Magnitude of monthly pubertal mandibular growth in class II controls, and the relationship between upper and lower incisor movements and horizontal vs. vertical expression of chin growth

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ABSTRACT

Objective: To quantify how much the mandibles of untreated pubertal boys and girls grow per month, and to show that the horizontal and vertical expression of that growth of the chin is related to how the incisors change positions during that growth.

Materials and Methods: Lateral cephalograms from untreated deep bite class II boys and girls chosen to be of pubertal age were selected. Films were approximately two years apart. The films were fiducialized, and landmarks were drawn on the T1 film and transferred to the T2 film by one experienced investigator. Changes in upper and lower incisor positions and Gnathion were measured for both vertical and horizontal components. The average monthly radial movement of Gnathion was calculated and the relation between incisor movements and Gnathion horizontal and vertical movement was graphed.

Results: For boys the average monthly movement of Gnathion was 0.27 mm/mo. For girls, it was 0.18 mm/mo. The horizontal and vertical movements of the lower incisor were then subtracted from the horizontal and vertical movements of the upper incisor, and that sum was graphed against the ratio of the Gnathion horizontal movement vector (or the Gnathion vertical movement vector) to the Gnathion radial movement vector, and a near-linear relationship was found for both boys and girls.

Conclusion: The percentage horizontal growth (and vertical growth) changes in Gnathion is related approximately linearly to the sum of horizontal and vertical growth movements of the incisors. Pubertal untreated boys grow the chin 50% more than pubertal girls.

INTRODUCTION

It is reported to be possible to increase mandibular growth compared to what would have occurred in untreated controls, using mandibular advancers, provided that the treatment occurs during puberty, and provided that the treatment period be long enough duration [1-4], but it has not been specifically reported how much the mandible grows per month during puberty in control boys and control girls. We have studied herein one group each of untreated boys and girls to establish gnathion growth information for untreated "Controls" which may be used hereafter in other papers for comparison. It has been reported that the horizontal /vertical growth re-positioning of the chin depends on the amount and direction of condylar growth, the amount and direction of glenoid fossa growth, and other factors which control the rotation of the mandible [5]. Few if any papers have discussed the relationship between incisor position changes and horizontal/vertical chin profile changes, in controls or in treated groups. It has been published that the pubertal period averages 30 months, during which the unassisted mandibular growth rate averages 59% higher for boys and 34% higher for girls than the pre-puberty average of 2.4-2.1 mm per year [6].

If the optimum time to try to improve horizontal chin projection is during pubertal growth, correctly estimating the timing of the pubertal growth is important. Mellion et al's [6] study of untreated pubertal teens (most of whom were not class II's), showed that peak mandibular growth in boys averages 4 months later than their peak statural growth, and for girls the peak mandibular growth rate averages 7 months later than their peak statural growth [6]. They showed that boys begin the mandibular growth spurt at an average age 11.9, and girls begin it at an average age 9.5, leading us to conclude that because of the pubertal age differences and the mandibular growth magnitude differences, mixing sexes in selection of control groups and clinical trials should be avoided. Historically, the reason studies have mixed girls with boys may have been the difficulty in finding large enough samples of untreated class II control girls in the proper age range.

This retrospective study aims to quantify how much the mandibles of untreated pubertal boys and girls grow per month, and to show that the horizontal/vertical expression of that growth is related to how the incisors change positions during that growth.

As shown in (Figures 1 and 2), drawings of the mechanics of mandibular growth [7] suggest that the horizontal/vertical components of Gnathion growth depend on how the upper and lower incisors move (in deep bites), because the drawings show that extrusion and retraction of the upper incisor, whether by orthodontic movement within the maxilla or by orthopedic movement of the maxilla, or both, is accompanied by downward vertical rotation and some backward rotation of the chin, and extrusion and protraction orthodontic movement of the lower incisor increases vertical rotation of the growing chin.

MATERIALS AND METHODS

This is a retrospective study of a sample of untreated boys and girls obtained from the Michigan and Bolton-Brush growth studies [8]. We selected class II boys and girls but excluded open bites because of our intention to test the relationship of incisor change to horizontal chin change. As shown in (Table 1), for 24 boys, the average T1 age was 13.2 years, and the average T2 age was 15.2 years. The average film interval was 24.6 ± 3.6 months, range 21-39 months. For 15 girls, the average T1 age was 10.6 years, and the average T2 age was 12.9 years. The average film interval was 28.4 ± 8.8 months, range 12-38 months.

In selecting a method to assess pubertal status, we chose Mellion's chronological age method. Gabriel et al [9] reported poor reliability between observers using the CVM [10] method, and Mellion [6] reported that the CVM method was the least reliable at predicting pubertal growth spurts. This paper shows distinct results of boys and girls control selections.

In both (boys and girls) control groups, the T1 and T2 digital films were fiducialized and corrected for known magnification, per published reports [11]. Lines were drawn on the T1 film for SN, S-A, S-U1, S-Gn, palatal plane, and functional occlusal plane (Figure 3A). Also the incisal tip of L1 was marked, and three dots circumscribed sella. These points were chosen because they are easy midline structures to identify accurately. Although many published studies measured Co-Gn, or Ar-Gn to assess mandibular length, we found to be easier to see S-Gn when comparing two films. This method had a small error of overlooking glenoid fossa growth, which we chose to ignore due to its small magnitude and due to the short T1-T2 intervals. Mandibular radius was approximated to be from Sella to Gnathion for both T1 and T2, wherein only the change in Gnathion was examined.

Then the T1 lines and dots were grouped, copied and pasted (Figure 3B), and transferred to the T2 film and superimposed

on SN at S (Figure 3C). Sometimes the T2 film had to be rotated in PowerPoint so the grouped lines would superimpose correctly on SN, depending on the variation in tip angle of the head between T1 and T2. The T2 A pt, U1, L1, and Gn were then marked and grouped onto the T2 film (Figure 3C).

Next, the incisor changes and Gnathion change (ΔU1, ΔL1, and ΔGn) were measured in their X and Y distances from the T1 U1, L1, and Gn, using the T1 occlusal plane as the reference X axis (Figure 4A,B,C) . The Δ measurements were made by viewing the films at 200% to increase accuracy, and then correcting the tables to 100% in Excel.

As shown on the legend for Table 2, we measured the X and Y changes of the upper incisor, the lower incisor, and Gnathion, for 24 boys and 15 girls, over a period of a little more than two years.

RESULTS

Note that as shown in Table 3,
the lower dentition of the Control boys moved backward 0.4mm in 24.5 months, or -0.02 mm/month
Average ΔGn of all control boys = 0.27 mm/month during peak mandibular growth.
Average ΔGnX of all control boys = 0.17 mm/month.
Average ΔGnY of all control boys = 0.22 mm/month.
The lower dentition of the Control girls moved backward 0.8mm in 28.4 months, or -0.03 mm/month
Average ΔGn of all control girls = 0.18 mm/
month during peak mandibular growth.
Average of all control girls GnX = 0.12 mm/month.
Average of all control girls GnY = 0.14 mm/month.
Note that in Controls, the pubertal chin growth has a higher vertical component than horizontal component. For clarity, the Table 3 entries called "AVG ΔU1-ΔL1" should more accurately be called "AVG (ΔU1X + ΔU1Y - ΔL1X - ΔL1Y).
For Control Boys and Girls, the sum of the upper incisor X and Y movements, minus the sum of the lower incisor X and Y movements, was related linearly to the proportion of chin growth that was horizontal and to the proportion of chin growth that was vertical. For control boys, the Pearson correlation coefficient was $r = 0.8262$, and the probability factor was $p = < 0.00001$. The result is significant at $p < 0.05$. For Control Girls, the Pearson correlation coefficient was $r = 0.8081$, and the probability factor was $p = 0.000267$. The result is significant at $p < 0.05$.
Movements of the upper incisor forward and upward tend to accompany the horizontal expression of growth at Gnathion, and movements of the lower incisor downward and backward also appear to accompany the horizontal expression of growth at Gnathion. As shown in the Figure 5 graphs, the sum of the upper incisor movements in x and y direction, minus the sum of the lower incisor movements in x and y direction, is approximately related linearly to the percent of mandibular radial growth which is expressed in the horizontal (x) direction (x being the T1 occlusal plane). Conversely, the same sum of incisor movements is also related linearly to the percent of mandibular radial growth which is expressed in the vertical (y) direction.

DISCUSSION

Future authors in studying the effect of mandibular advancers on increasing mandibular radial growth in pubertal teens can assume that pubertal control boys would grow 0.27 mm/mo., and that pubertal control girls would grow 0.18 mm/mo., relative to superimposition on Sella. Clinicians hoping to maximize horizontal chin profile expression may do well to avoid retracting or extruding upper incisors in deep bite cases. Clinicians hoping to maximize vertical chin profile expression may do well to retract and extrude upper incisors and avoid intruding or retracting lower incisors.

CONCLUSIONS

- For Control boys, the mandibular growth was 0.27 mm/month, and it was 44% horizontal. (ΔGnX/(ΔGnX + ΔGnY))
- For Control girls, the mandibular growth was 0.18 mm/month, and it was 46% horizontal. (ΔGnY/(ΔGnX + ΔGnY))
- Pubertal untreated boys grow the chin 50% more than pubertal girls.
- Because of the large mandibular growth rate difference between pubertal boys and girls, they should not be mixed in studies involving mandibular growth.
- The vertical component of untreated pubertal mandibular growth is larger than the horizontal component.
- For both boy and girl pubertal controls with deep bite class II's, the upper incisor forward and upward movements, minus the lower incisor forward and upward movements (sum) was related linearly to the ratio between the horizontal vector of mandibular growth and the radial vector of mandibular growth, and also to the ratio between the vertical vector of mandibular growth and the radial vector.
- Incisal guidance seems at least to be related to direction of chin profile expression. The drawings of the mechanics involved suggest the relationship is causative.

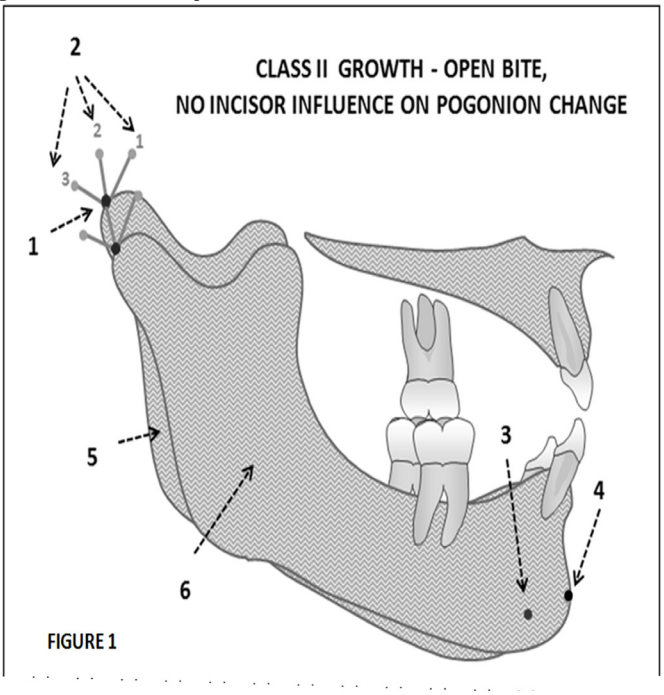

Figure 1: 1) condyle position before growth; 2) condyle position after growth, depending on direction of growth (Bjork)7; 3) original pogonion position before growth; 4) new position of pogonion after growth of condyle to position 2; 5) original mandible position before growth; 6) new mandible position after growth.

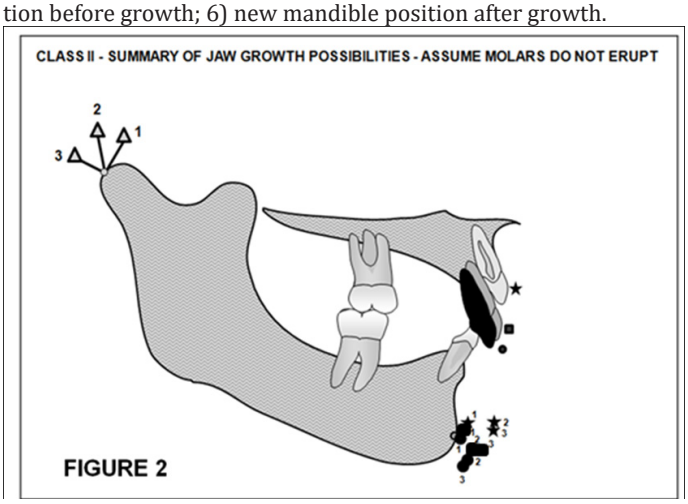

Figure 2: Summary of possible Pogonion growth changes, depending on upper incisor behavior. (Δ = condylar growth direction, according to Bjork7, □ = new pogonion position with no incisal guidance (O moves to □),■= new pogonion position with deep bite incisor guidance (O moves to ■),● = new pogonion position with upper incisors moving down and backward (O moves to ●).

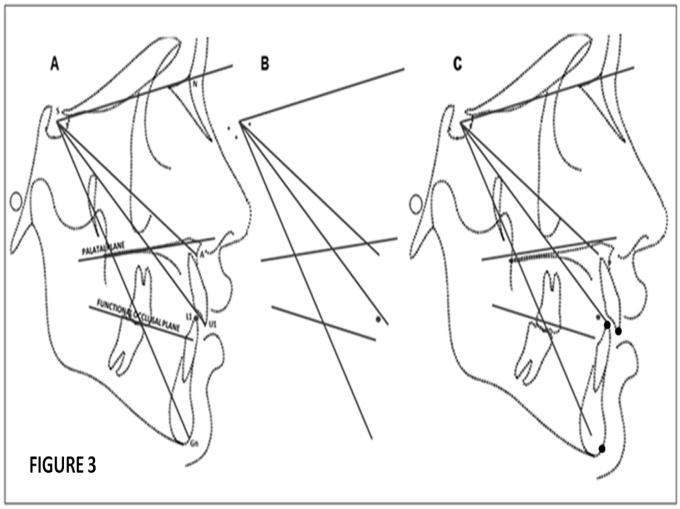

Figure 3: A) T1 film with reference lines and dots, U1=upper incisor, L1=lower incisor, Gn=Gnathion, A=A point, S=Sella, N=Nasion; B) T1 grouped lines and dots ready to transfer; C) T2 film with T1 lines and dots superimposed, and new dots for U1 (upper incisor) , L1 (lower incisor), and Gn (Gnathion).

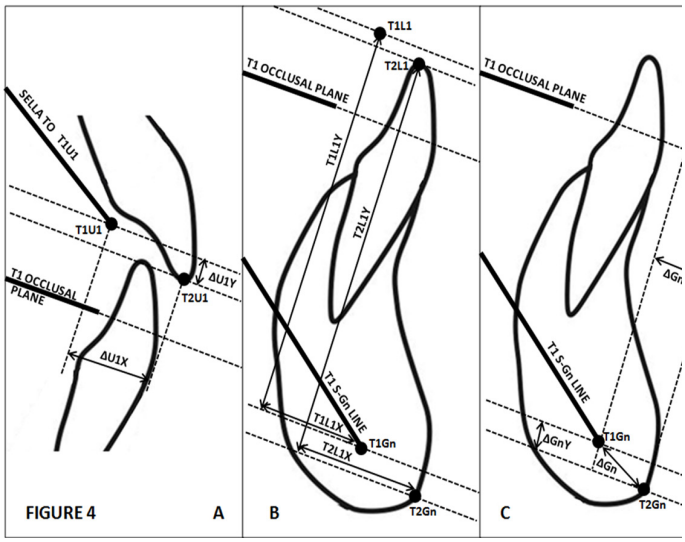

Figure 4: from T1-T2, registered on SN at Sella, relative to T1 occlusal plane as the X axis, A) Upper incisor changes, how far the upper incisor tip moved forward and downward, T2U1 = Time 2 Upper incisor, T1U1 = Time 1 Upper incisor, ΔU1X = movement of Upper incisor parallel to T1 occlusal plane, ΔU1Y = movement of Upper incisor perpendicular to T1 occlusal plane; B) Lower incisor changes, how far the lower incisor tip moved forward and downward relative to Gnathion, T2L1 = Time 2 Lower incisor, T1L1 = Time 1 Lower incisor, T2L1X = distance of T2 Lower incisor from T2 Gnathion parallel to T1 occlusal plane, T1L1X = distance of T1 Lower incisor from T1 Gnathion parallel to T1 occlusal plane, T2L1Y = distance ofT2 Lower incisor from T2 Gnathion perpendicular to T1 occlusal plane, T1L1Y = distance of T1 Lower incisor from T1 Gnathion perpendicular to T1 occlusal plane, Δ (change in) L1X = T2L1X - T1L1X, Δ (change in) L1Y = T2L1Y - T1L1Y: C) Gnathion changes, how far Gnathion moved forward and downward, T2Gn = Time 2 Gnathion, T1Gn = Time 1 Gnathion, ΔGnX = change in Gnathion from T1-T2, parallel to T1 occlusal plane, ΔGnY = change in Gnathion from T1-T2, perpendicular to T1 occlusal plane.

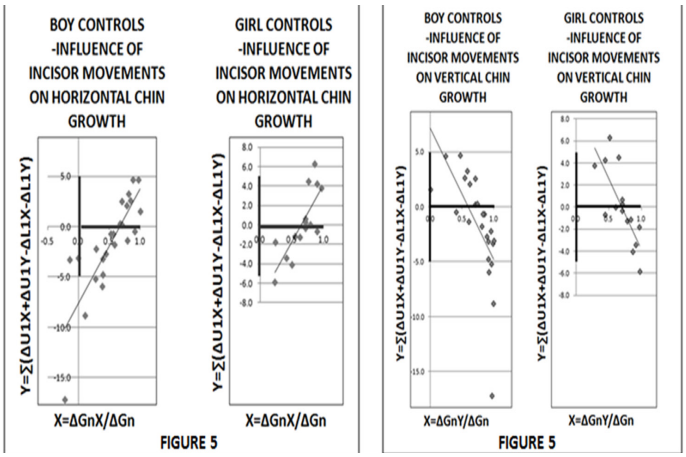

Figure 5: Graphs showing Boy and Girl Controls relation between pubertal growth incisor changes and horizontal chin change and vertical chin change. ΔGnX = growth of Gnathion from T1-T2 parallel to T1 occlusal plane. ΔGnY = growth of Gnathion from T1-T2 perpendicular to T1 occlusal plane. ΔGn = overall growth of Gnathion. ΔU1X = movement of Upper incisor from T1-T2 parallel to T1 occlusal plane. ΔU1Y = movement of Upper incisor from T1-T2 perpendicular to T1 occlusal plane, ΔL1X = movement of Lower incisor relative to Gnathion from T1-T2 parallel to T1 occlusal plane, ΔL1Y = movement of Lower incisor relative to Gnathion from T1-T2 perpendicular to T1 occlusal plane.

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