Original Article

Comparison between the chin position of male and female untreated growing Class I subjects: a mixed-longitudinal study

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ABSTRACT

Objectives: To evaluate the position of the chin of untreated male and female Class I growing subjects.

Materials and Methods: A sample of 51 growing Class I subjects, 29 male and 22 female, from 7 to 16 years of age, was studied. The total number of 359 lateral cephalograms included at least one cephalogram for each subject taken in the early mixed dentition (younger than 10 years), one in late mixed dentition (between 10 and 12 years), and one in the permanent dentition phase (older than 12 years old).

Results: Descriptive statistics for the X component (horizontal) and Y component (vertical) of the cephalometric landmark Gnathion (Gn) were recorded. Student *t*-tests showed no differences between male and female growing subjects for the X component (horizontal), but significant differences for the Y component (vertical).

Conclusions: Displacement of the mandible over the timeframe studied differs between male and female untreated subjects. Although most of the orthodontic literature addresses such differences as an anteroposterior phenomenon, this study found that the difference is mainly due to the vertical, and not horizontal, component of such displacement. (*Angle Orthod*. 2025;95:304–309.)

KEY WORDS: Craniofacial growth and development; Orthodontics; Cephalometrics; Class I malocclusion; Chin position

INTRODUCTION

Data from the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1991) showed that 45.5% of U.S. children from 8 to 11 years old present with permanent first molars in Class I relationship and irregularities in the incisor area, and such prevalence increases with age. Approximately 14.7% of the U.S. population have permanent first molars in a Class II relationship, and such prevalence decreases with age. Class III malocclusion is present in approximately 5% of the U.S. population.[1]

The orthodontic literature has highlighted the importance of understanding craniofacial growth, especially mandibular growth, to diagnose and correct malocclusions fully. Class I malocclusion implies “normal” craniofacial parameters and a normal relationship between the upper and lower permanent first molars. It is considered a malocclusion because teeth may be malpositioned or rotated, and an overbite, or crossbite may occur. Understanding Class I malocclusion is the first step to quantifying the “departure from normal” observed by Class II and Class III subjects.

Mandibular anterior rotation per se is the primary determinant of chin position.[2–6] It is influenced by the amount and direction of growth at the condyles, which is congruent with remodeling at the mandibular rami and corpus and dentoalveolar compensations.[2–6]

Mathematical models have been presented to assess potential differences in mandibular growth between genders,[7] and between classes of malocclusion.[8] However, craniofacial growth is very complex, and such models make many assumptions that may forbid direct clinical application. The most reliable method for craniofacial growth assessment has used metallic implants,[9] and introduced the concept of true rotation of the maxilla[10] and mandible.[4,5]

Maxillary growth is influenced by anterior cranial base growth. True anterior rotation[10] is masked by superficial bone remodeling and more eruption of the maxillary molars than maxillary incisors. Remodeling

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Table 1. Number of Subjects and Cephalograms (Taken Annually)

	7-y-old	8-y-old	9-y-old	10-y-old	11-y-old	12-y-old	13-y-old	14-y-old	15-y-old	16-y-old	Total Cephalograms	Total Subjects
Male	11	21	27	27	26	26	27	19	18	12	214	29
Female	9	14	19	18	19	17	18	15	11	5	145	22
Total											359	51

is mainly resorptive at the anterior part of the maxilla and the nasal floor, and appositive at the hard palate, with significant bone deposition at the maxillary tuberosities.

Mandibular true anterior rotation[2–4,11–14] is also altered by superficial bone remodeling, mainly at the rami, condyles, and the base of the mandibular corpus, especially at the gonial area. Condylar growth occurs synchronously with mandibular rami growth, meaningfully more in a superior direction than in a posterior one.[15] Remodeling at the gonial region is linked with the functional mandibular rotation pattern.[2] Chronologically, it has been demonstrated that mandibular rotation is more significant in the early stages of development.[11–13]

Dentoalveolar growth can provide compensation for possibly deficient maxillary–mandibular relationships,[6,16] and it is significantly related to the vertical facial dimensions.[17–19] Being relatively plastic, therapeutic dentoalveolar growth modification facilitates the correction of malocclusions[6,20,21]

As a limitation, craniofacial data is commonly presented as linear and angular measurements, and there are no clear answers about what happens independently with each one of the landmarks. Cephalometric assessment by Cartesian coordinates offers a significant contribution since it considers each landmark per se, without depending on linear or angular measures. This study aimed to describe the position of the chin of male and female untreated growing Class I subjects using the Cartesian assessment method.

MATERIALS AND METHODS

The materials and methods were reviewed by the Institutional Review Board and considered “exempt” (Protocol #4060). This paper complies with the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) protocol.[22]

Sample

The sample was drawn from the University of Michigan Growth Study archives, generously provided by the AAOF (American Association of Orthodontists Foundation) Craniofacial Growth Legacy Collection (AAOF-CGLC). A sample of 359 cephalograms was taken in 51 Class I untreated subjects: 29 male and 22 female (Table 1).

The criteria for inclusion of subjects and cephalograms were: (1) Angle Class I malocclusion (according to the AAOF-CGLC website classification); (2) at least three cephalograms at time points including one for each of the age phases: early mixed dentition (10 years old or younger), late mixed dentition (older than 10 and younger than/or 12 years old), and permanent dentition (older than 12 years old); (3) all cephalograms with good quality for precise anatomic identification; and (4) permanent molars fully erupted at the first time point. Exclusion criteria were: (1) history of prior orthodontic treatment; and (2) presence of a craniofacial anomaly. Cephalograms were excluded for the following: (1) open mouth and/or protruded mandible, and (2) double imaging of the mandibular base due to lateral head tipping.

Data Collection

All the cephalograms were sized to 150 dpi (converted by GIMP, open source, http://www.gimp.org), before being analyzed using Viewbox 4 (dHAL Software, Kifissia, Greece, www.dhal.com). All cephalograms were oriented with the SN line minus 7° constructed line parallel to the horizontal natural plane. Sella was used as (0,0) reference for the horizontal and vertical planes, to which horizontal and vertical coordinates (X,Y) for the landmarks of interest (in millimeters) were assessed. To help identify Gnathion, potentially reduce method error, and increase reproducibility, the digitalization of a geometric curve followed the outline of anatomical structures. The software automatically identified Gnathion according to its anatomic definition,[23] and best fit into the Viewbox predetermined geometric curves.

Statistical Analyses

Data were exported from Viewbox 4 to Excel 365 software (Microsoft, Redmond, WA). The statistical package GraphPad-Prism was used for calculations.

Descriptive data (mean, standard deviation, and standard error of the mean) for the X component (horizontal) measurement (mm) and Y component (vertical) measurement (mm) of the landmark Gnathion were calculated. The horizontal reference line was constructed using the original S-N line minus 7°. The vertical reference line was perpendicular to the horizontal reference line at Sella, establishing the (0,0) reference (Figure 1A).

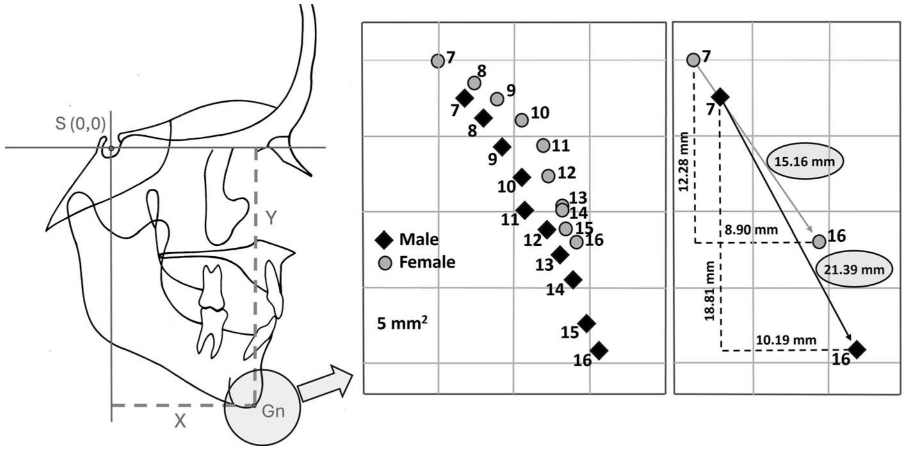

Figure 1. (A) Cartesian coordinates (X,Y) of Gnathion. (B) All ages considered. (C) Overall differences.

The same operator digitized and redigitized 30 cephalograms within a 1-month interval. Intraclass correlation (ICC)[24] measurements were 0.9982 for the X component of Gnathion and 0.9984 for its Y component. Dahlberg[25] resulted in 0.483 for the X component of Gnathion and 0.383 for its Y component.

RESULTS

Descriptive data for the X and Y components are presented in Tables 2 and 3, respectively. An unpaired *t*-test with Welch correction[26] was used to compare the male and female groups for the components X and Y.

For the male group, the horizontal component (X) of the landmark Gnathion was 10.19 mm (Table 2) and the vertical component was 18.81 mm (Table 3). The total anterior-inferior mandibular displacement during the timeframe considered was 21.39 mm for the male group (Figures 1B and 1C).

For the female group, the horizontal component (X) of the landmark Gnathion was 8.90 mm (Table 2) and the vertical component was 12.28 mm (Table 3). The total anterior–inferior mandibular displacement during the timeframe considered was 15.16 mm for the female group (Figures 1B and 1C).

For the X component, there was no statistically significant difference between the male and female groups (Table 4). For the Y component, no statistically significant differences between the male and female groups occurred at the ages 7 and 8 years, but statistically significant differences between the groups were detected for the ages 9 to 16 years (Table 5).

DISCUSSION

Craniofacial growth and development must be assessed from a pluralistic view. Genetic and functional developmental influences are tangled and are not easily identified individually. The morphology and functional drift of the maxillary bases (maxilla and mandible) are directly related to cranial base growth.

Most often, mandibular growth has been assessed by linear or angular measurements.[21] For example, the measurements of Condylion-Gnathion, Condylion-Gonion, and Gonion-Gnathion are larger for male than female subjects between the ages of 10 and 15 years,[27] and total mandibular length and ramus height (but not corpus length) are different for male and female subjects.[23] Conversely, other authors have found gender differences in corpus length.[28,29]

Male subjects demonstrate more intense pubertal growth than female subjects, which may explain such differences.[30,31] The growth velocity peak is usually attained at 13.6 ± 1.3 years of age for boys, and at

Table 2. Descriptive Data of the Horizontal Component of Gnathion (X) for Male and Female Subjects. Means are Followed by ± Standard Deviation (SD); SEM: Standard Error of Mean

	7-y-old	8-y-old	9-y-old	10-y-old	11-y-old	12-y-old	13-y-old	14-y-old	15-y-old	16-y-old
Gn (X)										
Male N = 29										
Mean ± SD	43.90 ± 4.67	44.54 ± 3.83	45.62 ± 4.09	46.94 ± 3.74	47.21 ± 5.09	49.37 ± 4.59	52.52 ± 4.90	51.71 ± 4.53	52.38 ± 5.49	54.09 ± 7.24
SEM	1.40	0.83	0.78	0.72	0.99	0.90	0.94	1.04	1.29	7.24
Female N = 22										
Mean ± SD	42.97 ± 5.64	44.55 ± 5.88	45.66 ± 6.04	47.82 ± 6.01	49.43 ± 5.79	49.56 ± 7.29	49.51 ± 6.45	49.40 ± 6.31	49.99 ± 10.06	51.87 ± 9.44
SEM	1.88	1.57	1.38	1.41	1.33	1.76	1.52	1.75	3.03	4.22

Table 3. Descriptive Data of the Vertical Component of Gnathion (Y) for Male and Female Subjects. Means are Followed by ± Standard Deviation (SD); SEM: Standard Error of Mean

	7-y-old	8-y-old	9-y-old	10-y-old	11-y-old	12-y-old	13-y-old	14-y-old	15-y-old	16-y-old
Gn (X)										
Male N = 29										
Mean ± SD	78.07 ± 4.62	79.87 ± 4.15	82.35 ± 4.13	84.40 ± 4.08	86.11 ± 4.27	87.16 ± 4.48	86.46 ± 4.78	92.05 ± 5.20	95.31 ± 5.59	96.88 ± 4.62
SEM	1.39	0.90	0.79	0.78	0.83	0.87	0.92	1.19	1.31	1.33
Male N = 29										
Mean ± SD	75.95 ± 4.47	77.75 ± 3.64	78.74 ± 3.87	80.51 ± 3.87	82.15 ± 4.35	84.17 ± 3.79	85.93 ± 4.14	86.76 ± 4.27	87.49 ± 5.35	88.23 ± 3.12
SEM	1.49	0.97	0.88	0.91	1.00	0.91	0.97	1.10	1.61	1.39

11.8 ± 1.2 years of age for girls.[31] The current data reflect such differences between genders, with the growth velocity peak of anterior and downward positioning of Gnathion earlier in female than male subjects (Tables 2 and 3, and Figure 1).

There is no significant surface modeling (bone apposition or resorption) on the tip of the chin during adolescence and later,[4,32] and its displacement is mainly due to mandibular rotation. Growth at the posterior part of the mandible, condyles and rami, play a significant role in the process of rotation, and modeling at the lower mandibular border may camouflage true mandibular rotation, since clinical/radiographic assessment shows apparent mandibular rotation.[33]

No statistical difference exists between genders in true or apparent rotation, either during childhood or adolescence.[11–14,34] Therefore, it is reasonable to assume that mandibular rotation followed the same pattern in male and female subjects. Still, the vertical component of the chin position is larger in males than in females since male subjects have longer faces, especially in adolescence.[23]

Few studies have compared true mandibular rotation between subjects with different Angle malocclusions. No significant differences in true rotation, apparent rotation, and remodeling between Class I and Class II have been detected.[12,13] However, Class I subjects had more gonial remodeling during late childhood and adolescence than Class II subjects,[12] and there is a close relationship between the true rotation and lower border remodeling.[11,12]

In the craniofacial area, results have been primarily presented as linear or angular measurements, which encompasses a potential drawback since landmarks are all related to each other geometrically. For example, if the total mandibular length is measured from Condylion to Gnathion, measured differences do not explain whether the changes occurred at Condylion and/or Gnathion. Such assessments do not control for geometrical limitations either, since an increase does not necessarily mean anterior chin projection.[27] Computing the average Cartesian coordinates of a certain landmark does not provide a genuine growth chart since it does not consider each individual's growth curve but, rather, the average among individuals of the same age.

The development of vertical posterior facial height is very important for development of the face and dental occlusion. In other words, it is essential for mandibular rotation. Posterior facial height is built by condylar and ramus remodeling, including the gonial region. Condyles showed the most significant vertical growth and remodeling changes,[15] and Gonion showed the greatest posterior growth and remodeling changes.[2,32] Male subjects demonstrated significantly more growth at both sites than female subjects.[2] The current results agreed that the vertical component is more important for the anterior mandibular displacement than the anteroposterior component. However, the difference of approximately five times more inferior than anterior mandibular displacement between 10 and 15 years of age reported by Buschang and Gandini[2] was not confirmed. Including subjects from 7 to 16 years of age, the current results showed a vertical/horizontal ratio of 1.84 times for male subjects and 1.38 times for female subjects. The assessment during a longer timeframe may have diluted the difference between the vertical and horizontal components.

CONCLUSIONS

- The present study shows a Cartesian assessment of the cephalometric landmark Gnathion without

Table 4. Unpaired *t*-Test With Welch's Correction Comparing the Horizontal Component (X) of Gnathion of Male and Female Subjects

	7-y-old	8-y-old	9-y-old	10-y-old	11-y-old	12-y-old	13-y-old	14-y-old	15-y-old	16-y-old
Gn (X)										
Male	43.90	44.54	45.62	46.94	47.21	49.37	50.52	51.71	52.38	54.09
Female	42.87	44.55	45.66	47.82	49.43	49.56	49.51	49.40	49.99	51.87
T-Test	0.697	0.995	0.982	0.583	0.190	0.925	0.578	0.270	0.481	0.654

Table 5. Unpaired *t*-Test With Welch's Correction Comparing the Vertical Component (Y) of Gnathion of Male and Female Subjects. *t*-test significance: $^{*}P < .05$; $^{**}P < .01$; $^{***}P < .001$

	7-y-old	8-y-old	9-y-old	10-y-old	11-y-old	12-y-old	13-y-old	14-y-old	15-y-old	16-y-old
Gn (X)										
Male	78.07	79.87	83.35	84.40	86.11	87.16	89.46	92.05	95.31	96.88
Female	75.95	77.75	78.74	80.51	82.15	84.17	85.93	86.76	87.49	88.23
t-test	0.314	0.120	0.004**	0.002**	0.004**	0.024*	0.012*	0.027*	0.001**	0.0009***

relying upon any linear or angular measurement involving other cephalometric landmarks.
- There is a significant difference in the vertical component (Y) of Gnathion position between male and female untreated growing Class I subjects, but no difference in its horizontal component (X).

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