugae predominated in the distal step plane, circular rugae were more frequent in the mesial step plane and droplet-shaped incisive papilla was the most common finding across all age groups. Thus, palatal rugae patterns show limited association with terminal plane relationships and provide baseline evidence for exploring their role in early orthodontic risk assessment and pediatric dental screening.

Keywords: Malocclusion, palatal folds, primary dentition, rugae, terminal planes

Background:
Palatal rugoscopy which is also termed as rugoscopy is a study for the assessment of the palatal rugae pattern used with the aim of human identification as post-mortem. Palatal rugae are usually elevated and transverse mucosal folds that comprised of dense fibrous tissues and are seen on the surface of the hard palate in the maxilla of the oral cavity **[1]**. The development of the palatal rugae starts after 3 months of conception in the fetus in uterus. The orientation pattern of the palatal rugae is completely established in 12th to 14th weeks of prenatal life and remains completely in the stable form till its degeneration post-mortem in the oral mucosa **[2].** On the contrary to the frictional pattern of the ridges present on the digits, pattern of the palatal rugae remains protected from the physical trauma and thermal injuries owing to their distinctive anatomical position in the body of the humans. This protective roles aided by surrounding structures of oral cavity as osseous structures of lower and upper arch, tongue, teeth, lips and/or cheeks **[3]**. Further, in subjects where complete incineration is done leading to frictional ridge detail obliteration, they might still be identified by analysing the pattern of the palatal rugae when morphology of the oral cavity is unharmed. Palatal rugoscopy concept was first introduced by Trogo Hermosa in the year 1932 that established its role in forensic assessment **[4].** Primary dentition is a vital phase that has adequate occlusal guidance opportunity and malocclusion interception in the permanent dentition. In primary dentition, which is a developing phase, there is highest accuracy for prediction of the malocclusion in permanent dentition. Palate, alveolus, lips, palms and fingers also develop with rugae in same embryonic phase **[5]**. Existing literature data have reported association in sagittal dental malocclusions and thumbprints. Rugoscopy is also used for malocclusion determination in adults, however, there is paucity of data that compared palatal rugae pattern and primary dentition in all three planes in young child subjects **[6]**. Knowledge of these associations can help in providing valuable data concerning early management modality which allows better dentition development and potential for decreasing future malocclusion development as subjects develop to permanent dentition. Understanding this context can find ways for better procedures in pediatrics which can increase ability for prevention and prediction of orthodontic concerns before them turning to complexity in conjunction with rugae patterns **[7].** This approach not only focus on vital role of early identification, but, also focus on need for customized treatment made as unique modality in each child. By assessing the characteristics and patterns of the palatal rugae, clinicians can identify subjects at risk in early stage which allows prompt intervention promoting adequate dental alignment and overall health of a child as they grow. Presently, pediatric dentistry studies ate lacking concerning the correlation in primary dentition malocclusion in three primary molar terminal planes and pattern of the palatal rugae limiting their ability in prediction of early malocclusion **[8].** Therefore, it is of interest to assess any existing correlation in terminal planes in primary dentition and the various patterns seen in the palatal rugae.

Materials and Methods:

This research was determined to assess any existing correlation in terminal planes in primary dentition and the various patterns seen in the palatal rugae. It considered 1200 child subjects in the age range of 3 years to 6 years that visited the Department of Pediatric Dentistry of the Institute in the confined study frame. Ethical committee of the Institute gave approval for research conduction and verbal and written informed consent was taken for records. Before study initiation, all parents were asked to consent and sign on it after its thorough understanding and steps were made for ensuring the unanimous nature by keeping all personal information gathered as confidential. The research only included children from primary dentition with no congenital anomalies and no carious teeth in their oral cavity. The study discarded subjects that had improper tongue posture, functional habits, active lesions, palatal trauma, congenital anomalies and soft-tissue and bone protuberances. The pattern of the rugae in study sample was categorized following the modified classification system by Thomas and Kotze applied for evaluation of the orientation and pattern of the rugae **[9]**. The study cohort was made comfortable in the dental chair followed by establishing the primary molar relationship following the Baume's classification. The pattern of the palatal rugae and incisive papilla shape were also assessed utilizing an intraoral scanner and were divided into three groups as flush terminal plane, distal step and mesial step. Collected data from study subjects were statistically assessed using SPSS software version 22.0 (IBM Corp., Armonk, NY, USA). For intergroup comparison of orientation of the palatal rugae, their pattern, unification and number of rugae, chi-square test was used. To compare the intergroup shape of the incisive papilla, chi-square test was used. The level of statistical significance was kept at p-value of <0.05.

Results:

The research included 1200 subjects with equal number of subjects in each terminal plane namely flush terminal plane, distal step plane and mesial step plane. The study cohort comprised or 598 ales and 602 female subjects. No variation was seen in the gender distribution on the statistical grounds in the three study groups. The groups were Group I, II and III with 400 subjects each and group I mesial step had 214 female and 186 male subjects, group II/distal step had 220 female and 180 male subjects and Group III/flush terminal plane has 168 female and 232 male subject respectively. The study detail confirmed no statistical difference in the number of rugae among the three terminal planes assessed. Majority of the children in study presented with 9 rugae on both left and right side in all three planes namely mesial terminal plane, distal terminal plane and flush terminal plane. Study results depicted a higher predominance for the wavy and circular pattern of the rugae depicting statistically significant results with $p<0.05$ with the Chi-square test with $p<0.05$ **(Table 1 and 2).** No statistical difference was noted for the differences in the intergroup orientation for both the left and the right side in the palatal rugae and all the terminal planes showed a perpendicular orientation in the study subjects. Also, there were no statistical difference concerning the unification on intergroup assessment for both left and right side of the palatal rugae in all the terminal planes and converging type of unification was seen for all the terminal planes **(Table 3)**. It was also noted from the study findings that the most common shape of the incisive papilla observed was droplet shape followed by the cylindrical shape, round shape, diamond shape and double droplet shape respectively. Also, on intergroup comparison, no statistically significant difference was noted **(Table 4).**

Table 1: Distribution of number of rugae and various terminal planes corresponding to it in study subjects

Rugae number on left and right side (primary, secondary and tertiary rugae)	Terminal planes			p-value
	Mesial (%)	Distal (%)	Flush (%)	
6	0	0.5	0.1	**0.000**
7	2	0.5	1.5	
8	3.5	8.3	8.3	
9	16.5	14.5	12	
10	9.5	8	7.1	
11	1.1	0.5	3	
12	0	0	0.1	

Table 2: Distribution of shape of rugae and various terminal planes corresponding to it in study subjects

Rugae shape on left and right side	Terminal planes			p-value
	Flush (%)	Distal (%)	Mesial (%)	
Wavy	16.1	18	9.5	**0.000**
Straight	12.3	9	4.5	
Curvy	0	2.3	1	
Circular	4.3	3.5	18	

Table 3: Distribution of direction of rugae and various terminal planes corresponding to it in study subjects

Parameter	Terminal planes			p-value
	Flush (%)	Distal (%)	Mesial (%)	
Rugae unification				
Diverging	10.5	11.5	12.5	0.145
Converging	22.5	21.5	20.5	
Rugae direction on left and right side				
Perpendicular	18.3	19.5	22	0.431
Forward	4.6	5	3	
Backward	10	8.3	8.1	

Table 4: Distribution of papilla shape and various terminal planes corresponding to it in study subjects

Papilla shape	Terminal planes			p-value
	Flush (%)	Distal (%)	Mesial (%)	
Round	2.1	4.3	1	**0.001**
Double droplet	0.2	0.5	0	
Diamond	3	1	3.5	
Droplet	16.6	16.6	18.6	
Cylindrical	10.6	10	9.5	

Discussion:

Palatal rugae are unique to each individual and are distinctive. Few literature studies reported minimal sexual dimorphism based on the rugae, whereas other data suggest significant difference in transgender and in between the genders. On the contrary, our study reported no significant difference in orientation of the palatal rugae and number of rugae among female and male study subjects. This can be due to the ethnic variability. Palatal rugae usually develop in the 3rd month of the intrauterine life in the humans and extend through the palatal shelves that comprise of anatomical folds that are anteriorly present on the palatal mucosa next to the incisive papilla. The number of the palatal rugae is in the range of 4-6 on every side and is developed before the palatine shelves fusion. Rugae pattern becomes irregular at the end of gestation as anterior rugae become more prominent and posterior rugae start to diminish **[10]**. A study by van der Linden in 1978 reported that there is no elongation in palatal rugae after 10 years **[11].** Another study on Pediatric subjects by Virdi *et al.* **[12]** reported that pattern of palatal rugae is stable and distinct causing exclusion for rugae length in evaluation of their pattern. By 3 years of age, terminal plane can be adequately classified and pattern of palatal rugae are formed completely and remain unchanged, justifying the reference age of 3-6 years in study subjects. Previous data has reported that rugae hold a functional significance for speech, deglutition and mastication **[13, 14].** The data by Lysell has reported that rugae pattern are largely influenced and governed by the dorsal surface of the tongue **[15].** Position of the tongue differs based on type of malocclusion which suggests that rugae pattern varies for various types of malocclusions. For class II malocclusion, tip of the tongue is posteriorly placed and dorsal part is elevated compared to Class I and III. Developmental factors that because malocclusion can also affect the pattern of the rugae depicting the environmental and hereditary pattern can affect and result in rugae abnormalities. Dutra reported that child subjects having mesial step in primary dentition have high probability for class III malocclusion. It is also reported that >50% child subjects with flush terminal primary occlusion develop either class I or II occlusion in permanent teeth **[16].** Majority of mesial step occlusion result in class I permanent occlusion with few cases being class III, whereas cases of distal step are not self-correcting and cause class II malocclusion which warrants early assessment and management. Hence, pattern of the palatal rugae can be assessed in primary dentition **[17].** The assessment of the patterns in rugae for present study depicted that circular palatal rugae pattern is predominant in mesial step terminal plane followed by wavy pattern then straight pattern and curvilinear patterns. For flush terminal and distal terminal plane, wavy pattern was seen most commonly followed by straight pattern, circular pattern and curvilinear pattern. Other studies by Lalitya *et al.* and Kapoor *et al*. have reported that there is no definitive print pattern of rugae that correlated to any specific molar relationship which could be due to small number of subjects considered for the study which might not be sufficient for variations identification **[18, 19].** In all the terminal planes of the study, converging unification pattern was observed along with the 9 rugae. The orientation for the rugae pattern was perpendicular in predominance for all the terminal planes with rugae being seen in forward and backward orientation. These results were in line with previous work of Lalitya *et al.* **[18]** and in contrast to Thoke *et al.* **[2]** which can be attributed to deviations in study subjects and their ethnicity. The shape of the incisive papilla recorded in this study predominantly was droplet shape followed by cylindrical, round, double droplet and diamond shape. This is in accordance with Santosh Priya *et al.* where authors also reported most dominant shape being droplet in Indian subjects in all three terminal planes **[20].** This study used 3D scans for measuring parameters and used software with high reliability on the contrary to traditional impression models.

Conclusion:

Palatal rugae patterns remained stable across primary dentition, with no significant differences in their number, orientation, or unification among the three terminal plane relationships. Wavy rugae predominated in the distal step plane, whereas circular rugae were more frequent in the mesial step plane, suggesting distinct morphological trends. These findings support the potential use of palatal rugae patterns as an adjunctive tool for early orthodontic screening and assessment of developing occlusal relationships.

References:

[1] https://www.redalyc.org/pdf/637/63749543065.pdf
[2] Thoke B *et al. Cureus.* 2023 **15**:e40544. [PMID: 37465785]
[3] Shailaja AM *et al. J Oral Maxillofac Pathol.* 2018 **22**:430. [PMID: 30651694]
[4] Gandikota C *et al. J Pharm Bioallied Sci.* 2012 **4**:S358. [PMID: 23066290]
[5] Chamarthi VR *et al. J Indian Soc Pedod Prev Dent.* 2025 **43**:499. [PMID: 41235555]
[6] Bansode SC & Kulkarni M. *J Forensic Dent Sci.* 2009 **1**:77. [DOI: 10.4103/0974-2948.60378]
[7] Fatima F *et al. Dental Press J Orthod.* 2019 **24**:37e1. [PMID: 30916254]
[8] Ziar N *et al. Egypt J Forensic Sci.* 2023 **13:**14. [DOI: 10.1186/s41935-023-00334-5]
[9] Thomas CJ & Kotze TJ. *J Dent Assoc S Afr.* 1983 **38**:158. [PMID: 6243060]
[10] Baume LJ. *J Dent Res.* 1950 **29**:123. [PMID: 15415484]
[11] Van der Linden FP. *Am J Orthod.* 1978 **74**:142. [PMID: 278487]

[12] Virdi et al. Int J Forensic Sci. 2009 **4**:1 [https://ispub.com/IJFS/4/2/10809]
[13] Patil MS *et al. J Am Dent Assoc.* 2008 **139**:1471. [PMID: 18978384]
[14] Nunzi MG *et al. J Neurocytol.* 2004 **33**:359. [PMID: 15475690]
[15] Lysell L. *Acta Odontol Scand.* 1955 **13**:5. [PMID: 14387629]
[16] https://periodicos.uninove.br/saude/article/view/1640
[17] Golovachova E *et al. J Dent Res Dent Clin Dent Prospects.* 2022 **16**:24. [PMID: 35936940]
[18] Lalitya D *et al. Int J Clin Pediatr Dent.* 2019 **12**:307. [PMID: 31866716]
[19] Kapoor P *et al. J Forensic Res.* 2015 **6**:272. [DOI: 10.4172/2157-7145.1000272]
[20] Santosh Priya AKR *et al. Dent J Indira Gandhi Int Med Sci.* 2025 **4**:6. [DOI: 10.25259/DJIGIMS_35_2024]

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