Three-dimensional evaluation of relationship between maxillary central incisor and nasopalatine canal

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ABSTRACT

Introduction: Primarily, orthodontic treatment is based on improving the occlusal relationship however, more attention is now laid to enhance the facial esthetics. Upright maxillary incisors are more preferable than the protruded ones. During the retraction of incisors there is a risk of contact with nasopalatine canal leading to apical root resorption which warrants the evaluation of the relationship between nasopalatine canal and maxillary central incisor root.

Objective: To evaluate the distance between maxillary central incisor and nasopalatine canal on Cone beam computed tomography.

Materials and Method: This is a cross-sectional observational study on the samples aged above 18 years. The study was conducted on CBCT records of 46 patients as per the inclusion criteria. The distance between maxillary central incisor root and nasopalatine canal was measured on the CBCT files.

Result: The mean anteroposterior distance between the most medial portion of maxillary central incisor root and nasopalatine canal was 4.4±0.96 mm at the mid-level (L2) and 4.2±1.2 mm at the oral opening of nasopalatine canal (L3). The mean anteroposterior distance between the most posterior portion of maxillary incisor root and the most lateral portion of nasopalatine canal was 4.1±1.44 mm at L2 and 3.4±1.02 mm at L3. Student t-test showed no significant gender variation.

Conclusion: The anteroposterior distance between the maxillary central incisor root and nasopalatine canal ranged from 3.4 to 4.4 mm. Proper CBCT evaluation is required for orthodontic movement of maxillary incisors.

Keywords: Cone beam computed tomography; Maxillary central incisor; Nasopalatine canal.

INTRODUCTION

The key factors of motivation for adults seeking orthodontic treatment are dissatisfaction with the appearance, desire to align the teeth and to improve the smile.[1,2] Primarily, orthodontic treatment is based on improving the occlusal relationship, but more attention is laid towards enhancing the facial esthetics.[3] The labiolingual inclination of maxillary incisors has an important role in the facial esthetics. An upright maxillary incisor is more preferable than the protruded ones.[4] Therefore, orthodontic treatment mainly focuses on retraction of protruded incisors in order to meet the patient's esthetic need.

During the retraction of incisors there is always a risk of contact with hard tissue structures, such as the labial, palatal or nasopalatine canal cortical plates. This may lead to apical root resorption and root deviation from the alveolar housing of dentition leading to dehiscence and fenestration.[5] Ackerman et al. have formulated "envelope of discrepancy" which has given limits for orthodontic tooth movement, according to which the limit for orthodontic retraction of upper incisor is 7mm.[6,7]

The nasopalatine canal can act as a constraint for orthodontic tooth movement, mainly for retraction and intrusion of maxillary incisors. It is an anatomic structure present in the midline of the palatine process of maxilla, posterior to the roots of maxillary central incisors.[8] It consist of nasopalatine vessels and nerves, branches of maxillary division of the trigeminal nerve and the maxillary artery within a thick cortical bone.[9] Contact of root with nasopalatine canal during orthodontic tooth movement leads to root resorption and subsequently resulting in other unfavorable outcomes. Therefore, proper evaluation of the nasopalatine canal in relation to maxillary central incisor is one of the important requirements in orthodontic diagnosis and treatment planning.

Lateral and anteroposterior cephalograms are commonly used investigations in orthodontics.[10] Since all the anatomic structures cannot be properly evaluated using the two-dimensional radiographs, three-dimensional analysis

with cone-beam computed tomography (CBCT) is now popular. Likewise, precise evaluation of the nasopalatine canal and its surrounding structure is not possible with two-dimensional radiographs. This study aims to evaluate the distance between maxillary central incisor and nasopalatine canal using CBCT files.

MATERIALS AND METHOD

This is an observational cross-sectional study done using secondary data in the Department of Orthodontics, Kantipur Dental College and Hospital, Kathmandu. The study was conducted in July 2022 after obtaining the ethical clearance from the Institutional Review Committee (Ref no. 16/022). A total number of 46 adults (20 female and 24 male) were selected meeting the inclusion criteria set for the study, which are (1) good quality pretreatment CBCT images; (2) age group of above 18years; (3) presence of maxillary incisors and (4) angle between the long axis of the maxillary central incisors and the palatal plane(U1-PP) within normal range ($110.1 < U1\text{-}PP \leq 121.5^{o}$).[11]

CBCT reports from the Department of Oral Medicine and Radiology, were collected in a hard drive. Data information sheet was developed to gather the information from the samples. CBCT images were taken via Care Stream (CS) 9300, USA machine using standard protocol at 85 kV, 6.3 mA, 11.30 s, voxel size of 300 μm and 17x13 cm field of view at lowest possible radiation using 'as low as reasonably achievable' concept.

Measurements were made as described by Cho *et al*.[12] The selected Digital Imaging and Communication in Medicine (DICOM) file was opened in CS imaging suite software and orthogonal slicing was selected. Prior to measurements, the three planes, sagittal, horizontal, and coronal were defined in each image and reference lines were drawn on each plane (Figure 1,2 and 3).

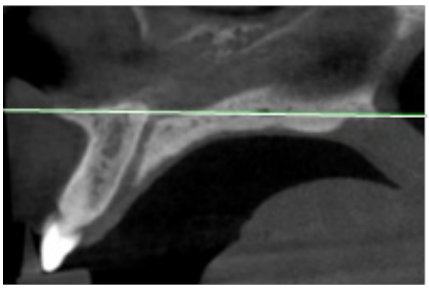

Figure 1: Palatal plane joining anterior nasal spine and posterior nasal spine in axial section

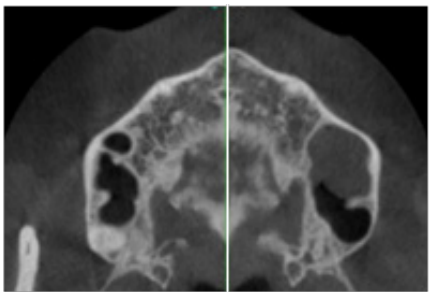

Figure 2: Line passing through the mid-palatal suture in sagittal section

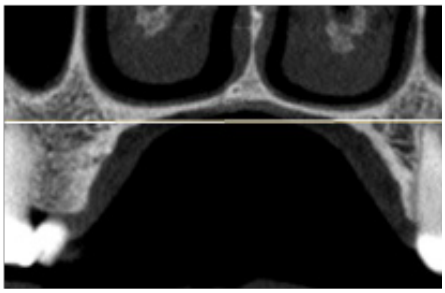

Figure 3: Line passing through the right and left greater palatine foramina in coronal section

Linear measurements were done in the axial section at three vertical levels (Figure 4,5): Root apex of maxillary central incisor (Level 1), mid root (Level 2) and oral opening of nasopalatine canal (Level 3).

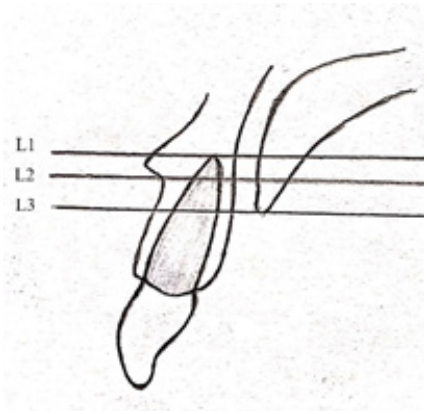

Figure 4: Schematic diagram of vertical levels

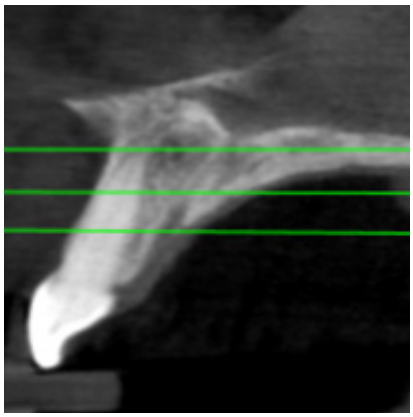

Figure 5: Vertical levels in CBCT

The linear measurements done in axial section are shown in Figure 6,7,8 and 9. Inter-root distance was measured as a distance from Rm to Rm (Rm - most medial portion of maxillary central incisor root) and Rp to Rp (Rp - most posterior portion of maxillary central incisor root). Canal width was measured as a distance from Cl to Cl (Cl - most lateral portion of nasopalatine canal). Antero-posterior distance was measured from Rm and Rp to the canal respectively.

Angular measurements were done in the sagittal section. The angle formed by palatal plane (AB) with the long axis of maxillary central incisor (BE) and long axis of nasopalatine canal (CF) were measured (Figure 10 and 11).

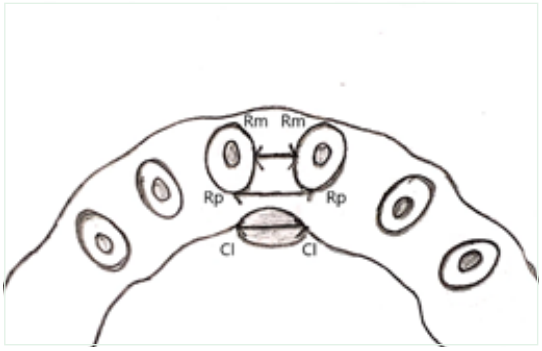

Figure 6: Schematic diagram of landmarks for transverse measurements

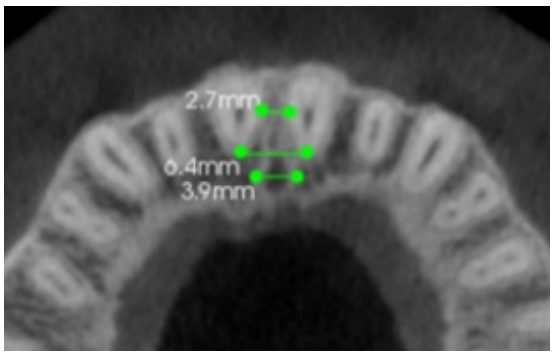

Figure 7: Transverse measurements in axial section of CBCT

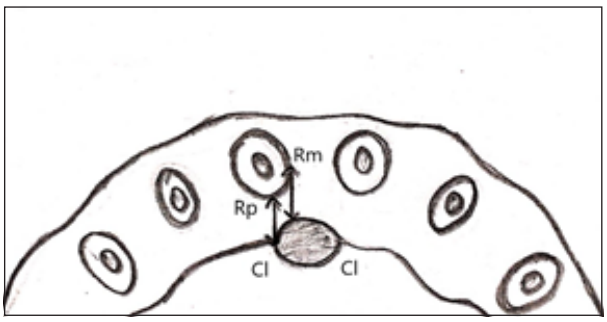

Figure 8: Schematic diagram of landmarks for anteroposterior measurements

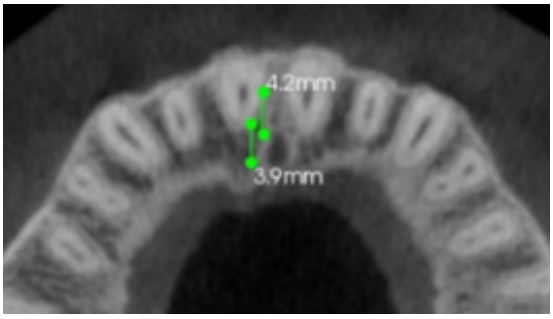

Figure 9: Antero-posterior measurements in axial section of CBCT

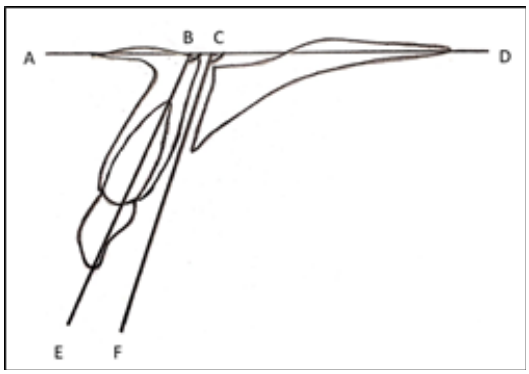

Figure 10: Schematic diagram of angular measurements

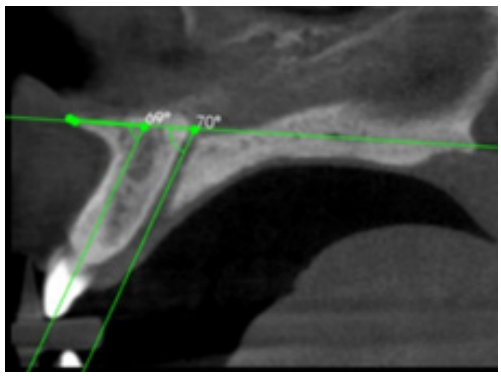

Figure 11: Angular measurements in sagittal section of CBCT

Data were collected and analyzed using SPSS V21.0. Descriptive statistics including mean and standard deviation were calculated for each parameter. Student's t-test was used to determine the gender variation. Pearson's correlation coefficient test was determined to evaluate the correlation between the angular parameters. The p-value <0.05 was considered statistically significant. Ten percentage of the sample size were re-evaluated after 4 weeks by the same investigator for intra-examiner reliability of the measurements.

RESULT

The sample comprised of CBCT reports of 46 subjects aged above 18 years. The descriptive statistics of canal width and inter-root distance of maxillary central incisors is presented in Table 1.

Table 1: Canal width and inter-root distance of maxillary central incisors

Vertical level			
Measurements	Root Apex (L1)	Mid-Level (L2)	Opening (L3)
	Mean ± SD	Mean ± SD	Mean ± SD
Canal width(mm)	4.7 ± 1.34	5.0 ± 1.20	5.1 ± 1.11
Rm-Rm	5.2 ± 1.56	4.7 ± 1.35	3.9 ± 1.26
Rp-Rp	7.2 ± 1.56	7.3 ± 1.51	7.1 ± 1.34

The width of the canal was found to be greatest at Level 3 and least at Level 1 (Figure 11).

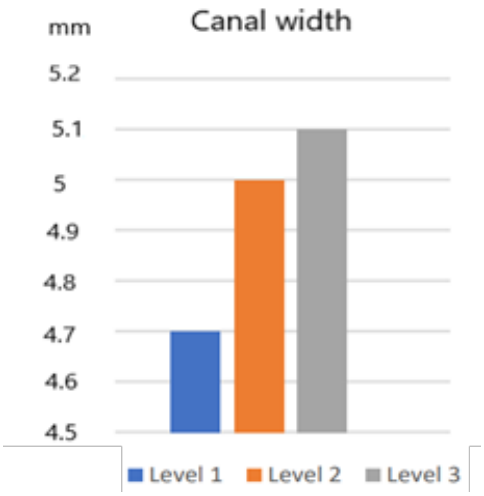

Fig No.12: Canal width at three levels

The descriptive statistics of antero-posterior distance of maxillary central incisor root and nasopalatine canal is presented in Table 2. Antero-posterior distance was not measurable at Level 1 because the root apex was farther away from the most lateral border of the incisive canal in all subjects. Student t-test showed no significant gender variation on antero-posterior measurements ($p>0.05$) as shown in Table 3.

Table 2: Antero-posterior distance of maxillary central incisor root and nasopalatine canal

Vertical level			
Measurements	Root Apex (L1)	Mid-Level (L2)	Opening (L3)
	Mean ± SD	Mean ± SD	Mean ± SD
Canal width(mm)	4.7 ± 1.34	5.0 ± 1.20	5.1 ± 1.11
Rm-Canal	N/A	4.4 ± 0.96	4.2 ± 1.2
Canal-Rp	N/A	4.1 ± 1.44	3.4 ± 1.02

Table 3: Comparison of antero-posterior distance of maxillary central incisor root and nasopalatine canal between male and female

Vertical level						
Measurements		Mid-Level (L2)			Oral opening of nasopalatine canal (L3)		
		Mean ± SD	t-value	p-value	Mean ± SD	t-value	p-value
Rm-Canal	Male	4.4 ± 0.96	1.37	0.89	4.4 ± 1.17	0.69	0.49
	Female	4.4 ±1.00			4.1 ± 1.10		
Canal-Rp	Male	4.0 ± 1.07	-0.47	0.64	3.4 ± 1.00	0.34	0.73
	Female	4.2 ± 1.76			3.3 ± 1.08		

The percentage of subjects with nasopalatine canal width greater than the inter-root distance (Rm-Rm) was 71.73% and 78.26% at Level 2 and 3 respectively (Figure 12 and 13). At Level 1 nasopalatine canal width was smaller than the inter-root distance. Similarly, nasopalatine canal width was smaller than inter-root distance (Rp-Rp) in all subjects at all vertical levels (Table 2).

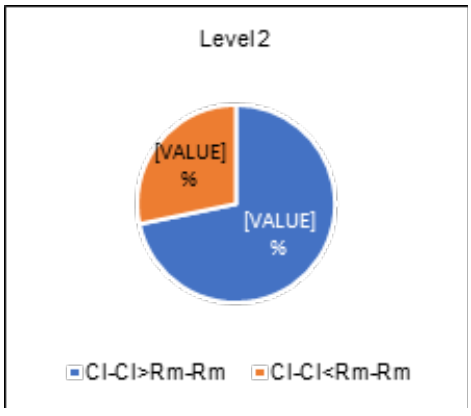

Figure 13: 28.27% and 71.73% of subjects with nasopalatine canal width greater than inter-root distance of the maxillary central incisors at Level 2

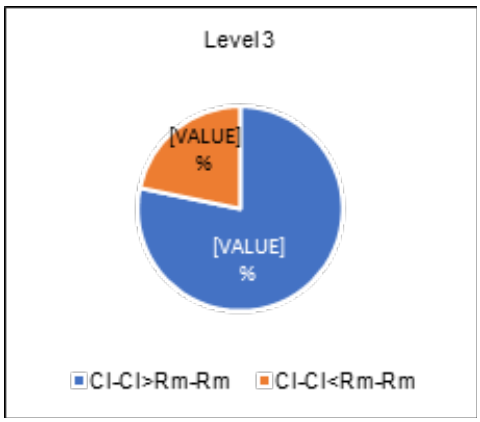

Figure 14: 21.74% and 78.26% of subjects with nasopalatine canal width greater than inter-root distance of the maxillary central incisors at Level 3

Pearson correlation coefficient showed moderate positive correlation ($r=0.62$) between angle formed by palatal plane with the long axis of maxillary central incisor and nasopalatine canal (Figure 14).

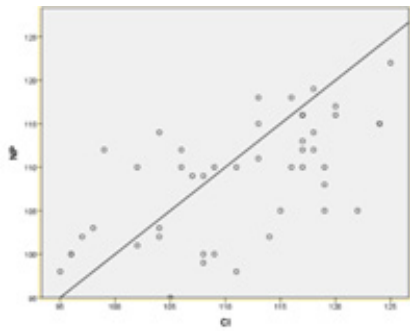

Figure 15: Pearson correlation coefficient between the angle formed by palatal plane with the long axis of maxillary central incisor and nasopalatine canal

DISCUSSION

The present study included samples with mixed growth patterns, as Costa *et al.*[22] reported little influence of growth pattern on the anteroposterior distance between maxillary central incisors and nasopalatine canal. Extraction of premolars followed by the retraction of anterior segment is a usual treatment modality in cases of convex facial profile with protrusive anterior teeth. The contact of maxillary central incisor root to the nasopalatine canal can cause root resorption.[13-17] It can also result in delayed tooth movement, with possible perforation and dehiscence.[15,18-20]

According to the 'envelope of discrepancy', the maximum amount of maxillary anterior retraction possible is 7 mm.[5] Moreover, the use of skeletal anchorage has broadened the limit of orthodontic tooth movement.[6] Contact of maxillary central incisor root to nasopalatine canal was fairly high after maximum anterior retraction.[21] The anteroposterior distance ranged from 3.4 to 4.4 mm in the present study, 5 to 6 mm in the study by Cho *et al.*[12] and Gull *et al.*[14] and 4.7 to 6 mm in the study by Al-Rokhami *et al.*[24] The differences in the measurements could be due to the variations in the craniometric measurements among different ethnic groups.[25]

The nasopalatine canal width increased from the level of root apex to the oral opening which is in concordance with the study by Cho *et al.*[12] and Khurana *et al.*[26] There was a positive correlation between the angle formed by palatal palate with long axis of maxillary central incisor and nasopalatine canal, which is similar to the study by Matsumara *et al.*[27] There was no gender variation in the anteroposterior distance which was in agreement to the study by Costa *et al.*[22]

Despite the measured anteroposterior distance, the risk of root contact is present only if the width of the nasopalatine canal is greater than the inter-root distance.[22] The present study showed more than 70% of the samples had canal width greater than the inter-root distance, indicating that about 3/4th of the cases might pose such a risk. Similarly, Cho *et al*. reported the frequency to be 60%.[13] Based on the anteroposterior measurements, the possibility of contact to the canal by the mesio-palatal aspect of the root (Level 2 and 3) is greater than by the root apex (Level 1) during orthodontic retraction. Therefore, three-dimensional image plays a pivotal role in determining the amount of maxillary incisor retraction.

CONCLUSION

The anteroposterior distance between maxillary central incisor root and nasopalatine canal ranged from 3.4 to 4.4 mm. More than 70% of the samples possessed greater width of the nasopalatine canal than the inter-root distance, indicating that a greater number of patients have contact of root with nasopalatine canal during incisor retraction. Envelope of discrepancy should be taken as a guideline for the determination of the amount of upper incisors retraction with proper CBCT evaluation for the precise orthodontic diagnosis and treatment planning.

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