Maxillary Central Incisor–Incisive Canal Relationship: A Cone Beam Computed Tomography Study

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The purpose of this study was to determine the maxillary central incisor–incisive canal (CI-IC) relationship by comparing the visibility of the incisive canal on the two-dimensional sagittal images of the central incisors acquired from two cone beam computed tomography (CBCT) reconstruction modalities. A retrospective review of CBCT images from 60 patients (30 men and 30 women) with a mean age of 57.9 years (range: 19 to 83 years) was conducted. The CBCT images were evaluated using the manufacturer's recommended method (MRM) and a modified method (MM). The CI-IC relationship was classified as invisible, partially visible, or completely visible. The frequency distribution of the CI-IC relationships of the 60 samples indicated that the visibility of the incisive canal is significantly greater at all locations when using the MRM compared to the MM and on the right central incisor versus the left central incisor. Evaluation of the CI-IC relationship using the proposed method may allow the clinician to better determine whether additional surgical procedures are necessary when planning immediate implant placement and provisionalization at the maxillary central incisor positions. *(Am J Esthet Dent 2012;2:180–187.)*

The success of immediate implant placement and provisionalization is greatly dependent on the initial implant stability.[1,2] Initial stability for immediate implant placement in the anterior maxilla requires the implant to engage 4 to 5 mm of bone apical to the root tip socket and palatal bone.[3,4] However, when a failing maxillary central incisor is to be replaced, the proximity of the incisive canal can become a limiting factor[5,6] that precludes immediate implant placement. Therefore, it is imperative that the central incisor–incisive canal (CI-IC) relationship is accurately identified during diagnosis and treatment planning.

Due to its accuracy[7–11] and relatively low effective dose of ionizing radiation,[12] the use of cone beam computed tomography (CBCT) during treatment planning for implant placement has increased. Because the diagnostic features of CBCT can be customized, it is important that the data are properly reconstructed to provide an accurate diagnosis.

The purpose of this study was to determine the CI-IC relationship by comparing the visibility of the incisive canal on two-dimensional (2D) sagittal images of the central incisors acquired from two CBCT reconstruction modalities. The clinical implications are also discussed.

MATERIALS AND METHODS

Patient selection

This retrospective study was approved by the Institutional Review Board of Loma Linda University and was conducted at the Center for Prosthodontics and Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, California. Treatment records and CBCT images of patients who received treatment from May 2006 to November 2009 were reviewed. To be included in this study, the patients must *(1)* be at least 18 years of age, *(2)* have both central incisors, *(3)* have stable posterior occlusal support, and *(4)* show no clinical or radiographic evidence of alterations to the anterior maxilla (surgical alteration and/or trauma).

Data reconstruction and image acquisition

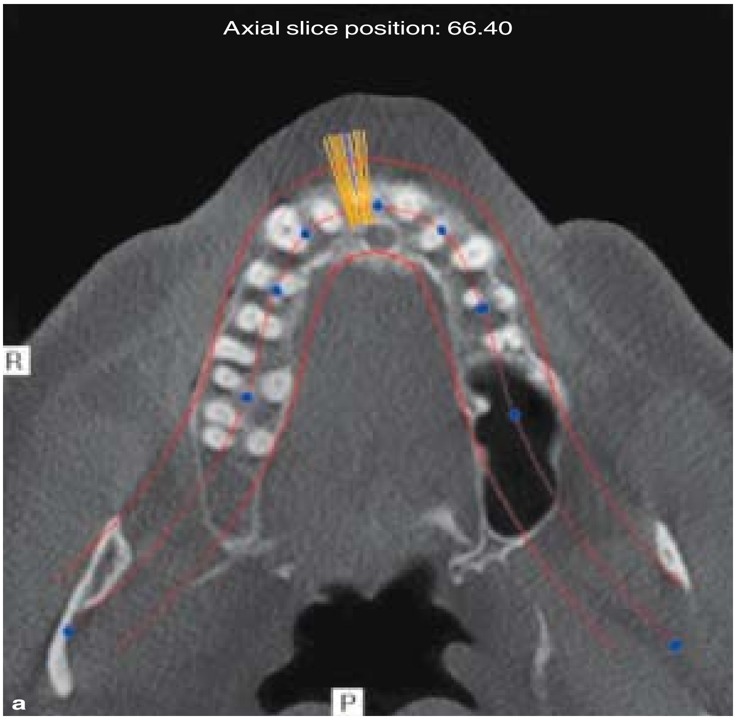
All CBCT scans were performed using the i-CAT system (Classic i-CAT, Imaging Sciences International). Following the primary reconstruction, the volumetric data were opened using the 2D orthogonal multiplanar reformatting viewer for the secondary reconstruction. The image was rotated so that the palatal plane (the line joining the anterior and posterior nasal spines) was parallel to the horizontal and vertical reference lines in the sagittal and axial views, respectively. In the coronal view, the image was rotated so that the vertical line bisecting the facial structures was perpendicular to the horizontal reference line. The data were exported as a DICOM (Digital Imaging and Communications in Medicine) file and opened using a proprietary software viewer (i-CAT Vision, Imaging Sciences International).

In the axial view, an open polygon was created using 11 mapping points. From this radiographic mapping, a panoramic view and a series of 2D cross-sectional images were created along the open polygon. The reconstructed 2D cross-sectional (sagittal) images of the maxillary central incisors were used to evaluate the CI-IC relationship. In this study, two reconstruction modalities were used:

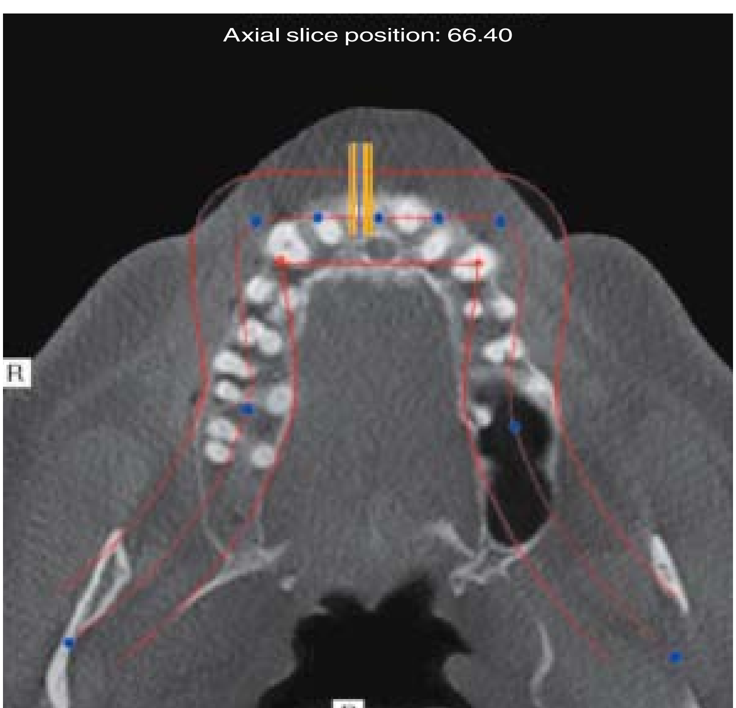
1. Manufacturer's recommended method (MRM): Nine mapping points were evenly distributed on the alveolar housings or, in their absence, on the residual ridge, following its contour in a curvilinear fashion (Figs 1a and 1b).
2. Modified method (MM): Five anterior mapping points were adjusted to create a line tangential to the anterior maxillary arch form at the midline and parallel to the facial surface of the central incisors (Figs 2a and 2b).

Data collection

The visibility of the incisive canal on nine reconstructed 2D sagittal images of each maxillary central incisor (middle of the tooth [Mid] and 0.8, 1.6, and 2.4 mm mesial [M] and distal [D] to Mid) using both CBCT modalities were recorded and compared. The visibility of the incisive canal was classified as invisible, partially visible, or completely visible. Descriptive statistics were used to analyze the data.



Figs 1a and 1b *(a)* Axial view with the open polygon tool bisecting the alveolar process; *(b)* sagittal view of the failing tooth using the MRM.



Figs 2a and 2b *(a)* Axial view with the open polygon tool parallel to the facial surface of the maxillary central incisors; *(b)* sagittal view of the failing tooth using the MM.

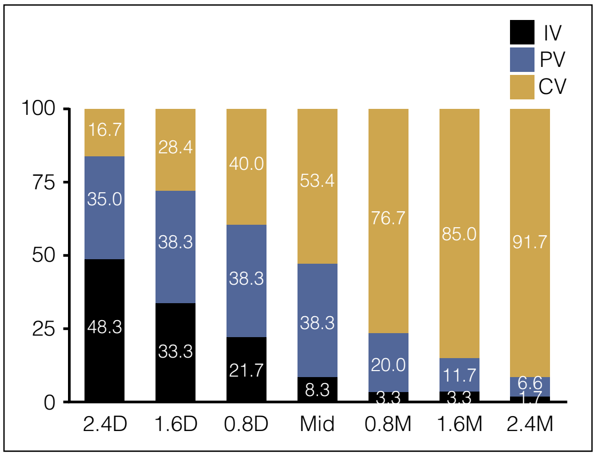


Fig 3 Percentage distribution of incisive canal visibility on the maxillary right central incisor sagittal images using the MRM. IV = invisible; PV = partially visible; CV = completely visible.

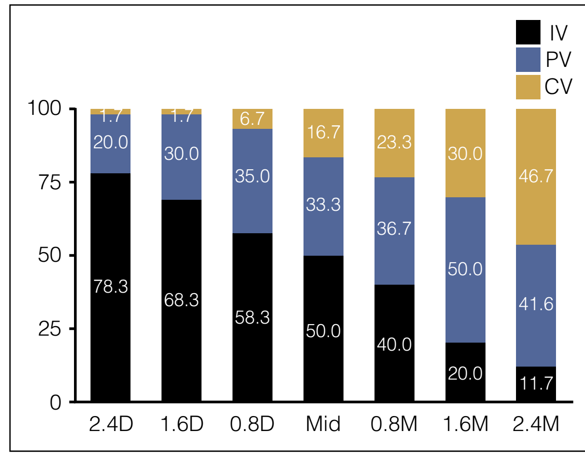


Fig 4 Percentage distribution of incisive canal visibility on the maxillary left central incisor sagittal images using the MRM. IV = invisible; PV = partially visible; CV = completely visible.

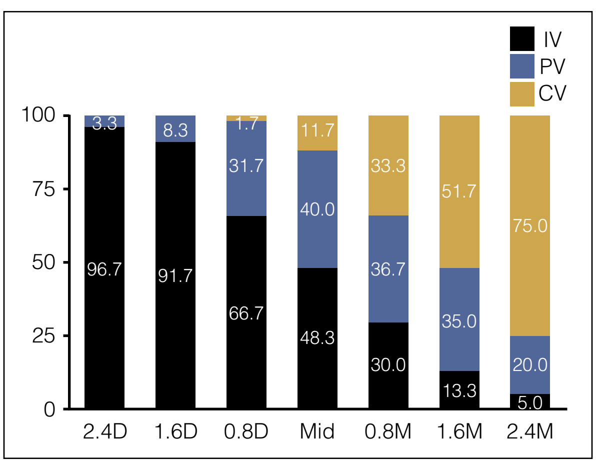


Fig 5 Percentage distribution of incisive canal visibility on the maxillary right central incisor sagittal images using the MM. IV = invisible; PV = partially visible; CV = completely visible.

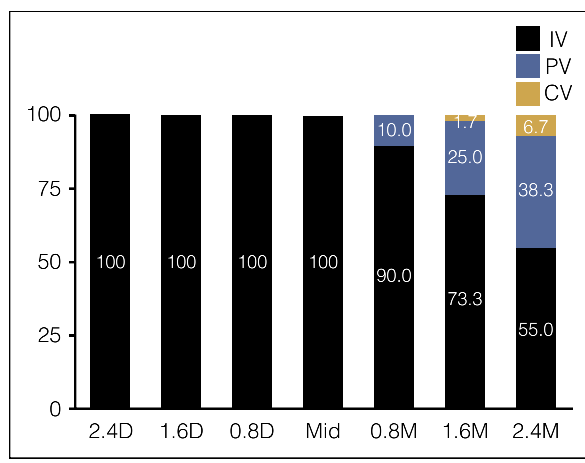


Fig 6 Percentage distribution of incisive canal visibility on the maxillary left central incisor sagittal images using the MM. IV = invisible; PV = partially visible; CV = completely visible.

RESULTS

A total of 60 patients (30 men and 30 women) with a mean age of 57.9 years (range: 19 to 83 years) were included in this study.

The percentage distributions of the visibility of the incisive canal on the sagittal images are presented in Figs 3 to 6. The visibility of the incisive canal was significantly greater at all locations (2.4 mm D to 2.4 mm M) when using the MRM (Figs 3 and 4) as opposed to the MM (Figs 5 and 6) and on the right central incisor (Figs 3 and 5) versus the left central incisor (Figs 4 and 6).

DISCUSSION

The position of the incisive canal can occasionally interfere with immediate implant placement and provisionalization due to its proximity to the root of the central incisor. Several authors have recommended grafting the incisive canal prior to or simultaneously with implant placement whenever encroachment to this anatomical structure is expected.[13–16] This requires an additional surgical procedure to remove the incisive canal contents, followed by placement of particulate graft material into the canal. Depending on the proximity of the incisive canal to the failing tooth or prospective osteotomy site, a two-stage implant placement approach may be required.[13–16] Overdiagnosis of the CI-IC relationship (ie, considering them to be in closer proximity than they actually are) would likely subject the patient to additional procedures (eg, removal of incisive canal contents and subsequent grafting) and preclude the possibility of immediate implant placement and provisionalization in a timely manner. On the other hand, underdiagnosis of the CI-IC relationship (ie, considering them to be farther apart than they actually are) may result in encroachment of the incisive canal during osteotomy preparation and/or implant placement. Therefore, it is essential that accurate diagnosis of the CI-IC relationship be made to avoid potential complications.

When using CBCT images for implant planning, the most commonly used views are the series of sagittal images since they are easy to produce and can be viewed collectively. In most circumstances, the sagittal images perpendicular to the alveolar process (MRM; Fig 1) are adequate in determining the implant position. However, because the implant position relies more on the incisal edge position and facial surface of the contralateral central incisor and less on the arch form, the CI-IC relationship visualized using the MRM may be inaccurate. In this situation, the MM, in which the open polygon is created tangentially to the anterior maxillary arch form at the midline and parallel to the facial surface of the central incisors (Fig 2) may be a more appropriate method of evaluating the CI-IC relationship for immediate implant placement.

In this study, the incidence of partial or complete visibility was evaluated at seven different points for each central incisor (2.4 mm D to 2.4 mm M; Figs 3 to 6). The overall partial and complete visibility of the incisive canal was significantly greater when using the MRM (82.9% and 53.3% for the right and left central incisors, respectively; Figs 3 and 4) than the MM (49.8% and 11.7% for the right and left central incisors, respectively; Figs 5 and 6). This is because the sagittal images perpendicular to the curved open polygon (MRM) converge palatally and therefore involve the incisive canal more frequently than those perpendicular to the straight open polygon (MM). This fact demonstrates that modifying the open polygon along which the sagittal images are acquired can alter the visualization of the CI-IC relationship and that using the MRM may result in an overdiagnosis of the CI-IC relationship.

While the visibility (or lack thereof) of the incisive canal on the CBCT

Figs 7a and 7b *(a)* Axial and *(b)* sagittal 3D surface-rendered images of the CI-IC relationship (Amira 5.2.2, Visage Imaging). Purple = CI; green = IC; yellow = periodontal radiolucency.

sagittal images provides the clinician with a quick overview of the CI-IC relationship, the quantitative CI-IC proximity should be verified via actual measurement when planning implant placement in questionable situations. Furthermore, since the sagittal images are only 2D, an adjunctive evaluation of the axial view series may also be necessary in these situations. The 3D surface-rendered images of the area of interest can be an invaluable diagnostic tool (Figs 7a and 7b). However, the cost and complexity of the software may prove prohibitive to most clinicians.

In this study, all CBCT raw data were reconstructed in a standardized way so that the image orientations were appropriate in all three planes: axial, coronal, and sagittal. This was intended to minimize potential errors or inconsistencies during image acquisition. Nonetheless, it is interesting that the incisive canal appeared to be consistently deviated toward the right central incisor (ie, greater incisive canal visibility) among the subjects in this study. Using anatomical, histologic, and computed tomography assessments, Liang et al[17] demonstrated that there were large anatomical variations associated with incisive canal dimensions and neurovascular content. The results of the present study, while unusually skewed in one direction, should not undermine the fact that variance among individual patients exists. The CI-IC relationship of an individual tooth and/or an individual patient should be evaluated as its own entity.

CONCLUSIONS

Cone beam computed tomography has become a commonly used diagnostic device for implant treatment planning in the anterior maxilla. Evaluation of the central incisor–incisive canal relationship using the proposed method may allow the clinician to better determine whether additional surgical procedures are necessary when planning for immediate implant placement and provisionalization at the maxillary central incisor positions.

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