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Locating the Mandibular Foramen Relative to the Occlusal Plane using Panoramic Radiography

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Abstract: The aim of this study was to locate the mandibular foramen in relation to the occlusal plane using panoramic radiography in 7-10-year-old children referred to the Mashhad School of Dentistry. A total of 200 panoramic radiographs and 200 madibular dental casts related to patients aged 7-10 years were available for examination applying Planmeca software. Mesiodistal width of the endmost fully erupted tooth on both left and right sides of each cast was measured. Having scanned the radiographs, the measured widths were input in the software in millimeter to calibrate the radiographs magnification. Then, points of study were determined and lines were drawn from the most anterosuperior point of the mandibular canal to the occlusal plane, as well as to the anterior, posterior and inferior borders of ramus on the scanned radiographs by the software. Also gonial angle was measured by the software. Finally, a total of four lines and one angle were available for each side on the radiographs. In about 4% of 7-year-olds, who were all girls, the most anterosuperior point of the mandibular canal was acquired above the occlusal plane. As the children reached the age of 10, this amount increased to 86% in both sexes. The gonial angle had a negative correlation with the distances between the most anterosuperior points of the mandibular canal to each mandibular border. The inferior alveolar nerve anesthesia should be administered above the occlusal plane in 10-year-old children.

Key words: Mandibular foramen, panoramic radiography, children, occlusal plane, local anesthesia

INTRODUCTION

One of the most important aspects of behavior management in pediatric dentistry is pain control (McDonald *et al*., 2004). Local anesthesia is still the main technique for pain control in pediatric dental treatments, when deep operative or surgical procedures are undertaken for the mandibular primary or permanent teeth, the Inferior Alveolar Nerve (IANB) should be blocked (McDonald *et al*., 2004). However, there is no consensus on the position of the mandibular foramen (MF) in relation to the occlusal plane in children to realize where the needle tip should be placed in the standard IANB. Olsen recommended inserting the needle tip below the occlusal plane for mandibular primary teeth (Olsen, 1956). Benham (1976) conversely, recommended administering anesthesia to the MF either at or slightly above the occlusal plane in primary dentition.Benham. Also Hwang *et al*. (1990) showed that the position of foramen in children is more inferoanterior compared with adults (Hwang *et al*., 1990). Various researches have been conducted on cephalometric and panoramic radiographs regarding the position of Tsai (2002, 2004) and Kanno *et al*. (2005). Basically, in order to have a rapid, deep and safe local anesthesia, location of MF in relation to the occlusal plane should be acquired. As the child grows up, the position of MF changes. Hence, for a successful mandibular local anesthesia, consideration to such changes is imperative. Bishara *et al*. (1990) showed that dento-facial parameters are bound to ethnic origins.

The objective(s) of this study was to locate the MF relative to the occlusal plane on the panoramic radiographs related to 7-10 year-old children, who were referred to the Mashhad School of Dentistry, Iran, for taking radiography.

MATERIALS AND METHODS

This study was conducted on 200 panoramic radiographs and 200 dental casts related to a total of 200 children (106 girls and 94 boys), who were referred to the Mashhad School of Dentistry, Iran during 2005 through 2007. The subjects were divided into four groups of 7, 8, 9 and 10-year-old children.

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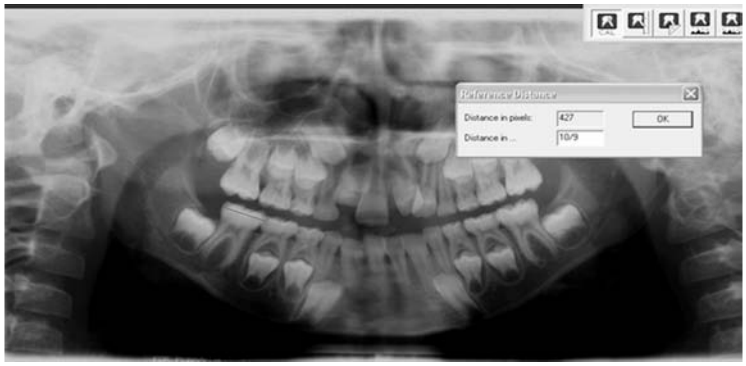

Fig. 1: Calibration of a panoramic image using Planmeca dimaxis classic software

Fig. 2: Points of study

Point 1: The most superior anterior point of mandibular canal
Point 2: The deepest point on the anterior border of the ramus
Point 3: The most prominent point on the canine crown
Point 4: The most prominent point on the end-most fully erupted tooth
Point 5: The most prominent inferior point at the angle of mandible
Point 6: The most prominent posterior point on condyle
Point 7: The most prominent posterior point at the angle of mandible

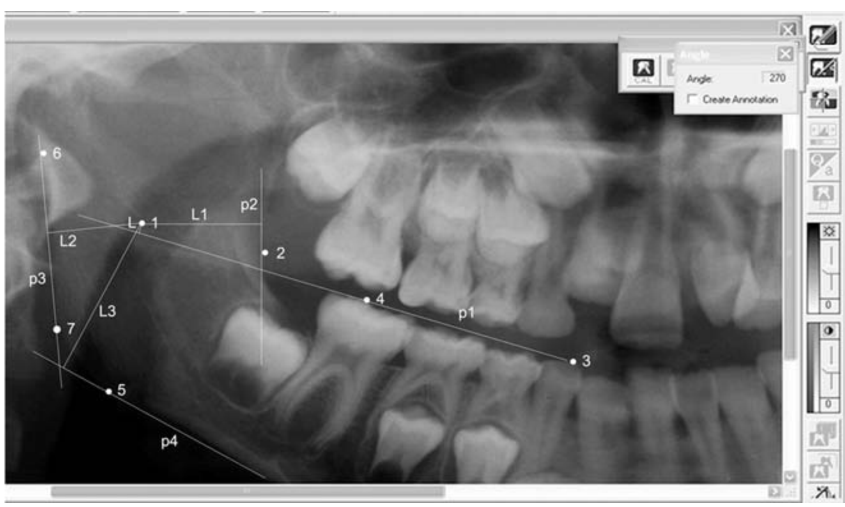

Fig. 3: Hypothetical Lines

P1	:	occlusal plane connecting points 3 and 4	P2	:	perpendicular line to point 2
P3	:	ramus posterior plane connecting points 6 and 7	P4	:	mandibular plane tangent to point 5
L	:	perpendicular line from point 1 to P1	L1	:	perpendicular line from point 1 to P2
L2	:	perpendicular line from point 1 to P3	L3	:	perpendicular line from point 1 to P4
A	:	internal angle between P3 and P4			

To follow ethics, the subjects were selected among the patients who had already referred to the School of Dentistry for radiography; that is, they were not recommended for radiography just for the study. The age range was 7 to 10 years. The criteria that every individual had to meet to be involved in this investigation were listed as normal facial morphology, presence of all posterior teeth in the mouth. Based on the study standard for radiographs, horizontal Frankfort plane was paralleled with the earth-horizon during radiography to avoid chin tilt, and only one technician took all the radiographs. Radiographs with gross distortion and children under orthodontic treatment were excluded from the study.

Radiographic records were obtained using a dental radiography instrument (Orthopantomograph Apparatus, Planmeca 2002, Model cc, Finland) at the Mashhad School of Dentistry. Then the informative consent was obtained from the parents.

Panoramic radiographs were scanned by a high-resolution scanner (600 dpi resolution) (Umax Powerlook, Model 2100, Taiwan) by magnification of 1:1 and the inputs were saved in related files.

In order to have a precise linear measurement of anterior superior point of mandibular canal to the occlusal plane and also for calibration of radiograph magnification, we used the software Planmeca Dimaxis Classic which measures the variables in pixels as default but there is also a capability of conversion into millimeters.

Mesiodistal width of the most posterior mandibular tooth on both sides of each dental cast was measured in millimeter using a caliper. Thus, two distances were acquired on both left and right sides to calculate linear measurements and to calibrate the magnification in the software (RVG Planmeca 2002, Dimaxis 3 2 2) (Fig. 1). The points and the lines of study (Fig. 2, 3) were drawn by the software, with the accuracy of 100th millimeter. The mandibular gonial angles were also calculated on the radiographs (Fig. 3).

All the quantities were obtained in millimeters and by a single calibrated examiner, examining only five panoramic radiographs daily for prevention of any eye error. In a pilot study on the scans of five panoramic radiographs, the mean and standard deviation were set as 0.5±0.1 mm for duplicate measurements of intra-examiner and it considered being a reflection of intra-examiner reliability.

To evaluate the validity of the method, four skulls were placed in panoramic head holder (MF and occlusal plane, identified by steel wire, placed at the lingual and buccal cusp of mandibular posterior teeth, respectively). Then images were acquired when Frankfort plane of each skull was parallel with the earth-horizon. The mean and standard deviation were not found to be significantly different in duplicate vertical and horizontal measurements of lines in the skulls and on the panoramic radiographs.

The distances from the most anterior superior point of mandibular canal to above, at and below the occlusal plane were recorded as positive, zero and negative whole numbers, respectively. Then, data were analyzed using SPSS (11.5, SPSS Inc., Chicago Ill, USA) and the means were compared with each other by Bivariate-ANOVA and Pearson tests.

RESULTS

A total of 200 children (106 girls and 94 boys) were evaluated in the study described herein. The findings for the left and right sides were compared; consistent with no significant difference in the means of variables ($p>0.05$).

The distance between the most anterosuperior points of mandibular canal (point 1) to the occlusal plane (L) showed significant difference with both age and sex ($p<0.001$). The mean of L based on the age and sex have come in Fig. 4 and Table 1.

Also, among the 10-year-old children, MF was observed above and at the occlusal plane in about 86%

Table 1: Distance between point 1 (mandibuar foramen) and occlusal plane in millimeter (mean values of left side)

Measurements			L (girls)		L (boys)	
Age	N (girls)	N (boys)	Mean	SD	Mean	SD
7	5	17	-2.09	1.66	-3.05	1.42
8	24	25	-1.19	1.34	-1.83	1.81
9	21	22	0.36	1.99	-0.9	1.62
10	36	30	1.69	1.33	1.42	1.78
Bivariate-ANOVA analysis			p<0.001		p<0.001	

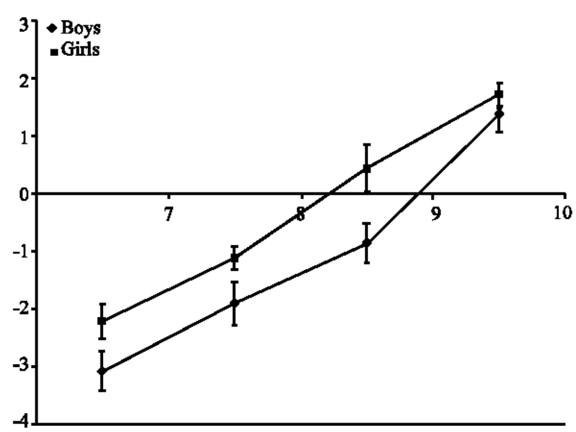

Fig. 4: Graphic demonstration compares average distances of L1 and L2. Vertical line: Average distance (mm), Horizontal line: Age (years old)

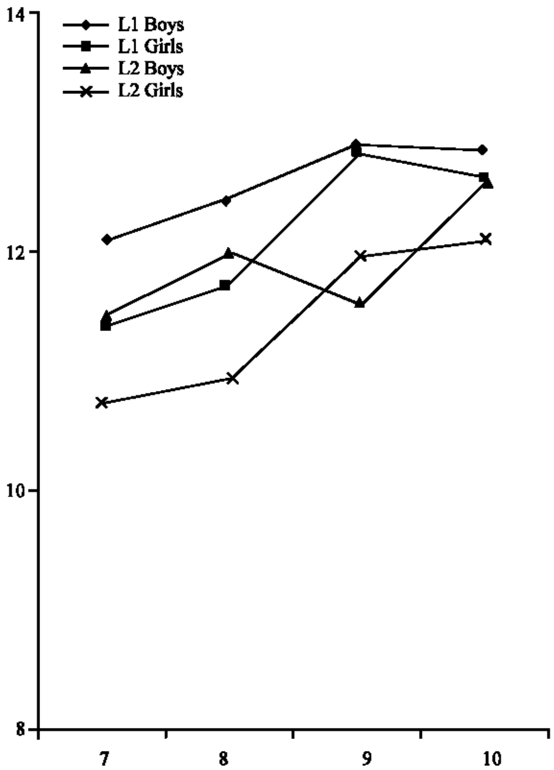

Fig. 5: Graphic demonstration compares average distances of L3 based on sex, Vertical line: Average distances (mm), Horizontal line: Age (years old)

Table 2: Pearson correlation test

Measurements	L	L1	L2	L3	A
L		0.18•	0.12*	0.35•	ns
L1			0.29•	0.56•	-0.25
L2				0.60•	-0.20•
L3					-0.33•
A					

*Correlation is significant in 0.05 levels, • Correlation is significant in 0.01 levels, NS: Not significant

and 4%, in that order. The distance from point 1 to the anterior border of ramus (L1) represented significant difference with age ($p<0.01$), however, no sex-specific trends were identified ($p>0.05$).

In addition, there was a statistical difference between age ($p<0.001$) and sex ($p<0.01$) with the distance from point 1 to the posterior border of ramus (L2). Also a significant difference was found between both age and sex with the distance from point 1 to the inferior border of ramus (L3) ($p<0.001$).

The findings revealed L1 to be greater than L2 in all age-range and both sexes Fig. 5. The Mean of L3 in 7-10 years old children increased by 2.8 mm and 4.1 mm in boys and girls, respectively Fig. 6. Moreover, gonial angle (A)

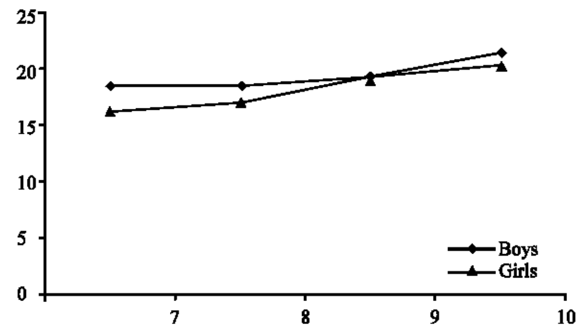

Fig. 6: Graphic demonstration compares average distances of L3 based on sex, Vertical line: Average distances (mm), Horizontal line: Age (years old)

showed significant difference with age ($p<0.01$) and no significant difference between the gonial angle and sex was found ($p>0.05$). The means and the standard deviation of linear and angular measurements and the results of Analysis of Variance (ANOVA) have come in Table 1. Furthermore, all measurements were tested by Pearson to find the correlations (Table 2).

DISCUSSION

The position of the mandibular foramen and its importance for a successful inferior alveolar anesthesia has been well documented. The aim of this study was to locate the position of the mandibular foramen in relation to the occlusal plane on the panoramic radiographs of 7-10-year-old Iranian children.

Basically, there are some limitations in the study of mandibular foramen position on dry skull, such as unknown age and sex, indefinite anatomic landmarks and mandibular tooth loss. Moreover, distortion of mandibular foramen area on panoramic radiographs is a primary concern. Afsar *et al.* (1998) showed that panoramic radiography was as good as oblique cephalometry for the location of mandibular foramen. Unlike Harrison (1948) but similar to Tsai (2004) investigation. The difference between the location of MF on the left and right sides was not statistically significant in the present study. However, there was a significant difference in distance from point 1 to the occlusal plane (L) with age and sex.

We recommend placing the needle tip below the occlusal plane for 7-8-year-old children although in one 8-year-old boy (1% of 7-8-year-olds) point 1 was +4.4 mm (above the occlusal plane), which was probably related to the specific anatomical characteristic of the boy.

We also recommended inserting the needle below the occlusal plane in 9-year-old boys while the needle tip in

9-year-old girls suggested to be placed slightly above the occlusal plane, as a result of pre-pubertal growth.

Furthermore, anesthesia should be administered above the occlusal plane in 10-year-old children as MF was observed above and at the occlusal plane in about 86 and 4%, respectively. We found that if the injection is administered below the occlusal plane only 10% of 10 year-old children undergo mandibular teeth anesthesia.

Kanno *et al*. (2005) found a gradual increase in distance between the lingual and the occlusal plane in both sexes aged 7 to 10 years. They also recommended inserting the needle tip at least 6 mm above the occlusal plane for this age range.

Benham (1976) analyzed the distance between the mandibular foramen and the occlusal plane on lateral cephalometric radiographs in 5-7, 7-9 and 9-11-year-olds, concluded in no significant difference in 7 to 9 years of age. However, in 9-11-year-olds there was an upward increase in the distance between the mandibular foramen and the occlusal plane, which was attributed to the eruption of canines and premolars. In an investigation by Afsar *et al*. (1998) no difference was found in linear measurements of the mandibular foramen and the occlusal plane with age and sex, as opposed to this study.

In horizontal measurements, L1 was greater than L2 in the four groups of the study.

Mandibular foramen, in our study, maintained a more posterior position to mid-ramus that was related to the growth of ramus in various directions, agreed with some other investigations (Benham, 1976; Enlow, 1982).

In addition, we found a significant difference between L2 and sex in the four groups, which can be explained by the growth and bone mineralization in the posterior border of the ramus due to genital hormones. There was also a growth spurt in the posterior border of the ramus in girls after the age of 8.

However, Kanno *et al*. (2005) found no statistical differences in the distance of foramen to anterior and posterior borders. Tsai (2004) showed that growth of anterior border of ramus was stable whereas posterior border of mandible showed growth spurt after the third stage of hellman.

The greatest mean for increase in L1 was observed in 8-9-year-old girls by 1 mm and the least mean in 9-10-year-old boys by 0.05 mm. The growth in the anterior border of the ramus found to be almost constant; however, the posterior border underwent a sudden growth after the age of 8 and 9 in boys and girls, respectively, which might be due to growth of condyle and apposition of the bone in the posterior border of the mandibular ramus and the gonial angle.

The mean of perpendicular distance from point 1 to the lower border of the mandible increased by 2.82 mm in boys and 4.10 mm in girls aged 7-10 years and the greatest increase found to be about 2.05 mm and 2.2 mm in 9-year-old girls and 10-year-old boys, respectively.

The positional changes in vertical direction might be referring to the growth of the ramus and the apposition of the bone in the lower mandibular border.

Mandibular growth is partly associated with the gonial angle. Moreover, growth and development of nasomaxillary complex is related to the vertical growth of ramus resulting in downward rotation of the mandible. Such inclination may lead to anterior open bite which will be compensated compensate with anterior development of the jaws.

Basically, mandibular anterior teeth show more upward trend than canine and premolar teeth which is followed by alveolar process growth (Enlow, 1982). Simultaneously, gonial angle decreases during transition from mixed dentition to permanent dention (Tsai, 2002). This pattern eventually causes posterior downward inclination of the occlusal plane.

In our study, decrease of the gonial angle in 8 to 9-year-olds was as a result of distance increase between foramen and occlusal plane, particularly at the age of 9 years, which caused L to be positive. There was also more posterior downward inclination of occlusal plane in 9 year-old girls than boys.

Increase of gonial angle in this study was observed in 9 to 10-year-olds which can be associated with vertical growth of the condyle during this age period, as Bjork (1963).

In general, gonial angle increases and decreases by vertical and sagittal growth of the condyle, respectively. This study resulted in a negative relationship between gonial angle and the distances between the most anterosuperior points of the mandibular canal to each mandibular border. That is, more obtuse gonial angle more mandibular growth potential is, as Tsia agrees with Tsai (2004).

CONCLUSION

The position of the most superior anterior point of the mandibular foramen on the ramus changes horizontally and vertically which is related to the age and sex. IANB should be administered below and above the occlusal plane in 7-9 and 10-year-old boys, respectively. Also, IANB should be administered below and above the occlusal plane in 7-8 and 9-10-year-old girls, in that order.

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