# The Role of Objective Plane Angulation on the Mandibular Image Using Cross-Sectional Tomography

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KEY WORDS

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Cross-sectional jaw images in the buccolingual direction obtained by conventional or computerized tomography are used in the image diagnosis of dental implant treatment. This study was performed to clarify the subjective image quality of the mandibular depiction by shifting the angles of the tomographic objective plane. A panoramic machine with a linear tomographic function was used to obtain cross-sectional tomographic images on bilateral first molar regions of 10 dried human mandibles. The angles of tomographic objective planes were shifted horizontally within a range of ±20° at intervals of 5° from the tomographic objective plane, which was automatically determined. The image qualities of 4 anatomical structures—alveolar crest, buccal and lingual cortical bone, and mandibular canal—were subjectively scored on a 5-point scale method. As a result, the permitted tomographic objective angles were from –1.7° to 2.5°, a range of 4.2° for all 4 anatomical structures. When this result was compared with a previous geometric result, the permitted range of the angles was quite narrow. The tomographic objective angles should be manually set in accordance with an optimal tomographic plane for individual patients by using the positioning technique in linear tomography.

## INTRODUCTION

Cross-sectional jaw images in the buccolingual direction obtained by conventional or computerized tomography (CT) are used in the image diagnosis of dental implant treatment.[1–4] The measurement accuracy of the jaw images obtained by conventional tomography has been evaluated by using dried mandibles and cadavers; the mean differences between the actual and measured values of the mandible were relatively low and equivalent to the CT results.[2,5] In a previous study of conventional tomography, the effective doses were calculated as 0.04 mSv for Cronex Tomo radiography and 0.084 mSv for Scanora machine in mandibular molar regions.[6] However, in the standard scan using spiral CT, the effective dose was estimated to be 0.48 mSv in the mandible.[7] The radiation exposure of patients is relatively low in conventional

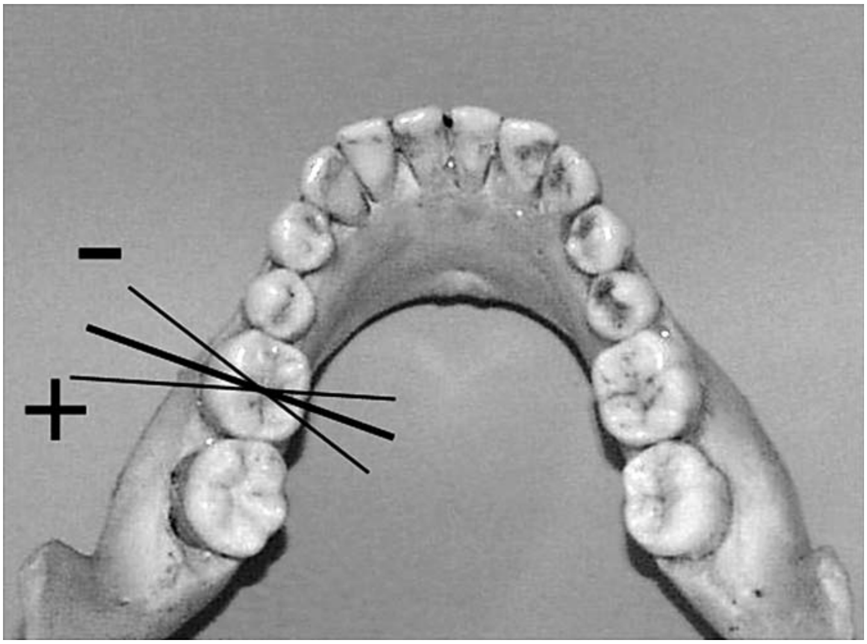



FIGURE 1. Tomographic objective plane. The bold line shows a tomographic objective plane set automatically by a machine.

tomography. At present, conventional cross-sectional tomography is recommended by the American Academy of Oral and Maxillofacial Radiology for most patients receiving implants.[8] Also, in the European Association for Osseointegration guidelines, conventional cross-sectional tomography is recommended for diagnostic imaging in a single tooth and partial and edentulous dentates except in multiple regions.[9]

In conventional tomography, it was reported that the mandibular shape changed when shifting angles of the tomographic objective plane.[10,11] The angle from the optimal plane, which permitted magnification within 0.5 mm in buccolingual width, showed a range of 21.9° in the first molar.[11] In the imaging diagnosis for dental implant treatment, it was important that the angles of the objective planes were adjusted for each position in individual patients. As for this objective, the positioning systems were developed with a panoramic X-ray machine with a tomographic function.[4,12]

Therefore, this study evaluated the image quality in terms of mandibular depiction by shifting the angles of the tomographic objective plane and the permitted ranges of the tomographic objective angle for imaging diagnosis in dental implant treatment.

## MATERIALS AND METHODS

### *Cross-sectional tomography with dried human mandibles*

A panoramic machine with a linear tomographic function (AZ3000DLP, Asahi Roentgen Ind. Co, Kyoto, Japan) was used to obtain cross-sectional tomographic images on bilateral first molar regions of 10 dried human mandibles. The occlusal plane of each mandible was set parallel to the floor base plane of the panoramic machine. The central fossa of the mandibular first molar was set as the center of the tomographic objective plane, and the angles of tomographic objective planes were shifted horizontally within a range of ±20° at intervals of 5° from the tomographic objective plane, which was automatically determined (Figure 1). Tomography was performed at an exposure of 65 kV and 6 mA with a 0.5-mm copper filter. Tomographic projection angles were set 40° and the nominal slice thickness was 1.1 mm. These linear tomographic images were processed and printed on film with a computerized radiography (CR) system (HQ9000, Fuji Medical, Tokyo, Japan) and a linear gradation and frequency processes (Figure 2). The magnification of the printed images was 1.34. The mandibular width between the surface of the buccal and lingual cortical bone in the center between the alveolar crest and inferior border of the mandible on each image was measured 5 times with a digital caliper (CD-S15, Mitsutoyo, Tokyo, Japan) and was averaged (Figure 3). Next, the optimal tomographic plane was defined as the plane representing the thinnest buccolingual width on each region (Figure 2).

### *Visual evaluation*

Three oral radiologists with 15 years of experience used a subjective rating score to independently evaluate the mandibular depiction of the tomographic images. The image qualities of the 4 anatomical structures—alveolar crest, buccal and lingual cortical bone, and mandibular canal—were scored on a 5-point scale to determine whether the image could be used for treatment (Figure 3). The 5-point scale was as follows: 0 = impossible, 1 = unlikely impossible, 2 = unsure, 3 = likely, 4 = possible. Next, the

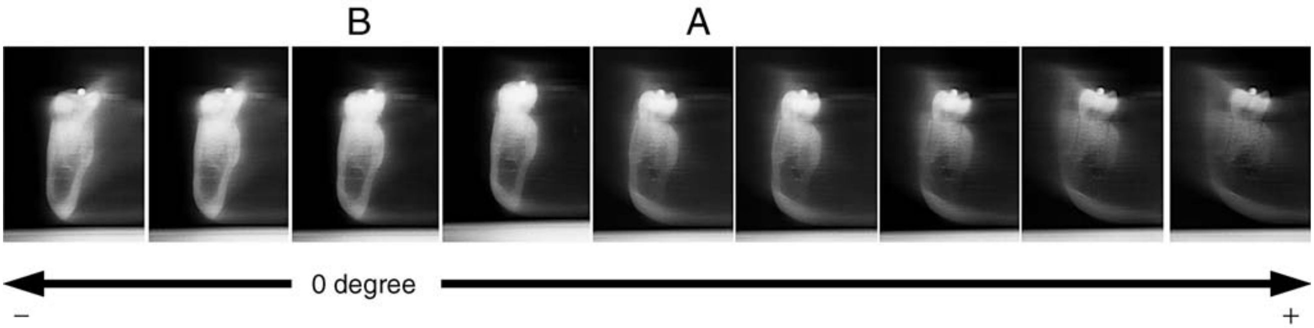



FIGURE 2. Cross-sectional tomographic images. Tomographic objective planes were shifted horizontally within a range of ±20 degrees at intervals of 5° from the tomographic objective plane, which was automatically determined. (A) Tomographic objective plane set automatically. (B) Optimal tomographic objective plane (0°).

average value in each angle of the tomographic objective plane was calculated, and the angles permitting a score of 3 or 4 were determined.

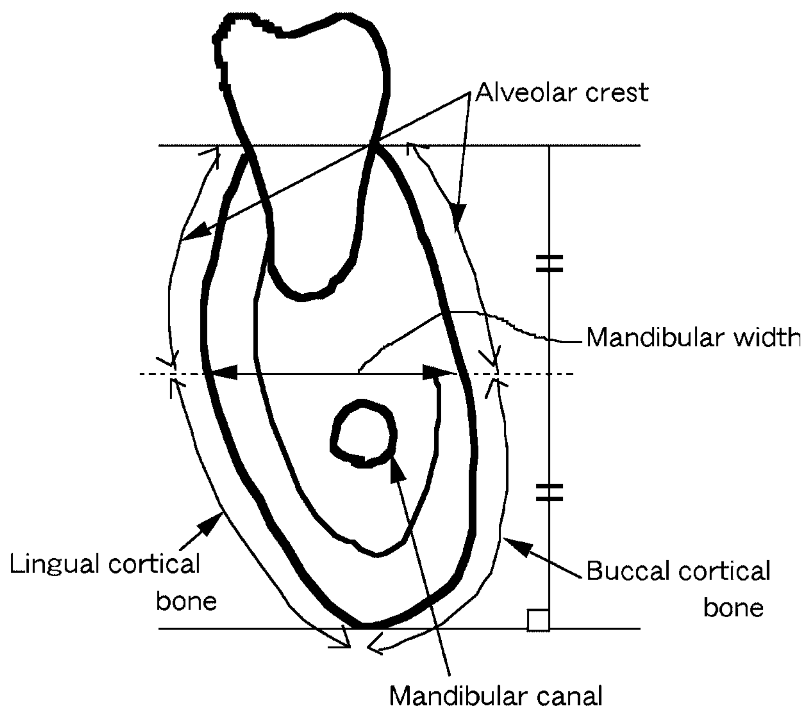
## Results

The image quality for each anatomical structure is shown in Figure 4. The top of each graph was approximately –5° in buccal and lingual cortical bones, approximately 5° for the mandibular canal, and between 5° and 10° for the alveolar crest. With a score of 3 or 4 in the image quality, the angles of the tomographic objective plane were from –1.7° to 15.0° for the alveolar crest. The permitted angles were from –12.4° to 2.5° for lingual cortical bone and from –2.4° to 6.1° for the mandibular canal. For buccal cortical bone the permitted angle in the positive direction was 10.4°, but the permitted angle in the negative direction could not be determined. For all 4 anatomical structures, the permitted tomographic objective angles were from –1.7° to 2.5°, a range of 4.2°.

## Discussion

Cross-sectional jaw images by conventional tomography were used in an image diagnosis for dental implant treatment.[1,2,4] In cross-sectional linear tomography, mandibular shape changes when shifting the angles of the tomographic objective plane. It has been previously determined that the angles from the optimal plane were from –12.1° to 9.8°, a range of 21.9° in the first molar region when permitting magnification within 0.5 mm of buccolingual width.[11] The permitted range of angles was geometrically determined solely based on geometrical measurements. Therefore, in this investigation, the image quality of mandibular depiction by shifting the angles of tomographic objective plane was evaluated subjectively by using 4 anatomical structures that are important in the imaging diagnosis of dental implant treatment.

From the present results, the permitted range of angles was 16.7° in the alveolar crest, 14.9° in the lingual cortical bone, and 8.5° in the mandibular canal. In total, the permitted angles were from –1.7° to 2.5°, a range of 4.2°. When this result was compared with our previous study,[11] the permitted range of angles was quite narrow. The angle between the top of the lingual cortical graph and the top of the crest graph was deferred approximately 12.5°. This fact reflected the different arch curvatures in the alveolar crest and lingual cortical bone. In buccal and lingual cortical bone, the highest image quality values were 4. However, the highest value in the mandibular canal was approximately 3.36. The location and configuration of the mandibular canal were important in dental implant treatment. In previous studies, visualization of the mandibular canal was evaluated by panoramic radiography and tomography.[13–15] Lindh and coworkers[13] used 6 specimens and reported that the rate for clear visualization was approximately 25% in panoramic radiographs, 47.2% in hypocycloidal cross-sectional tomograms (thickness: 1.7 mm), and 52.8% in spiral cross-sectional tomograms (thickness: 4 mm). Hallikainen and coworkers[14] reported that the rate of excellent or good visualization was 65.5% in spiral cross-sectional tomograms (thickness: 4 or 8 mm) in clinical practice. Moreover, Aryatawong and Aryatawong[15] reported that the rate of excellent or good visualization was 74% in hypocycloidal cross-sectional tomograms (thickness: 1 mm) in clinical practice. However, visualization of the mandibular canal was improved by tomography compared with panoramic radi-

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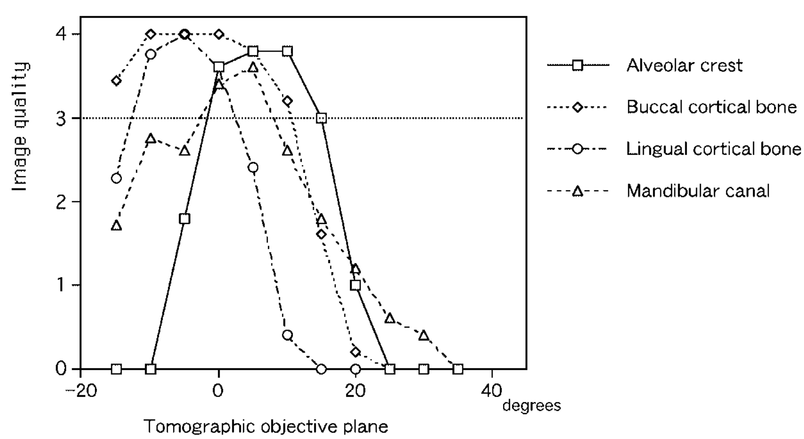


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FIGURES 3 and 4. Figure 3. Schematic drawing of measurements for mandibular width and the 4 anatomical structures (alveolar crest, buccal and lingual cortical bone, and mandibular canal) in the cross-sectional image. FIGURE 4. Results of a mandibular depiction from cross-sectional images. 0° in x-axis of the graph indicates the optimal tomographic plane.

ography, and in tomograms the mandibular canal may be difficult to visualize in some cases.[13] In tomography, when the direction of the X-ray beam was set tangentially to the wall of the mandibular canal, the mandibular canal was clearly observed. In this study, the optimal tomographic plane was determined by dimensional accuracy of the buccolingual mandibular width. Because the buccolingual course of the mandibular canal, which passes from the mandibular foramen in the lingual side to the submandibular foramen in the buccal side, is not parallel to the buccal or lingual cortical bone, the mandibular canal may not be observed.

In comparison with previous reports, a score of 3 or 4 for a dental implant imaging diagnosis in this study was higher. In the previous reports, a screen-film system was used, whereas in this study a CR system was used with linear gradation and frequency processes, which were used the same way in our dental implant imaging.

## CONCLUSION

The permitted tomographic objective angle was from –1.7° to 2.5° and over a range of 4.2° for all 4 anatomical structures—alveolar crest, buccal and lingual cortical bone, and mandibular canal—by using linear tomograms. From these data, the tomographic objective angles should be manually set in accordance with the optimal tomographic plane for individual patients by using a positioning technique such as the direct laser positioning system in linear tomography.[4]

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