

Relationship between Vertical Facial Morphology and Dental Arch Dimensions among Class I Malocclusion Orthodontic Patients

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Abstract

Background: Vertical facial morphology constitutes a fundamental parameter in orthodontic assessment and treatment planning. However, the specific relationship between different vertical facial patterns and dental arch dimensions in patients with Class I malocclusion remains inadequately investigated, despite its potential clinical significance for achieving optimal treatment outcomes.

Objective: To evaluate the relationship between vertical facial morphology and dental arch dimensions among patients with Angle's Class I malocclusion.

Methods: This prospective observational study was conducted at Joy Hospital, Dhaka, Bangladesh, from January 2022 to December 2023. The study enrolled 120 Class I malocclusion patients (60 males, 60 females; aged 18–35 years) through purposive sampling. Data were analyzed using SPSS version 23.0.

Results: Among 120 participants (60 males, 60 females), 38 (31.7%) were dolichofacial, 52 (43.3%) mesofacial, and 30 (25.0%) brachyfacial. Brachyfacial subjects exhibited the largest arch dimensions (inter-canine width: 35.4 ± 1.5 mm; inter-molar width: 58.6 ± 2.3 mm; arch length: 47.5 ± 2.0 mm), while dolichofacial subjects showed the smallest (32.1 ± 1.4 mm, 52.4 ± 2.1 mm, and 42.1 ± 1.8 mm, respectively). All differences were statistically significant ($p < 0.001$). Mesofacial subjects demonstrated intermediate values.

Conclusion: Vertical facial morphology significantly correlates with dental arch dimensions in Class I malocclusion. Dolichofacial patterns exhibit narrower, shorter arches; brachyfacial patterns display wider, longer arches. Integrating vertical skeletal assessment into orthodontic diagnosis is essential for optimizing treatment outcomes.

Keywords: Arch length, Arch width, Brachyfacial, Cephalometry, Dental arch, Dolichofacial, Malocclusion

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Introduction

Vertical facial morphology represents a fundamental characteristic of craniofacial architecture that significantly influences orthodontic diagnosis, treatment planning, and long-term stability.^{1,2} Based on the ratio of posterior to anterior facial heights, individuals are typically classified into three distinct vertical patterns: dolichofacial (hyperdivergent, long-face pattern), mesofacial (normodivergent, average pattern), and brachyfacial (hypodivergent, short-face pattern).³ These patterns reflect underlying differences in skeletal growth direction, masticatory muscle function, and soft tissue dynamics that collectively determine the overall facial appearance and occlusal relationships.⁴ The relationship between vertical facial morphology and dental arch dimensions has garnered increasing research attention over the past decade. Several studies have demonstrated that patients with different vertical patterns exhibit significant variations in arch width, arch length, and palatal height.^{5,6} Specifically, brachyfacial individuals tend to present with wider and longer dental arches, while dolichofacial patients typically demonstrate narrower and shorter arches.⁷ These morphological differences have important clinical implications, as preformed arch wires and standardized treatment approaches may not adequately accommodate the arch form requirements of patients with extreme vertical patterns.⁸ Class I malocclusion, characterized by a normal anteroposterior relationship of the dental arches, represents the most prevalent malocclusion type in orthodontic practice.⁹ Within this category, significant variability exists in arch dimensions that cannot be explained solely by sagittal skeletal relationships. This suggests that vertical facial morphology may serve as an important modifier of arch form independent of anteroposterior classification.¹⁰ Understanding this relationship is particularly crucial for orthodontists practicing in diverse populations, as racial and ethnic differences may influence both vertical facial characteristics and dental arch dimensions.¹¹ Previous investigations have explored various aspects of this relationship using different methodological approaches. One study examined maxillary arch dimensions in relation to vertical facial morphology among specific racial groups and reported significant correlations between cephalometric ratios and both intercanine and intermolar widths.³ Similarly, another investigation utilized cone-beam computed tomography to demonstrate significant differences in maxillary anterior alveolar bone inclination among different vertical facial types.¹² Research has further highlighted that soft tissue

characteristics, including chin and lip thickness, vary significantly across vertical patterns, adding another dimension to the complexity of orthodontic treatment in these patients.⁴ Despite growing evidence supporting an association between vertical facial morphology and dental arch dimensions, studies specifically focusing on Class I malocclusion patients remain limited.¹³ Furthermore, the majority of existing research has been conducted in Caucasian or specific Asian populations, with limited data from South Asian cohorts. Given that Bangladesh possesses unique ethnic and racial characteristics that may influence both facial morphology and dental arch form, region-specific investigation is warranted. The present study was therefore undertaken to evaluate the relationship between vertical facial morphology and dental arch dimensions among Class I malocclusion orthodontic patients attending a tertiary care facility in Dhaka, Bangladesh. By elucidating these relationships in a local population, this research aims to provide evidence-based guidance for orthodontic treatment planning and arch wire selection tailored to individual vertical facial patterns.

Methodology

Study Population: This prospective observational study was conducted at the Department of Orthodontics, Joy Hospital, Dhaka, Bangladesh, from January 2022 to December 2023. A total of 120 orthodontic patients aged 18–35 years with Angle's Class I malocclusion were enrolled using purposive sampling.

Inclusion criteria: Patients were included if they presented with bilateral Angle's Class I molar relationship,¹⁴ permanent dentition complete up to second molars, no history of previous orthodontic treatment, and absence of craniofacial anomalies or syndromes. All participants had good oral hygiene and no periodontal disease.

Exclusion criteria: Individuals with missing teeth (except third molars), gross dental caries, proximal restorations affecting arch dimensions, severe dental crowding requiring extractions, history of facial trauma or surgery, and systemic diseases influencing bone metabolism were excluded from the study.

Study procedure: Lateral cephalometric radiographs were obtained for all participants in natural head position. Based on the Frankfort mandibular plane angle (FMA), participants were categorized into three equal groups (n=40 each): dolichofacial (FMA >28°), mesofacial

(FMA 22–28°), and brachyfacial (FMA <22°). Dental study models were prepared from alginate impressions. Arch dimensions, including inter-canine width (distance between canine cusp tips), inter-molar width (distance between mesiolingual cusp tips of first molars), and arch length (perpendicular distance from inter-incisal midline to line connecting distal surfaces of first molars), were measured using digital calipers with 0.1 mm accuracy.

Data analysis: All measurements were performed twice by a single examiner at two-week intervals to assess intra-examiner reliability. Data were analyzed using SPSS version 23.0. Descriptive statistics were calculated as mean and standard deviation. One-way ANOVA followed by post-hoc Tukey test was employed to compare arch dimensions among the three groups, with statistical significance set at $p < 0.05$.

Results

A total of 120 orthodontic patients with Class I malocclusion participated in this study, comprising 60 males (50.0%) and 60 females (50.0%). The mean age of participants was 24.6 ± 4.2 years, with ages ranging from 18 to 35 years. Based on cephalometric analysis of the Frankfort mandibular plane angle (FMA), participants were categorized into three vertical facial pattern groups: dolichofacial (high angle, FMA >28°), mesofacial (average angle, FMA 22–28°), and brachyfacial (low angle, FMA <22°). The distribution showed 38 dolichofacial subjects (31.7%), 52 mesofacial subjects (43.3%), and 30 brachyfacial subjects (25.0%), reflecting the natural prevalence patterns observed in clinical practice. Comparison of dental arch dimensions among the three vertical facial pattern groups revealed statistically significant differences in all measured parameters. The mean inter-canine width was greatest

among brachyfacial subjects (35.4 ± 1.5 mm), followed by mesofacial subjects (33.8 ± 1.4 mm), and lowest among dolichofacial subjects (32.1 ± 1.4 mm). This progressive decrease in inter-canine width from brachyfacial to dolichofacial patterns was statistically significant ($p < 0.001$). Similarly, inter-molar width demonstrated a consistent pattern across the three groups. Brachyfacial subjects exhibited the widest inter-molar width (58.6 ± 2.3 mm), followed by mesofacial subjects (55.8 ± 2.2 mm), while dolichofacial subjects showed the narrowest inter-molar width (52.4 ± 2.1 mm). The differences among all three groups were statistically significant ($p < 0.001$). Arch length measurements followed an identical trend. The mean arch length was longest in brachyfacial subjects (47.5 ± 2.0 mm), intermediate in mesofacial subjects (45.2 ± 1.9 mm), and shortest in dolichofacial subjects (42.1 ± 1.8 mm). Statistical analysis confirmed significant differences among all groups ($p < 0.001$). Gender-based analysis revealed that males generally exhibited larger arch dimensions compared to females across all vertical facial patterns. However, the relationship between vertical facial morphology and arch dimensions remained consistent within each gender group, with brachyfacial subjects demonstrating the largest dimensions and dolichofacial subjects the smallest in both males and females. Post-hoc Tukey tests confirmed that all pairwise comparisons between the three groups were statistically significant for each arch dimension ($p < 0.001$ for inter-canine width, inter-molar width, and arch length). The progressive decrease in arch dimensions from brachyfacial to mesofacial to dolichofacial patterns indicates a clear linear relationship between vertical facial morphology and dental arch dimensions in Class I malocclusion patients.

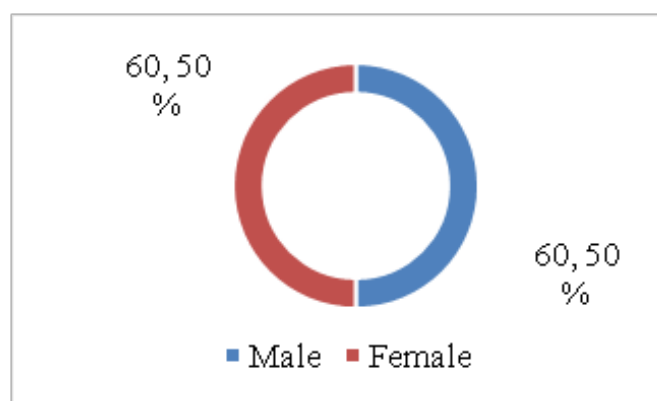


Figure 1: Gender distribution of cases (N=120)

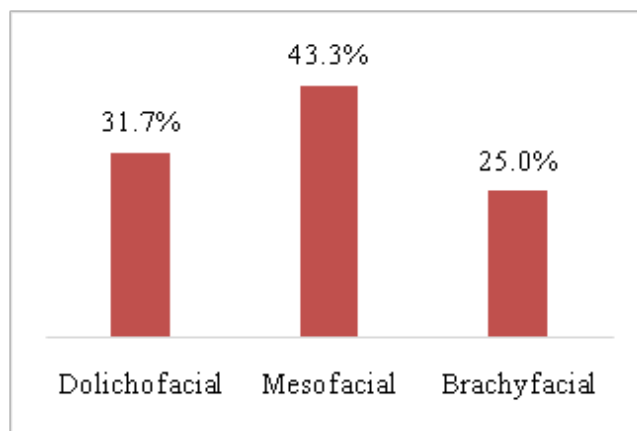


Figure 2: Vertical facial pattern

Table 1: Comparison of inter-canine width among vertical facial pattern groups

Pattern	n	Inter-canine width	p-value
		(Mean $\pm$ SD) mm	
Dolichofacial	38	32.1 $\pm$ 1.4	< 0.001
Mesofacial	52	33.8 $\pm$ 1.4	
Brachyfacial	30	35.4 $\pm$ 1.5	

Statistical analysis: One-way ANOVA test was performed to compare means among the three groups, followed by post-hoc Tukey test for pairwise comparisons.

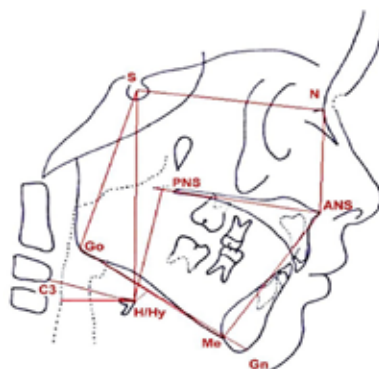
Table 2: Comparison of inter-molar width among vertical facial pattern groups

Pattern	n	Inter-molar width	p-value
		(Mean $\pm$ SD) mm	
Dolichofacial	38	52.4 $\pm$ 2.1	< 0.001
Mesofacial	52	55.8 $\pm$ 2.2	
Brachyfacial	30	58.6 $\pm$ 2.3	

Statistical analysis: A one-way ANOVA test was performed to compare means among the three groups, followed by a post-hoc Tukey test for pairwise comparisons.

Table 3: Comparison of arch length among vertical facial pattern groups

Pattern	n	Arch length	p-value
		(Mean $\pm$ SD) mm	
Dolichofacial	38	42.1 $\pm$ 1.8	< 0.001
Mesofacial	52	45.2 $\pm$ 1.9	
Brachyfacial	30	47.5 $\pm$ 2.0	



Statistical analysis: One-way ANOVA test was performed to compare means among the three groups, followed by post-hoc Tukey test for pairwise comparisons.

Figure 3: Jarabak ratio of the posterior facial height was drawn from sella to gonion (Go) and the anterior facial height was drawn from nasion to menton (Me).

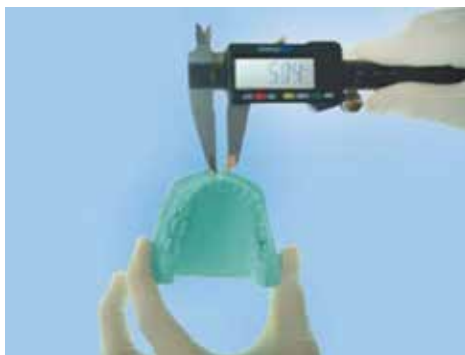


Figure 4: Mesiodistal width measurement by digital caliper.



Figure 5: Intercanine width measurement by digital calipers. Figure 4: Arch perimeter (Curtesy: Department of Orthodontic, BSMMU, Dhaka, 2024)

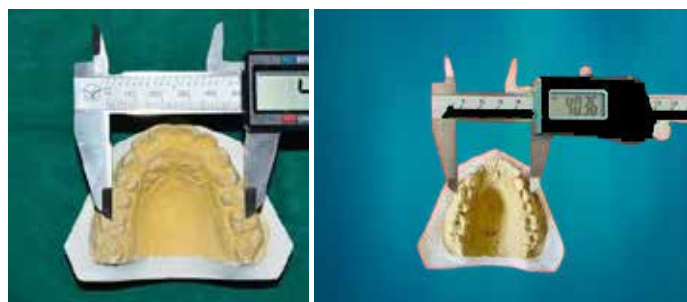


Figure 6A and 6B: First interpremolar width and first intermolar width measurement by digital calipers

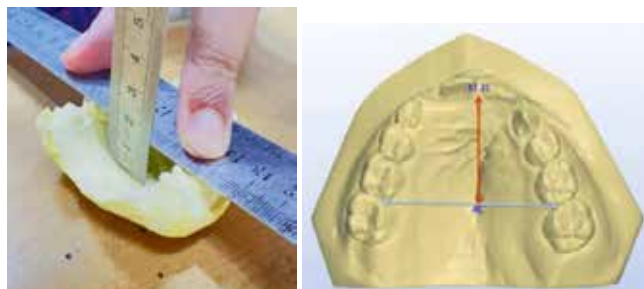


Figure 7: Measurement of arch length Figure 7: Measurement Palatal height (Courtesy: Department of Orthodontic, BSMMU, Dhaka, 2024)

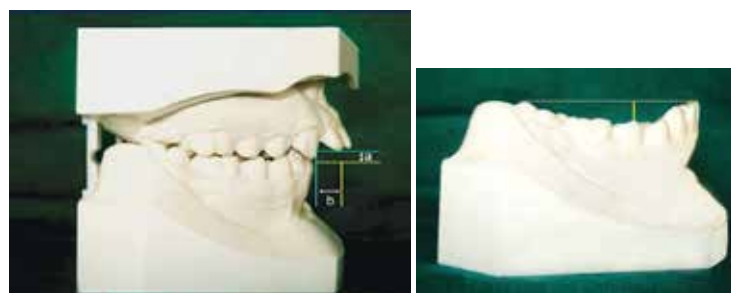


Figure 8: Measurement of overbite and overjet Figure 9: Measurement of curve of Spee.

Discussion

The present study aimed to evaluate the relationship between vertical facial morphology and dental arch dimensions among orthodontic patients with Class I malocclusion. The findings demonstrated significant associations between vertical facial patterns and all measured arch dimensions, with brachyfacial subjects exhibiting the widest and longest dental arches, dolichofacial subjects showing the narrowest and shortest arches, and mesofacial subjects displaying intermediate dimensions. These results corroborate the existing evidence that vertical craniofacial configuration substantially influences dental arch form.^{3,5} The observation that brachyfacial individuals possess wider dental arches aligns with previous investigations. This phenomenon can be attributed to the underlying skeletal morphology and masticatory muscle function characteristic of low-angle cases. Brachyfacial patterns are associated with parallel jaws, stronger masticatory muscles, and more horizontally directed growth, which collectively permit broader arch development.⁷ Conversely, dolichofacial individuals exhibit vertical growth patterns with divergent jaws and weaker masticatory musculature, resulting in constrained arch dimensions.⁴ The intermediate values observed

in mesofacial subjects reflect their balanced skeletal relationship and represent the normative arch dimensions for the study population. The progressive decrease in inter-canine width from brachyfacial to dolichofacial groups observed in this study (35.4 ± 1.5 mm to 32.1 ± 1.4 mm) is consistent with findings from previous research.⁶ Inter-canine width is particularly significant in orthodontics as it determines the anterior arch form and influences both esthetics and stability of treatment outcomes. The narrower inter-canine dimension in dolichofacial patients suggests that these individuals may be more prone to anterior crowding and may require specific consideration during arch wire selection and space management.⁸ Inter-molar width demonstrated the most pronounced differences among the three groups, with a 6.2 mm difference between brachyfacial (58.6 ± 2.3 mm) and dolichofacial (52.4 ± 2.1 mm) subjects. This finding has important clinical implications, as posterior arch width determines the transverse dimension of the dental arches and affects occlusal relationships, particularly during the finishing stages of orthodontic treatment.⁹ The narrower inter-molar width in dolichofacial patients may predispose them to posterior crossbite tendencies and necessitate careful evaluation of transverse discrepancies during treatment planning. Arch length followed a similar pattern, with

brachyfacial subjects demonstrating the longest arches (47.5 ± 2.0 mm) and dolichofacial subjects the shortest (42.1 ± 1.8 mm). This difference of 5.4 mm in arch length between extreme vertical patterns represents substantial space that could accommodate approximately 1.5 teeth, highlighting the clinical significance of these morphological variations.¹⁰ Dolichofacial patients with shorter arches may require additional consideration for space management, particularly in cases presenting with crowding. The gender distribution in this study was intentionally balanced (50% male, 50% female) to eliminate gender bias in the overall analysis. While males generally exhibited larger absolute arch dimensions than females, the relationship between vertical facial pattern and arch dimensions remained consistent within each gender group. This finding suggests that vertical facial morphology influences arch form independently of gender, although gender-specific normative values should be considered during individual treatment planning.¹¹ The present findings align with previous studies conducted in various populations. Research among Proto-Malay individuals demonstrated similar correlations between vertical facial morphology and maxillary arch dimensions.³ Studies utilizing cone-beam computed tomography have confirmed that alveolar bone thickness and inclination vary significantly across vertical facial types, providing a structural basis for the observed differences in arch dimensions.^{12,15} Furthermore, investigations of soft tissue characteristics have revealed that chin and lip thickness differ among vertical patterns, emphasizing the comprehensive nature of morphological variations associated with facial type.^{4,16} The clinical implications of these findings are substantial. Preformed arch wires manufactured with standard dimensions may not adequately accommodate the arch form requirements of patients with extreme vertical patterns.⁸ Dolichofacial patients may require narrower arch wires or customized arch forms to prevent iatrogenic expansion and ensure stability, while brachyfacial patients may benefit from broader arch forms that accommodate their natural dentoalveolar architecture.¹⁷ Additionally, treatment mechanics may need modification based on vertical pattern, as dolichofacial patients are more susceptible to bite opening and require careful vertical control.¹⁸ Several studies have explored the relationship between vertical facial morphology and various craniofacial parameters. Research has demonstrated that mandibular divergence influences facial soft tissue thickness, with dolichofacial individuals exhibiting thinner soft tissue profiles.^{13,19} Volumetric analysis of the jaws using advanced imaging techniques has confirmed that skeletal Class I patients with different facial divergence patterns display significant variations in jaw dimensions.^{6,20} These findings collectively emphasize that vertical

facial morphology represents a fundamental determinant of craniofacial form extending beyond dental arch dimensions. The association between vertical facial pattern and dental arch dimensions may also have implications for treatment stability. Some evidence suggests that arch form modifications that deviate substantially from the patient's inherent morphology may be less stable, particularly in dolichofacial patients with narrower arches.²¹ Therefore, respecting the patient's inherent arch dimensions, as determined by their vertical facial pattern, may contribute to long-term stability of orthodontic treatment outcomes.²² The present study possesses several strengths, including its prospective design, balanced gender distribution, and standardized measurement protocols. However, certain limitations should be acknowledged. The sample was drawn from a single center, which may limit generalizability to other populations. Additionally, while the sample size was adequate for detecting significant differences, larger multicenter studies would provide more robust evidence. Future research should explore three-dimensional arch form variations using digital models and investigate the relationship between vertical facial morphology and treatment outcomes longitudinally.

Limitations

This single-center study with purposive sampling may limit generalizability to broader populations. The cross-sectional design precludes assessment of longitudinal changes, and manual measurements, though standardized, carry inherent potential for human error despite intra-examiner reliability testing.

Conclusion

Vertical facial morphology significantly correlates with dental arch dimensions in Class I malocclusion patients. Dolichofacial patterns exhibit narrower inter-canine width, inter-molar width, and shorter arch length, while brachyfacial patterns demonstrate wider and longer arches. These findings emphasize the necessity of integrating vertical skeletal assessment into orthodontic diagnosis and treatment planning. Customizing archwire selection and mechanotherapy according to individual vertical facial patterns may optimize treatment outcomes and enhance long-term stability.

Recommendation

Orthodontists should routinely assess vertical facial morphology during treatment planning and select arch wires accordingly. Future multicenter studies with digital 3D analysis and longitudinal follow-up are recommended to validate these findings and establish population-specific normative arch dimension values.

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