International Clinical and Medical Case Reports Journal
Research Article (ISSN: 2832-5788)

Evaluation of the Configurational Interactions between the Maxillary Incisors and the Incisive Canal in the Front Region of the Maxillary Alveolar Bone in Patients Undergoing Orthodontic Treatment Using CBCT

Bibek Kumar Mandal*, Ali Asger Nakib

Department of Dentistry Bankura Sammilani Medical College and Hospital, Bankura, West Bengal, India

Citation: *Bibek Kumar Mandal, Ali Asger Nakib. Evaluation of the Configurational Interactions between the Maxillary Incisors and the Incisive Canal in the Front Region of the Maxillary Alveolar Bone in Patients Undergoing Orthodontic Treatment Using CBCT. Int Clinc Med Case Rep Jour. 2022;1(3):1-7.*

Received Date: 18 June, 2022**; Accepted Date:** 23 June, 2022**; Published Date:** 25 June, 2022

***Corresponding author:** Bibek Kumar Mandal. Department of Dentistry Bankura Sammilani Medical College and Hospital, Bankura, West Bengal, India

ABSTRACT

Aim: The purpose of this study was to use cone beam computed tomography (CBCT) scans to examine the configurational interactions between the maxillary incisors and the incisive canal in the front region of the maxillary alveolar bone in patients undergoing orthodontic treatment.

Methods and materials: 186 patients who required CBCT for diagnosis and treatment planning among those between the ages of 18 and 39 who sought orthodontic treatment were chosen. The maxillary and mandibular dentoalveolar regions of each patient were imaged using CBCT technology as part of the pre-treatment examination. L stands for the incisive canal's length, while $\theta 1$, $\theta 2$, and $\theta 3$ represent the angles formed, respectively, by the palatal plane and the axis of the maxillary alveolar border, the incisive canal, and the left central incisor of the maxilla.

Results: The mean values of $\theta 1$ in male was 109.5 ± 7.8 degrees while it was 109.4 ± 7.9 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.22). The mean values of $\theta 2$ in male was 106.6 ± 9.7 degrees while it was 110.7 ± 8.1 degrees in females. The difference in findings between male and female was statistically significant (p=0.01). The mean values of $\theta 3$ in male was 113.2 ± 8.8 degrees while it was 113.3 ± 11.4 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.10). The mean values of D in male was 5.6 ± 2.3 mm while it was 5.1 ± 1.5 mm in females.

Conclusion: Anatomical variations in the maxillary alveolar bone's anterior region have produced morphometric data that may be helpful for orthodontic treatment planning in patients who need to significantly correct their maxillary incisal inclination or root position, or in patients who need to have implants placed in the anterior region.

Keywords: Incisive foramen; Nasopalatine canal; CBCT, Orthodontic treatment

INTRODUCTION

Patients undergoing orthodontic treatment frequently need to improve their facial aesthetics. The maxillary incisor's spatial position is important for both facial aesthetics and maxillofacial function. Therefore, when setting goals for orthodontic treatment, three-dimensional (3D) location and inclination of the maxillary incisor is considered to be a dominant component.[1-2] The notion of "envelope of discrepancy" was introduced by Ackerman et al. in relation to maxillary incisor movement, and it explains the restrictions on the orthodontic movement range of the maxillary incisor.[3-7] One of the iatrogenic side effects of orthodontic therapy is the possibility of apical root resorption in the maxillary incisor when it comes in contact with hard tissue structures like the labial, palatal, or incisive canal cortical plates.[8-10]

Additionally, excessive tooth movement during orthodontic therapy might cause the dentition's roots to deviate from the alveolar housing, which can result in dehiscence and fenestration. In order to prevent these potential difficulties, it has been suggested to restrict the mobility of the maxillary incisors in conjunction with cephalometric examination.[11-13] In orthodontics, lateral and anteroposterior cephalometric measurements have typically been analysed in two dimensions (2D) for diagnostic and treatment planning. However, traditional cephalometric radiographs cannot provide a precise assessment of the incisive canal and cortical plate on the sagittal plane of maxillary incisors.[14]

More thorough information could be obtained thanks to recent advancements in 3D analysis of dental cone-beam computed tomography (CBCT) images. Setting goals for orthodontic treatment may require taking into account the morphologies of the maxillary incisor roots, the incisive canal, and the maxillary alveolar bone, according to several studies utilising dental CBCT.[15] Although earlier CT and CBCT investigations elucidated the anatomical links between the maxillary incisors and the incisive canal, they lacked sufficient imaging resolution to accurately assess the form and thickness of the alveolar bone.[16] The purpose of this study was to use cone beam computed tomography (CBCT) scans to examine the configurational interactions between the maxillary incisors and the incisive canal in the front region of the maxillary alveolar bone.

METHODS

Subjects

Only those patients who required CBCT for diagnosis and treatment planning among those between the ages of 18 and 39 who sought orthodontic treatment were chosen. All subjects were given their written consent after being informed of the purpose and objectives of the study. The exclusion criteria included a history of orthodontic treatment, missing or extra teeth, midline deviation of the maxillary incisors greater than 2 millimetres from the midline of the face, maxillary incisor prosthodontic treatment, obvious nasopalatine pathology (such as nasopalatine duct cysts), history of trauma to the maxillary incisors, and congenital anomalies (e.g., cleft lip and palate). 186 subjects (male, 62; female, 124; mean age, 25.4 5.7 years) were ultimately chosen based on the inclusion and exclusion criteria. Their mean ANB was 3.2 3.6 (range: 4.7–9.1) and their skeletal pattern was Class I, Class II, and Class III.

CBCT

The maxillary and mandibular dentoalveolar regions of each patient were imaged using CBCT technology as part of the pre-treatment examination using the following settings: normal mode (16.8 s, 4.10 mGy, 90 kV, and 4 mA); slice thickness, 0.147 mm; field of view (FOV), 81 74 mm; and voxel size, 0.146 mm. The head was positioned along the Frankfort horizontal plane, which runs parallel to the ground, for the acquisition of all photographs. Sagittal and horizontal views of images that were saved as digital imaging and communication in medicine (DICOM) files were retrieved and assessed using image analysis software (ImageJ version 1.48; USA). Sagittal, horizontal, and coronal planes were determined in each image prior to measurement, and the three dimensions were calibrated. Following are definitions for linear and angular measurements in the midsagittal plane:

Platal plane

L stands for the incisive canal's length, while θ1, θ2, and θ3 represent the angles formed, respectively, by the palatal plane and the axis of the maxillary alveolar border, the incisive canal, and the left central incisor of the maxilla.

The distance from the maxillary incisors to the incisive canal (D) and the cross-sectional area of the incisive canal (CSA) were measured at each level. The measurements were carried out in the horizontal plane at three vertical tiers: n, r, and o (levels of the nasal opening of the incisive canal, root apex of the maxillary incisor, and oral opening of the incisive canal, respectively. One examiner handled all of the measurements, and they were all redone after two months.

Statistical analysis

SPSS 22.0 was the computer programme used for all statistical analysis (IBM, Armonk, NY, USA). For all measures, mean values and standard deviations (SDs) were computed. The two-sample t test was used to compare variables between male and female patients. The Pearson's correlation analysis and Bonferroni correction for multiple comparisons were used to investigate correlations between parameters. P 0.05 was chosen as the significance level for each analysis..

RESULTS

In this study male participants were 62 and female participants were 62. The mean values of L in male was 14.9 ± 2.3 mm while it was 13.3 ± 3.4 mm in females. The difference in findings between male and female was statistically significant (p=0.001). The mean values of θ1 in male was 109.5 ± 7.8 degrees while it was 109.4 ± 7.9 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.22). The mean values of θ2 in male was 106.6 ± 9.7 degrees while it was 110.7 ± 8.1 degrees in females. The difference in findings between male and female was statistically significant (p=0.01). The mean values of θ3 in male was 113.2 ± 8.8 degrees while it was 113.3 ± 11.4 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.10). The mean values of D in male was 5.6 ± 2.3 mm while it was 5.1 ± 1.5 mm in females. The difference in findings between male and female was statistically non-significant (p=0.33). The mean values of CSA in male was 75.3 ± 10.4 mm^2 while it was 75.3 ± 10.4 mm^2 in females. The difference in findings between male and female was statistically non-significant ($p=0.89$). (Table 1)

The correlation between θ1 and θ2 was statistically significant ($r=0.8290$, $p<0.01$). The correlation between θ2 and θ3 was statistically significant ($r=0.599$, $p<0.01$). The correlation between θ3 and θ1 was statistically significant ($r=0.739$, $p<0.01$). (Table 2)

Table 1: Values of different parameters of linear measurements, angular measurements and area measurements in males and females

Parameters	L (mm)	θ1 (degrees)	θ2 (degrees)	θ3 (degrees)	D (mm)	CSA ($mm^{2)}$
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Male (n = 62)	14.9 ± 2.3	109.5 ± 7.8	106.6 ± 9.7	113.2 ± 8.8	5.6 ± 2.3	75.3 ± 10.4
Female (n = 124)	13.3 ± 3.4	109.4 ± 7.9	110.7 ± 8.1	113.3 ± 11.4	5.1 ± 1.5	76.1 ± 15.8
p	0.001	0.22	0.01	0.1	0.33	0.89
Gender comparison	Significant	NS	Significant	NS	NS	NS

Table 2: Analyzing precise measurements of angles θ1, θ2, and θ3 statistically

Comparisons	θ1 vs θ2	θ2 vs θ3	θ3 vs θ1
Correlation coefficient	0.829	0.599	0.739
p	<0.01	<0.01	<0.01

DISCUSSION

The nasopalatine vessels and nerves, branches of the trigeminal nerve, and the maxillary artery are all contained within the incisive canal, an anatomical structure that runs parallel and posterior to the maxillary incisors on the midsagittal plane of the maxillary bone.[17-18] The canal is also surrounded by a substantial amount of cortical bone. The likelihood of sensory impairment in the front region and failure of osseointegration has been observed in cases of contact of the incisive canal by surgical treatments such as dental implant implantation because of its proximity to maxillary incisors.[19-20] According to a recent study by [21], the degree of root resorption following significant incisal retraction may depend on how close the maxillary incisal roots are to the incisive canal. Therefore, it is crucial to check the precise placement of the maxillary incisors and the incisive canal when planning orthodontic treatment, as well as to ascertain the morphology of the alveolar bone. There is no published information on the imaging of anatomical structures in the maxillary anterior region by CBCT with a constrained FOV.[22] In the current investigation, CBCT images obtained with a constrained FOV were used to assess the morphologies of and positional relationships between the incisive canal and maxillary incisors.

According to our knowledge, this is the first study to use CBCT images to examine the anatomical features of the maxillary incisors, the incisive canal, and the maxillary alveolar boundary in a large population.

The length of the incisive canal in male patients in the present study was substantially longer than that in female patients, which is consistent with the findings of a prior study [18]. Second, there was a strong correlation between the inclination of the maxillary incisors and the angles of the incisive canal and the maxillary alveolar boundary. The CSA of the incisive canal at the level of the maxillary incisor root apex was significantly higher compared to those at the levels of oral and nasal openings, and the maxillary incisors were situated closer to the incisive canal at the level of the root apex than at the level of the oral opening of the incisive canal.

In this study male participants were 62 and female participants were 62. The mean values of L in male was 14.9 ± 2.3 mm while it was 13.3 ± 3.4 mm in females. The difference in findings between male and female was statistically significant (p=0.001). The mean values of θ1 in male was 109.5 ± 7.8 degrees while it was 109.4 ± 7.9 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.22). The mean values of θ2 in male was 106.6 ± 9.7 degrees while it was 110.7 ± 8.1 degrees in females. The difference in findings between male and female was statistically significant (p=0.01). The mean values of θ3 in male was 113.2 ± 8.8 degrees while it was 113.3 ± 11.4 degrees in females. The difference in findings between male and female was statistically non-significant (p=0.10). The mean values of D in male was 5.6 ± 2.3 mm while it was 5.1 ± 1.5 mm in females. The difference in findings between male and female was statistically non-significant (p=0.33). The mean values of CSA in male was 75.3 ± 10.4 mm^2 while it was 75.3 ± 10.4 mm^2 in females. The difference in findings between male and female was statistically non-significant (p=0.89).
The correlation between θ1 and θ2 was statistically significant (r=0.8290, p<0.01). The correlation between θ2 and θ3 was statistically significant (r=0.599, p<0.01). The correlation between θ3 and θ1 was statistically significant (r=0.739, p<0.01).

Only a little amount of information about the 3D maxillofacial features may be obtained from 2D analysis in order to determine the degree of maxillary incisor movement. The maxillary incisor area has frequently been the subject of reports of apical root resorption. Due to the roots' proximity to or contact with the labial, palatal, or incisive canal cortical plates, it has been observed that unanticipated apical root resorption in maxillary incisors following anterior retraction often happens.[23] Numerous orthodontic treatments have so far been carried out effectively in clinical settings using only traditional cephalometric analysis. However, more modern temporary anchorage systems, like as miniscrew implants, have broadened the scope of orthodontic therapy and allowed for significant maxillary incisor mobility.[24] Anatomical aspects of the maxillofacial region should be thoroughly investigated in each patient in order to diagnose post-orthodontic treatment issues such root resorption, gingival recession, dehiscence, and fenestration following root deviation from the alveolar bone housing.[25] According to the current research, FOV-limited CBCT is a suitable modality for maxillary protrusion orthodontic diagnosis.
Anatomical variations in the maxillary alveolar bone's anterior region have produced morphometric data that may be helpful for orthodontic treatment planning in patients who need to significantly correct their maxillary incisal inclination or root position, or in patients who need to have implants placed in the anterior region.

Salient Visionary Publications

REFRENCES

1. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofac Orthop. 2001;120:98–111.
2. Turley PK. Evolution of esthetic considerations in orthodontics. Am J Orthod Dentofac Orthop. 2015;148:374–379.
3. Sarver DM. Interactions of hard tissues, soft tissues, and growth over time, and their impact on orthodontic diagnosis and treatment planning. Am J Orthod Dentofac Orthop. 2015;148:380–386.
4. Shuying Y, Yunfei G, Xianrui Y, Feng Z, Jian W, Jingyi Q, et al. Effect of mesiodistal angulation of the maxillary central incisors on esthetic perceptions of the smile in the frontal view. Am J Orthod Dentofac Orthop. 2015;148:396–404.
5. Spear FM, Kokich VG, Mathews DP. Interdisciplinary management of anterior dental esthetics. J Am Dent Assoc. 2006;137:160–169.
6. Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res. 1999;2:49–52.
7. Graber LW, Vanarsdall RL, Jr, Vig KW. Orthodontics: current principles and techniques. 5. Philadelphia: Elsevier; 2011. pp. 15–17.
8. Tian YL, Liu F, Sun HJ, Lv P, Cao YM, Yu M, et al. Alveolar bone thickness around maxillary central incisors of different inclination assessed with cone-beam computed tomography. Korean J Orthod. 2015;45:245–252.
9. Handelman CS. The anterior alveolus: its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. Angle Orthod. 1996;66:95–109.
10. Weltman B, Vig KW, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: a systematic review. Am J Orthod Dentofac Orthop. 2010;137:462–476.
11. Enhos S, Uysal T, Yagci A, Veli İ, Ucar FI, Ozer T. Dehiscence and fenestration in patients with different vertical growth patterns assessed with cone-beam computed tomography. Angle Orthod. 2012;82:868–874.
12. Ackerman JL, Proffit WR. Soft tissue limitations in orthodontics: treatment planning guidelines. Angle Orthod. 1997;67:327–336.
13. Melsen B. Biological reaction of alveolar bone to orthodontic tooth movement. Angle Orthod. 1999;69:151–158.
14. Kapila SD, Nervina JM. CBCT in orthodontics: assessment of treatment outcomes and indications for its use. Dentomaxillofac Radiol. 2015;44:20140282.
15. Horiuchi A, Hotokezaka H, Kobayashi K. Correlation between cortical plate proximity and apical root resorption. Am J Orthod Dentofac Orthop. 1998;114:311–318.
16. Cho EA, Kim SJ, Choi YJ, Kim KH, Chung CJ. Morphologic evaluation of the incisive canal and its proximity to the maxillary central incisors using computed tomography images. Angle Orthod. 2016;86:571–576.

17. Springate SD. The effect of sample size and bias on the reliability of estimates of error: a comparative study of Dahlberg's formula. Eur J Orthod. 2012;34:158–163.
18. Güncü GN, Yıldırım YD, Yılmaz HG, Galindo-Moreno P, Velasco-Torres M, Al-Hezaimi K, et al. Is there a gender difference in anatomic features of incisive canal and maxillary environmental bone? Clin Oral Implants Res. 2013;24:1023–1026.
19. Da Silveira PF, Fontana MP, Oliveira HW, Vizzotto MB, Montagner F, Silveira HL, et al. CBCT-based volume of simulated root resorption—influence of FOV and voxel size. Int Endod J. 2015;48:959–965.
20. Ballrick JW, Palomo JM, Ruch E, Amberman BD, Hans MG. Image distortion and spatial resolution of a commercially available cone-beam computed tomography machine. Am J Orthod Dentofac Orthop. 2008;134:573–582.
21. Chung CJ, Choi YJ, Kim KH. Approximation and contact of the maxillary central incisor roots with the incisive canal after maximum retraction with temporary anchorage devices: Report of 2 patients. Am J Orthod Dentofac Orthop. 2015;148:493–502.
22. Liang X, Jacobs R, Martens W, Hu Y, Adriaensens P, Quirynen M, et al. Macro- and micro-anatomical, histological and computed tomography scan characterization of the nasopalatine canal. J Clin Periodontol. 2009;36:598–603.
23. Song WC, Jo DI, Lee JY, Kim JN, Hur MS, Hu KS, et al. Microanatomy of the incisive canal using three-dimensional reconstruction of microCT images: an ex vivo study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108:583–590.
24. Artzi Z, Nemcovsky CE, Bitlitum I, Segal P. Displacement of the incisive foramen in conjunction with implant placement in the anterior maxilla without jeopardizing vitality of nasopalatine nerve and vessels: a novel surgical approach. Clin Oral Implants Res. 2000;11:505–510.
25. Kan JY, Rungcharassaeng K, Roe P, Mesquida J, Chatriyamuyoke P, Caruso JM. Maxillary central incisor-incisive canal relationship: a cone beam computed tomography study. Am J Esthet Dent. 2012;2:180–187.