Assessment of Mandibular Foramen Position for Inferior Alveolar Nerve Block in Children

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ABSTRACT

Introduction: In children the administration of inferior alveolar nerve block at the target site varies and repeated injection may result in a negative behavior and also increase the risk of overdose. This study aimed to correlate the relative position of the mandibular foramen with occlusal plane as a clinical guide for inferior alveolar nerve block in children.

Methods: A cross-sectional study was conducted on 180 orthopantomographs of children aged 3–13 years from June 2021 to October 2021. The radiographs were digitally traced and analyzed to obtain linear and angular measurements of mandibular foramen to occlusal plane, anterior, posterior and lower border of mandible along with gonial angle. Paired t-test, unpaired t-test was used along with Karl Pearson’s test for correlation.

Results: The results suggested that the needle for inferior alveolar nerve block should be placed below the occlusal plane in 3–4 years (L-1.38, R-1.36 mm approximately), above the level of occlusal plane in 5–7 years (L-2.59, R-2.77 mm), 7–9 years (L-3.71, R-3.86 mm), 9–12 years (L-3.5, R-4.14 mm), 11–12 years (L-3.97, R-4.35 mm), and 12–13 years (L-4.24, R-4.7 mm) old children respectively. The distance of the mandibular foramen from anterior border of ramus was greater than that from posterior border and the gonial angle decreased with subsequent stages. However, there was bilateral statistically significant mean difference in position of mandibular foramen from anterior border of ramus as well as occlusal plane in the same individual.

Conclusions: Present study showed alteration in the vertical and horizontal position of the mandibular foramen. Thus, it is necessary to modify the position of needle insertion during inferior alveolar nerve block with advancing age of growing children pertaining to skeletal growth. The decrease in gonial angle indicated an increase in growth potential of the mandible with age.

INTRODUCTION

Pain control is an important aspect in behavior management of pediatric dental patients and local anesthesia is widely used for pain control.1 Painful experience during dental procedure in children may lead to uncooperative child who maybe apprehensive for future...
dental treatment. 2

Inferior alveolar nerve block (IANB) is the most commonly used technique for achieving mandibular anesthesia. 3 It has one of the highest failure rates ranging from 15 to 30%, among dental anesthetic techniques. 4 Major factors which lead to failure of this block in children are: accessory innervations of the mandibular dentition, anatomical variations and most commonly, the fault in the placement of the needle due to improper recognition and evaluation of anatomic landmarks. 5 The position of the mandibular foramen (MF) in children is still debated and a lower level is considered as a standard in primary dentition. 8

Occlusal plane (OP) is an important clinical guide for IANB in children. 9 The eruption and shedding of teeth plays an important role in the bone remodeling process particularly at the anterior border of the ramus and the crest of the alveolar bone which indirectly influences the position of the mandibular foramen and the IANB procedure in children. 10 Though many studies have been carried out to assess the position of mandibular foramen, not many have been in primary dentition taking occlusal plane as a clinical guide to IANB. 4-7

This study aimed to evaluate and find any changes in the relative position of mandibular foramen with respect to the occlusal plane in growing children aged 3-13 years using orthopantomographs (OPG) for IANB technique in children and to measure the gonial angle (GoA) that attributes to vertical growth of condyle according to age.

METHODS

An analytical cross sectional comparative study was conducted from June 2021 to October 2021. Approval for the study was granted from Institutional Review Committee of Kantipur Dental College and Hospital (Reference number IRC:25/2021). The study was carried out in children of age group 3-13 years who visited Department of Pedodontics and Preventive Dentistry, Kantipur Dental College and Hospital, Kathmandu, Nepal for regular dental checkup and required orthopantomograph as routine diagnostic aid. The nature and purpose of the study was explained in detail to the parents or guardians of the children and informed written consent was obtained from them.

Six groups as per the Hellman’s dental developmental stages were used for the study: (1) II A; (2) II C; (3) III A; (4) III B; (5) III C; (6) IV A [Table 1]. 11 Children with previous orofacial trauma, surgery, temporomandibular joint and craniofacial disorders and those falling under Hellman’s stages of IA, IC, IVC and VA were excluded as they do not fit into the age group selected.

Sample size

A total sample size of 180 was calculated using, mean 1.43 mm and standard deviation of 1.64 mm from study by Chandran S et al. 12 at 95% confidence interval and 90% power.

Sample size, n= f(α, β) x 2x SD²

\[
\text{n} = \frac{10.5 \times 2 \times (1.64)^2}{(1.43)^2}\]

n= 56.5/2

n= 28.25 rounding off to 30 to account for gender strata (15 Male and 15 Female) per group

Sample size was adjusted to 180 to account for 6 groups based on the Hellman’s dental developmental stages [nx6, 30x6=180 (90 boys and 90 girls)]

Table 1. Hellman’s dental developmental stages based on dental age and clinical findings.
Inclusion criteria: Orthopantomographs recorded by single dental orthopantomogram machine (Planmeca Proline EC Panoramic X-ray/ KODAK model number - CS9300 Carestream India) at 74 kvp, 12 mA for 14.3 seconds. Radiographs without any gross anatomical abnormalities and acceptable mandibular occlusal plane.

Exclusion criteria: Orthopantomographs with poor image quality, children with: previous history of maxillofacial trauma, temporomandibular disorders, undergoing orthodontic treatment, anatomical abnormalities, extracted teeth, mandibular teeth which are submerged or supraerupted that can affect mandibular occlusal plane, and where occlusal plane cannot be established due to lack of posterior teeth.

A convenient sampling technique was used. 180 OPG were exported in ImageJ software version 1.53a. Linear and angular parameters were traced using the same software. Calibration was done for 1:1 magnification. Linear and angular measurements were determined followed by marking of all the anatomic points and lines drawn on either sides.

Figure 1: An example of a traced orthopantomograph with the three anatomic points marked and the planes drawn. Points: 1 – Most superior point of mandibular canal, 2 – Deepest point on anterior border of ramus, 3 – Most prominent point on the canine cusp tip, 5 – Most prominent point on end most fully erupted tooth, 6 – Most prominent posterior point on condyle, 7 – Most prominent posterior point on angle of mandible, 8 – Most prominent inferior point at the angle of mandible, 9 – Most prominent inferior point on body of mandible at canine area. Plane 1 – Occlusal plane connecting point 4 and point 5, Plane 2 – Plane connecting point 2 and point 3, Plane 3 – Plane connecting point 6 and point 7, Plane 4 – Plane connecting point 8 and point 9. (Left side) LL – Left side of mandible, L1 – Perpendicular line from point 1 to plane 2, L2 – Perpendicular line from point 1 to plane 3, L3 – Perpendicular line from point 1 to plane 4, L4 – Perpendicular line from point 1 to plane 1 A1 – Internal angle of left side between Plane 3 and Plane 4. Right side respectively as RR, R1, R2, R3, R4, A2.

For checking the intra-examiner reliability, a total of 30 samples (five from each group) were randomly selected and the landmarks were identified, traced and measured. After a gap of 2 weeks, the same samples were retraced, measured and the values were compared using intraclass correlation coefficient. A value of >0.8 was obtained which showed good reliability. Only 10 orthopantomographs were traced per day for eye bias prevention.

Statistical Analysis: Data was tabulated, coded then analyzed using the SPSS version 22. The mean values, standard deviations of linear and angular measurements were calculated in each of the Hellman’s stage and one-way analysis of variance was used for comparison of measurements at different stages and paired t-test was done to find the difference between left and right side on all stages. Karl Pearson’s correlation coefficient test was performed for all the linear and angular measurements between both sides and in between the same sides. Gender differences were compared in all the stages. Here, the level of significance was kept at $P < 0.05$. 
RESULTS

The difference in various linear measurements in different Hellman’s stages were statistically significant in both right and left sides ($P < 0.001$) (Table 2). There was difference in the distance from mandibular foramen to the anterior border of ramus, MF to posterior border of ramus and MF to the occlusal plane in both left and right sides in different Hellman’s stage.

**Table 2.** The mean and standard deviations of linear measurements of left side (L) and right side (R) in each stage.

<table>
<thead>
<tr>
<th>Hellman’s Stages</th>
<th>N</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>IIA</td>
<td>30</td>
<td>15.43</td>
<td>2.06</td>
<td>13.92</td>
<td>1.75</td>
<td>22.86</td>
<td>2.60</td>
<td>-1.38</td>
<td>1.44</td>
</tr>
<tr>
<td>IIC</td>
<td>30</td>
<td>15.57</td>
<td>2.04</td>
<td>15.97</td>
<td>2.53</td>
<td>26.37</td>
<td>3.62</td>
<td>2.59</td>
<td>1.06</td>
</tr>
<tr>
<td>IIIA</td>
<td>30</td>
<td>17.71</td>
<td>3.08</td>
<td>16.70</td>
<td>1.94</td>
<td>29.63</td>
<td>2.75</td>
<td>3.71</td>
<td>1.54</td>
</tr>
<tr>
<td>IIIB</td>
<td>30</td>
<td>17.75</td>
<td>2.91</td>
<td>17.11</td>
<td>2.16</td>
<td>29.75</td>
<td>2.79</td>
<td>3.50</td>
<td>2.05</td>
</tr>
<tr>
<td>IIIC</td>
<td>30</td>
<td>17.72</td>
<td>2.95</td>
<td>18.47</td>
<td>2.11</td>
<td>32.50</td>
<td>2.73</td>
<td>3.97</td>
<td>1.31</td>
</tr>
<tr>
<td>IVA</td>
<td>30</td>
<td>19.82</td>
<td>3.31</td>
<td>19.25</td>
<td>1.69</td>
<td>35.07</td>
<td>4.58</td>
<td>4.24</td>
<td>1.31</td>
</tr>
</tbody>
</table>

p-value* < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001 < 0.001

* One way ANOVA

L1, R1 - linear measurement from MF to anterior border of ramus, L2, R2 - linear measurement from MF to posterior border of ramus, L3, R3 - linear measurement from MF to lower border of mandible, L4, R4 - linear measurement from MF to Occlusal Plane.

There was statistically significant difference in gonial angle measurements between different Hellman’s stages on both left ($P < 0.001$) and right sides ($P < 0.001$) (Table 3).

**Table 3.** The mean and standard deviations of angular measurements in each stage of Left and Right side.

<table>
<thead>
<tr>
<th>Hellman’s Stages</th>
<th>N</th>
<th>A1 Mean</th>
<th>Std. Deviation</th>
<th>A2 Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>30</td>
<td>130.8483</td>
<td>7.14919</td>
<td>129.3310</td>
<td>5.15124</td>
</tr>
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<td>IIC</td>
<td>30</td>
<td>128.3215</td>
<td>6.79728</td>
<td>127.8223</td>
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<tr>
<td>IIIA</td>
<td>30</td>
<td>126.6353</td>
<td>5.04241</td>
<td>126.6400</td>
<td>5.86223</td>
</tr>
<tr>
<td>IIIB</td>
<td>30</td>
<td>124.7863</td>
<td>5.88317</td>
<td>124.5961</td>
<td>5.67252</td>
</tr>
<tr>
<td>IIIC</td>
<td>30</td>
<td>121.1505</td>
<td>4.42442</td>
<td>122.5614</td>
<td>4.55649</td>
</tr>
<tr>
<td>IVA</td>
<td>30</td>
<td>123.1641</td>
<td>8.84285</td>
<td>123.8138</td>
<td>7.70453</td>
</tr>
</tbody>
</table>

p-value* < 0.001 < 0.001

* One way ANOVA

A1 – Gonial angle of left side, A2 – Gonial angle of right side

Overall, there was significant positive correlations ($P < 0.05$) of linear measurements on left side (L1, L2, L3 and L4) with the corresponding measurements on the right side (R1, R2, R3 and R4). Similarly, angular measurements on the right and left side were also positively correlated ($P < 0.05$). However, statistically significant difference ($P = 0.017$) of 0.4 ± 2.2 mm was reported on linear measurement between two sides at anterior border of ramus to mandibular foramen (Table 4). Similarly, statistically significant difference ($P < 0.001$) of 0.3 ± 0.8 mm was reported on linear measurement between two sides at occlusal plane to mandibular foramen ($P < 0.05$) (Table 5).

The gender difference in the mean values of linear and angular measurements on both sides were
not found to be statically significant in any of the groups (not given in Table).

**Table 4.** Correlation of linear and angular measurements on both sides.

<table>
<thead>
<tr>
<th></th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.731*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>0.690*</td>
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<td></td>
</tr>
<tr>
<td>R3</td>
<td></td>
<td>0.876*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td></td>
<td></td>
<td>0.954*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td></td>
<td></td>
<td></td>
<td>0.831*</td>
<td></td>
</tr>
</tbody>
</table>

* Pearson Correlation Coefficient; Bold signifies statistical significance at \( P < 0.05 \)

**Table 5.** Difference between linear and angular measurements on both sides.

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Right</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>p-value^</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior border of ramus to mandibular foramen</td>
<td>17.3397</td>
<td>3.11959</td>
<td>17.7402</td>
<td>2.94597</td>
<td>-.40048</td>
<td>2.23154</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.017</td>
</tr>
<tr>
<td>Posterior border of ramus to mandibular foramen</td>
<td>16.9078</td>
<td>2.66268</td>
<td>17.0834</td>
<td>2.56918</td>
<td>-.17558</td>
<td>2.06233</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.255</td>
</tr>
<tr>
<td>Lower border of mandible to mandibular foramen</td>
<td>29.3665</td>
<td>5.10685</td>
<td>29.2703</td>
<td>4.96879</td>
<td>.09624</td>
<td>2.50952</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.608</td>
</tr>
<tr>
<td>Occlusal plane to mandibular foramen</td>
<td>2.7761</td>
<td>2.42945</td>
<td>3.0806</td>
<td>2.53314</td>
<td>-.30448</td>
<td>.76077</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Angular measurement</td>
<td>125.8177</td>
<td>7.19347</td>
<td>125.7941</td>
<td>6.30109</td>
<td>.02359</td>
<td>4.01355</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.937</td>
</tr>
</tbody>
</table>

^ Paired t-test; Bold signifies statistical significance at \( P < 0.05 \)

The mean average linear distance of mandibular foramen to occlusal plane from both sides was, below 1.37 mm in 3-4 years and above: 2.68 mm in 5-7 years, 3.78 mm in 7-9 years, 3.82 mm in 9-12 years, 4.16 mm in 11-12 years and 4.47 mm in 12-13 years.

The linear measurements were positively correlated with each other on both the sides. Similarly, there was a negative correlation of linear measurements with the angular measurement which were statistically significant at \( P < 0.05 \) (Table 6,7).

**Table 6.** Correlation of different linear and angular measurements on left side.

<table>
<thead>
<tr>
<th></th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>0.387*</td>
<td>0.538*</td>
<td>0.300*</td>
<td>-0.244*</td>
</tr>
<tr>
<td>L2</td>
<td>0.709*</td>
<td>0.463*</td>
<td>-0.464*</td>
<td></td>
</tr>
<tr>
<td>L3</td>
<td>0.528*</td>
<td></td>
<td>-0.626*</td>
<td></td>
</tr>
<tr>
<td>L4</td>
<td></td>
<td>-0.265*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Pearson Correlation Coefficient; Bold signifies statistical significance at \( P < 0.05 \)
**Table 7.** Correlation of different linear and angular measurements on right side.

<table>
<thead>
<tr>
<th></th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>A2</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0.534*</td>
<td>0.620*</td>
<td>0.392*</td>
<td>-0.342*</td>
</tr>
<tr>
<td>R2</td>
<td>0.745*</td>
<td>0.485*</td>
<td>-0.453*</td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>0.542*</td>
<td>-0.638*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>-0.244*</td>
<td></td>
<td></td>
<td></td>
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</table>

*Pearson Correlation Coefficient; Bold signifies statistical significance at \( P < 0.05\)

**DISCUSSION**

Pain prevention in pediatric dentistry is crucial for a child in achieving a positive experience during the dental visit, building trust and cooperation, and making future visits enjoyable. The usefulness of locating the mandibular foramen in children consists of optimally planning anesthetic procedures for clinical interventions. The most likely cause for failed local anesthesia is the technical errors of positioning the needle too high, too low, superficially or intravascularly that contributes to missed block.

The present study used orthopantomographs for the assessment of position of MF with the OP along with other linear and angular measurements as in other studies. Panoramic radiography, one of the convenient techniques to determine the position of MF is as reliable as oblique cephalometric radiographs with no significant difference, shows negligible distortion of ramus length, useful tool for measuring GoA which is an indicator of mandibular steepness and, subsequently mandibular growth directions. The image quality of panoramic radiography can be increased using digital panoramic radiography and by using software programs. Studies have used software to draw and calculate linear and angular measurements and in the present study we have used ImageJ software.

The current study has used Hellman’s dental developmental stages and classifying subjects accordingly seemed to be more appropriate, taking into consideration the clinical situation of the mandibular growth instead of the chronological age.

Present study showed overall increase in both horizontal and vertical dimensions through Hellman’s stages which were statistically significant in both right and left sides. This showed that there was vertical and horizontal growth in anterior, posterior and lower border of the mandible in both the sides as the skeletal growth continued age wise similar to Phukan AH et al. study.

Present study showed a significant difference in vertical direction as the distance from mandibular foramen to the occlusal plane was found to be below the occlusal plane in 3-4 years old children as 1.38 mm in Left (L), 1.36 mm Right (R) and above the occlusal plane in: 5-7 years old (L-2.59, R-2.77 mm), in 7-9 years old (L-3.71, R-3.86 mm), in 9-12 years old (L-3.5, R-4.14 mm), in 11-12 years old (L-3.97, R-4.35 mm) and in 12-13 years old (L-4.24, R-4.7 mm) respectively implying there is need of change in the placement of needle insertion position during IANB with advancing age. Similarly, study by Shukla RH et al. and Krishnamurthy NH et al. showed that the bony landmark kept changing within the jaw thus modification of placement of needle is needed during local anesthesia techniques with advancing age. Hwang TJ et al. found the foramen to subsequently move upward as age advanced and MF was located 4.12 mm below the occlusal plane at the age of three years, at the same level of occlusal plane by nine years and to 4.16 mm above the occlusal plane in the adult patients as accordance to our study. Akbari F et al. found the mandibular foramen distance relative to the occlusal plane as 7-9 years (0.47 ± 2.75 mm), 9-10 years (2.86 ± 2.44 mm) and 11-12 years (2.51 ± 0.02 mm) which was lower in comparison to our study. Study by Kanno CM et al. reported that inferior alveolar anesthesia should be administered at least 6 mm above the occlusal plane in 7-8 years old, while 10 mm could be indicated for 9-10 years old children, which was way higher than our result. A study by Afsar A et al. was in contrast to the findings of our study and concluded that there was no difference in the linear distance between the mandibular foramen and the occlusal plane in terms of age and sex. In the study by Altunsoy M et al. it was found that the location of the MF was 2.5-3.6 mm above the occlusal plane of the molars and there were no statistically significant changes in the location of the MF with age.
Many studies have shown the result of the MF to OP and recommended needle insertion above or below the OP without the measurement. Ponnacha KS et al.10 concluded that IANB can be given by placing the needle at the level of occlusal plane in children of the age group 3 to 13 years and the mandible and its growth did not alter the position of the MF, both vertically and horizontally. Olsen NH7 reported the mandibular foramen was at a lower level than the occlusal level of the primary teeth and to administer the injection at a point lower and posterior in children than adults. Mohavved T et al.21 recommended placing the needle tip below OP for 7-8 years children and above the OP in 10 years old children.

However, in current study there was statistically significant difference seen during correlation test on linear measurements between two sides; from anterior border of ramus to mandibular foramen with mean difference of 0.4 ± 2.231 mm and occlusal plane to mandibular foramen with mean difference of 0.3 ± 0.76 mm which was lesser in left side than on right side. Similarly, Chandran S et al.12 also found a significant difference between the right side and left side in measuring the vertical distance between the mandibular foramen and the occlusal plane in both 7–9 years and 4–6 years age group children. However, no significant differences between the measurements on the right and left were observed in other studies.24,27 The eruption and shedding process of the teeth plays an important role in bone remodeling, particularly at the anterior border of the ramus and the alveolar crestal plane, which may influence the position of MF and simultaneously in the IANB procedure in children.10 Thus from current study we can report that there should be an approximate height of insertion and alteration in the needle insertion position on right and left side according to the growth of the child age-wise.

Overall, present study showed gradual increase in linear growth which had statistically significant positive correlations of linear measurements on left side (L1, L2, L3 and L4) with the corresponding measurements on the right side (R1, R2, R3 and R4). There was a correlation between the vertical and horizontal growth of the mandible i.e., in anterior, posterior, and lower border of the mandible in both the sides. As a child grows there is remodeling of the mandible mostly on the anterior border of the ramus and the alveolar crest.23 Similarly, studies by Mohammad DA,18 Tsai HH19 and Tsai HH28 showed that the distance of MF to the ramal border gradually increased significantly with aging process and in both sexes and there were positive correlations among linear measurements.

Present study showed that in the horizontal direction, the distances of the mandibular foramen from anterior ramus plane were greater than from posterior ramus plane similar to Tsai HH,28 Mohavved T et al.,21 Phukan AH et al.,23 Tsai HH,19 Kang SH et al.,15 and Shukla RH et al.13 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.

Current study showed there was gradual decrease in the gonial angle which was statistically significant between different Hellman’s stages with advancing age on both left and right sides. Similarly, Shukla RH et al.13 and Ponnacha KS et al.10 also found that the gonial angle values decreased with increasing age indicating growth of the mandible.

In present study, there was a negative correlation of linear measurements with the angular measurement which were statistically significant at P < 0.05. Similarly, Mohammad DA,18 Tsai HH19 and Tsai HH28 showed that the gonial angle had a negative correlation with the 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. The reason of this may be due to changes in vertical and sagittal growth of mandibular condyle and more posterior downward inclination of occlusal plane, and this mostly happens during the transition from mixed to permanent dentitions.28

Present study showed significant difference on linear measurement between two sides at anterior border of ramus to mandibular foramen and occlusal plane to mandibular foramen. Similarly, Krishnamurthy NH et al.24 also showed that the position of the mandibular foramen was not bilaterally symmetrical in the considered age group of children. However, no significant differences between right and left were observed in other studies.21,27

In current study, the gender difference in the mean values of linear and angular measurements on both sides were not found to be statistically significant in any of the groups. Similarly, Afsar A et al.6 and Tsai HH19 have also shown no age or gender correlations. However, Mohavved T et al.21 reported different results according to sex and age.

**Limitation of the study:** The limitation of present study would be based on the fact that the sample consists of Nepalese child population re-
siding in the central region of the country only. Various other parameters play a role, like the ethnic and racial variations in the jaw growth patterns, nutritional status, general health of the child, accuracy of the radiographic machine, the magnification factors, proper patient positioning, identification of the landmarks on radiographs and, also identification of the landmarks intraorally during IANB, which are highly individualistic. Therefore, similar studies may have to be conducted on large population groups on the ethnic grounds with advanced diagnostic aids like CBCT imaging and other emerging technologies in future.

CONCLUSIONS

The present study indicated variable positional change in mandibular foramen without bilateral symmetry during the skeletal growth in children. The mandibular foramen moved upward during mandibular growth and the occlusal plane followed this development with the eruption of the first and second permanent molars. Thus, occlusal plane can be used as a reference plane and average distance of 1.37 mm below OP in 3-4 years and above OP by 2.68 mm in 5-7 years, 3.78 mm in 7-9 years, 3.82 mm in 9-12 years, 4.16 mm in 11-12 years and 4.47 mm in 12-13 years can be used from it to reach the mandibular foramen while performing inferior alveolar nerve block from primary to permanent dentition changes in children which will enable the dentist for more accurate and effective anesthesia. The gonial angle indicated an increase in growth potential of the mandible with age.

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