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Evaluation of Palatal Height Variability in Relation to Craniofacial Growth Patterns: A Comparative Study

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ABSTRACT

Background: Palatal height plays a crucial role in maintaining a balanced facial structure and achieving proper occlusion. Orthodontic treatments can influence this anatomical feature and vary across different craniofacial growth patterns. Previous studies have examined palatal dimensions in various malocclusion types, yet limited research exists on how growth patterns influence palatal height.

Objective: This study aimed to compare the palatal height between male and female subjects exhibiting horizontal, average, and vertical craniofacial growth patterns.

Materials and Methods: A total of 60 pre-treatment study models from Indian subjects (30 males and 30 females, aged 18-30) were selected. Participants were categorized into three groups based on their craniofacial growth patterns: Class I (average), Class II (horizontal), and Class III (vertical). Palatal height was measured using a digital Vernier caliper, and cephalometric analysis was performed to classify growth patterns. One-way ANOVA was used to analyze the differences between the groups.

Results: For males, the average palatal height was significantly higher in the vertical growth pattern group (20.95 mm ± 1.95), compared to the horizontal group (18.35 mm ± 1.03), with $p = 0.010$. In females, a similar trend was observed, with the vertical growth pattern group showing the highest mean value (19.60 mm ± 1.10) and the horizontal group showing the lowest (15.90 mm ± 1.20), with $p < 0.0001$. These results demonstrate significant differences in palatal height related to gender and growth pattern.

Conclusion: The study establishes that palatal height significantly varies with craniofacial growth patterns, with vertical growers exhibiting greater palatal depth compared to horizontal and average growers. Gender also influences these variations, with females showing a more pronounced difference across growth orientations. The findings highlight the importance of considering palatal morphology in orthodontic diagnosis and treatment planning.

KEYWORDS: Craniofacial growth, Gender differences, Horizontal growth pattern, Palatal height, Vertical growth pattern.

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INTRODUCTION

The palate is a crucial anatomical structure within the human craniofacial system, playing a pivotal role in determining the overall skeletal pattern and facial appearance [1]. It contributes significantly to the functions of speech, breathing, and mastication, and its morphology can influence the alignment of teeth and the development of the upper jaw [2]. Among the various parameters of the palate, palatal height stands out as one of the most critical morphological features that affect facial aesthetics and occlusal function. Palatal height significantly impacts the facial profile, influencing the balance between the upper and lower facial thirds. A balanced palatal height is essential not only for aesthetic harmony but also for proper occlusion and the efficient functioning of the oral cavity [3].

The relationship between palatal morphology and skeletal patterns is complex, with palatal dimensions playing a key role in diagnosing and planning orthodontic treatment. Anomalies in palatal structure can lead to skeletal discrepancies, which may contribute to various malocclusions, such as Class I, Class II, and Class III malocclusions [4]. As orthodontic treatment often aims to correct these skeletal and dental discrepancies, a thorough evaluation of palatal dimensions becomes a necessary step before initiating any orthodontic intervention. Accurate measurements of the palatal height and width are essential for understanding the underlying skeletal framework and planning effective treatment strategies to achieve optimal functional and

aesthetic outcomes [5].

Numerous studies have been conducted to investigate the variations in palatal dimensions across different occlusal classifications and conditions. For instance, comparative studies between Class I and Class II malocclusions have highlighted significant differences in palatal height and shape, which may contribute to the distinct skeletal features observed in these conditions [6]. Similarly, research comparing normal occlusion to various malocclusions, such as open bite, deep bite, and crossbite, has demonstrated that abnormal palatal morphology often correlates with the presence of these malocclusions, further underscoring the importance of evaluating palatal dimensions before orthodontic treatment [8].

Moreover, palatal morphology has been studied in populations with specific medical conditions, such as Turner syndrome, a genetic disorder that can affect skeletal development. These studies often reveal that individuals with Turner syndrome may exhibit altered palatal dimensions, which can influence their occlusal relationships and orthodontic needs [9]. Similarly, comparing subjects with open bite and deep bite malocclusions to individuals with normal occlusion has provided valuable insights into the role of palatal structure in the development of these conditions. In such cases, orthodontic treatment may involve altering the palatal shape to facilitate proper dental alignment and improve occlusion [10].

In light of these findings, it is evident that evaluating palatal dimensions is a crucial component of the orthodontic assessment process. Understanding the relationship between palatal morphology and skeletal patterns not only aids in diagnosing malocclusions but also informs treatment planning, ensuring that interventions are tailored to the individual's unique needs [11]. Given the influence of palatal shape on facial aesthetics, occlusion, and overall oral function, a comprehensive assessment of palatal dimensions is critical for achieving successful orthodontic outcomes and maintaining long-term oral health [12].

This study aimed to compare the palatal height of both males and females in different growth patterns, specifically horizontal, average, and vertical growth patterns.

MATERIALS AND METHODS

Sample

The sample included 60 sets of pre-treatment study models for 60 Indian subjects selected from patients who reported to the Department of Orthodontics from December 2024 to July 2025.

Sample Criteria

Inclusion Criteria

1. Patients aged between 18 and 30 years
2. Patients having a complete permanent dentition regardless of third molars
3. Intact tooth structure.
4. No history of significant medical disease.
5. No history of trauma to face.
6. No previous orthodontic, prosthetic, or surgical treatment.

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Exclusion Criteria

1. Patient age below 18 years or above 30 years.
2. Patients with previous orthodontic treatment, prosthetic rehabilitation in the facial region, or surgical treatment.
3. Syndromic or craniofacial deformity patients.
4. Patients having retained deciduous or missing teeth, regardless of third molars
5. Patients having a history of trauma to face.
6. Patients having grossly decayed maxillary first molars.
7. Patients having periodontal pathological conditions.
8. Patients having a torus in the palate.

The sample was divided into 3 groups according to craniofacial growth pattern:

1. Class I group: included casts of 20 subjects who had an average growth pattern and consisted of 10 males and 10 females.
2. Class II group: included casts of 20 subjects who had a horizontal growth pattern and consisted of 10 males and 10 females.
3. Class III group: included casts of 20 subjects who had a vertical growth pattern and consisted of 10 males and 10 females.

METHODS

History and clinical examination

Each subject was asked to sit comfortably in the dental chair and provide information about their name, age, origin, medical history, history of facial trauma, and orthodontic treatment. Then they were asked to look forward horizontally (Frankfort plane parallel to the floor) for clinical examination (extra-orally and intra-orally) to check their fulfillment of the required sample selection.

After selecting the patients, lateral cephalograms of the selected patients were manually traced to assess their growth patterns. All the subjects were then divided into 3 groups according to their growth pattern [9,10].

GROUP I: Average Growth Pattern:
1.Go-Gn(Gonion to Gnathion) to S-N(Sella to Nasion) between $32^0 \pm 4$ 2. FMA(Frankfort Mandibular Plane Angle) between $25^0 \pm 3$
GROUP II: Horizontal Growth Pattern:
1. Go-Gn(Gonion to Gnathion) to S-N(Sella to Nasion) below 26^0
2. FMA(Frankfort Mandibular Plane Angle) below 22^0

GROUP III: Vertical Growth Pattern:
1. Go-Gn (Gonion to Gnathion) to S-N (Sella to Nasion) above 36^0
2. FMA (Frankfort Mandibular Plane Angle) above 28^0

Palatal Height Measurement:
The vertical distance between the depth of the palate and the occlusal surface at the first molar region was measured using a metallic scale and a depth rod of a digital Vernier caliper. The vertical distance between the depth of the first molar fissure and the height of the palatal cusp of the first molar was subtracted from this distance to obtain the palatal height as described by Korkhaus.

Statistical Analysis:
The data was entered using MS Excel 2016. The data was analysed using IBM SPSS Statistics (Version 27). The continuous variables were presented in terms of Mean and Standard Deviation (SD). Categorical values were presented as frequencies and percentages. Inferential statistics for the comparison of the groups were done using a one-way ANOVA test. The p-value was set at 0.05.

RESULTS

The comparative analysis between male and female participants revealed distinct variations across the measured orientations. Among males, the mean value for the average dimension was 19.45 ± 2.13, with a 95% confidence interval (CI) ranging from 17.93 to 20.97, and observed values ranging from 15.0 to 22.0. Within this group, the horizontal orientation recorded a mean of 18.35 ± 1.03, while the vertical orientation showed a higher mean of 20.95 ± 1.95, indicating a directional influence on the measured outcome. The between-group comparison in males was statistically significant ($F = 5.444$, $p = 0.010$), suggesting a meaningful difference among orientations.

For females, the overall mean for the average dimension was 17.95 ± 0.69 (95% CI: 17.46–18.44), with a range of 17.0 to 19.0. The horizontal orientation exhibited the lowest mean value (15.90 ± 1.20), while the vertical orientation showed a markedly higher mean of 19.60 ± 1.10, reflecting a substantial orientation-related disparity. The statistical analysis revealed a highly significant difference across orientations in the female group ($F = 33.102$, $p < 0.0001$).

Overall, the data indicate that both males and females demonstrated significant differences in mean values between horizontal and vertical orientations, with females showing a more pronounced variation. The vertical orientation consistently exhibited higher mean values across genders, suggesting a directional trend that may be influenced by anatomical or procedural factors relevant to the study context.

Group	N	Mean	Std. Dev	95% Confidence Interval for Mean	Min	Max	F Score/p-value
Male							
Average	10	19.450	2.1272	17.928 - 20.972	15.0	22.0	5.444 / 0.010*
Horizontal	10	18.350	1.0288	17.614 - 19.086	16.0	19.5	
Vertical	10	20.950	1.9501	19.555 - 22.345	18.0	24.0	
Total	30	19.583	2.0218	18.828 - 20.338	15.0	24.0	
Female							
Average	10	17.950	0.6852	17.460 - 18.440	17.0	19.0	33.102 / <0.0001*
Horizontal	10	15.900	1.1972	15.044 - 16.756	14.0	17.5	
Vertical	10	19.600	1.1005	18.813 - 20.387	18.0	21.0	
Total	30	17.817	1.8264	17.135 - 18.499	14.0	21.0	

*Statistically significant

Table 1: Comparison of Measurement Scores Between Male and Female Participants Across Horizontal and Vertical Conditions

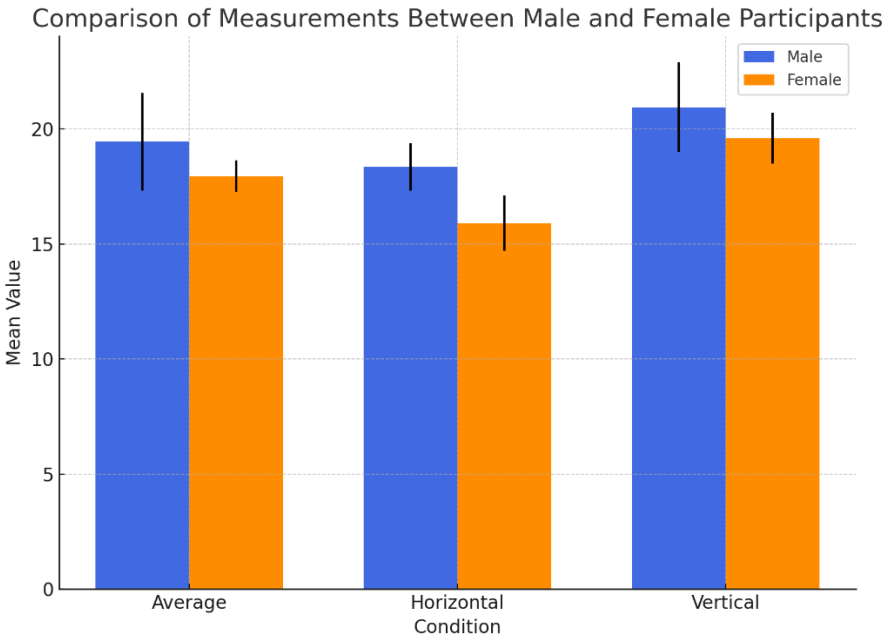

Figure 1: Graphical representation of the mean height of the study parameters

DISCUSSION:

The present study aimed to assess and compare palatal height among individuals exhibiting different craniofacial growth patterns, including horizontal, average, and vertical, in both males and females. The results demonstrated a significant association between craniofacial growth direction and palatal morphology, confirming that individuals with a vertical growth pattern possess a markedly greater palatal height than those with horizontal or average growth patterns. This finding is consistent with the concept that vertical growth tendencies are often accompanied by increased palatal depth, reflecting the morphological adaptations that occur during craniofacial development [13].

In males, the mean palatal height was highest in the vertical growth pattern group (20.95 ± 1.95 mm) and lowest in the horizontal growth group (18.35 ± 1.03 mm), with statistically significant differences between the groups ($p = 0.010$). Similarly, in females, a highly significant variation ($p < 0.0001$) was observed, with the vertical group showing the highest mean value (19.60 ± 1.10 mm) and the horizontal group the lowest (15.90 ± 1.20 mm). These results suggest that palatal morphology is influenced not only by the skeletal growth pattern but also by gender, as females exhibited a more pronounced difference across growth orientations compared to males.

The increase in palatal height in vertical growers can be attributed to altered vertical skeletal proportions and dental eruption patterns commonly associated with this type of growth. Vertical growth patterns are characterized by a steep mandibular plane angle and longer lower anterior facial height, both of which may contribute to the elongation and deepening of the palatal vault. Conversely, individuals with horizontal growth patterns typically display a flatter palate due to reduced vertical facial development and a tendency toward forward mandibular rotation. These differences highlight the intricate relationship between craniofacial structure and palatal morphology.

The results of the present study are in agreement with earlier findings by P. Christou (2008) [14], who observed distinct correlations between the craniofacial complex and palatal form. Similarly, I Tucci (2025) [15] reported that subjects with vertical facial patterns exhibited higher palatal depths compared to those with normal or horizontal growth trends. Moreover, studies such as those by AlShahrani I (2019) [16] have emphasized that variations in palatal dimensions are closely related to occlusal classifications and skeletal discrepancies, reinforcing the influence of craniofacial directionality on palatal architecture.

The gender differences observed in the current study may be attributed to inherent variations in craniofacial size, hormonal influences on skeletal development, and differences in muscle function between males and females. Males generally exhibit larger craniofacial dimensions overall; however, the relative palatal height difference across growth patterns appears more pronounced in females, possibly reflecting greater adaptive morphological changes in the female maxillary complex.

Clinically, these findings reveal the importance of evaluating palatal height as part of orthodontic diagnosis and treatment planning. A deeper palate in vertical growers may present challenges for achieving ideal occlusion and arch coordination. In contrast, a flatter palate in horizontal growers may necessitate different biomechanical considerations during expansion or leveling procedures. Understanding these variations enables clinicians to design individualized treatment strategies that accommodate the patient's unique craniofacial morphology, ensuring both functional stability and aesthetic harmony.

CONCLUSION

The present study demonstrates that palatal height exhibits significant variation in relation to craniofacial growth patterns and gender. Vertical growers consistently exhibit higher palatal vaults, followed by average and horizontal growth types. These findings reinforce the role of palatal morphology as a crucial diagnostic parameter in orthodontics, underscoring the importance of a comprehensive assessment of craniofacial growth direction before initiating treatment.

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