Prediction of mandibular growth in Japanese children age 4 to 9 years

H. Oueis, DDS Y. Ono, DDS, PhD Y. Takagi, DDS, PhD

Dr. Oueis is a PhD candidate, Dr. Ono is assistant professor, and Dr. Takagi is chairman and professor, Department of Pediatric Dentistry, Tokyo Medical and Dental University, Tokyo, Japan. Correspond with Dr. Oueis at oueis.dohs@tmd.ac.jp

Abstract

Purpose: The purpose of this study was to propose mathematical models for predicting mandibular growth direction and amount in children with normal skeletal relationship from 4 to 9 years of age using the craniofacial characteristics found on the head films. **Methods**: Lateral cephalograms of 27 Japanese children with normal occlusion at 4 (T1) and 9 (T2) years of age were traced and measured. Fifteen linear and angular measurements were performed. The angle NSGn and the distance S-Gn were used to represent the growth direction of the mandible and its growth amount, respectively. The data were analyzed by multiple linear regression analysis. **Results**: The multiple regression analysis revealed 2 models for the mandibular growth prediction. The equation (model) for the mandibular growth direction is YD=-39.844+1.206 X1+0.333 X2, where YD is the predicted value of the angle NSGn at T2. X1 is the value of the angle NSGn at T1 and X2 is the value of the angle SNB at T1 (R^2=0.719, P<0.05). The equation for the mandibular growth amount is YA=99.052+0.782 X3-0.517 X4, where YA is the predicted value of the distance S-Gn at T2. X3 is the distance S-Gn at T1 and X4 is the angle NSAr at T1 (R^2=0.610, P< 0.05). **Conclusions**: The direction of the mandibular growth at 9 years of age can be predicted by 72% with the regression equation using the angles NSGn and SNB at 4 years of age. The amount of growth of the mandible can be predicted by 62% by using the distance S-Gn and the angle NSAr at 4 years old. The model for the growth amount provides a relatively lower predictive value than that of the growth direction. *(Pediatr Dent 24:264-268, 2002)*

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Craniofacial growth is a complex and multifactorial process, which is a subject of research to investigators in different fields. Knowledge of craniofacial growth is highly beneficial for dentists to help the child patient achieve a balanced occlusion and harmonious craniofacial complex. All of the decisions regarding timing, duration and prognosis of the treatment for malocclusions should also be based on the knowledge of the future growth of the mandible, the maxilla and the other craniofacial structures.

Since the mandible has shown different growth patterns during the course of growth,[1] cephalometric prediction has been practiced to estimate the future growth changes of the mandible by studying the growth process of the craniofacial complex longitudinally on the serial headfilms.[2-4] Many methods for mandibular growth prediction have been proposed for clinical use by using different cephalometric measurements. Lower facial height,[5] symphysis morphology,[6] mandibular antegonial notch[7] and the frontal sinus[8] have been reported as growth indicators for mandibular growth. Skieller et al,[3] using implants on extreme samples, suggested 4 cephalometric variables that, in combination, could be used to explain 86% of the variability of mandibular growth rotation. Leslie et al,[9] using Skieller's 4 independent variables on a randomly untreated sample, found that only 6% of the total variability of mandibular rotation could be explained. Johnston[10] suggested the use of the grid method, based on the addition of the mean increments to the existing facial pattern, to forecast mandibular growth. Ricketts[4] proposed a method for mandibular growth

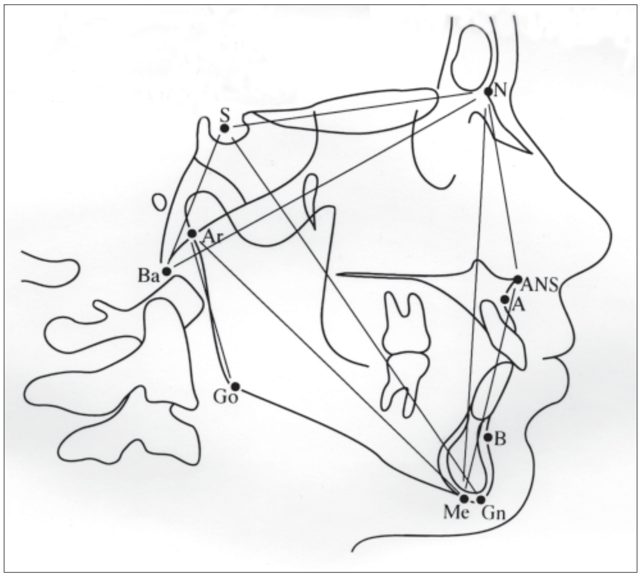

Fig 1. Cephalometric linear measurement

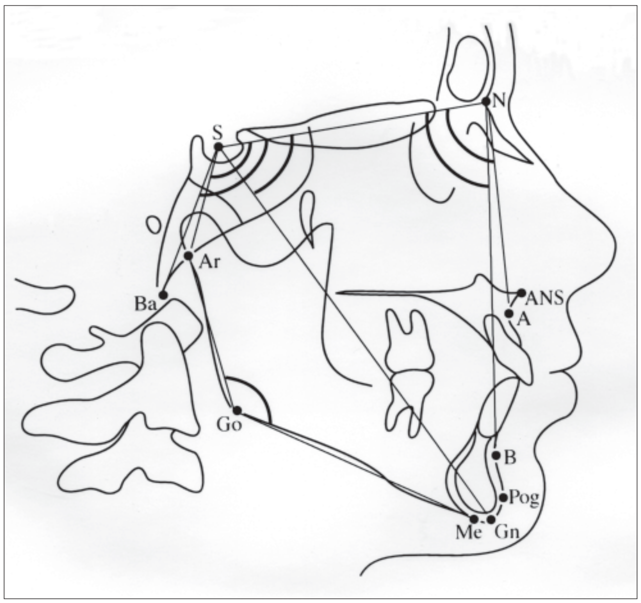

Fig 2. Cephalometric angular measurement

prediction based on his finding that the mandible grows along an arc. He agreed with Moss' theory[11] that the mandible grows in a logarithmic spiral. On the other hand, Suzuki[12] used parental data to report a model that predicted the future craniofacial form of Japanese children.

Most of the previous studies of mandibular growth prediction focused on studying children at the age of the permanent-dentition period after receiving orthodontic treatment. References seem to be lacking that relate to the mandibular growth prediction for children at an earlier age with normal occlusion.

The purpose of this study was to propose mathematical models (using the craniofacial characteristics found on the head films) for predicting mandibular growth direction and growth amount in children 4 to 9 years old with a normal skeletal relationship.

Methods

The sample for this study consisted of 27 Japanese children. A set of two lateral radiographs for 19 males and 8 females, at the initial stage (T1: 4.6±0.69 years) and the last stage (T2: 9.0±1.02 years), was selected from the longitudinal records of the department of pediatric dentistry, Tokyo Medical and Dental University. The collection of the samples began in 1960, and the semiannual records for 130 children were collected until 15 years of age.[13] In this study, the selection of the samples was limited to individuals with a normal occlusion and skeletal relationship. The children had complete dentition with class I molar relationship. None of the children had received any type of orthodontic treatment and no crowded teeth were found.

Cephalograms of the subjects at T1 and T2 were traced and digitized. The midpoints were used when there are landmarks on right and left sides. On the T1and T2 radiographs, 11 cephalometric landmarks were used as references to construct 9 linear and 6 angular measurements (Figs 1 and 2). These measurements were chosen to describe the horizontal and vertical relationship of the maxilla, mandible and cranial base. Two authors identified the cephalometric landmarks on the films separately, and the tracings were compared. When the variation in landmark location was found, the midpoint was used to eliminate the discrepancy in landmark identification. All the measurements were repeated 3 times by one of the authors and the means of these 3 measurements were used for the following analysis.

For the evaluation of the measurement error, half of the films were selected randomly and measured by the author on two separate occasions within a 1-week interval. The differences between the measurements were evaluated by student *t*-test with the paired design. No significant differences were found between the measurements at the different occasions ($P<0.05$), and the standard deviations ranged from 0.20 to 0.36 mm for the distances and 0.15° to 0.25° for the angles.

The growth direction of the mandible was determined by the angle NSGn, and the growth amount of the mandible was represented by the linear measurement S-Gn. The point Gnathion (Gn) was defined as the intersection point between the symphyseal contour and the line bisecting the angle between the mandibular plane (ME-Go) and facial plane (N-Pog).[14] The SN line was used as a reference line for the superimposition of the two cephalograms. The obtained data was analyzed by statistical software SPSS Version 7.5 for Windows (SPSS Inc. Chicago, USA).

In the multiple regression analysis, the values of the measurements at T1 were used as independent (explanatory) variables, and the values of the angle NSGn and the distance S-Gn at T2 were used as dependent (predicted) variables. The selections of the independent variables were completed according to the stepwise method. The correlation between the observed and predicted values of the dependent variables and the squared multiple correlation coefficient R^2 were

Table 1. Cephalometric Measurements at T1 and T2				
Measurement	Mean (T1)	SD	Mean (T2)	SD
<NSBa	133.2	3.94	131.8	3.73
<NSAr	124.8	3.61	125.4	3.46
<NSGn	71.0	2.53	71.08	2.82
<ArGoME	129.0	4.99	126.1	5.63
<SNB	76.0	3.01	76.80	2.70
<SNA	81.4	3.47	81.50	3.20
N - S	61.7	2.54	65.20	3.11
N-Ba	92.9	3.34	100.4	3.33
S-Ba	39.2	2.10	44.54	1.94
N - ANS	44.3	2.58	50.93	2.94
S-Gn	101.9	4.58	114.3	5.23
Ar-Go	36.3	3.49	39.84	3.64
Ar-ME	84.9	4.68	95.60	4.81
N - ME	102.0	4.16	113.2	5.01
ANS - ME	60.5	3.03	64.42	3.15

Table 2. The Best Models for Growth Direction and Amount					
	R	R^2	*a*	*b*1	*b*2
Growth direction	.848	.719	-39.844	1.206	0.333
Growth amount	.781	.610	99.052	0.782	-0.517

computed. R^2 indicates the portion of the variability of the dependent variable, which could be explained by the independent variables. The regression models were obtained for both the direction of the growth and the amount of the growth. The prediction equations of the best models were calculated. For evaluating the prediction equations, the residual analysis was performed.

Results

Table 1 shows the means and the standard deviations for the obtained cephalometric measurements.

The multiple regression equation for the prediction model is usually stated as Y=*a*+*b*1 X1+*b*2 X2+….+*b*n Xn, where Y is the predicted value, *a* denotes constant, and *b*1, *b*2, …*b*n are the regression coefficients of the independent variables X1, X2, … Xn. The regression analysis in the present study revealed the following best models (Table 2). The equation (model) for the growth direction was YD=-39.844+1.206 X1+0.333 X2, where YD is the predicted value of the angle NSGn at T2, X1 is the value of the angle NSGn at T1, and X2 is the value of the angle SNB at T1. The combination of the angles NSGn and SNB at T1 explained the variability of Y by 72% (R^2=0.719, *P*<.05). The equation for the growth amount was YA=99.052+0.782 X3-0.517 X4, where X3 is the distance S-Gn at T1, X4 is the angle NSAr at T1 (R^2=0.610, *P*<.05). The residuals for each case were presented as illustrations (Fig 3).

Discussion

In the present study, the craniofacial structures of children from both genders were followed longitudinally for 5 years. Sakamoto reported that the sexual dimorphism regarding the craniofacial dimensions of the Japanese children is found after 10 years of age.[15] Thus, male and female samples in the present study were considered in one group.

To better distinguish the direction of the growth from the amount of the growth of the mandible on the radiograph, many former researchers utilized the distance S-Gn along with its angle formed with NS line to express the growth amount of the mandible and the direction of the growth, respectively.[16,17] Although there are different superimposition techniques, no particular one is the best.[14] In this study, the line SN was used. Many similar studies have utilized the same method[16,17,24]. The measurement errors in this study are comparable to that of other studies.[18,19]

The regression analysis was employed in this research to define prediction models that could be used to forecast the individual future growth changes of the mandible for any given child. In the analysis, the stepwise method was utilized to select the explanatory variables. In the stepwise procedure, the variable that has the highest correlation with the dependent variable is selected first, and the next variable to be considered is the one that significantly increases R^2 by the largest amount. The procedure continues until there are no remaining independent variables that provide a significant increase in R^2. The regression coefficients of the selected variables are described to formulate an equation, which could be used as a regression model.

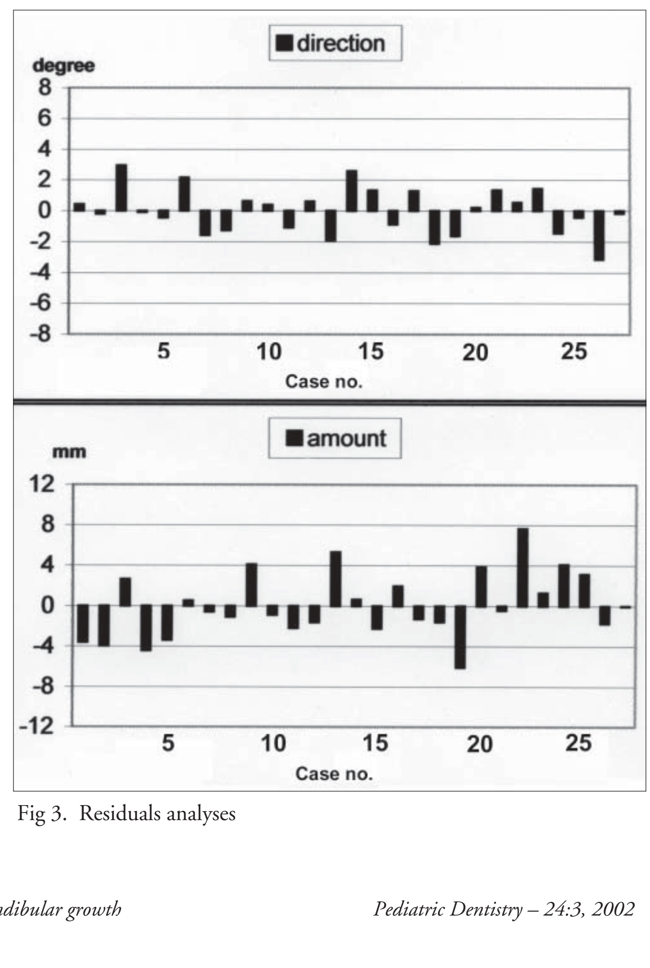

Fig 3. Residuals analyses

The variability of the dependent variable that could be explained by the regression model is characterized by R^2, which is considered high for biological data when it ranges from 30% to 67%.[20] Skieller[3] reported a high level of prediction when R^2 was 86%, which was explained by the fact that the sample included many cases with extreme growth pattern, making the biologic relations easier to find. The present sample consisted of 27 cases, which are twice as many as the number of independent variables. This is the satisfactory number to make the regression coefficients and the R^2 values true representatives of the actual population.[21]

As a result of the statistical analysis on the present sample, a set of two independent variables was significantly selected among the studied parameters to explain each dependent variable. On the growth direction, the most informative parameter is the angle NSGn (X1 in the equation). The means of the angle NSGn, which represent the growth direction of the mandible, at T1 and T2 are 71.0 and 71.08, respectively, with their corresponding standard deviation equal to 2.53 and 2.82, indicating that the growth direction of the mandible stayed constant between T1 and T2. A similar observation was described by Buschang[17] who reported slight changes in the growth direction of the point Gnathion from 292° to 291° between 6 and 15 years of age.

The angle SNB is the second variable (X2) to be selected, and it has relatively less informative value (b=0.33). The positive regression coefficients of the angles NSGn and NSB indicate a positive relationship with the angle NSGn at T2. The use of the angles NSGn and NSB, together as a model for predicting the direction of the growth, will explain 72% of the total variability of mandibular growth direction at T2 (R^2=0.719).

Regarding the growth amount, the distance S-Gn was the first independent variable to be selected as a most informative variable. Nanda[22] reported a significant correlation between the distance S-Gn at 9 years of age and at 13 years of age on a female sample. In this study, similar findings were also found except for children from 4 to 9 years of age. The second variable is the angle NSAr with negative regression coefficient, indicating a negative relationship between the angle NSAr at T1 and the distance S-Gn at T2. The findings of this study, that a low position of the condyle in relation to the cranial base (small NSAr) at 4 years old, along with a large S-Gn distance, could be used as indicators for a large mandible at 9 years old. Using distance S-Gn and the angle NSAr at T1 for predicting the amount of the growth is going to verify 61% of the total variability of mandibular growth amount.

To further evaluate the fit of the regression equations, the analysis of the residuals was performed. The residuals are the differences between the actual and the predicted values.[21] Figure 3 shows the differences between the actual values and the predicted values for each case individually for both the growth direction and the growth amount. For 24 cases, the predicted values of the angle NSGn ranged within one standard deviation (2.82°) from the actual values. For the growth amount as shown in Fig 3, the predicted values for most cases are within one standard deviation (5.23 mm). The model for the growth amount provides a relatively low predictive value. Ricketts[23] used the length S-Gn to measure the growth amount of the mandible. He reported that the amount of the growth is difficult to determine and knowledge of the average would be the starting point for estimating any case.

The results in this study suggest that the most informative variables to explain the direction of the growth and the amount of the growth of the mandible at 9 years of age included the same variables that represent the direction and the amount at an earlier age. Johnston[24] found that the original size of the measure A-B, the distance between A point and B point on the occlusal plane, is significantly related to its future size. However, in this study, the results showed that other variables, SNB and NSAr, are needed to reach a higher level of prediction.

Conclusions

The proposed models from the present study are able to explain 72% of the total variability of mandibular growth direction and 61% of the growth amount. The model for the growth amount provides relatively low predictive value.

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Abstract of the Scientific Literature

Dental Pain and Dental Treatment of Young Children Attending the General Dental Service

The purpose of this retrospective chart review study was to determine the relationship between dental pain and the extent of restorative care provided for primary molars. The charts of 677 pediatric patients who were regularly treated by a group of 50 general dentists were examined for this study. All of the patients had at some point presented with dental caries. Data related to the following variables was collected: (1) history of pain, extraction and antibiotic use for dental infection; (2) total number of carious teeth; (3) the proportion of carious teeth restored; (4) the age caries was first diagnosed; (5) patient gender. At least one episode of pain was reported by 48% of the patients. The results demonstrated that the history of primary molar decay was a significant predictor of pain, extraction and antibiotic use for dental infection. However, no significant relationship was noted between these variables and the proportion of carious teeth restored. The authors concluded that the total decay experience in primary molars, and not the level of restorative care, is the best predictor of pain, extraction and the need for antibiotics.

Comments: This manuscript emphasizes an idea that should already be well accepted, that is, the most effective way to reduce dental pain in children is to prevent dental caries. **MM**

Address correspondence to Dr. M. Tickle, Department of Dental Research and Development, Chester & Halton Community NHS Trust, Moston Lodge, Countess of Chester Health Park, Liverpool Road, Chester, UK CH2 1UL.

Milson KM, Tickle M, Blinkhorn AS. Dental Pain and Dental Treatment of Young Children Attending the General Dental Service. ***Brit Dent J.*** **2002;192:280-284.**

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