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ISSN: 2663-9491 e-ISSN: 2789-6897

ORIGINAL ARTICLE

Influence of Vertical Facial Divergence on Intercanine, Interpremolar and Intermolar Arch Dimensions: A Cross-Sectional Study

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Received: 20 October 2026
Accepted: 06 November 2026
Published Online: 16 November 2026

Published by:
Gopalganj Medical College, Gopalganj, Bangladesh

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DOI: 10.5281/zenodo.24269499

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ABSTRACT

Background: *Vertical facial divergence influences craniofacial morphology and may affect dental arch dimensions. Understanding these relationships is essential for individualized orthodontic treatment planning, as arch width variations impact stability and aesthetics.* ***Objective:*** *To evaluate the influence of vertical facial divergence on intercanine, interpremolar, and intermolar arch dimensions in untreated orthodontic patients.* ***Methods & Materials:*** *This cross-sectional study was conducted at the Department of Orthodontics, BSMMU, Dhaka, from January 2016 to December 2016. Fifty-eight untreated patients (18-25 years) were classified into hypodivergent (n=18), normodivergent (n=20), and hyperdivergent (n=20) groups based on the MP-SN angle. Dental arch widths (intercanine, interpremolar, intermolar) were measured on pretreatment dental casts. Data were analyzed using ANOVA, Chi-square, and unpaired t test.* ***Results:*** *Arch widths varied significantly across vertical facial patterns in both sexes ($p<0.05$). In males, maxillary intermolar width (mesiobuccal cusp) decreased progressively from hypodivergent (57.25±3.49 mm) to normodivergent (52.14±3.34 mm) and hyperdivergent (47.00±3.10 mm) groups. Similar trends were observed in females (51.35±2.36 mm, 48.73±4.12 mm, 47.57±2.31 mm). All arch measurements were significantly greater in males compared to females ($p<0.05$).* ***Conclusion:*** *Vertical facial divergence significantly influences dental arch dimensions, with hyperdivergent patterns associated with narrower arches. Sex-specific differences in arch width should be considered during orthodontic diagnosis and treatment planning to ensure stable and aesthetic outcomes.*

Keywords: *Arch dimensions, Dental cast, Hypodivergent, Interpremolar, Mandibular plane angle, Vertical facial divergence*

(The Insight 2026; 9(3): 1010-1014)

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INTRODUCTION

Vertical facial divergence, determined by the steepness of the mandibular plane relative to the anterior cranial base, is a fundamental component of craniofacial assessment in orthodontic diagnosis and treatment planning [1]. The mandibular plane angle (MP-SN) serves as a reliable indicator of vertical facial pattern, with individuals classified as hypodivergent (low angle), normodivergent (average angle), or hyperdivergent (high angle) based on established cephalometric norms [2]. These vertical skeletal patterns are known to influence not only overall facial aesthetics but also the spatial relationships of the dentoalveolar structures, including dental arch dimensions [3]. Understanding the relationship between vertical facial morphology and arch width is essential for achieving stable, functional, and esthetic orthodontic outcomes, as arch form and width significantly impact treatment mechanics, stability, and the risk of relapse [4]. Dental arch width, encompassing intercanine, interpremolar, and intermolar dimensions, represents a critical parameter in orthodontic assessment [5]. These measurements influence the selection of appropriate archwires, the planning of tooth movements, and the long-term stability of orthodontic results [6]. Moreover, arch width discrepancies between the maxilla and mandible can contribute to occlusal interferences, crossbites, and compromised facial esthetics [7]. Previous studies have demonstrated that dental arch dimensions exhibit considerable variability among individuals, influenced by factors including genetics, ethnicity, sex, and craniofacial morphology [8]. Among these factors, vertical facial divergence has emerged as a significant determinant of arch width, with hyperdivergent patterns frequently associated with narrower dental arches and hypodivergent patterns with wider arches [9]. The relationship between vertical facial divergence and dental arch dimensions has been investigated in various populations using both two-dimensional and three-dimensional imaging modalities [10]. A three-dimensional evaluation of adults with various vertical facial patterns

ISSN: 2663-9491 e-ISSN: 2789-6897

reported that an increase in the mandibular plane angle is associated with tendencies of narrow mandibular arches, thinner maxillary alveolar bones, and higher palatal arches in both sexes [11]. Similarly, a comparative study assessing various cephalometric facial planes with intercanine width concluded that there is a statistically significant relationship between vertical skeletal patterns and intercanine width in untreated orthodontic patients [12]. Sex-specific differences in arch width have also been consistently documented, with males generally exhibiting greater arch dimensions compared to females across various populations and vertical facial types [13]. Despite these documented associations, the influence of vertical facial divergence on specific arch width parameters—particularly the progressive changes across intercanine, interpremolar, and intermolar regions—remains incompletely characterized, especially in South Asian populations [14]. Furthermore, the interplay between vertical facial pattern and sex in determining arch dimensions warrants further investigation to inform individualized treatment approaches [15]. Given the paucity of data on the Bangladeshi population, this cross-sectional study was undertaken to evaluate the influence of vertical facial divergence on intercanine, interpremolar, and intermolar arch dimensions in untreated orthodontic patients. We hypothesized that hyperdivergent individuals would exhibit significantly narrower arch widths compared to normodivergent and hypodivergent individuals, and that males would demonstrate greater arch dimensions than females across all vertical facial patterns.

METHODS & MATERIALS

This descriptive cross-sectional study was conducted at the Department of Orthodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from January 2016 to December 2016. A total of 58 untreated orthodontic patients aged 18 to 25 years were enrolled using convenience sampling. The sample size was calculated using the formula for comparing means across multiple groups, with 18 patients in the hypodivergent group, 20 in the normodivergent group, and 20 in the hyperdivergent group [16].

Inclusion criteria: Patients with permanent dentition (minimum 20 teeth, excluding third molars), aged 18 to 25 years, with pretreatment lateral cephalograph and dental casts of both jaws were included. Only Bangladeshi natives with no history of orthodontic treatment were enrolled.

Exclusion criteria: Patients with carious, missing, restored, hypoplastic, worn, malformed, or orthodontically moved teeth at measurement landmarks were excluded. Those with damaged casts, craniofacial disorders, facial asymmetries, history of trauma, edentulous spaces, bruxism, or abnormal masticatory muscular patterns were also excluded.

Study procedure: Pretreatment lateral cephalograph were obtained using a cephalometric X-ray machine with a 165-cm film-to-tube distance and rigid head fixation [17]. Subjects were positioned with the Frankfort plane parallel to the horizontal plane and teeth in centric occlusion. The MP-SN angle was measured to classify vertical facial patterns: hypodivergent (<28°), normodivergent (28°-36°), and hyperdivergent (>36°) [1]. Dental casts were obtained, and arch widths were measured using a caliper at five landmarks: intercanine (cusp tip distance), inter-first premolar (buccal cusp distance), inter-second premolar (buccal cusp distance), and inter-first molar (mesiobuccal cusp and central fossae distances) in both maxilla and mandible. Measurements were recorded by a single investigator.

Data analysis: Data were analyzed using SPSS version 20.0. Descriptive statistics (mean, standard deviation) were calculated. One-way ANOVA compared arch widths across the three groups. The Chi-square test assessed sex distribution. An unpaired t-test compared arch width between males and females. A p-value <0.05 was considered statistically significant.

Ethical clearance: Ethical approval was obtained from the Institutional Review Board of BSMMU. Informed written consent was obtained from all participants. Confidentiality and privacy were maintained throughout the study.

RESULT

A total of 58 untreated orthodontic patients were enrolled in this cross-sectional study. Patients were classified into three groups based on MP-SN angle: hypodivergent (n=18), normodivergent (n=20), and hyperdivergent (n=20). All patients completed the study without attrition. The demographic characteristics of the study population are presented in *Table I*. The mean age was comparable across groups (p=0.940). Female predominance was observed in all groups, with no significant association between sex and vertical facial pattern (p=0.646).

Table I: Demographic Characteristics of the Study Population (*n*=58)

Variables	Hypodivergent (n=18)	Normodivergent (n=20)	Hyperdivergent (n=20)	pvalue
Age (year), Mean ±SD	21.33±2.77	21.40±2.68	21.65±3.4	0.940ns
Sex, n (%)				0.646ns
Male	8 (44.4)	7 (35.0)	6 (30.0)	
Female	10 (55.6)	13 (65.0)	14 (70.0)	

Data were expressed as mean ±SD or frequency (percentage); ANOVA and Chisquare tests were performed; ns = not significant.

Comparison of arch widths across vertical facial patterns is presented in *Table II*. All maxillary and mandibular arch measurements showed significant variation across the three groups in both sexes (p<0.05). The maxillary intermolar width (mesiobuccal cusp) decreased progressively from hypodivergent to normodivergent to hyperdivergent groups in both males and females. *Figures 1* and 2 illustrate the serial changes in maxillary and mandibular arch widths, respectively.

ISSN: 2663-9491 e-ISSN: 2789-6897

Table II: Comparison of Arch Width Based on Vertical Facial Pattern (*n*=58)

Variable (mm)	Hypodiver gent	Normodiver gent	Hyperdiver gent	F-value	p-value
	Mean ±SD	Mean ±SD	Mean ±SD		
Maxilla					
Intercanine width					
Male	37.06±3.08	35.14±2.41	31.83±3.82	4.877	0.020*
Female	34.80±3.15	34.35±1.18	30.79±2.49	11.329	<0.001*
Inter-first molar width (MB cusp)					
Male	57.25±3.49	52.14±3.34	47.00±3.10	16.288	<0.001*
Female	51.35±2.36	48.73±4.12	47.57±2.31	4.463	0.019*
Mandible					
Intercanine width					
Male	28.75±3.28	25.86±1.57	24.67±1.86	5.287	0.016*
Female	26.45±1.86	25.23±2.04	23.57±2.82	4.607	0.017*
Inter-first molar width (MB cusp)					
Male	48.38±3.42	43.57±3.99	41.17±2.99	7.763	0.004*
Female	45.40±2.08	44.00±2.68	40.64±2.79	8.001	0.001*

*Data were expressed as mean ±SD. ANOVA test was performed. MB=Mesiobuccal. *Significant.*

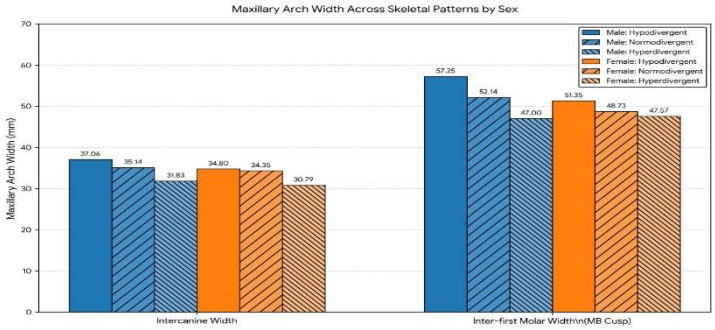


Figure 1: Bar diagram showing the maxillary arch width on different skeletal patterns in male and female patients

Figure 1 demonstrates the progressive decrease in maxillary arch widths from hypodivergent to normodivergent to hyperdivergent patterns in both sexes. Hyperdivergent individuals consistently exhibit the narrowest maxillary arch dimensions.

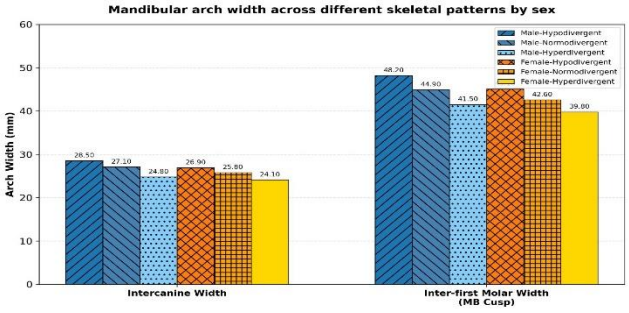


Figure 2: Bar diagram showing the mandibular arch width on different skeletal patterns in male and female patients

ISSN: 2663-9491 e-ISSN: 2789-6897

Figure 2 illustrates the similar progressive narrowing of mandibular arch widths across vertical facial patterns in both sexes. Hypodivergent individuals show the widest, while hyperdivergent individuals show the narrowest mandibular arch dimensions. Sex-based comparison of arch widths is presented in Table III. All maxillary and mandibular arch measurements were significantly greater in males compared to females ($p<0.05$ for all), with the mandibular inter-first premolar width showing the most substantial difference.

Table III: Comparison of Arch Width Between Males and Females (*n*=58)

Variable (mm)	Male (n=21) Mean±SD	Female (n=37) Mean±SD	t-value	p-value
Maxilla				
Intercanine width	35.02±3.47	33.12±2.94	2.221	0.030*
Inter-first premolar width	41.64±4.23	39.22±4.33	2.070	0.043*
Inter-second premolar width	45.90±5.49	43.10±3.16	2.477	0.016*
Inter-first molar width (MB cusp)	52.62±5.31	49.00±3.36	3.182	0.002*
Inter-first molar width (CF distance)	47.98±4.64	45.04±2.76	3.028	0.004*
Mandible				
Intercanine width	26.62±2.92	24.93±2.56	2.293	0.026*
Inter-first premolar width	36.00±3.11	32.77±2.82	4.041	<0.001*
Inter-second premolar width	41.10±4.81	38.14±3.33	2.762	0.008*
Inter-first molar width (MB cusp)	44.71±4.55	42.65±3.12	2.045	0.044*
Inter-first molar width (CF distance)	41.50±3.83	39.30±2.80	2.513	0.015*

*Data were expressed as mean ±SD. An unpaired t-test was performed. MB=Mesiobuccal; CF=Central fossae. *Significant.*

DISCUSSION

The present study was undertaken to evaluate the influence of vertical facial divergence on intercanine, interpremolar, and intermolar arch dimensions in untreated orthodontic patients. Our findings demonstrate that dental arch widths vary significantly across hypodivergent, normodivergent, and hyperdivergent facial patterns, with hyperdivergent individuals consistently exhibiting the narrowest arch dimensions and hypodivergent individuals the widest. These results support the hypothesis that vertical facial morphology is a significant determinant of transverse dental arch dimensions and highlight the importance of considering facial pattern in orthodontic diagnosis and treatment planning. The most consistent finding of this study was the progressive decrease in arch widths from hypodivergent to normodivergent to hyperdivergent groups in both sexes. In males, the maxillary intermolar width (mesiobuccal cusp) decreased from 57.25±3.49 mm in hypodivergent to 52.14±3.34 mm in normodivergent and 47.00±3.10 mm in hyperdivergent groups ($p<0.001$). Similar trends were observed for all arch width parameters in both maxilla and mandible. These findings align with previous studies that have reported narrower dental arches in hyperdivergent individuals compared to hypodivergent individuals [2,4]. A study on untreated adults found a significant negative correlation between MP-SN angle and arch width, with arch widths decreasing as the mandibular plane angle increased [18]. Another study evaluating arch width in a North Indian population reported that dental and alveolar arch widths were maximum in hypodivergents followed by normodivergents and minimum in hyperdivergents in both maxillary and mandibular arches [19]. A recent cross-sectional study on orthodontic patients also confirmed that hypodivergent subjects consistently exhibited the greatest arch widths, while hyperdivergent subjects showed the narrowest, with normodivergent individuals occupying an intermediate position [20]. The observed relationship between vertical facial divergence and arch width can be explained by the functional and developmental interactions between the facial skeleton and the dentoalveolar complex. Hyperdivergent facial patterns are characterized by a clockwise rotation of the mandible, increased lower anterior facial height, and a steep mandibular plane [1]. These skeletal features are often associated with reduced masticatory muscle activity and forces, which may lead to narrower dental arches due to decreased transverse growth stimulus [7]. In contrast, hypodivergent individuals exhibit a counterclockwise rotation, reduced facial height, and stronger masticatory muscle forces, which may promote wider arch development [8]. A three-dimensional study of dental arch form in relation to vertical facial pattern reported that high-angle facial patterns were associated with a 'V'-shaped arch form, while low-angle patterns typically displayed an ovoid arch form [21]. Sex-specific differences in arch width observed in this study are consistent with the existing literature. All maxillary and mandibular arch measurements were significantly greater in males compared to females ($p<0.05$), with the mandibular inter-first premolar width showing the most substantial difference (36.00±3.11 mm in males versus 32.77±2.82 mm in females, $p<0.001$). These findings corroborate previous reports that males generally exhibit larger dental arch dimensions than females across various populations [10,11]. A study on a South Indian population reported that male arch widths were significantly larger than those of females [12]. Similarly, a Sudanese sample study found that upper arch dimensions were higher in males than females [13]. The sexual dimorphism in arch width is likely attributable to differences in overall body and craniofacial size between males and females, as well as variations in muscle mass and masticatory forces [14]. The clinical implications of our findings are noteworthy. Understanding the relationship between vertical facial divergence and arch width can aid orthodontists in selecting appropriate archwires and planning tooth movements. Hyperdivergent patients with narrow arches may require careful archwire selection to avoid excessive expansion that could compromise stability [15]. Conversely, hypodivergent patients with wider arches may tolerate greater arch width changes during treatment. The use of individualized archwires according to each patient's pretreatment arch form and width has been suggested to ensure stable, functional, and aesthetic outcomes [4,12]. Additionally, recognizing the association between facial pattern and arch width can help predict treatment response and identify patients at risk of relapse. Vertical facial divergence significantly influences dental arch dimensions, with hyperdivergent individuals exhibiting the narrowest and hypodivergent individuals the widest arch widths across all measured parameters. Sex-specific differences in arch width

should be considered during orthodontic diagnosis and treatment planning. These findings emphasize the importance of individualized treatment approaches based on vertical facial morphology to achieve stable and aesthetic outcomes.

LIMITATIONS

The study is limited by its cross-sectional design, modest sample size, convenient sampling technique, single-center setting, and reliance on manual caliper measurements on dental casts, which may be less precise than digital or three-dimensional techniques.

CONCLUSION

Vertical facial divergence significantly influences dental arch dimensions, with hyperdivergent individuals exhibiting the narrowest and hypodivergent individuals the widest arch widths across all measured parameters. Sex-specific differences in arch width should be considered during orthodontic diagnosis and treatment planning. These findings emphasize the importance of individualized treatment approaches based on vertical facial morphology to achieve stable, functional, and aesthetic outcomes.

RECOMMENDATION

Future prospective studies with larger sample sizes, three-dimensional imaging modalities, and diverse populations are recommended to further validate these findings. Digital arch analysis using intraoral scanners may enhance measurement precision. Individualized archwire selection based on vertical facial pattern is suggested for improved treatment stability.

CONFLICT OF INTEREST STATEMENT: The authors declare no conflicts of interest. No funding was received for this study. The corresponding author had full access to all data and final responsibility for the decision to submit for publication.

AI DECLARATION

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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