Correlation of Mandibular Foramen to Occlusal Plane as a Clinical Guide for Inferior Alveolar Nerve Block in Children: A Digital Panoramic Radiographic Study

Abstract

Aim: The study aimed to correlate the position of mandibular foramen with occlusal plane as a clinical guide for inferior alveolar nerve block (IANB) injection in children from 3 to 13 years of age. Materials and Methods: The study was carried out on 180 children visiting our department and required orthopantomogram as a routine diagnostic aid. Mandibular casts were obtained and radiographs were digitally analyzed to obtain linear and angular measurements. Statistical Analysis: The measurements were correlated with the position of mandibular foramen with Karl Pearson's correlation test. Results: The results of the study suggest that the needle for IANB should be placed below the occlusal plane in 3–4-year-old children (1.26 mm approximately), almost at the level of occlusal plane in 5–7 years (0.33 mm), above the occlusal plane in 7–9 years (1.54 mm), 9–12 years (1.64 mm), 11–12 years (1.98 mm), and 12–13 years (2.9 mm), respectively. The distance of the mandibular foramen from anterior border of mandible was greater than that from posterior border. The gonial angle values decrease with increasing age. Conclusion: The bony landmarks within the jaws keep changing their relative positions along with the skeletal growth. It is therefore necessary to modify the placement of needle during local anesthesia techniques with advancing age.

Keywords: Inferior alveolar nerve block, mandibular foramen, occlusal plane

Introduction

Achieving local anesthesia in children for pain control is an important aspect of behavior management. Painful dental experience during any restoration or surgical procedure in children may lead to uncooperative child and develop apprehension for future dental treatment.[1] Inferior alveolar nerve block (IANB) is the most commonly used technique for achieving mandibular anesthesia. The success of this technique depends on the deposition of local anesthetic solution near mandibular foramen.[2] The position of mandibular foramen has been suggested by many authors to change during growth period. Furthermore, the dentofacial characteristics are said to show variations among various racial and ethnic groups.[3,4] Therefore, a thorough knowledge regarding the positional change of mandibular foramen during growth period is important.

Occlusal plane has been considered by many as an important clinical guide for IANB in children.[5] Although many studies have been carried out to assess the position of mandibular foramen, not many studies have been done in children with primary dentition taking occlusal plane as a clinical guide to IANB. Most of the earlier studies have been carried either on skulls directly or using manual tracing.[6–8] Esteva et al. have suggested that the advantages of using digital radiography is 0% of error by transferring the program to perform some cephalometric tracings and good sharpness to visualize anatomical structures.[9]

Not many studies have reported the position of mandibular foramen, particularly, in primary dentition with respect to the occlusal plane using digital radiography. Therefore, the purpose of the study was to evaluate the relative position of mandibular foramen in children of 3–13 years age group using digital panoramic radiographic technique.

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Materials and Methods

This study was carried out on 180 children within the age group of 3–13 years who visited the department for dental treatment and required the panoramic radiography as a routine diagnostic aid. To obtain a statistically significant values, minimum number of sample size in each group selected was 30 (15 males and 15 females). Since we divided the children into six age groups, the total sample size was 180. Ethical clearance was obtained from the institutional ethical committee before the commencement of the study. Informed written consent was obtained from the parents or the guardians of all the children who participated in the study. Children with previous history of craniofacial trauma, temporomandibular disorders, and orthodontic treatment, and for whom occlusal plane cannot be established because of lack of posterior teeth were excluded from the study.

The children were divided into six groups as per the Hellman’s dental developmental stages with 30 children in each group [Tables 1 and 2].

Panoramic radiographs were taken with KODAK model number - 8000C Carestream India at 85 kVp and 10 mA. Alginate impression of the mandibular arch was made for calibration of radiographic magnification. The posterior-most tooth on both side of each dental cast was measured in millimeters using a digital caliper. Thus, two distances were acquired on both left and right sides to calculate linear measurements and to calibrate the linear magnification in software (Digimizer 4 Image Analysis 2005–2014 (MedCalc Software bvba, Acacialaan 22, 8400 Ostend, Belgium)). The points and lines were drawn with 100th mm of accuracy. Gonial angle was also measured. Single examiner calibrated the values with five orthopantomograms (OPGs) per day for eye bias prevention. Intraexaminer reliability was also carried out for initial ten OPGs.

The points, planes, and angle that were analyzed for the study were as follows: [Figure 1]

Point 1 – The most superior point of mandibular canal
Point 2 – The deepest point on anterior border of ramus
Point 3 – The most prominent Point on the anterior border of ramus
Point 4 – The most prominent point on the canine cusp tip
Point 5 – The most prominent point on end most fully erupted tooth
Point 6 – The most prominent posterior point on condyle
Point 7 – The most prominent posterior point on angle of mandible
Point 8 – The most prominent inferior point at the angle of mandible.

Point 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
(Right side)
RL – Perpendicular line from Point 1 to Plane 1
RL1 – Perpendicular line from point 1 to plane 2
RL2 – Perpendicular line from point 1 to plane 3
RL3 – perpendicular line from point 1 to plane 4
RA – Internal angle between Plane 3 and Plane 4
(Left side)
LL – Perpendicular line from Point 1 to Plane 1

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Table 1: Hellman’s dental developmental stages

| Group | Age (years) | Hellman’s stage | Characteristics |
|-------|-------------|-----------------|----------------|
| 1     | 3-4         | II A            | Completion of primary occlusion |
| 2     | 5-7         | II C            | Eruptive phase of 1st permanent molar |
| 3     | 7-9         | III A           | Eruptive phase of 1st permanent molar completed |
| 4     | 9-12        | III B           | Exchange of lateral teeth |
| 5     | 11-12       | III C           | Eruption of permanent 2nd molars |
| 6     | 12-13       | IV A            | Eruption of permanent 2nd molars completed |

Table 2: Distribution of Children included in each group

| Sample size (n=180) | Groups according to Hellman’s dental developmental stages |
|---------------------|----------------------------------------------------------|
| 30                  | II-A (3-4 years)                                         |
| 30                  | II-C (5-7 years)                                         |
| 30                  | III-A (7-9 yrs)                                          |
| 30                  | III-B (9-12 years)                                       |
| 30                  | III-C (11-12 years)                                      |
| 30                  | IV-A (12-13 years)                                       |
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LL1 – Perpendicular line from point 1 to plane 2
LL2 – Perpendicular line from point 1 to plane 3
LL3 – perpendicular line from point 1 to plane 4
LA – Internal angle between Plane 3 and Plane 4

Statistical analysis
The data collected were subjected to statistical analysis. Statistical analysis was carried out using the MedCalc (R) version 12.7.5.0 for windows, (Acacialaan 22 8400 Ostend, Belgium).

1. Mean values and standard deviation of all linear and angular measurements in each stage were calculated
2. Paired t-test was performed to find the difference between left and right side through all the stages
3. One-way analysis of variance was used to compare the gender differences in all the six stages
4. Karl Pearson’s correlation coefficient test was performed to find the correlation between all the linear and angular measurements between the groups.

Results
It was observed that all linear measurements showed a statistically significant increase ($P < 0.05$) in values from Stage IIA (3–4 years) to stage IVA (12–13 years). Thus, it was observed that the distance of mandibular foramen to the occlusal plane, the anterior border of ramus, the posterior border of ramus, and the lower border of mandible increases gradually from early primary dentition to late permanent dentition.

The Gonial angle measurements showed a statistically significant decrease ($P < 0.05$) in values from IIA (3–4 years = 127.93°) to IVA (12–13 years = 121.52°). It was however observed that there was a slight increase in the mean values of the Gonial angle between stage IIIB (124.70°) and IIIC (125.34°).

Furthermore, it was observed that there was no statistically significant difference in the mean values of linear and angular measurements on the right and left side, as well as between the males and females in any of the groups. There was a positive correlation between all the linear measurements (L and L1, L and L2, L and L3, L1 and L2, L1 and L3, and L2 and L3) with $P < 0.05$, thereby being statistically significant. However, correlation between L and L2 was not statistically significant. There was a negative correlation between all the linear values and the angular measurement and all of these were statistically significant at $P < 0.0001$.

Discussion
IANB is one of the most common dental procedures with a failure rate of 15%–20%.[11] To increase the efficacy of the mandibular block, the local anesthetic solution must be deposited as close as possible to the mandibular foramen. The mandibular foramen is of importance in regional block anesthesia in dentistry and does not have consistent location between patients, especially in growing children.
The most likely cause for failed local anesthesia is the faulty needle placement. Technical errors of positioning the needle too high, too low, superficially or intravascularly also contribute to missed blocks.\[12\]

In the present study, there was a significant difference in the distance from mandibular foramen to the occlusal plane (in vertical direction) with age. As per the results, it was observed that the mandibular foramen was located 1.26 mm below the occlusal plane in 3–4-year-old children, almost at the level of occlusal plane in 5–7-year-old children (0.33 mm above the occlusal plane), in 7–9-year-old children 1.54 mm above occlusal plane, in 9–12-year-old children 1.64 mm above occlusal plane, 1.98 mm above occlusal plane in 11–12-year-old and 2.9 mm above the occlusal plane in 12–13 years and above children, respectively. Furthermore, the growth rate of distances between mandibular foramen to occlusal plane declined up to stage III B and then increased up to stage IV A.

Mohavved et al. studied the relationship of mandibular foramen to the occlusal plane using panoramic radiography in 7–10-year-old children and recommended placing the needle tip below the occlusal plane for 7–8-year-old children, below the occlusal plane in 9-year-old boys, while in 9-year-old girls to be placed slightly above the occlusal plane.

In our study, we included the two younger age groups of 3–4 years and 5–7 years, thus taking primary dentition into considerations as well. We did not find statistically significant difference for any linear or angular measurements between the genders. Furthermore, the distance between the mandibular foramen and the ramus anterior plane (L1) was greater than those between mandibular foramen and ramus posterior plane (L2) through all stages [Graph 1]. This was similar to the studies conducted by Benham\[6\] and Mohavved et al.\[13\]

The distance from mandibular foramen to mandibular lower border showed a significant increase from stage IIA to Stage IVA almost around 6 mm, which is similar to the studies done by Tsai\[8\] and Poonacha et al.\[7\]. In vertical direction, mandible developed more rapidly in mixed dentition stage. The positional changes in the vertical direction might be referring to the growth of the ramus and the apposition of the bone in lower mandibular border.\[12\]

There was a constant decrease in the gonial angle as the age increased [Graph 2]. However, a slight increase in the gonial angle in between stage IIIA and IIIB was observed, which certain authors have attributed to vertical growth of condyle during this age period.\[14\] These results are in accordance with the results of earlier studies done by Hetson et al.\[15\] and Tsai.\[8\]

Comparison of linear and angular measurements on the right and left side in each stage did not show any significant difference.\[16\]

Conclusion
Understanding the mechanism of growth and the ever-changing relative relationships between various landmarks in the mandibulo-maxillary complex of the above-mentioned observations and results will definitely help in facilitating more accurate and effective injection procedures in children.

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Conflicts of interest
There are no conflicts of interest.

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