International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Evaluation of the Age-Related Changes in Relative Position of Mandibular Foramen in Different Growth Patterns of Children: A Retrospective Radiographic Study

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Abstract: ***The Mandibular Foramen (MF) is a landmark for administering a local anaesthetic solution for Inferior Alveolar Nerve Block (IANB). The position of MF changes significantly amongst children of different ages. The purpose of this study was to evaluate the changes in relative position of the MF in children aged 3 to 13 as they transitioned from deciduous (Hellman's stage IIA) to early permanent dentition (Hellman's stage IVA). A total of 60 children's panoramic radiographs were used. Six linear measurements were taken on each OPG, two horizontal (L1), four vertical (L3, L4, L5, and L6), and two angular (A1 and A2). The Rakosi's criterion was used to determine growth patterns in OPGs of children aged 9 to 13, which were then divided into three groups based on the growth patterns. By comparing the linear and angular readings, the relative position of the MF was calculated. Tendency of MF to be positioned posteriorly with age was found in children aged 3 to 9, and the tendency of MF to be positioned anteriorly with age was found in children aged 9 to 13. The position of MF shifts posterosuperiorly in children with vertical growth patterns, while it shifts anteroinferiorly in children with horizontal growth patterns. As a result, in order to accomplish successful inferior alveolar nerve block, these changes in the position of the MF as a function of age and growth trends in the North Maharashtra population should be taken into account in clinical practice.***

Keywords: Mandibular Foramen, Growth Pattern, Inferior alveolar nerve block, Local anaesthetic technique, OPG

1. Introduction

Pain management is crucial in the treatment of paediatric dental patients. Local anaesthesia is a commonly used approach for pain control. To anaesthetize mandibular teeth, the inferior alveolar nerve must be blocked. The external oblique ridge, coronoid notch, pterygomandibular raphe, and occlusal plane on the ipsilateral side are considered landmarks for Inferior alveolar nerve block(IANB). (1) Unfortunately, with a reported failure rate of 15 to 30%, this approach has one of the greatest failure rates among dental anesthetic techniques. (2)Successful anesthesia of the mandibular arch is difficult to accomplish in children. (3) The failure is caused by two major factors: first is accessory innervations, and second, and the most common, is improper needle placement due to incorrect landmark evaluation. Repeated injections of the local anesthetic solution in children owing to IANB failure can be a time-consuming task, since it may result in the child's negative behavior and there is a risk of providing the solution above the recommended safe dose.

The needle tip must be placed in close proximity to the mandibular foramen for this procedure to work. For successful inferior alveolar anesthesia, a thorough investigation of the position of the mandibular foramen is essential. (4) In pediatric patients, the mandibular foramen is lower than the occlusal plane of the primary teeth, according to Olsen. (5) Another study found that during the primary dentition period, the foramen is at or slightly above the occlusal plane. Because the position of the mandibular foramen changes as a child grows, it's important to understand how this anatomical location changes.

To locate the mandibular foramen in this study, we used panoramic radiographs. This approach has several advantages over intraoral radiography, including a larger region of hard tissue coverage and continuity of the visualised area. The ability to view the entire body and ramus of the mandible allows for more precise horizontal and vertical localization of the mandibular foramen. (4)

Many studies have been conducted analysing the position of mandibular foramen in adult population but studies aiming paediatric population are limited (6). Hence, the present study was designed to evaluate the changes in relative position of mandibular foramen with respect to age and growth patterns.

2. Methodology

60 orthopantomogram of children were collected and divided into six groups based on the Hellman's dental developmental stages. (1) IIA, (2) IIC, (3) IIIA, (4) IIIB, (5) IIIC and (6) IVA. On each OPG various landmarks were mentioned as reference points (Figure 1) and were connected to form different planes and angles (Fig 1).

Six linear measurements, i.e., two horizontal (L1 and L2) and four verticals (L3, L4, L5 and L6), were made by connecting center of the Mandibular Foramen (MF) to each plane with a perpendicular line. (Fig 2) The relative position of the MF than arrived by comparing the dimensions of each of the linear and angular measurements as all of them were interconnected and showed complementary increase or decrease in values with growth. Along with these measurements on OPG's from group IIIB, IIIC, IVA, Gonial angle was measured at junction of the posterior and lower borders of the mandible. By using this angle, growth pattern is determined with Rakosi's criteria that normal value of gonial angle in patients with average growth pattern ranged from 128 degrees +/- 7 degrees. By following this criterion, OPG's are divided into 3 groups Horizontal growth pattern, Average Growth pattern and Vertical growth pattern.

3. Results

Table 1 shows the means and standard deviations of linear and angular measurements for each Hellman's developmental stage. In children aged 3 to 13 years, linear measurement L2 showed a statistically significant increase ($p<0.001$), while L3 and A1 ($p=0.004$) showed statistically significant decrease as age advanced. A statistically significant decrease ($p=0.007$) was observed in angular measurement A1.

Children in Groups IIIB, IIIC and IVA had their OPGs divided into three subgroups based on their growth patterns according to Rakosi's criteria. When patients in group IIIB (9-10years) with average, horizontal and vertical growth patterns were compared, children with an average and vertical growth pattern had a higher angular measurement, A2 than children with a horizontal growth pattern, which was statistically significant. When patients with horizontal and vertical growth patterns were compared in the same group, horizontal growers had significantly higher L2, L4, L5, A1 and lower L3 measurement. When patients with horizontal and average growth patterns were compared, L2, L4, L5, and A1 showed a statistically significant increase, while L3 and A2 showed a significant decrease in horizontal growers. There is no significant difference in any of the linear or angular measurements between vertical and average growers (Table 2).

When patients in group IIIC (11-12 years) with average, horizontal and vertical growth patterns were compared, patients with horizontal growth patterns, there was a significant increase in linear measurements L3, L4, L6 and significant decrease in angular measurements A1 and A2. When patients with horizontal and vertical growth patterns were compared, vertical growers had a significant increase in A2. There was a significant increase in L4 and L6 in patients with horizontal and average growers, but a significant decrease in A2 in horizontal growers. When comparing vertical and average growers, average growers had significantly lower L1 and A2 than vertical growers (Table 3).

In Group IVA, vertical growers had a statistically significant increase in A2 when patients with three different growth patterns were compared. No statistically significant difference was observed when patients with horizontal and average growth patterns were compared. (Table 4).

4. Discussion

The mandible is in a constant phase of remodelling as the child grows. It shows a differential growth pattern and remodelling at different areas. The eruption and shedding process of the teeth plays an important role in bone remodelling, particularly at the anterior border of the ramus and the alveolar crestal plane, which may influence the position of MF and, hence, the IANB procedure. The provision of the dental treatment depends on achieving excellent local anesthesia (LA). Pain-free treatment procedures are of obvious benefit both to the patient and to the operator, as treatment can be performed in a calm, unhurried fashion.

According to Afsar A et al, panoramic radiographs were found to be as effective as oblique cephalometric radiographs (3). They showed minimal ramus length distortion and are a useful tool for determining GoA, which is a measure of mandibular steepness and, as a result, mandibular growth directions. In determining the location of MF, no significant difference has been found between OPGs and oblique cephalometric radiographs. There is no difference in male and female values when it comes to determining the MF location, and there is no right or left side dominance in the ramus and MF. As a result, we used an Orthopantomograph to locate the position of the mandibular foramen in this study (13).

Different studies have shown different positions of the MF, just posterior to the middle of the ramus,(7) posterior to the middle of the ramus in the third quadrant,(8) at the midpoint,(9) about three-fourths of the distance from the anterior border,(1) approximately at the posterior third of the ramus in both vertical and horizontal directions,(10) vertically at the occlusal plane in children and no age-related difference in the anteroposterior position of the MF,(11) inferior to the occlusal plane,(1) midway and slightly inferior to the line connecting the deepest concavity on the internal oblique ridge and posterior border of ramus.(12) However, most of the studies carried out previously were on adult mandibles.

In the present study, patients aged 3 to 9 years had a tendency to shift MF posteriorly with age, meaning the distance between the mandibular foramen and the ramus posterior plane (L2) was found to be lower than that between the mandibular foramen and the ramus anterior plane (L1), whereas patients aged 9 to 13 years had a tendency to shift MF anteriorly. This can be a result of surface remodeling of mandible that is bone deposition at the posterior border of

ramus and resorption at anterior border of ramus. The angular measurement A1 gradually decreases with age, indicating gradual up-righting of the mandibular ramus.

When OPGs from groups IIIB (9-10 Years), IIIC (11-12 years), and IVA (12-13 years) were divided into three subgroups based on Rakosi's criteria, it was discovered that horizontal growers had a more anteroinferior mandibular foramen than the average and vertical growers which had a more posterosuperior mandibular foramen. Average and vertical growers had a more gradual up righting of the mandible when compared to children with a horizontal growth pattern.

5. Conclusion

Children aged 3 to 9 had a tendency for MF to be positioned posteriorly with age, while children aged 9 to 13 had a tendency for MF to be positioned anteriorly with age. In children with vertical growth patterns, the location of the mandibular foramen shifts posterosuperiorly, while in children with horizontal growth patterns, it shifts anteroinferiorly. As a result, in order to achieve successful inferior alveolar nerve block, these changes in the position of the mandibular foramen as a function of age and growth trends in the North Maharashtra population should be taken into account in clinical practice.

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Figures and Tables:

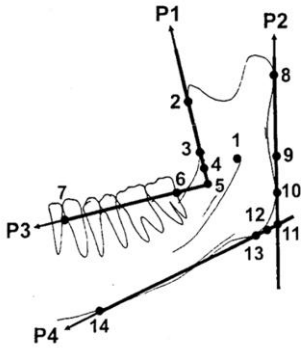

Figure 1: Reference points and planes. Point -1: Center of the MF. Point -2: Most prominent point on the anterior border of the ramus. Point -3: Deepest point on the anterior border of the ramus. Point -4: Intersecting point of the perpendicular line from the MF to P1. Point -5: Intersecting point of P1 and P3. Point -6: The distal alveolar crest of the most distal molar. Point -7: Mesial alveolar crest of the canine. Point -8: Most prominent posterior point of the condyle. Point -9: Intersecting point of the perpendicular line from the MF to P2. Point -10: Most prominent posterior point at the angle of mandible. Point -11: Intersecting point of P2 and P4. Point -12: Intersecting point of the perpendicular line from the MF to P4. Point -13: Most prominent inferior point at the angle of mandible. Point -14: Most prominent inferior point at the canine area. Plane 1 - (P1): Plane connecting reference points 2 and 3 (ramus anterior plane). Plane 2 - (P2): Plane connecting reference points 8 and 10 (ramus posterior plane). Plane 3 - (P3): Plane connecting reference points 6 and 7 (alveolar crest plane). Plane 4 - (P4): Plane connecting reference points 13 and 14 (mandibular plane).

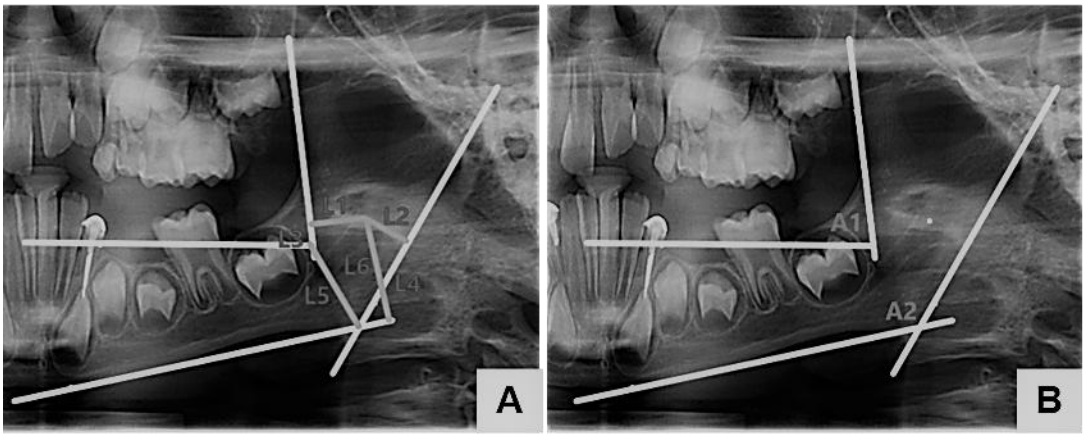

Figure 2: A. Linear and angular measurements between reference points and planes. L1: Distance between reference points 1 and 4 (Linear horizontal measurement). L2: Distance between reference points 1 and 9 (Linear horizontal measurement). L3: Distance between reference points 4 and 5 (Linear vertical measurement). L4: Distance between reference points 9 and 11 (Linear vertical measurement). L5: Distance between reference points 5 and 11 (Linear vertical measurement). L6: Distance between reference points 1 and 12 (Linear vertical measurement); B. A1: Angle between planes P1 and P3 (Angular measurement). A2: Angle between planes P2 and P4 (Angular measurement)

Tables

Table 1: Overall intergroup comparison of Horizontal, Vertical and angular measurements between different age groups

	L1 Mean (SD)	L2 Mean (SD)	L3 Mean (SD)	L4 Mean (SD)	L5 Mean (SD)	L6 Mean (SD)	A1 Mean (SD)	A2 Mean (SD)
3-4 Yrs	16.8 (4.28)	12.95 (2.55)	5.2 (4.92)	21.7 (7.2)	30.2 (6.6)	25.45 (6.92)	99.05 (11.63)	124.85 (5.16)
4-6 Yrs	18.33 (4.43)	13.71 (4.6)	7.42 (3.43)	21.21 (5.34)	29.38 (6.81)	25.59 (5.17)	88.792 (11.76)	130.79 (7.88)
7-9 Yrs	17.31 (3.89)	13.59 (2.73)	4.97 (4.98)	20.81 (4.6)	31.41 (4.86)	25.34 (4.15)	90.03 (11.24)	126.4 (7.92)
9-10 Yrs	15.22 (3.86)	16.95 (2.67)	3.56 (6.83)	17.56 (4.81)	30.61 (4.61)	24.94 (3.32)	83.33 (7.42)	123.05 (6.22)
11-12 Yrs	14.93 (3.22)	17.07 (2.79)	1.643 (4.84)	22.43 (4.22)	34.25 (3.79)	28.07 (3.69)	89.714 (5.17)	125.46 (6.71)
12-13yrs	14.05 (2.87)	18.5 (2.27)	-0.4 (3.68)	20.4 (3.23)	33.3 (4.8)	27.6 (3.06)	85.2 (6.44)	126.5 (7.67)
p value	p =0.061	p <0.001**	p =0.004*	p =0.335	p =0.180	p =0.393	p =0.007*	p =0.220

Table 2: Comparison of horizontal, vertical and angular measurements between three growth patterns in children aged 9-10 years

9-10 years	Group A (Horizontal Mean(SD)	Group B (Vertical) Mean(SD)	Group C (Average) Mean(SD)	p value Overall#	p value^ H vsV	p value^ H vs A	p value^ V vsA
L1	15.5 (3.6)	14.88 (4.3)	14.87 (5.2)	p=0.837	p =0.761	p = 0.752	p =0.999
L2	18.1 (2.38)	15.5 (3.1)	15.5 (1.22)	p =0.09	p = 0.043*	p = 0.031*	p = 0.732
L3	1.6 (7.89)	6 (6.8)	6.0 (5.8)	p=0.385	p =0.003*	p =0.007*	p = 0.952
L4	18.4 (3.57)	16.5 (4.8)	16.5 (7.01)	p = 0.611	p =0.002*	p =0.005*	p = 0.872
L5	33.1 (4.56)	27.5 (4.21)	27.5 (3.41)	p = 0.082	p = 0.022*	p = 0.028*	p =0.934
L6	25.3 (3.45)	24.5 (3.91)	24.5 (3.87)	p =0.753	p = 0.081	p =0.076	p = 0.971
A1	84.4 (7.79)	82 (6.4)	82 (8.75)	p =0.677	P =0.037*	p = 0.029*	P =0.983
A2	118.4 (3.34)	128.8 (3.9)	128.8 (4.26)	p =0.004*	P =0.001*	P =0.002*	P =0.991

Table 3: Comparison of horizontal, vertical and angular measurements between three growth patterns in children aged 11-12 years

11-12 years	Group A (Horizontal) Mean(SD)	Group B (Vertical) Mean(SD)	Group C (Average)	p value Overall#	p value^ H vsV	p value^ H vs A	p value^ V vsA
L1	16.33 (1.04)	20.0 (0.0)	14.0 (3.21)	p =0.045*	P = 0.359	P =0.444	P =0.043*
L2	18.83 (1.6)	18.0 (0.0)	16.6 (3.13)	p =0.588	p =0.991	P =0.625	P = 0.797
L3	3.33 (5.77)	2.0 (0.0)	1.1 (5.02)	p =0.790	P =0.953	P =0.776	P =0.970
L4	27.66 (2.51)	22.5 (0.0)	20.85(3.53)	p =0.024*	P =0.227	P =0.019*	P =0.791
L5	37.0 (2.64)	37.0 (0.0)	33.15 (3.81)	p =0.172	P =1.000	P =0.251	P =0.357
L6	33.0 (2.64)	29.0 (0.0)	26.5 (2.68)	p =0.008*	P =0.242	P =0.006*	P =0.444
A1	83.5 (3.9)	93.0 (0.0)	91.25 (4.31)	p =0.029*	P =0.06	P =0.033	P =0.845
A2	117.0 (2.78)	140.0 (0.0)	126.5 (3.83)	p<0.001**	P<0.001**	P =0.004*	P =0.001*

Table 4: Comparison of horizontal, vertical and angular measurements between three growth patterns in children aged 12-13 years

12-13 years	Group A (Horizontal) Mean (SD)	Group B (Vertical) Mean (SD)	Group C (Average)	p value Overall#	p value^ H vsV	p value^ H vs A	p value^ V vsA
L1	14.5 (3.5)	12.0 (0.0)	15.0 (3.46)	P =0.569	P = 0.681	P =0.977	P = 0.553
L2	19.83 (2.51)	17.25 (2.47)	18.75 (2.06)	P = 0.507	P =0.478	P =0.816	P =0.742
L3	0.33 (5.5)	1.0 (1.41)	1.0 (3.91)	P=0.846	P =0.984	P =0.913	P =0.854
L4	22.33 (3.51)	18.5 (4.94)	10.0 (2.94)	P=0.508	P =0.502	P =0.681	P =0.879
L5	34.0 (8.66)	31 (2.82)	34.25 (3.3)	P=0.791	P =0.834	P = 0.998	P =0.791
L6	29.66 (2.08)	25.5 (4.94)	27.5 (3.0)	P=0.402	P =0.380	P =0.662	P =0.756
A1	81.33 (7.57)	92.5 (6.36)	83.5 (3.69)	P= 0.165	P =0.162	P =0.876	P =0.242
A2	119.0 (1.0)	136.5 (0.7)	124.75 (4.34)	P=0.003*	P =0.002*	P =0.117	P =0.012*

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