Estimating the Prevalence and Variation in Anterior Loop of Inferior Alveolar Nerve with Cone-Beam Computed Tomography in North Indian Population: An In Vivo Study

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Abstract

Purpose The present in vivo study aimed to estimate the prevalence and variation in anterior loop of inferior alveolar nerve (IAN) in relation to mental foramen to assess the safe zone in anterior part of mandible for implant placement with cone-beam computed tomography (CBCT) in North Indian population.

Materials and Methodology To conduct this study, 70 patients were selected and radiographically evaluated. All CBCT scans were made from Genoray Papaya 3D Plus. CBCTs were evaluated in CDSee software for anterior loop and height measurement anterior to mental foramen. Four parameters of prevalence of loop length and height anterior to mental foramen on right and left side each and four parameters of variation in loop length and height on right and left side each were recorded with the help of descriptive statistical analyses (mean, median, mode, and range) and paired t-test. Level of significance (p) was also calculated.

Result Paired t-test value for comparison on both the right and left sides for loop length of IAN anterior to mental foramen was 0.140 and paired t-test value for loop height was 0.384. The p-values for loop length and height were 0.8891 and 0.7019, respectively.

Conclusion Within the limitation of the study, it was observed that the anterior loop has a wide range of prevalence and variation in terms of loop length and loop height suggesting that it is difficult to get a defined measurement of loop length for a given population and surgical procedures cannot be performed based on the given data for IAN loop anatomy.

Keywords ► anterior loop length ► CBCT ► inferior alveolar nerve

Introduction

Inferior alveolar nerve (IAN) is a branch of posterior division of mandibular nerve that comprises both motor and sensory fibers. Mandibular nerve is a branch of the fifth cranial nerve, trigeminal nerve. Trigeminal nerve has three branches: upper branch, middle branch, and lower branch. Upper branch of trigeminal nerve is the ophthalmic nerve that...
enters the forehead. Middle branch of trigeminal nerve is the maxillary nerve that innervates the maxilla and mid face. Lower branch is the mandibular nerve that innervates the mandibular teeth, lateral mucosa of the mandible, facial skin of cheek, lower lip, and chin. The IAN enters in the mandibular canal through mandibular foramen and mandibular teeth are supplied by it. It leaves the mandibular canal through the mental foramen as the mental nerve. Nerve is approximately 3 mm in diameter in the canal and its passage is different in every individual. It runs with gentle curve toward the mental foramen, or it can have a forward or backward route. Mental foramen is situated apical to second premolar or amid the apex of premolars, and can be round or oval. This foramen may not emerge on conventional radiographs but computed tomography (CT) is more precise to locate, as this is the most important landmark for any surgical procedure in mandible.

The mandibular canal might bifurcate in 1% of patients that can be seen as more than one mental foramen. This is not visible in a two-dimensional radiograph. As suggested by Dario, clinicians must ask for a preoperative cone-beam CT (CBCT) scan when doing any osteotomy for implant placement above the inferior alveolar canal.

The terminal end of IAN occasionally routes beneath the lower border and anterior wall of mental foramen. After giving off the smaller mandibular incisive branch, it comes back to enter the foramen. Before leaving the canal anterior to the mental foramen, IAN gives an extension as anterior loop. This is also described by other authors as anterior loop as it travels inferiorly and anteriorly, which should be considered during osteotomy anterior to mental foramen. In cases where anterior loop is present, the bone coronal to the mental foramen will also be available. However, it is difficult in cases where implants longer than the length of safety zone are used. So either surgical exposure or CT scan is must in these cases.

In the present study, CBCT was used to assess the prevalence and average measurement of length and height of the anterior loop of the IAN to estimate a safe zone in anterior mandible for implant placement in North Indian population.

**Material and Methodology**

This in vivo study was designed to evaluate prevalence and variation in loop length and height in relation to IAN at mental foramen with help of CBCT in North Indian population. To conduct this study, 70 patients were selected and radiographically evaluated.

The materials and methodology used in the study are discussed as under.

**Materials Used**

Materials used in this study were: Diagnostic set (API India), CBCT machine (Genoray Papaya 3D Plus, Seongnam-Si, Gyeonggi-Do, Republic of Korea), Laptop (Apple MacBook, Cupertino, California, United States), Operating software (TRIANA - Genoray’s 3D, Seongnam-Si, Gyeonggi-Do, Republic of Korea), and DSLR camera (Nikon 5100, Japan).

**Methodology**

To conduct this study, 70 adult subjects were randomly selected from the North Indian population irrespective of age, sex, religion, etc. All 70 subjects were thoroughly informed about the study protocol and written consent was taken from each patient.

Patients with 20 to 70 years of age from North India, healthy with full development, with no history of mandibular fracture, trauma, or surgery were included.

Patients with carcinoma, radiation therapy, pregnant females, and mentally compromised were not included in the study.

**Patient Evaluation**

Each subject was thoroughly diagnosed to match the inclusion and exclusion criteria for the study. After the patients were selected, mandible CBCT scans were made. All scans were taken from Genoray Papaya 3D Plus machine with field of view 16 x 8 with 7.7 seconds of scan time and voxel size of 75 micron. Both right and left sides of anterior loop length (ANLL) were measured in each subject by TRIANA CDSee software, version 2.5.11.0.

In total, 140 sections were recorded; 70 on each side.

**Patient’s Position during CBCT**

Before CBCT, patient was asked to remove glasses, dentures, hearing aids, ear rings, nose studs, necklaces, and any other metal accessories. Patient was asked to stand into the CBCT machine. Patient’s head was carefully positioned and centered in the focal trough with the patient’s Frankfort plane parallel to the floor and the mid-sagittal plane perpendicular to the floor, and was asked to stand still while the scan was taken. He was also advised not to swallow, talk, or move jaw during the exposure (Fig. 1).

**CBCT Evaluation**

After generating CBCT in three-dimensional (3D) graphics, data were volumized into dental view, multiplanar reconstruction (MPR) view, and curve view. Loops were measured using MPR. In MPR, we get three sections: sagittal plane, coronal plane, and axial plane. Coronal section was used to evaluate ANLL because it helps us best evaluate the opening of mental foramen (Fig. 1).

**Anterior Loop Length Measurement**

Anterior loop of IAN was measured in dental view. In this view, we get cross-sectional, panoramic, and longitudinal sections. An oblique plane was created by passing a cut through the center of the mental foramen by enlarging longitudinal section. This helps in visibility of mental foramen as well as anterior loop. A line (Line 1) was drawn parallel to the buccal plate and another line (Line 2) was made perpendicular to Line 1, which passed through the most anterior point of the anterior loop. (It could be the origin of incisive canal or the most anterior point of the...
mental loop curvature.) ANLL was measured from the most anterior point of the mental foramen to Line 2. The same procedure was applied on the other side of the CBCT slide of the patient.

**Anterior Loop Height Measurement**
For measuring the height of anterior loop, sagittal section was used in similar manner as described in longitudinal section. A line (Line 3) was drawn parallel to the buccal plate and another line (Line 4) was made perpendicular to Line 3. ANLL was measured from the most anterior point of the loop to the superior point of the nerve. The same procedure was applied on the other side of the CBCT slide of the patient (Fig. 2).

In total 280 readings were recorded for 140 sections, 70 each for height and length of the anterior loop on each side.

**Parameters Observed**
Following parameters were observed:

- Prevalence of loop length of IAN anterior to mental foramen on left and right sides.
- Prevalence of loop height of IAN anterior to mental foramen on left and right sides.
- Variation in loop length of IAN anterior to mental foramen on left and right sides.
- Variation in loop height of IAN anterior to mental foramen on left and right sides.

**Observations and Result**
Collected data were statistically analyzed (SPSS 22.00 for Windows). Mean, median, standard deviation, and paired t-test were used for each side for loop length and height.

Paired t-test value for comparison on both the right and left sides for loop length of IAN anterior to mental foramen is 0.140. Level of significance (p) is 0.8891, which is not significant.

Paired t-test used for comparison on both the right and left sides for loop height of IAN anterior to mental foramen is 0.384 and p-value is 0.7019 (not significant).

**Loop Length of IAN on the Right Side** (Fig. 3 and Table 1)

- Variation of loop length of IAN on the right side in 70 subjects came out to be $3.50 \pm 3.17$, with $t = 10.87$.
- Prevalence of loop length of IAN on the right side in 70 subjects is 82%.

*Fig. 1* Papaya 3D Plus cone-beam computed tomography.
Loop Length of IAN on the Left Side (►Fig. 4 and ►Table 1)
- Variation of loop length of IAN on the left side in 70 subjects came out to be $3.44 \pm 2.84$, with $r = 10.06$.
- Prevalence of loop length of IAN on the left side in 70 subjects is 85%.

Loop Height of IAN on the Right Side (►Fig. 5 and ►Table 2)
- Variation of loop height of IAN on the right side in 70 subjects is $4.00 \pm 2.24$.
- Prevalence of loop height of IAN on the right side in 70 subjects is 98.6%.

Loop Height of IAN on the Left Side (►Fig. 6 and ►Table 2)
- Variation of loop height of IAN on the left side in 70 subjects is $3.89 \pm 2.04$.

Prevalence of loop height of IAN on the left side is 100% (►Table 3).

Discussion
The study aimed to evaluate a more conservative presurgical diagnostic approach to preserve the health, anatomy, and function of IAN. The IAN sometimes goes beyond the mental foramen and curves back to form a loop known as anterior...
loop. It is an anatomical variation but for implant osteotomy anterior to mental foramen, its identification is must to avoid complications in terms of nerve injury.\textsuperscript{4} The development of anterior loop of the mental nerve is due to shifting of mental nerve after eruption of the second deciduous molar.

According to Mardinger et al.\textsuperscript{5} there were five different patterns of the mental nerve: posterior, anterior, a right- or left-angled pattern, multiple foramina, and those not possible to evaluate due to resorbed ridges (\textsuperscript{Fig.} 7).

Al-Juboori et al.\textsuperscript{6} in 2016 assessed the zone of safety to insert a posterior implant, and they also determined available bone height in different posterior regions with the help of 550 orthopantomograms, which were used to mark the lines to assess the safety zone—line A, line B, and line C. Line A was drawn parallel to posterior plane of occlusion, line B at superior aspect of mental foramen, and line C was formed by marking the perpendicular lines from A and B, which becomes the line C. The safest zone is the length of line C. Four lines tangent to line A at the position of mesial first molar, mid first molar, mesial second molar, and mid second molar were drawn.\textsuperscript{6} There were four zones: mesial and distal first molar zones, and mesial and distal second molar zones.

The vertical bone height available was measured by the distance between lines A and B in the safe zone below line B (\textsuperscript{Fig.} 8).

Table 2 Paired \( t \)-test used for comparison on both the right and left sides for loop height of inferior alveolar nerve (IAN) anterior to mental foramen

<table>
<thead>
<tr>
<th>Paired ( t )-test</th>
<th>Loop height of IAN superior to mental foramen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right side</td>
</tr>
<tr>
<td>Mean</td>
<td>4.00</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.242</td>
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<tr>
<td>Median</td>
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<tr>
<td>Mode</td>
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<tr>
<td>Number</td>
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<td>Maximum</td>
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<tr>
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</tr>
<tr>
<td>Range</td>
<td>10.71</td>
</tr>
<tr>
<td>Mean difference</td>
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</tr>
<tr>
<td>( p )-Value</td>
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</tr>
<tr>
<td>Table value at 0.05</td>
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</tr>
<tr>
<td>Result</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Table 3 Master table

<table>
<thead>
<tr>
<th>Prevalence of loop length (LL) on right side</th>
<th>Prevalence of LL on left side</th>
<th>Prevalence of loop height (LH) on right side</th>
<th>Prevalence of LH on left side</th>
<th>Variation in LL on right side</th>
<th>Variation in LL on left side</th>
<th>Variation in LH on right side</th>
<th>Variation in LH on left side</th>
</tr>
</thead>
<tbody>
<tr>
<td>82%</td>
<td>85.6%</td>
<td>98.2%</td>
<td>100%</td>
<td>3.50 ± 3.17</td>
<td>3.44 ± 2.84</td>
<td>4.0 ± 2.24</td>
<td>3.89 ± 2.04</td>
</tr>
</tbody>
</table>
Nortjé et al in 1977 determined the positions of inferior dental canal by reviewing them on panoramic radiograph. They might be bilateral, single “high” or “low” canals running within 2 mm of the cortical plate of the lower border of the mandible; or bilateral, single “intermediate” canals between the root apices and lower border of mandible or other variations.

During implant osteotomy, it has been suggested that there should be at least 1 mm, 4 mm, or 6 mm width of bone at the distal implant anterior to the foramen to avoid injury to the nerves. Length of anterior loop has been given 9 mm by Uchida et al and 11 mm by Neiva et al. For these studies to avoid injury to the nerve, the rule of 1, 4, or 6 mm had been applied.

As stated by Santana and Uchida, lengths of anterior loop measured on cadavers and CBCT images were same, although CBCT was more accurate. Apostolakis et al and Chun et al reported ANLL from 0.89 mm to 6.92 mm. They even found different methods of measuring the ANLL on CBCT. Santana et al had compared the mental loop length on panoramic views with CBCT scans.

In contrast to this study, Al-Mahalawy et al recorded the prevalence of 46.2% in Saudi population. Also in contrast to Al-Mahalawy et al study, the coincident factor of loop length on the left and right sides was found to be 0.07 in our study whereas they recorded a coincident factor of 0.15. As per Juan et al in 2016, they reported 99% prevalence and an average of 0 to 0.68 mm of range of anterior loop. In line with this study, present study showed 100% prevalence and 3.89 ± 2.04 of variation in left side of mandible.

Limitations of this study were limited sample size, gender, and age.

**Conclusion**

Within the limitations of the study, it has been observed that the anterior loop has a wide range of prevalence and variation in terms of loop length and loop height suggesting that it is difficult to get a defined measurement of loop length for a given population and surgical procedures cannot be performed based on the given data for IAN loop anatomy. It is recommended that before any surgery involving anterior part of mandible, an in-depth analysis is required through a 3D CBCT scan for every patient individually to analyze the prevalence and variation in anterior loop anatomy of IAN anterior to mental foramen.

Conflict of Interest
None declared.

References