

Panoramic radiographic findings of the mandibular foramen from deciduous to early permanent dentition

Hung-Huey Tsai*

The purpose of this study was to investigate the position of the mandibular foramen from deciduous (Hellman's stage IIA) to early permanent dentition (Hellman's stage IVA). Panoramic radiographs of 311 Taiwanese children were used. The results revealed that the distances between the mandibular foramen and ramus anterior plane were greater than those between the mandibular foramen and ramus posterior plane through all stages. The mean difference between them was the smallest (0.25 mm) in stage IIA and the greatest (1.18 mm) in stage IIIC. The distance from the mandibular foramen to the alveolar crest plane showed a little change from stage IIA (3.99 mm) to IVA (5.26 mm). The gonial angle had a negative correlation with the distances between the mandibular foramen and each mandibular border. Evaluation of the mandibular foramen from the oral aspect can be influenced by the degree of mouth opening.

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INTRODUCTION

Mandibular anesthesia is most commonly achieved through the use of standard inferior alveolar nerve blockage. The success of this technique is dependent on placing the needle tip in close proximity to the mandibular foramen. Therefore, accurate investigation of the position of the mandibular foramen is important for successful inferior alveolar anesthesia. Olsen¹ reported that the mandibular foramen is situated at a level lower than the occlusal plane of the primary teeth in pediatric patients. Another study reported that the foramen is at or slightly above the occlusal plane during the period of the primary dentition.² Because the position of the mandibular foramen changes during growth, it is very important to have a thorough understanding of the developmental changes of this anatomic location.

The usefulness of panoramic radiography in epidemiological studies of dental health was demonstrated in a previous study.³ The advantages of this technique over intraoral radiography include a greater area of hard and soft tissue coverage and continuity of the visualized area. The ability to view

the entire body and ramus of the mandible^{4,5} should allow more-accurate localization of the mandibular foramen in both the horizontal and vertical dimensions.

Although there have been many studies⁶⁻¹¹ evaluating the location of the mandibular foramen, the positional changes of this anatomic landmark in growing children, however, have rarely been reported. The purpose of this study was to investigate the position of the mandibular foramen on the panoramic radiographs from deciduous to early permanent dentition in Taiwanese children.

MATERIALS AND METHODS

Panoramic radiographs of 311 Taiwanese children from deciduous to early permanent dentition were obtained from the files of our department. No subject had previous craniofacial trauma or surgery, or temporomandibular joint or craniocervical disorders. All panoramic radiographs were of good quality. The materials were divided into five groups according to the Hellman's dental developmental stages: stages (1) IIA, (2) IIIA, (3) IIIB, (4) IIIC, and (5) IVA. The numbers of radiographs examined in each stage were 36, 61, 69, 56, and 89, respectively.

The left side of the outline of the mandible on each radiograph was traced on overlying matte acetate paper using an radiographic viewer, and reference points and planes (Figure 1) were identified. The selected landmarks were digitized using an image analyzer, converted to an X-Y coordinate system, and input into a personal computer. Six linear and two angular measurements on the mandibular gonial area (Figure 2) were calculated by using these points.

* Hung-Huey Tsai, DDS, PhD. Professor, Department of Pedodontics, School of Dentistry, China Medical University, No. 91 Syuehshih Rd., North District, Taichung 404, Taiwan (R.O.C.)

Voice: 886-4-22055674

Fax: 886-4-22014043

E-mail: hunghuey@mail.cmu.edu.tw

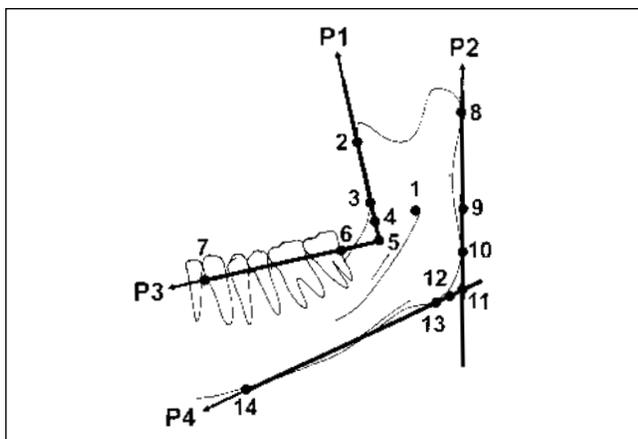


Figure 1. Reference points and planes

- 1: the center of the mandibular foramen
- 2: the most prominent point on the anterior border of the ramus
- 3: the deepest point on the anterior border of the ramus
- 4: intersecting point of the perpendicular line from the mandibular foramen to P1
- 5: intersecting point of P1 and P3
- 6: the distal alveolar crest of the lower most distal molar
- 7: the mesial alveolar crest of the lower canine
- 8: the most prominent posterior point on the condyle
- 9: intersecting point of the perpendicular line from the mandibular foramen to P2
- 10: the most prominent posterior point at the angle of mandible
- 11: intersecting point of P2 and P4
- 12: intersecting point of the perpendicular line from the mandibular foramen to P4
- 13: the most prominent inferior point at the angle of mandible
- 14: the most prominent inferior point at the canine area
- P1: the plane connecting reference points 2 and 3 (ramus anterior plane)
- P2: the plane connecting reference points 8 and 10 (ramus posterior plane)
- P3: the plane connecting reference points 6 and 7 (alveolar crest plane)
- P4: the plane connecting reference points 13 and 14 (mandibular plane)

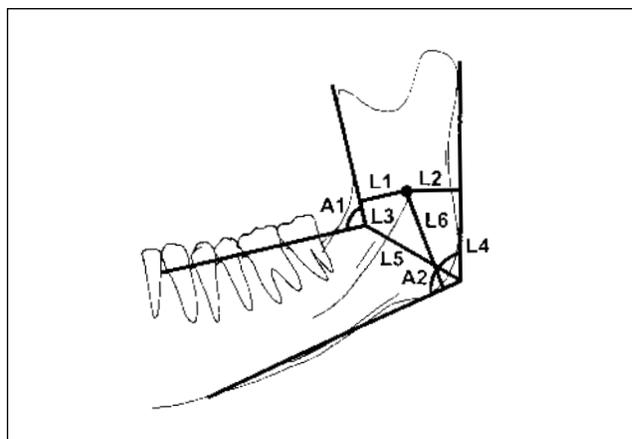


Figure 2. Measurements

- L1: linear distance between reference points 1 and 4
- L2: linear distance between reference points 1 and 9
- L3: linear distance between reference points 4 and 5
- L4: linear distance between reference points 9 and 11
- L5: linear distance between reference points 5 and 11
- L6: linear distance between reference points 1 and 12
- A1: angle between planes P1 and P3
- A2: angle between planes P2 and P4

Reliabilities of measurement techniques, landmark identification, and tracing method, as well as inter-rater reliability were statistically analyzed before commencing the study. Ten randomly selected panoramic radiographs were traced five times on separate days. Resultant measurements on interval variables were averaged and tested for significance by means of analysis of variance (ANOVA) *F*-test. A one-factor repeated-measure model was separately fitted to each variable, and significance values were set at $p < 0.05$. All of the panoramic measurements displayed p values > 0.05 . This indicated that no significant variability was noted between tracings.

Statistical analysis was done using SigmaStat (vers. 2.0) software. Mean values and standard devi-

ations of the X and Y coordinate values of the reference points and the linear and angular measurements in each stage were calculated. One-way analysis of variance (ANOVA) was used for comparison of mean values for each measurement among five stages. The Spearman rank order correlation test between all measurements was then performed. Significant differences for all correlation coefficients were established at $p < 0.05$.

RESULTS

The means and standard deviations of linear and angular measurements in each stage and the results of analysis of variance are shown in Table 1. There were statistically significant differences in all linear measurements among

Table 1. The mean values and standard deviations of linear and angular measurements in each stage and the results of analysis of variance

Measurements		L1		L2		L3		L4		L5		L6		A1		A2	
Stage	N	Mean	SD														
IIA-IIC	36	8.64	1.79	8.39	1.26	3.99	2.24	9.72	1.60	16.30	2.36	12.81	1.63	97.59	8.95	121.85	6.33
IIIA	61	9.35	1.56	8.74	1.48	4.01	2.01	10.45	1.89	17.51	2.56	13.50	1.83	102.19	6.55	124.27	6.72
IIIB	69	9.80	1.73	8.92	1.10	4.44	1.78	13.06	2.05	19.06	2.52	15.64	1.92	98.92	6.69	122.34	5.27
IIIC	56	10.14	1.65	8.96	1.30	4.46	1.89	13.42	2.05	19.18	2.47	16.50	1.81	102.78	6.09	121.11	6.51
IVA	89	10.48	1.60	9.81	1.20	5.25	2.20	14.53	2.30	19.58	2.71	16.99	2.15	96.76	5.59	118.59	5.90
ANOVA test		P<0.001		P<0.001		P<0.001		P<0.001		P=0.002		P<0.001		P=0.544		P=0.747	

Table 2. Spearman rank order correlation test

Measurements	L1	L2	L3	L4	L5	L6	A1	A2
L1		0.293	0.208	0.355	0.705	0.400	n.s.	n.s.
L2			n.s.	0.293	0.687	0.528	n.s.	-0.273
L3				0.265	n.s.	0.293	n.s.	0.208
L4					0.511	0.941	-0.282	-0.495
L5						0.617	n.s.	-0.535
L6							-0.292	-0.471
A1								0.412
A2								

n.s. not significant

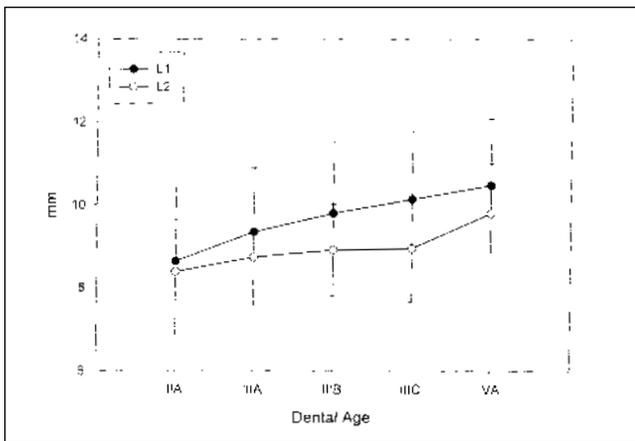


Figure 3. Growth changes of horizontal linear measurements.

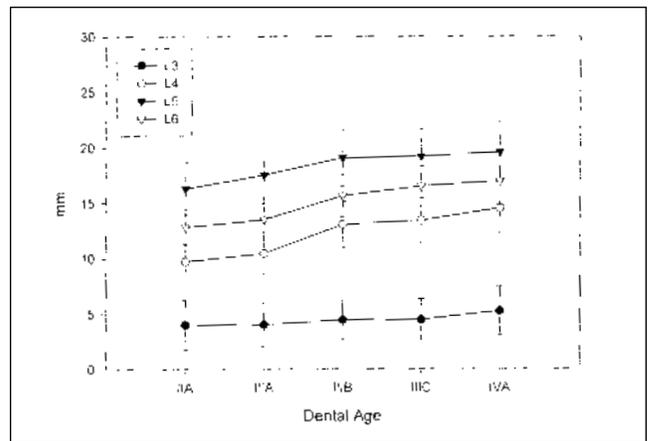


Figure 4. Growth changes of vertical linear measurements.

the five stages, however, there were few differences in angular measurements. All linear measurements gradually increased in size from stage IIA to IVA.

The results of the correlation analysis are shown in Table 2. There were positive correlations among linear measurements and negative correlations between linear and angular measurements.

The mean values and standard deviations for the horizontal (L1 and L2) and vertical (L3 to L6) linear measurements were plotted and are presented in Figures 3 and 4. The distances between the mandibular foramen and ramus anterior plane (L1) were greater than those between the mandibular foramen and ramus posterior plane (L2) through all five stages. The mean difference between L1 and L2 was the smallest in stage IIA and the greatest in

stage IIIC (Figure 3). The vertical linear measurement, L3, showed a little change from stage IIA to IVA; however, L4, L5, and L6, showed similar developmental changes with conspicuous growth appearing from stage IIIA to IIIB (Figure 4).

The mean amounts of increase of linear measurements between each stage were also plotted and are presented in Figures 5 and 6. The mean amounts of increase in L1 were greater than those of L2 before stage IIIC; however, the mean amount of increase in L2 was much greater than that of L1 after stage IIIC (Figure 5). The mean amounts of increase in L4, L5, and L6 showed similar developmental changes, and the greatest increases appeared between stages IIIA and IIIB (Figure 6).

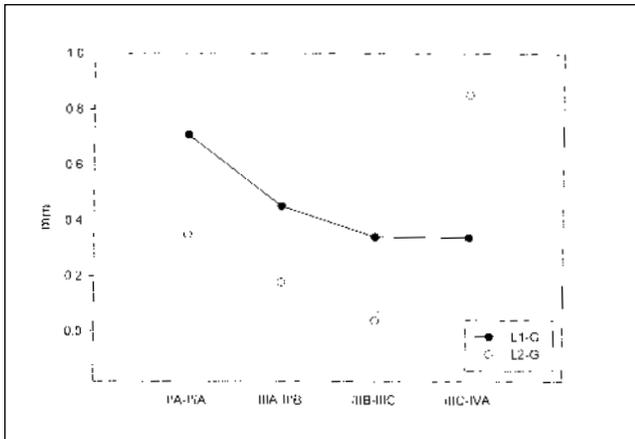


Figure 5. Mean amounts of increase of horizontal linear measurements between each stage.

L1-G: mean amount of increase in the L1 measurement
 L2-G: mean amount of increase in the L2 measurement

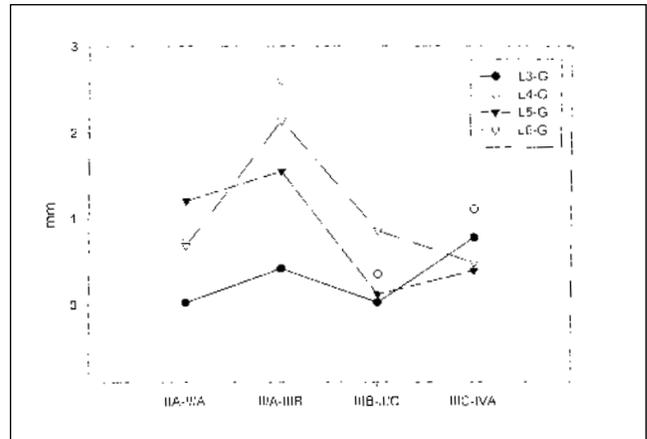


Figure 6. Mean amounts of increase of vertical linear measurements between each stage.

L3-G: mean amount of increase in the L3 measurement
 L4-G: mean amount of increase in the L4 measurement
 L5-G: mean amount of increase in the L5 measurement
 L6-G: mean amount of increase in the L6 measurement

DISCUSSION

It is generally agreed that the position of the mandibular foramen changes by bone remodeling as a child matures into adulthood. For greater accuracy in anesthetic procedures, dentists should relate the positional changes in the mandibular foramen with dental age when performing block anesthesia for the inferior alveolar nerve. A previous study reported that panoramic radiographs were as good as oblique cephalometric radiographs for locating the mandibular foramen.¹² Therefore, this study was undertaken to determine the positional changes of the mandibular foramen from deciduous to early permanent dentition using panoramic radiographs.

Concurring with previous observations,^{8,12} there was no right- or left-side dominance in the ramus size or position of the mandibular foramen, and no age or gender correlations were found. Therefore, only data on left sides were used, and data from boys and girls were pooled in this study.

The mandibular foramen has been reported to be located just posterior to the middle of the ramus⁶, in the third quadrant^{7,8}, at the midpoint^{9,10}, or approximately at the posterior third of the ramus, in both the vertical and horizontal directions.¹¹ In the horizontal direction, the results of this study found that the distances between the mandibular foramen and ramus anterior plane (L1) were greater than those between the mandibular foramen and ramus posterior plane (L2) through all stages. The mean difference between them was 0.72 mm, with the smallest difference (0.25 mm) in stage IIA and the greatest (1.18 mm) in stage III C. The mean amounts of increase in L1 between each stage were greater (uniformly about 0.4 mm) than those in L2, and both of

them gradually lessened from stage IIA to III C. However, the greatest mean amount of increase in L2 (about double that of L1) occurred after stage III C. These changes may be a reflection of mandibular growth in different directions during different developmental stages. Results of this study reveal that growth of the ramus anterior border was constant; however, growth of the ramus posterior border underwent a growth spurt after stage III C. This conspicuous growth may have been due to growth of the condyle and apposition of the bone in the posterior border of the mandibular ramus and gonial angle.

In the vertical direction, results of this study showed that the distance from the mandibular foramen to the alveolar crest plane changed a little from stage IIA (3.99 mm) to IVA (5.26 mm). However, the distance from the mandibular foramen to the lower border of the mandible increased about 4 mm from stage IIA to IVA. The positional changes of the mandibular foramen in the vertical direction may have been influenced by the growth of the ramus itself and the apposition of the bone in the mandibular lower border. This study found that these changes were greatest between stages III A and III B. This suggests that in the vertical direction, the mandible developed more in the late mixed dentition stage than in other stages.

The mandibular foramen has assumed great prominence due to location of the so-called Xi point by Ricketts¹³ in growth prediction. If the inferior alveolar neurovascular triad is considered to be a soft tissue matrix, the mandible and its growth will not alter the position of the matrix. Therefore, the bone itself is not an indicator of the position of the mandibular foramen,

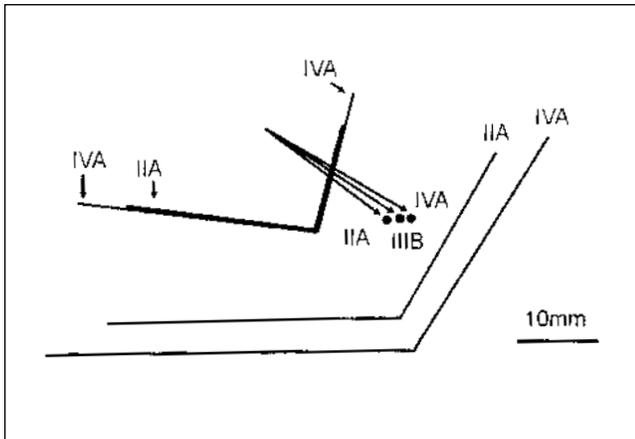


Figure 7. Superimposition of the mean outlines of the mandible in IIA and IVA stages

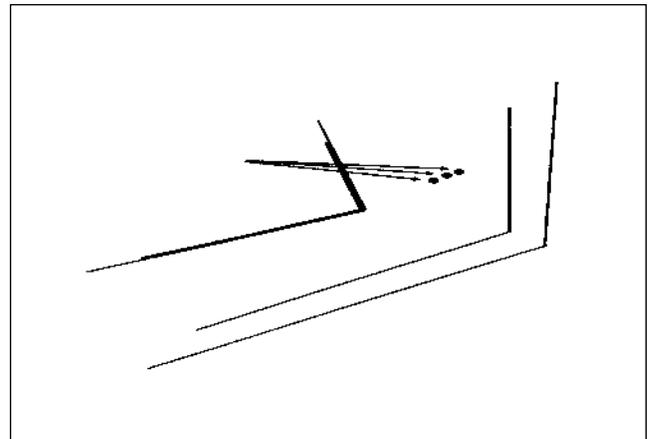


Figure 8.

but the mandibular foramen and the contents of the foramen are the key factor in the relationship to mandibular growth potential. This degree of growth is related to the gonial angle rather than to other bony measurements. In this study, the gonial angle had a negative correlation with distances between the mandibular foramen and each mandibular border. This means that a more-obtuse gonial angle represents expanded growth potential of the mandible, while a less-obtuse gonial angle indicates lower growth potential of this bone.

The external and internal oblique ridges, the anterior border of the ramus, and the occlusal plane are examples of landmarks that are usually used to determine correct placement of a needle relative to the mandibular foramen. The mean outlines of the mandible in stages IIA, IIIB, and IVA were superimposed on the inner border of the mandible (Figure 7) in order to evaluate how to approach this anatomic landmark in clinical dentistry. The positions of the mandibular foramen were horizontally on the same level from stage IIA to IVA when the mandibular plane was even with the ground (upper figure). However, because inferior alveolar anesthesia is administered with the mouth open, therefore, when the mandibular plane rotates downward, the mandibular foramen changes the relative position upward from stage IIA to IVA (lower figure). From these figures, it is easy to understand that evaluation of the mandibular foramen from the oral aspect can be influenced by the degree of mouth opening.

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