Original Article

Influence of Vertical Facial Patterns on Dental Arch Parameters in Class III Malocclusions: A Cross-Sectional Study

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Main Points

- Sagittal and vertical patterns affect intermolar width.
- The Class III low-angle subgroup had the greatest intermolar width in both the maxilla and the mandible. This difference should be considered in diagnosis, treatment planning, wire selection, or restorative procedures.
- Intercanine width, arch length, and arch depth are not affected by sagittal and vertical-patterns

ABSTRACT

Objective: To evaluate how vertical-patterns influence dental arch dimensions in class I (CI) and class III (CIII) malocclusions.

Methods: Pretreatment patient files, lateral cephalometric parameters, and initial intraoral digital models of adult patients were retrieved from the archive in an academic setting. Skeletal and dental CI and CIII individuals were divided into three subgroups (n=20 for each group) according to frankfort-mandibular plane angle (FMA) values (angle between Frankfurt horizontal and mandibular planes): FMA <22° for low-angle (L), FMA=22-28° for normal-angle (N), and FMA >28° for high-angle (H) vertical patterns. Dental arch parameters were measured on digital models using 3D Slicer software (version 5.6.1; www.slicer.org). One-way analysis of variance, Kruskal-Wallis test, and Spearman correlation analysis were performed. The significance level was set at p<0.05.

Results: A significant difference in maxillary intermolar width was found between CI-H and CIII-L groups (p=0.004). A significant difference in the maxillary intermolar angle was found between the CIII-N and CI-N groups and between the CIII-N and CI-L groups (p=0.003). A significant difference in intermolar mandibular width was observed between the CI-H and CI-L groups (p=0.002). Occlusal angle differed significantly between the CI-N and CIII-H groups and between the CI-N and CIII-L groups (p=0.002). No differences were observed in intercanine width, arch length, or arch depth.

Conclusion: CIII-L group has a significantly greater intermolar width for both maxillary and mandibular arches. The clinical implications of this result can be particularly important when selecting prefabricated archwires. Therefore, it is recommended that this difference be taken into consideration in diagnosis and treatment planning to achieve effective and stable outcomes.

Keywords: Digital models, class III diagnosis, dental cast analysis

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INTRODUCTION

Dentoalveolar structures are the primary focus of orthodontics and play a crucial role in the planning and execution of orthodontic treatment. While recent advancements in orthodontics focus on craniofacial and 3-dimensional effects of orthodontic treatment, the importance of incorporating dentoalveolar features into treatment strategies has been well documented.[1,2]

The literature includes research on various malocclusions and dental characteristics. Increased backward rotation of the mandible was associated with decreased maxillary intermolar width (IMW).[3] Similarly, Nasby et al.[4] reported that a greater Sella-Nasion-Mandibular plane (SN-MP) angle was linked to a reduction in both maxillary and mandibular IMW. Sex is another factor found to influence dental features and vertical parameters.[5,6] For example, Forster et al.[5] observed that the arch widths of males were significantly larger than those of females. They also noted that arch widths in both males and females decreased as the SN-MP angle increased.[5]

Class III (CIII) malocclusion is a frequently encountered clinical condition. Its incidence may vary across racial groups and geographic regions.[7] The highest prevalence (15.80%) is reported in Southeast Asian populations, while the average prevalence is 7.04%.[7] The treatment strategy for CIII malocclusion depends on several factors, including case severity, genetic predisposition, patient maturation stage, and the presence of comorbidities.[8] In borderline adult cases, the decision between orthognathic surgery and camouflage treatment can be challenging. Camouflage therapies are interventions that adjust the patient's malocclusion to the extent permitted by biological factors. The vertical components of the problem and the dental features are critical in such cases.[9,10]

Previous studies of dental arch parameters in patients with CIII malocclusions have not assessed vertical growth direction.[11-13] Therefore, the primary aim of this study was to investigate the effect of vertical patterns on dental arch parameters in a group of nongrowing CIII patients. The secondary aim was to compare the results of these patients with those of Class I (CI) patients and investigate the differences between the groups with respect to sagittal and vertical dimensions. The null hypothesis was that there would be no significant differences in dental arch parameters among different sagittal-vertical subgroups.

METHODS

This retrospective study was conducted in the Department of Orthodontics, Faculty of Dentistry, Marmara University. Ethical approval was obtained from the Faculty of Medicine, Marmara University (approval number: 09.2024.1183, date: 16.11.2024). The records of patients who presented to the university clinic for orthodontic treatment between 2018 and 2024 were reviewed using the following inclusion and exclusion criteria.

Inclusion criteria were:

• Cervical vertebral maturation stage 6

• All permanent teeth are present and normally erupted (3rd molars not evaluated)

• Having no impacted or supernumerary teeth

• Good-quality digital cephalometric radiographs and initial digital diagnostic models

Exclusion criteria were:

• Patients with craniofacial syndrome or deformity

• History of trauma

• Having previous orthodontic treatment

• Crowding greater than 8 mm

• Any environmental interventions or hereditary deviations that affect the size or form of teeth

• Patients with maxillary constriction

Missing Records

Two researchers reviewed more than 2000 patient records. Based on the inclusion and exclusion criteria, 200 patients were selected. A priori power analysis (G*Power software version 3.1.9.6; Heinrich-Heine-Universität, Düsseldorf, Germany) was performed based on the "Arch Length" parameter of the CI hyperdivergent group from a reference study.[14] Using an effect size of 0.52, an alpha level of 0.05, and a power of 95% for an F-test (ANOVA) across the six subgroups, the minimum total sample size required was calculated to be 84 subjects (14 per subgroup). To ensure robust statistical power, the final sample size was set at 20 patients per subgroup, resulting in a total of 120 patients. Lateral cephalometric radiographs were traced and analyzed using the NemoCeph program (Nemotec, Madrid, Spain) (Figure 1).

The initial data pool contained digital models acquired by both laboratory and intraoral scanners. To standardize the data acquisition method, models obtained via intraoral scanners were excluded from the study. The final sample consisted entirely of models digitized using a 3Shape E3 laboratory scanner (3Shape, Copenhagen, Denmark). Images were then saved as .stl (stereolithography) files.

The patients' sagittal and vertical skeletal parameters, dental parameters, ages, sexes, and the method of digital model acquisition were recorded in an Excel spreadsheet. Skeletal and dental characteristics were evaluated using frankfort-mandibular plane angle (FMA) (the angle between the Frankfort horizontal and mandibular plane), angles between the S-N plane and points A and B, respectively (SNB-SNA), UI-SN (the angle between the upper incisor axis and the S-N plane), and IMPA (the angle between the lower incisor axis and the mandibular plane) (Figure 1).

Sexual dimorphism is a well-established factor influencing dental arch dimensions, with males typically exhibiting larger

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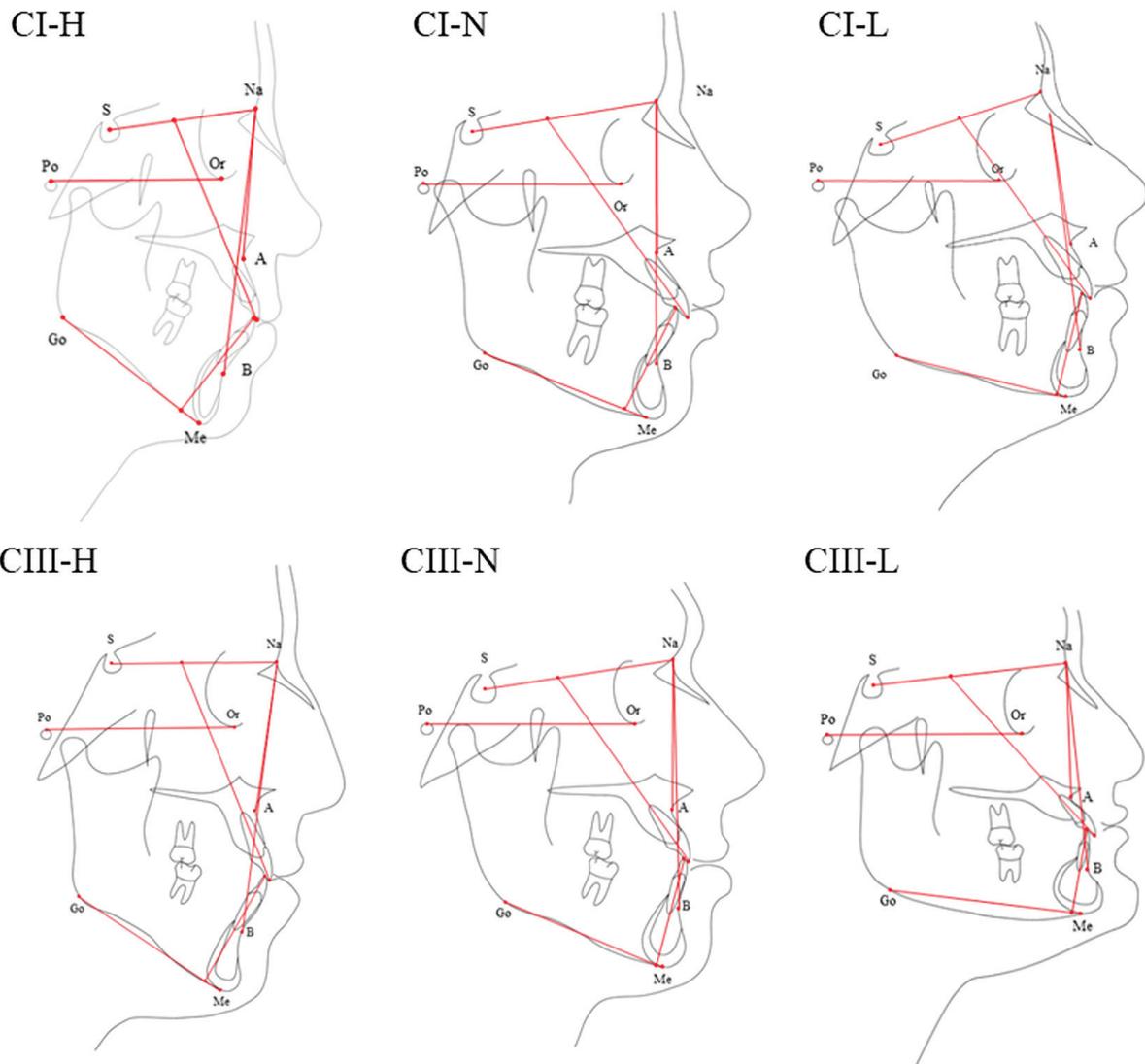
Figure 1. Lateral cephalometric measurement of each subgroup. CI: Class I; CIII: Class III; H: high-angle; N: normal-angle; L: low-angle. FMA inditcates angle between Frankfurt Horizontal plane (Po-Or) and mandibular plane (Go-Me). ANB indicates angle between A, N and B points, SNA indicates angle between S, N and A points. SNB indicates angle between S, N and B points. UI-SN indicates angle between upper incisor long axis and Sella-Nasion plane. IMPA indicates angle between lower incisor long axis and mandibular plane.

arch widths than females.[5] In the initial pool, the number of male patients was insufficient to form subgroups with statistical power. To eliminate sex as a confounding variable and to ensure high internal validity, male patients were excluded. Thus, homogeneity was maintained by restricting the sample to female patients.

Six subgroups were formed in total by combining two distinct sagittal groups (based on ANB angles and molar relationships) with three FMA-based groupings. The CI group was selected based on a bilateral CI molar relationship and an angle formed by point A, Nasion, and point B (ANB) of 0°-4°, whereas the CIII group was selected based on a bilateral CIII molar relationship and an ANB of <0°. Three subgroups were created within each sagittal group according to their FMA angles: low-angle vertical patterns (L) were those with FMA <22°, normal-angle vertical patterns (N) were those with FMA between 22 and 28°, and

high-angle vertical patterns (H) were those with FMA >28°.[15,16] Finally, six groups were formed, each with 20 patients: CI-H, CI-N, CI-L, CIII-H, CIII-N, and CIII-L.

The dental parameters were measured separately for the maxilla and the mandible using 3D Slicer software (version 5.6.1; www.slicer.org) (Figure 2).[17] Dental measurements are:

Intermolar width (mm): Three-dimensional distance between mesiobuccal cusp tips of first molars on both sides (Figure 2).[14]

Intercanine width (ICW) (mm): Three-dimensional distance between cusp tips of canines on both sides (Figure 2).[14]

Intermolar angle (IMA) (°): Angle formed by the lines crossing the mesiobuccal and distobuccal cusps of the left and right first permanent molars (Figure 2).[18]
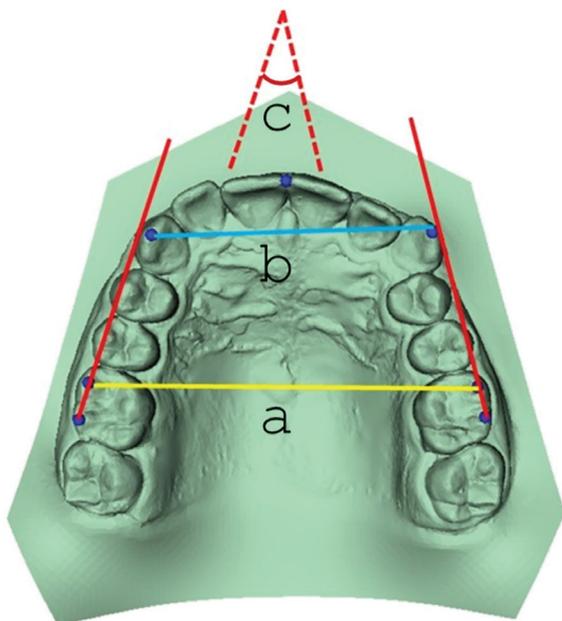
Figure 2. (a) Intermolar width; (b) Intercanine width; (c) Intermolar angle.
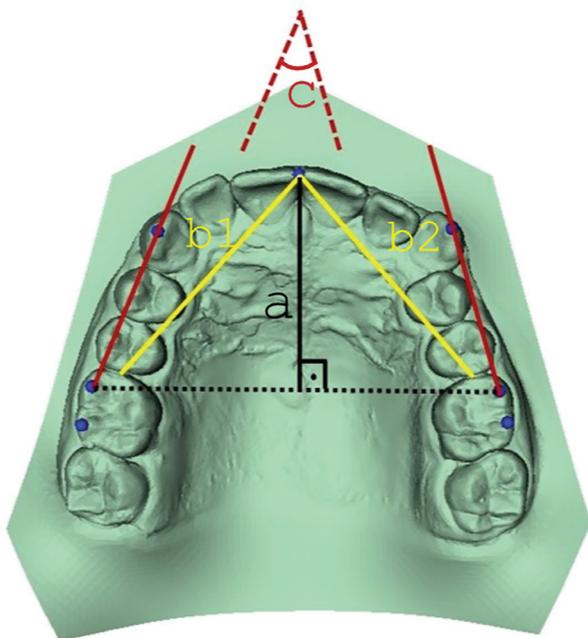

Figure 3. (a) Arch depth; (b) Arch length is the sum of b1 + b2; (c) Occlusal angle.

Arch depth (AD) (mm): Three-dimensional perpendicular distance from the most occlusal contact point of the central teeth to the line that connects mesiobuccal cusp tips of first molars on both sides (Figure 3).[14]

Arch length (AL) (mm): Sum of the three-dimensional distances from the most occlusal contact point of the central teeth to mesial surfaces of the first molars (Figure 3).[14]

Occlusal angle (OA) (°): The angle formed by the lines connecting the mesiobuccal cusp tip of the left first permanent

molar to the left canine cusp tip and the mesiobuccal cusp tip of the right first permanent molar to the right canine cusp tip (Figure 3).[18]

To assess measurement reliability, 25 patients were randomly selected from the total sample. All dental and cephalometric parameters for these patients were remeasured by the main examiner (G.Y) after a 4-week interval to assess intra-examiner reliability, and by a second independent examiner (E.A.Ö) to assess inter-examiner reliability.

Statistical Analysis
IBM SPSS Statistics version 25.0 (IBM Corp., NY, USA) was used to conduct statistical analyses. ICC was used to assess both intra- and inter-examiner measurement reliability. The Shapiro-Wilk test was used to determine whether the data were normally distributed. One-way analyses of variance (ANOVA) and the Kruskal-Wallis test were used to determine intergroup differences. Parametric variables are presented as mean ± standard deviation with 95% confidence intervals; while nonparametric variables as median with interquartile range. For post-hoc pairwise comparisons, Tukey's honestly significant difference test was applied. Spearman's correlation analysis was performed to examine relationships between sagittal, vertical, and dental measurements. Statistical significance was set at $p<0.05$.

RESULTS

The mean ages and the mean and median values of FMA, ANB, SNA, and SNB angles for the groups are presented in Table 1. No significant differences in age were observed among the groups. No significant difference was found in the SNA angle between the CI and CIII subgroups (Table 1, p=0.416, p=0.554, respectively). Significant differences were detected in SNB angle between CI subgroups CI-H and CI-L and between CIII subgroups CIII-H and CIII-L (Table 1; p=0.027 and p=0.025, respectively). Regarding incisor inclinations, no significant differences in UI-SN angle were observed among subgroups of either CI or CIII patients (Table 1, p=0.662, p=0.250, respectively). Similarly, no significant difference in IMPA was found among CI subgroups (Table 1, p=0.433). However, IMPA values differed significantly among CIII vertical subgroups (Table 1, p=0.002). Pairwise comparisons indicated that the CIII-H subgroup had significantly lower IMPA values than the CIII-N and CIII-L subgroups.

ICC analyses demonstrated high reliability for all skeletal and dental measurements. Intra-examiner reliability coefficients ranged from 0.947 to 0.975, indicating excellent reproducibility, and inter-examiner reliability coefficients ranged from 0.910 to 0.960, demonstrating excellent agreement between the two examiners.

In the Maxillary Dental Measurements
Statistically significant differences in IMW and IMA were found between groups (Table 2; p=0.004 and p=0.003, respectively). ICW, OA, AL, and AD parameters were not significant.

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Table 1: Descriptive statistics of study sample

	Age (years) Mean±SD	p	n	Gender	FMA (°) Mean±SD	Median	p	ANB (°) Mean±SD	Median	SNA (°) Mean±SD	Median	p	SNB (°) Mean±SD	Median	p	UI-SN (°) Mean±SD	Median	p	IMPA (°) Mean±SD	Median	p
CI-H	18.75±2.43		20	f (100%)	32.4±2.89	32		2±1.41	2	79±2.38	80		76.95±2.74^A	77		104.8±6.59	104.5		89.85±6.58	90	
CI-N	16.85±2.47		20	f (100%)	25.15±2.28	25.5	0.416	1.85±1.31	2	80±2.83	81	0.554	78.5±2.47^AB	79	0.027*	103.2±5.26	102	0.662	90.75±5.74	90	0.433
CI-L	18.13±1.89	0.554	20	f (100%)	19.2±2.35	20		2±1.52	2	81.1±3.6	82		79.5±3.35^B	80		103.25±6.96	104		92.45±6.86	90	
CIII-H	20.12±2.17		20	f (100%)	32.85±3.67	32		-2.85±2.16	-2.5	80.25±4.77	80		82.5±4.27^A	82.5		109.5±7.21	110		79±5.54^A	78.5	
CIII-N	20.75±1.19		20	f (100%)	26±1.97	26.5		-4.2±2.8	-4	81.3±3.56	80.5		85.5±3.56^AB	84	0.025*	113.05±7.74	113	0.250	85.3±8.27^CB	86.5	0.002*
CIII-L	17.80±1.09		20	f (100%)	18.6±3.97	20.5		-4.3±3.2	-3.5	81.85±3.03	81.5		85.9±3.24^B	85.5		113.15±8.39	113		87.35±8.12^BC	87	

Values are presented as mean ± standard deviation. "f" indicates female. CI-H: Class I High Angle Vertical Pattern; CI-N: Class I Normal Angle Vertical Pattern; CI-L: Class I Low Angle Vertical Pattern; CIII-H: Class III High Angle Vertical Pattern; CIII-N: Class III Normal Angle Vertical Pattern; CIII-L: Class III Low Angle Vertical Pattern. FMA indicates the angle between the Frankfurt Horizontal plane and the mandibular plane. ANB indicates the angle between points A, N, and B; SNA indicates the angle between points S, N, and A. SNB indicates the angle between points S, N, and B. UI-SN indicates the angle between the upper incisor long axis and the Sella-Nasion plane. IMPA indicates the angle between the long axis of the lower incisor and the mandibular plane. A, B, C: The same letters indicate that there were no statistically significant differences between interaction groups. "p" values for one-way analyses of variance (ANOVA) test. *p<0.05.

Pairwise comparisons revealed a significant difference in IMW between CI-H (50.3±2.1 mm) and CIII-L (53.4±3.8 mm) groups (Table 2, p=0.004). IMA values also significantly differed between CI-N (23.1±12°) and CIII-N (35±10.9°), and between CI-L (22.7±8.9°), and CIII-N (35±10.9°) (Table 2, p=0.003). No significant differences in vertical patterns among CI subgroups were observed for any parameter. No significant differences were observed among the CIII vertical pattern subgroups for any of the parameters.

In the Mandibular Measurements

Statistically significant differences in IMW and OA were found between groups (Table 3, p=0.002 for both). ICW, IMA, AL, and AD parameters were not statistically significant.

Pairwise comparisons revealed a significant difference in IMW between the CI-H (43.3 mm) and CIII-L (47.4 mm) groups (Table 3, p=0.002). OA values also showed significant differences between CI-N (45.7°) and CIII-H (58.3°) and between CI-N (45.7°) and CIII-L (56.5°) (Table 3, p=0.002). There were no significant differences in vertical-patterns of CI subgroups in any of the parameters. There were also no significant differences in vertical patterns of CIII subgroups across any of the parameters.

Spearman's correlation analysis showed that none of the dental measurements were associated with the FMA angle. IMW had a weak negative correlation with the ANB angle at the maxilla and a moderate positive correlation with the ANB angle at the mandible (p=0.001, p<0.001, respectively, Table 4). IMA showed a moderate negative correlation with ANB in the maxilla and a weak negative correlation in the mandible (p<0.001 and p=0.037, respectively; Table 4). OA had a weak positive correlation with ANB at the maxilla and a weak negative correlation with it at the mandible (p=0.018, p=0.002, respectively; Table 4).

DISCUSSION

In the literature, studies of dental arch parameters have reported that dental width decreases with increasing vertical dimension.[3-5] Current research indicates that, when analyzing the relationship between dental arch characteristics and vertical patterns, researchers often overlook sagittal malocclusions or assess dental parameters solely within the same sagittal malocclusion classification, disregarding vertical discrepancies.[5,11-13] In the study by Ocak et al.[14] focused on Class II (CII) malocclusion cases, vertical categorization was applied, and it was revealed that both sagittal and vertical morphology significantly influenced dental arch characteristics. Similarly, Grippaudo et al.[19] divided CII individuals into three separate vertical-patterns and reported a connection between vertical-patterns and ICW. However, the effects of vertical facial patterns on dental characteristics of CIII patients have not been investigated previously. Therefore, this study aimed to examine the dental arch parameters of CIII patients with different vertical patterns and to compare their results with those of their CI counterparts. To accurately measure arch parameters

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and maintain group homogeneity, patients requiring skeletal expansion for maxillary hypoplasia were excluded from the study. To account for the impact of sex on dental parameters, only female patients were included in the study because previous reports have indicated that dental arch width is larger in males than in females.[5,6,20]

With the development of technology, digital modeling has replaced analog modeling. In this study, digital models obtained before treatment were used. Previous studies comparing digital and manual measurements concluded that there was no significant difference between the two methods, regardless of crowding.[21,22]

Statistical analyses revealed a significant difference in SNB angles between the low- and high-angle subgroups within each main group. Ghafari and Macari[23] reported that in patients exhibiting increased vertical growth, chin and B point shifted posteriorly due to the clockwise rotation of the mandible. This may explain the significant disparity in SNB angle between the low- and high-angle subgroups.

In the present study, no differences were observed between vertical patterns within the same sagittal malocclusion groups. As a result, vertical patterns did not significantly affect the dental parameters within each group with the same sagittal skeletal relationship. AL, AD, and ICW did not show any differences between groups and were unaffected by either

Table 2. Maxillary measurements

Maxillary measurements	Class I groups			Class III groups			
	CI-H	CI-N	CI-L	CIII-H	CIII-N	CIII-L	p
Intermolar width (IMW) (mm)	50.3±2.1^B (49.3-51.3)	50.5±3.1^{AB} (49.0-51.9)	51.2±3.1^{AB} (49.8-52.7)	52.8±3.1^{AB} (51.3-54.2)	53.2±4^{AB} (51.3-55.0)	53.4±3.8^A (51.6-55.1)	0.004**
Intercanine width (ICW) (mm)	33.7±2.8 (32.4-35.1)	33.5±3.4 (31.9-35.1)	34.3±2.3 (33.2-35.3)	33.9±2.4 (32.8-35.1)	35±2.6 (33.8-36.2)	34.6±3.2 (33.1-36.2)	0.541
Intermolar angle (IMA) (°)	24.5±13 ^{ABC} (18.5-30.6)	23.1±12 ^{A} (17.5-28.7)	22.7±8.9 ^{AC} (18.5-26.8)	29.1±12.1^{ABC} (23.5-34.8)	35±10.9^B (29.9-40.1)	31.7±11.6^{ABC} (26.3-37.1)	0.003**
Occlusal angle (OA) (°)	46.3±9.8 (41.7-50.9)	45.5±8.9 (41.3-49.6)	46.8±7.9 (43.2-50.5)	50.2±8 (46.4-53.9)	48.3±8.6 (44.2-52.3)	51.04±8.9 (47.3-55.6)	0.217
Arch length (AL) (mm)	68±2.8 (66.7-69.3)	68.5±3.9 (66.7-70.3)	68±3.3 (66.4-69.5)	68.6±2.8 (67.3 -69.9)	70±4.9 (67.8-72.3)	70.2±4.4 (68.1-72.2)	0.237
Arch depth (AD) (mm)	27.5±2 (26.6-28.5)	27.6±2.4 (26.5-28.7)	27±2.2 (25.9-28)	26.9±1.9 (26.0-27.8)	27.5±2.4 (26.4-28.6)	27.6±2.4 (26.5-28.7)	0.796

Values are presented as mean ± standard deviation (95% confidence interval). CI-H, Class I High-Angle Vertical Pattern; CI-N, Class I Normal-Angle Vertical Pattern; CI-L, Class I Low-Angle Vertical Pattern; CIII-H, Class III High-Angle Vertical Pattern; CIII-N, Class III Normal-Angle Vertical Pattern; CIII-L, Class III Low-Angle Vertical Pattern. A, B, C: The same letters indicate that there were no statistically significant difference between interaction groups. "p" values for one-way analyses of variance(ANOVA)test. * p<0.05, ** p<0.01.

Table 3. Mandibular measurements

Mandibular measurements	Class I Groups			Class III Groups			
	CI-H	CI-N	CI-L	CIII-H	CIII-N	CIII-L	p
Intermolar Width (IMW) (mm)	43.3 (40.8-44.0)^A	43.2 (40.7-45.8)^{AB}	43.1 (40.9-46.3)^{AB}	46.5 (43.6-48.1)^{AB}	45.9 (41.8-49.2)^{AB}	47.4 (43.2-49.1)^B	0.002**
Intercanine Width (ICW) (mm)	26.6 (24.4-27.4)	26.7 (25.5-27.9)	26 (23.9-26.9)	25.9 (25.0-27.8)	26.5 (25.3-29.6)	26.5 (25.7-28.3)	0.227
Intermolar Angle (IMA) (°)	41.2 (34.1-52.6)	42.3 (35.1-49.7)	45.5 (41.0-51.8)	48.6 (42.0-55.1)	42.7 (37.0-59.3)	47.5 (41.5-60.3)	0.169
Occlusal Angle (OA) (°)	49.2 (41.3-54.3)^{AB}	45.7 (40.4-51.3)^A	49.6 (45-61.1)^{AB}	58.3 (49.0-69.2)^B	52.1 (45.1-57.1)^{AB}	56.5 (51.2-64.9)^B	0.002**
Arch Length (AL) (mm)	57.9 (55.7-58.8)	58 (56.3-59.6)	57.5 (55.7-59.1)	57.4 (55.2-59.2)	58.6 (56.5-64.8)	59.3 (56.8-62.0)	0.167
Arch Depth (AD) (mm)	22.9 (21.5-23.7)	23.2 (22.1-23.7)	22.7 (21.2-23.7)	21.7 (20.1-23.1)	23.6 (22.0-25.2)	22.2 (20.7-24.2)	0.062

Values are presented as median (IQR, 25th-75th percentiles). CI-H indicates Class I High Angle Vertical Pattern; CI-N, Class I Normal Angle Vertical Pattern; CI-L, Class I Low Angle Vertical Pattern; CIII-H, Class III High Angle Vertical Pattern; CIII-N, Class III Normal Angle Vertical Pattern; CIII-L, Class III Low Angle Vertical Pattern. A, B, C: The same letters indicate that there were no statistically significant difference between interaction groups. "p" values for Kruskal-Wallis test. *p<0.05, **p<0.01.

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sagittal or vertical patterns. IMA showed a significant difference in the maxilla (between CI-N and CIII-N, and between CI-L and CIII-N), whereas OA showed a significant difference in the mandible (between CI-N and CIII-H, and between CI-N and CIII-L). IMW was the parameter that most consistently showed significant differences between CI-H and CIII-L in both jaws. Studies have characterized the taper of the arches using measurements such as IMA and IMW.[18] In this study, maxillary IMA and mandibular OA were affected by different sagittal malocclusions and vertical patterns. From this perspective, CIII-N patients have a more tapered maxillary arch than CI-N patients due to differences in IMA. In the mandible, the most tapered subgroup was the CIII-L group when considering both OA and IMW. According to Grippaudo et al.,[19] the mandibular arch form is more V-shaped in individuals with low-angles and ovoid in those with high-angles, which partially supports our findings. In support of Grippaudo et al[19], when the mandibular OA and IMW values were taken into consideration in the CIII-L subgroup, it was found to be the group with the most tapered arches. However, examined in terms of maxillary IMA, our results showed that CIII-N sugbroups had more tapered arch characteristics than the CI-L subgroup, which was contrary to the results reported by Grippaudo et al.[19] In contrast, Ciavarella et al.[18] reported that a V-shaped arch was observed in patients with more high-angle individuals. However, unlike this study, the patients included in the study conducted by Ciavarella et al.[18] were not adults. Considering that IMA and OA can be affected by the buccolingual inclinations and rotations of the teeth, it may be safer to comment on arch taper based on IMW and ICW. While ICW did not show any differences in either the maxillary or the mandibular arch, IMW was increased in CIII-L. One may argue that, among CIII-L individuals, females have more tapered arch forms than other subgroups. However, this assumption contradicts the literature. Slaj et al.[24] stated that CIII individuals had more square-shaped arches, but in their study, vertical assessment was ignored. Kook et al.[25] examined arch forms according to ethnicity and malocclusion and stated that white CI groups had more tapered arches than others. Ethnic differences, sex differences, and differences in vertical values may underlie this conflict. This issue warrants clarification in future studies.

Uysal et al.[11] compared patients with CI and CIII malocclusions and found that maxillary and mandibular IMW were significantly different between these two malocclusions, similar to our results. While there was no significant difference in maxillary ICW in our study, they found a significant difference in mandibular ICW, which differs from our study. The fact that Uysal et al.[11] did not include vertical evaluations may be the reason for these differences. Braun et al.[26] reported that CIII individuals had greater dental arch widths than CI individuals, which was in accordance with this study. However, in their study, the vertical facial pattern was ignored.

Suk et al.[13] evaluated the mandibular dental and basal arch forms of patients with CI and CIII malocclusion using cone-beam computed tomography. They concluded that there was a difference in ICW but not in IMW. However, in their research, sex and vertical patterns were not considered. Koo et al.[12] examined dental casts and CT images to perform transverse evaluation of CI and CIII individuals with normal-vertical patterns and reported no significant difference in IMW and ICW between the groups for both arches, similar to the normal-angle subgroups of both CI and CIII individuals in this study. While their maxillary ICW in the CIII group was similar to that in this study, they found it to be 2.9 mm greater in the CI group.[12] However, they found that the maxillary IMW in the CI group was 4.8 mm greater and the maxillary IMW in the CIII group was 2.5 mm greater compared with our study.[12] Koo et al.[12] reported 1.5 mm and 1 mm greater mandibular ICW, 3.7 mm and 1.9 mm greater mandibular IMW respectively in the CI and CIII groups, compared to our study. The reason for these differences may be regional differences based on where the individuals in the samples were recruited, or the fact that there were only female individuals in this study, while sex was not taken into consideration in the Koo et al.'s[12] study.

Önçağ et al.[27] categorized skeletal CI, CII, and CIII patients based on their vertical-patterns and analyzed their arch widths, finding no significant differences among the categories. The difference in reported results, despite the study involving a similar population to ours, may be attributed to the inclusion of individuals aged 15-18, whose growth and development could still be in progress.

Table 4. Evaluation of the relationship between sagittal and vertical values and dental measurements												
	Intermolar width (IMW) (mm)		Intercanine width (ICW) (mm)		Intermolar angle (IMA) (°)		Occlusal angle (OA) (°)		Arch length (AL) (mm)		Arch depth (AD) (mm)	
	Maxillary Arch											
	r	p	r	p	r	p	r	p	r	p	r	p
ANB (°)	-0.287	0.001**	-0.045	0.628	-0.360	<0.001***	0.216	0.018*	0.058	0.529	0.112	0.224
FMA (°)	-0.121	0.190	-0.091	.325	0.041	0.657	0.060	0.518	0.096	0.297	-0.036	0.699
	Mandibular Arch											
ANB (°)	0.344	<0.001***	-0.141	0.124	-0.191	0.037*	-0.284	0.002**	-0.134	0.146	0.096	0.298
FMA (°)	0.105	0.254	-0.080	0.386	-0.040	0.665	-0.062	0.501	-0.096	0.295	-0.031	0.738

FMA inditcates angle between Frankfurt Horizontal plane and mandibular plane. ANB indicates angle between A, N and B points, SNA indicates angle between S, N and A points. "p" values for Spearman correlation analysis.*p<0.05, **p<0.01, ***p<0.001

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Dentoalveolar compensation is an important factor in maintaining interarch relationships, particularly with respect to the influence of CIII malocclusions on arch formation.[28] The compensatory mechanism helps maintain anterior tooth relationships through labial proclination of the maxillary incisors and lingual retroclination of the mandibular incisors, thereby compensating for the severity of the malocclusion. The literature suggests that the degree of dentoalveolar compensation may be related to vertical patterns in CIII cases.[28] In the present study, this relationship was demonstrated by the significantly lower IMPA values observed in the CIII-H subgroup, suggesting greater mandibular incisor retroclination as a compensatory mechanism in hyperdivergent patterns. The presence and degree of compensation are determinants of the decision to perform orthognathic surgery with camouflage treatment, especially in adult borderline CIII cases.[9] Therefore, when evaluating the effects of vertical patterns on arch dimensions, consideration of underlying dentoalveolar compensation mechanisms is crucial to individualize treatment planning.[28]

Based on the results of this study, the null hypothesis was partially rejected because some dental arch parameters differed significantly among subgroups. One of the limitations of the study was that it was conducted in a single-sex group, which restricts the applicability of the findings to mixed-sex populations. This modification to the sample selection was made to address issues related to sexual dimorphism arising from an insufficient initial sample size of males. This enhances internal validity by removing a potential confounder. However, further studies with larger samples that include both sexes are necessary to determine whether vertical patterns similarly influence male arch dimensions. The vertical pattern was characterized solely by the FMA; the inclusion of supplementary vertical indicators such as SN-MP or the Y-axis might have yielded a more thorough evaluation. The retrospective design introduced inherent selection bias, which may also limit the generalizability of the findings. Larger cohorts and different age groups would enhance generalizability. Consequently, it is recommended that future research incorporate both advanced morphometric analyses and 3-D radiographic imaging for a more thorough examination of dental and basal parameters. Clinically, these findings highlight that arch dimensions are not uniform across vertical patterns. Therefore, during treatment planning, archwire selection and individualized arch forms, considering the patient's vertical growth pattern, are essential to ensure stability and avoid iatrogenic expansion or relapse.

CONCLUSION

IMW is affected by sagittal and vertical patterns. The highest IMW value in both the maxilla and the mandible was found in the CIII-L group. It is recommended to consider this difference in diagnosis and treatment planning or to implement different restorative techniques, especially when choosing prefabricated wires for use in CIII-L individuals. ICW, AL, and AD are not affected by sagittal and vertical patterns. IMA at the maxillary arch and OA at the mandibular arch can be affected by sagittal and vertical-patterns. Since some dental arch measurements can be affected by vertical parameters, individualized arch forms should be applied based on the patient's initial intraoral condition and treatment objectives.

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