Cephalometric Evaluation of Maxillary Incisors Inclination, Facial, and Growth Axes in Different Vertical and Sagittal Patterns: An Original Study

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Aim: The aim of this study was to evaluate the inclination of the maxillary incisors (I), facial axis (FA), and growth axis (GA) in different vertical and sagittal patterns. Materials and Methods: A total of 498 consecutive orthodontic patients, with an average age of 18.87 years (range = 5–63 years), were grouped based on their vertical and sagittal patterns. Maxillary incisors, FA, and GA axes were traced and their corresponding angles to nasion-basion and true horizontal lines were measured. The sample was divided into three groups based on the mandibular divergence (mandibular plane-MP/sella-nasion [SN]): Group 1—hypodivergent pattern (MP/SN ≤ 27; n = 30), Group 2—normodivergent pattern (27 < MP/SN < 37; n = 254), and Group 3—hyperdivergent pattern (MP/SN ≥ 37; n = 214); the sample was then divided into three groups based on the sagittal pattern (ANB, angle between points A, Nasion and B): Group I—skeletal CLI (Class I) (0 < ANB < 4; n = 228), Group II—skeletal CLII (ANB ≥ 4; n = 216), and Group III—skeletal CLIII (ANB ≤ 0; n = 54). Group differences were evaluated using the analysis of variance and post hoc tests. Chi-square tests were used for testing relationships between categorical variables. Results: FA/nasion-basion (NBa) and GA/NBa were different among the vertical groups (P < 0.001). FA/NBa was found significantly different in the sagittal groups, whereas GA/NBa was only different between CLII and CLIII groups. Compensation in maxillary incisors’ inclination was present in the sagittal groups, but not in the vertical ones. CLI patients when stratified in vertical groups showed FA/NBa and GA/NBa to be different across the three vertical groups. Conclusion: FA/NBa was found different in the vertical and the sagittal groups. Maxillary incisors compensation was only found in the sagittal and not in the vertical groups.

Keywords: Cephalometry, facial axis, growth axis, maxillary incisors, sagittal, vertical dimension

INTRODUCTION

Orthodontists have always highlighted the importance of the maxillary incisors’ (I) position as one of the pillars of smile and facial aesthetics.[1,2] Cephalometric and clinical evaluation of maxillary incisors’ axial inclination during orthodontic treatment is a routine practice to ascertain an adequate positioning with regard to both bony and soft tissues structures. Therefore, orthodontists have always considered locating the maxillary incisors in an ideal position as a main objective of treatment planning. Accordingly, assessment of maxillary incisors’ position during and at the end of treatment remains a key factor in orthodontic treatment success.[3]
Contrary to conventional thought, the optimal position of the teeth in the face should be determined by the position of the maxillary incisors, rather than the mandibular ones. Furthermore, Creekmore suggests using the simplified Radney analysis, the modified Steiner analysis, or the modified Ricketts analysis when positioning the teeth in the face as it should be predicated on the position of the maxillary incisors.

Concordantly, Schudy stated that in producing functional harmony, the maxillary incisors should be first positioned in correct axial inclination from the standpoint of aesthetics and then the mandibular incisors position should be adjusted to produce the correct interincisal angle.

Furthermore, the orthodontic treatment should aim to optimize tooth positions within the existing skeletal pattern, taking into consideration the vertical and the sagittal pattern of the patient.

The axial inclination of the maxillary incisors is usually evaluated on the conventional lateral cephalograph and/or the articulated dental casts.

This inclination is assessed according to the different reference lines and planes at the beginning of treatment, throughout treatment, and after placing the maxillary incisors in an inclination that is judged optimal for the patient.

Traditionally, the inclination of the maxillary incisors is evaluated using cephalometric measurements of the long axis of the incisor (joining incisal tip to apex) and three main predictors and a probability level of 0.8 with three main predictors and a probability level of 0.05, the ideal sample size was calculated to be 543.

Before data collection, we calculated the optimal sample size for our study design. Using an anticipated effect size (f2) of 0.02 (large) and a power level of 0.8 with three main predictors and a probability level of 0.05, the ideal sample size was calculated to be 543.

Patients with craniofacial anomalies were excluded.

A total of 498 consecutive lateral cephalograms, who had an average age of 18.87 years (range = 5–63 years), were selected from patients’ data at the Department of Orthodontics and Dentofacial Orthopedics at the American University of Beirut, Beirut, Lebanon. Available lateral cephalometric radiographs of growing (n = 307) and adult (n = 183) patients (306 females, 192 males) taken before or at the end of orthodontic treatment (after removal of appliances) placed according to the natural head position at an appropriate distance (sagittal plane–film distance of 13cm) and all
taken in one machine were studied. Consent from the institutional review board at the American University of Beirut, Beirut, Lebanon, was granted (OTO.AM.01).

The 498 lateral cephalograms were digitized using the Dolphin Orthodontic software (Dolphin Imaging and Management Solutions, La Jolla, California). Angular measurements were computed to determine the inclination of maxillary incisor to SN, PP, and NA, as well as FA, GA, and maxillary incisor to NBa and true horizontal (H). MP/SN and ANB angles were also measured. Measurements of different variables were carried out on the digitized lateral cephalograms [Figure 1].

The sample was divided into three groups based on the vertical pattern (MP/SN) [Table 1]:
- Normodivergent group (27° < MP/SN < 37°; $n = 254$)
- Hypodivergent group (MP/SN ≤ 27°; $n = 30$)
- Hyperdivergent group (MP/SN ≥ 37°; $n = 214$)

It was also stratified into three other groups based on the sagittal pattern (ANB) [Table 2]:
- Skeletal CLI (0° < ANB < 4°; $n = 228$)
- Skeletal CLII (ANB ≥ 4°; $n = 216$)
- Skeletal CLIII (ANB ≤ 0°; $n = 54$)

The maxillary incisors’ inclination was measured relative to NA, PP, and SN.

Also, the angles between the long axis of maxillary incisors/FA/GA, and NBa line were measured. The maxillary incisors/FA/GA were also measured relative to the true horizontal [Figure 1].

**Statistical analyses**

Data cleaning was performed on all entered data to check for potential errors carried out during data entry. An initial frequency distribution was generated for all variables to check for any potential outliers.

When groups were stratified based on the vertical MP/SN and sagittal planes (ANB), the one-way analysis of variance (ANOVA) was used to test differences in variables between these groups followed by the *post hoc* Bonferroni test. The chi-square test was used to

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**Table 1: Means of selected cephalometric measurements in groups stratified on vertical pattern MP/SN**

| Groups (n = 498) | 1 (n = 30) Hypodivergent | 2 (n = 254) Normodivergent | 3 (n = 214) Hyperdivergent | ANOVA (P) | Comparisons among groups |
|------------------|--------------------------|---------------------------|---------------------------|-----------|------------------------|
| **Age (years)**  | Mean 23.32 SD 11.54      | Mean 17.99 SD 9.81        | Mean 18.18 SD 10.99       | 0.00      | 0.00 0.00 0.00 NS      |
| **Cephalometric measurements** | | | | | |
| Facial axis/NBa  | 94.25 5.14               | 89.98 4.98                | 85.65 4.98                | 0.00      | 0.00 0.00 0.00 0.00    |
| Facial axis/horizontal | 119.15 6.77             | 117.51 9.87              | 115.76 3.48              | 0.01      | NS NS NS 0.04         |
| Growth axis/NBa  | 99.33 7.40               | 94.56 4.80                | 90.05 7.40                | 0.00      | 0.00 0.00 0.00 0.00    |
| Growth axis/horizontal | 124.45 3.11            | 122.36 7.03              | 125.60 71.45             | 0.75      | NS NS NS NS           |
| I–NBa            | 84.63 13.23              | 84.41 10.57              | 82.96 9.57                | 0.28      | NS NS NS NS           |
| I–Horizontal     | 110.96 11.42             | 112.63 10.06             | 113.07 8.79               | 0.52      | NS NS NS NS           |
| I–NA             | 17.66 11.06              | 21.92 10.07              | 22.07 8.20                | 0.00      | 0.00 0.00 0.00 NS      |
| I/PP             | 109.22 11.54             | 111.39 11.95             | 109.25 11.01              | NS        | NS NS NS NS           |
| I/SN             | 98.81 12.23              | 102.29 12.21             | 102.14 9.17               | 0.04      | NS NS NS NS           |

The italic values in this table represent $P$-value < 0.05

SN = sella-nasion, NBa = nasion-basion, SD = standard deviation, PP = palatal plane, ANOVA = analysis of variance, I = maxillary incisor, NS = $P$-value > 0.05
gauge bivariate associations between malocclusion and vertical patterns. Post hoc results for the chi-square test were calculated by extracting the adjusted residuals. Chi-square values were calculated by multiplying each adjusted residual by itself. $P$ values were obtained by transforming the chi-square numbers through the Statistical Package for the Social Sciences (SPSS) software. For all parameters, two-sided $P$ values were reported. $P$ value < 0.05 was considered as statistically significant. All analyses were completed using IBM SPSS (IBM, released 2016, IBM SPSS Statistics for Windows, version 24.0, Armonk, New York).

**RESULTS**

Interrater reliability was calculated on all variables of randomly chosen cephalograms ($n = 50$). Intraclass correlation coefficients were high (>0.9).

Although age was statistically significantly different between the vertical groups, no gender differences existed.

The distribution of females and males between the groups was not statistically significantly different ($P$ value = 0.343).

The total sample was then subdivided into three groups based on the vertical pattern MP/SN: Group 1—hypodivergent pattern (MP/SN ≤ 27°; $n = 30$), Group 2—normodivergent pattern (27° < MP/SN < 37°; $n = 254$), and Group 3—hyperdivergent pattern (MP/SN ≥ 37°; $n = 214$) [Figure 2]. The age of Group 1 (hypodivergent) was different from the age of Groups 2 (normodivergent) and 3 (hyperdivergent). The mean of FA for each group was as follows: hypodivergent (mean FA = 94.25°), normodivergent (mean FA = 89.98°), and hyperdivergent (mean FA = 85.65°). ANOVA showed that FA/NBa was different across the three groups ($P < 0.00$) as well as FA/H ($P = 0.01$). The post hoc analysis showed that there was a significant difference in FA/NBa between normodivergent and hypodivergent, hypodivergent and hyperdivergent, and hyperdivergent and normodivergent, whereas FA/H showed only differences between normodivergent and hyperdivergent groups ($P$ value = 0.04). GA/NBa was

| Groups ($n = 498$) | I ($n = 228$) Class I | II ($n = 216$) Class II | III ($n = 54$) Class III | ANOVA ($P$) | Comparisons among groups |
|---------------------|-----------------------|-------------------------|--------------------------|------------|--------------------------|
|                     | Mean (SD)             | Mean (SD)               | Mean (SD)                |            | I–II I–III II–III        |
| Age (years)         | 17.69 (9.09)          | 20.01 (12.02)           | 19.21 (11.17)            | NS         | NS NS NS                |
| Cephalometric measures |                      |                        |                          |            |                          |
| Facial axis/NBa     | 89.48 (5.36)          | 86.69 (5.09)            | 90.46 (6.70)             | 0.00       | 0.00 NS NS             |
| Facial axis/horizontal | 117.05 (10.32)        | 116.15 (3.98)           | 118.85 (4.74)            | 0.06       | NS NS NS             |
| Growth axis/NBa     | 95.35 (7.72)          | 91.90 (5.84)            | 95.09 (5.11)             | 0.00       | NS NS NS             |
| Growth axis/horizontal | 126.90 (69.13)        | 120.96 (7.51)           | 122.76 (3.05)            | 0.40       | NS NS NS             |
| I–NBa               | 85.16 (8.89)          | 80.88 (11.32)           | 89.75 (8.05)             | 0.00       | 0.00 0.00 0.00        |
| I–Horizontal        | 113.55 (8.19)         | 110.70 (10.91)          | 117.31 (7.47)            | 0.00       | 0.00 0.02 0.00        |
| I–NA                | 23.08 (7.61)          | 17.51 (10.32)           | 29.22 (7.31)             | <0.001     | <0.001 <0.001 <0.001 |
| I/PP                | 110.74 (12.44)        | 108.01 (10.80)          | 116.56 (7.17)            | <0.001     | 0.033 0.002 <0.001    |
| I/SN                | 103.47 (8.55)         | 98.15 (12.88)           | 108.42 (7.94)            | <0.001     | <0.001 0.006 <0.001   |

The italic values in this table represent $P$-value < 0.05.

SN = sella-nasion, NBa = nasion-basion, SD = standard deviation, PP = palatal plane, ANOVA = analysis of variance, NA = nasion-A point, I = maxillary incisor, NS = $P$-value > 0.05

![Figure 2: Maxillary incisors, facial and growth axes in the three vertical Groups 1, 2, and 3 stratified on MP/SN: Group 1 (hypodivergent pattern), Group 2 (normodivergent pattern), and Group 3 (hyperdivergent pattern)](image-url)
also found different among the three groups \((P < 0.00)\), and post hoc analysis showed that there was a significant difference across the three groups. There was no difference in \(GA/H\), \(I/\text{NBa}\), and \(I/H\), \(I/\text{PP}\), and \(I/SN\). Only \(I/\text{NA}\) was different between Groups 1 and 2 and Groups 1 and 3 with more retroclined incisors in the hypodivergent group [Table 1].

Categorizing in the sagittal dimension, we subgrouped the sample according to ANB angle into: skeletal CLI \((0° < \text{ANB} < 4°; n = 228)\), skeletal CLII \((\text{ANB} \geq 4°; n = 216)\), and skeletal CLIII \((\text{ANB} \leq 0°; n = 54)\) [Figure 3]. No statistically significant difference was observed in age among the three sagittal groups. \(FA/\text{NBa}\) was found significantly different in the three skeletal groups \((P \text{ value} = 0.00)\) with Groups I and II being different as well as Groups II and III. \(GA/\text{NBa}\) was also found different \((P \text{ value} = 0.00)\) with differences only between Groups II and III. \(FA/H\) and \(GA/H\) were not found different. \(I/\text{NBa}\), \(I/H\), \(I/\text{NA}\), \(I/\text{PP}\), and \(I/SN\) were all found different across the three groups; the maxillary incisors being more proclined in CLIII and more retroclined in CLII [Table 2].

The sample was then divided into groups according to the vertical \((\text{MP}/\text{SN})\) and the sagittal \((\text{ANB})\) patterns [Table 3]. When classified on the sagittal dimension, hypodivergent pattern had the highest percentage of incidence in CLI \((53.3\%)\), hyperdivergent in CLII \((50.9\%)\), and normodivergent in CLIII \((66.7\%)\). Chi-square test revealed that the contingency table was statistically significantly different \((P = 0.005)\). Post hoc tests showed that the differences were mainly in the normodivergent to hyperdivergent patterns in CLII and CLIII \((0.0017 < P < 0.0173)\).

When divided into three groups based on the vertical pattern (hypodivergent, normodivergent, and hyperdivergent), CLI patients showed only \(FA/\text{NBa}\) and \(GA/\text{NBa}\) to be different across the three groups \((P \text{ value} = 0.00)\) [Table 4], whereas in CLII patients, \(FA/\text{NBa}\) and \(GA/\text{NBa}\) were found different between the hypodivergent and hyperdivergent as well as normodivergent and hyperdivergent, and \(FA/H\) was found different only between normodivergent and hyperdivergent [Table 4]. In CLIII patients, \(FA/\text{NBa}\) was only found significantly different between hypodivergent and hyperdivergent \((P \text{ value} = 0.01)\), whereas \(GA/\text{NBa}\) was found

![Figure 3: Maxillary incisors, facial and growth axes in the three sagittal Groups I, II, and III stratified on ANB: Group I (Angle CLI), Group II (Angle CLII), and Group III (Angle CLIII)](image)

| Groups \((n = 498)\) | I | II | III | Total |
|---------------------|---|----|-----|-------|
|                     | Class I | Class II | Class III |       |
|                     | % within DIV MP/ SN | % within CL | % within DIV MP/ SN | % within CL | % within DIV MP/ SN | % within CL | % within DIV MP/ SN | % within CL |
| Group 1 (hypodivergent) | 16 | 53.3 | 7.0 | 9 | 30.0 | 4.2 | 5 | 16.7 | 9.3 | 30 | 100 | 6.0 |
| Group 2 (normodivergent) | 121 | 47.6 | 53.1 | 97 | 38.2 | 44.9 | 36 | 14.2 | 66.7 | 254 | % | 51.0 |
| Group 3 (hyperdivergent) | 91 | 42.5 | 39.9 | 110 | 51.4 | 50.9 | 13 | 6.1 | 24.1 | 214 | 100 | 43 |
| Total | 228 | 45.8 | 100 | 216 | 43.4 | 100 | 54 | 10.8 | 100 | 498 | 100 | 100 |

SN = sella-nasion, MP = mandibular plane

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![Table 3: Sample size and distribution in groups stratified on vertical and horizontal patterns (MP/SN and ANB)](image)
different across the three groups (P value = 0.00), and GA/H between hypodivergent and hyperdivergent (P value = 0.00) and between hyperdivergent and normodivergent (P value = 0.00). No difference was observed across the groups in I/NA, I/PP, and I/SN [Table 4].

FA/NBa was then found different in the vertical as well as the sagittal groups, and maxillary incisors compensation was only found in the sagittal and not in the vertical groups.

**DISCUSSION**

The main contribution of this study was the association between maxillary incisors and GA and FA inclinations in different vertical and sagittal patterns.

In our study, we found that maxillary incisors’ inclination compensates in sagittal discrepancies but not in the vertical ones. Chirivella et al. [19] found that the inclination of the maxillary incisors differed among the three vertical types. Arriola-Guillen et al. [20] found the maxillary incisors to be more proclined in the skeletal open bite CLIII group when compared to the CLII group, and this was confirmed in our study as the maxillary incisors’ inclination was different among CLI, CLII, and CLIII, with CLIII showing the most proclination. Bajracharya [21] noted that the maxillary and mandibular incisors of low angle individuals were found to be proclined more than those with high and average angle individuals in a Chinese population, whereas we found no significant difference in maxillary incisors’ proclination among hypodivergent, normodivergent, and hyperdivergent groups.

Steiner [22] recommended positions for both maxillary and mandibular incisors in the face that were

| Measurement | Sagittal classification | Vertical dimension | 1 (Hypodivergent) | 2 (Normodivergent) | 3 (Hyperdivergent) | ANOVA (P) | Comparisons among groups |
|-------------|------------------------|-------------------|-------------------|-------------------|-------------------|------------|-------------------------|
| Facial axis/NBa | CLI | Mean | 95.96 | 4.60 | 90.51 | 4.76 | 86.96 | 4.83 | 0.00 | 0.00 | 0.00 | 0.00 |
| | CLII | 89.77 | 4.77 | 89.00 | 3.98 | 84.41 | 4.98 | 0.00 | NS | 0.00 | 0.00 | 0.00 |
| | CLIII | 96.80 | 1.30 | 90.83 | 7.31 | 87.00 | 3.41 | 0.00 | NS | 0.01 | NS | 0.00 |
| Facial axis/ horizontal | CLI | 121.37 | 3.28 | 116.88 | 13.77 | 116.53 | 3.21 | 0.00 | NS | NS | NS | NS |
| | CLII | 115.16 | 8.35 | 117.51 | 3.45 | 115.04 | 3.57 | 0.00 | NS | NS | 0.00 | 0.00 |
| | CLIII | 119.20 | 9.86 | 119.65 | 3.96 | 116.50 | 3.61 | 0.00 | NS | NS | NS | NS |
| Growth axis/ NBa | CLI | 99.37 | 4.79 | 94.67 | 4.95 | 90.53 | 8.95 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| | CLII | 96.94 | 9.76 | 94.08 | 5.08 | 89.57 | 5.07 | 0.00 | NS | NS | NS | NS |
| | CLIII | 103.50 | 9.24 | 95.48 | 3.19 | 90.76 | 2.66 | 0.00 | NS | 0.00 | 0.00 | 0.00 |
| Growth axis/ horizontal | CLI | 125.12 | 3.35 | 122.79 | 3.35 | 132.68 | 109.46 | NS | NS | NS | NS | NS |
| | CLII | 122.44 | 2.42 | 121.52 | 10.61 | 120.34 | 3.27 | NS | NS | NS | NS | NS |
| | CLIII | 125.90 | 9.86 | 123.16 | 2.63 | 120.46 | 3.08 | 0.00 | NS | 0.00 | 0.00 | 0.00 |
| I–NBa | CLI | 85.28 | 12.20 | 85.40 | 9.20 | 84.97 | 5.07 | 0.00 | NS | NS | NS | NS |
| | CLII | 78.88 | 13.88 | 80.96 | 11.88 | 80.96 | 10.68 | NS | NS | NS | NS | NS |
| | CLIII | 92.90 | 12.82 | 90.36 | 7.59 | 86.54 | 3.08 | NS | NS | NS | NS | NS |
| I–Horizontal | CLI | 110.56 | 10.91 | 113.36 | 8.35 | 114.31 | 7.35 | NS | NS | NS | NS | NS |
| | CLII | 107.55 | 11.50 | 109.91 | 11.94 | 111.65 | 9.87 | NS | NS | NS | NS | NS |
| | CLIII | 118.40 | 11.79 | 117.51 | 7.39 | 116.34 | 6.27 | NS | NS | NS | NS | NS |
| I–NA | CLI | 20.26 | 10.99 | 22.63 | 7.91 | 24.16 | 6.29 | NS | NS | NS | NS | NS |
| | CLII | 16.26 | 10.62 | 16.96 | 11.18 | 18.10 | 9.53 | NS | NS | NS | NS | NS |
| | CLIII | 29.70 | 11.93 | 29.09 | 6.89 | 29.40 | 7.04 | NS | NS | NS | NS | NS |
| I/PP | CLI | 109.76 | 12.18 | 110.90 | 12.42 | 110.70 | 12.62 | NS | NS | NS | NS | NS |
| | CLII | 106.72 | 13.31 | 108.17 | 11.35 | 107.98 | 10.16 | NS | NS | NS | NS | NS |
| | CLIII | 117.62 | 11.30 | 116.74 | 6.93 | 115.64 | 6.55 | NS | NS | NS | NS | NS |
| I/SN | CLI | 103.71 | 12.43 | 104.17 | 8.56 | 102.50 | 7.71 | NS | NS | NS | NS | NS |
| | CLII | 97.58 | 11.61 | 98.05 | 14.84 | 98.28 | 11.10 | NS | NS | NS | NS | NS |
| | CLIII | 111.48 | 13.94 | 109.17 | 7.23 | 105.15 | 6.67 | NS | NS | NS | NS | NS |

The italic values in this table represent P-value < 0.05.

SN = sella-nasion, MP = mandibular plane, NBa = nasion-basion, SD = standard deviation, PP = palatal plane, ANOVA = analysis of variance, NS = P-value > 0.05, NA = nasion-A point.
determined relative to lines NA and NB and to be modified according to the jaw relationships as indicated by the ANB angle. Our findings support Steiner’s recommendations and confirm that maxillary incisors’ inclination differs according to the sagittal positions of the maxillary bases.

**GROWTH/COMPENSATORY ISSUES**

The FA is an indicator of the growth pattern of the mandible. Therefore, a FA greater than 90° suggests a forward position of the chin and a horizontal vector of growth (hypodivergent pattern), whereas a FA smaller than 90° suggests a backward position of the chin and a vertical vector of growth (hyperdivergent pattern). When the FA is within normal range, growth occurs along the FA, down and forward (normodivergent pattern). In our study, we rejected the null hypothesis and found that facial and growth axes vary in both vertical and sagittal dimensions, more so in the vertical groups. However, the maxillary incisors showed less compensation in the vertical than that in the sagittal dimensions.

**CLINICAL IMPLICATIONS**

The findings of this study suggest that the inclination of the maxillary incisors, the FA, and the GA may be cephalometrically evaluated according to the vertical and sagittal pattern of the patient.

**RESEARCH ISSUES**

In our study, the small sample size of hypodivergent group (n = 30) might explain some marginal differences that were found among the groups.

It would be interesting to longitudinally follow patients while they are growing to evaluate changes in the association between maxillary incisors inclination and FA and according to the vertical and sagittal patterns. Nevertheless, and considering that mandibular plane rotation to cranial base does not change much throughout growth, our sample of growing and nongrowing individuals stands as a valid one to evaluate the aforementioned association. Therefore, the age difference that was found in our study among the different vertical groups is of no relevance, and the results found on growing patients can be considered as stagnant, not likely to undergo future changes. Furthermore, no differences existed between the groups when stratified on gender.

It would also be interesting to assess the FA inclination relative to the maxillary incisors’ axis in different soft tissue profiles and to evaluate the parallelism between those two axes in convex, straight, and concave profiles. A pilot study investigating this association was carried out.

Finally, some clinicians evaluate the inclination of the maxillary incisors on dental casts, as they consider that the use of the lateral cephalograph for that purpose is sometimes difficult and prone to errors caused by digitization of the radiographs. In our study, dental casts were discarded because of possible inappropriate trimming and because maxillary incisors’ proclination or retroclination cannot be assessed properly on study models.

**CONCLUSION**

- Facial (FA/NBa) and growth (GA/NBa) axes were different among the various vertical divergence groups, with more forward direction in hypodivergent pattern. However, when groups are stratified on sagittal dimension, facial and growth axes were only different between CLII and CLIII malocclusion groups.
- Maxillary incisors obviously compensated to the discrepancy in the sagittal dimension by retroclining in CLII and proclining in CLIII malocclusions. However, in the vertical pattern, maxillary incisors compensated more significantly in the hypodivergent group, and their inclination was within the normal range in the hyperdivergent group.
- Orthodontists should consider cephalometric evaluation of facial and growth axes as a routine practice and associate maxillary incisor inclination to the vertical direction of growth.

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**AUTHOR CONTRIBUTIONS**

Samar Bou Assi: Conceptualization, Methodology, Validation, Writing- Original draft preparation, Visualization, Investigation, Writing- Reviewing and Editing, Corresponding Author.

Anthony Macari: Conceptualization, Methodology, Data curation, Writing- Reviewing and Editing.
Antoine Hanna: Methodology, Formal analysis.
Roula Tarabay: Conceptualization, Methodology.
Ziad Salameh: Conceptualization, Methodology, Validation.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT
Consent from the institutional review board at the American University of Beirut, Beirut, Lebanon, was granted (OTO.AM.01).

PATIENT DECLARATION OF CONSENT
Not applicable.

DATA AVAILABILITY STATEMENT
Cephalometric records were selected from patients’ data at the Department of Orthodontics and Dentofacial Orthopedics at the American University of Beirut, Beirut, Lebanon.

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