A Comparative Study on the Observation Effect of Different Performance CBCT on Mandibular Neural Canal

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Abstract: CBCT products with different performance characteristics have great differences in imaging field of view and detail performance capabilities. In this study, the CBCT imaging results of different performance parameters are compared. The observation effect, position and direction of the mandibular neural canal were analyzed. It provides a reference for the use of CBCT images in mandibular dental implant surgery. The selected mainstream CBCT equipment can clearly image the mandibular neural canal, but the CBCT equipment with a field of view of 8 cm or less cannot completely observe the entire mandibular neural canal.

1 INTRODUCTION

The position and orientation of the mandibular neural canal is the focus of dental implantation in the mandible. Traditional oral panoramic radiographs (curved tomography) can show the position of the mandibular neural canal and its relative relationship with the surrounding teeth, but the overlapping and deformation of anatomical structures in the images often pose risks to the judgment of clinicians (Wang, 2019). Because of its advantages in imaging principle, CBCT can obtain more accurate and clear images of the mandibular canal.

The purpose of this study is to compare the imaging performance of different equipments for mandibular canal. It is expected to provide a reference for the application of CBCT images in mandibular implant surgery.

2 MATERIALS AND METHODS

2.1 Patient Information

CBCT imaging data of patients treated in Yantai Stomatological Hospital from June 2021 to January 2022. The data screening criteria are as follows: The patient has no history of mandibular fractures or major surgery; The patient is over 18 years old; The mandible has no metal objects that seriously affect CBCT imaging and measurement, such as metal correction brackets, amalgam fillings, etc.

After screening, 60 cases of CBCT data meeting the research criteria were included, including 30 males and 30 females.

2.2 Equipment

The data used in this study were obtained using the following equipment:

Equipment 1: Meyer, SS-X12008DPro-3D. Scanning parameters: 115kV, 8mA, reconstruction voxel size 0.25mm. Field of view size 23x18 cm.

Equipment 2: NewTom, VGi. Scanning parameters: 110kV, 3mA, reconstruction voxel size 0.30mm. Field of view size 15x12 cm.

Equipment 3: Sirona, ORTHOPHOS XG 3D CEPH. Scanning parameters: 90kV, 8mA, reconstruction voxel size 0.16mm. Field of view size 8x8 cm.

Equipment 4: MORITA, Veraviewwpocs X550. Scanning parameters: 90kV, 5mA, reconstruction voxel size 0.16mm. Field of view size 8.8x8 cm.

2.3 Method

The observation effect of the mandibular neural canal is analyzed from two aspects: First, whether the mandibular neural canal can be clearly observed and the position can be accurately judged; The second is whether the mandibular neural canal can be completely displayed in the field of vision.

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In terms of clarity and location of the mandibular canal, Clinically, the direction of the mandibular neural canal varies. If the shape and position of the mandibular neural canal can be clearly observed in the CBCT image, we classify and record it according to the following principles: Divide into 3 equal parts from the top of the alveolar ridge to the upper edge of the mandibular cortex. The one near the root of the tooth is called the high position, the one close to the cortical bone is called the low position, the one in the middle is called the median position (Wang, 2019). Patients were classified as "unobservable" if their mandibular canal had low bone wall density or many branches, making it difficult to determine its shape. In the classification process, in addition to observing the clarity and position of the mandibular neural canal, anatomical parameters important for implant surgery, such as the distance from the mandibular neural canal to the alveolar process (canal ridge distance), are also measured.

In terms of the integrity of the mandibular canal observation, we marked the mental foramen on the side of the jawbone clip as the anterior opening of the mandibular canal, as shown in Figure 1; the mandibular foramen on the lingual side of the jaw was marked as the posterior opening of the mandibular canal, as shown in picture 2. If the entire structure between the anterior opening and the posterior opening of the mandibular neural canal can be clearly observed in the CBCT image, it is considered that the entire neural canal can be observed completely; otherwise, it is considered that the entire neural canal cannot be completely observed.

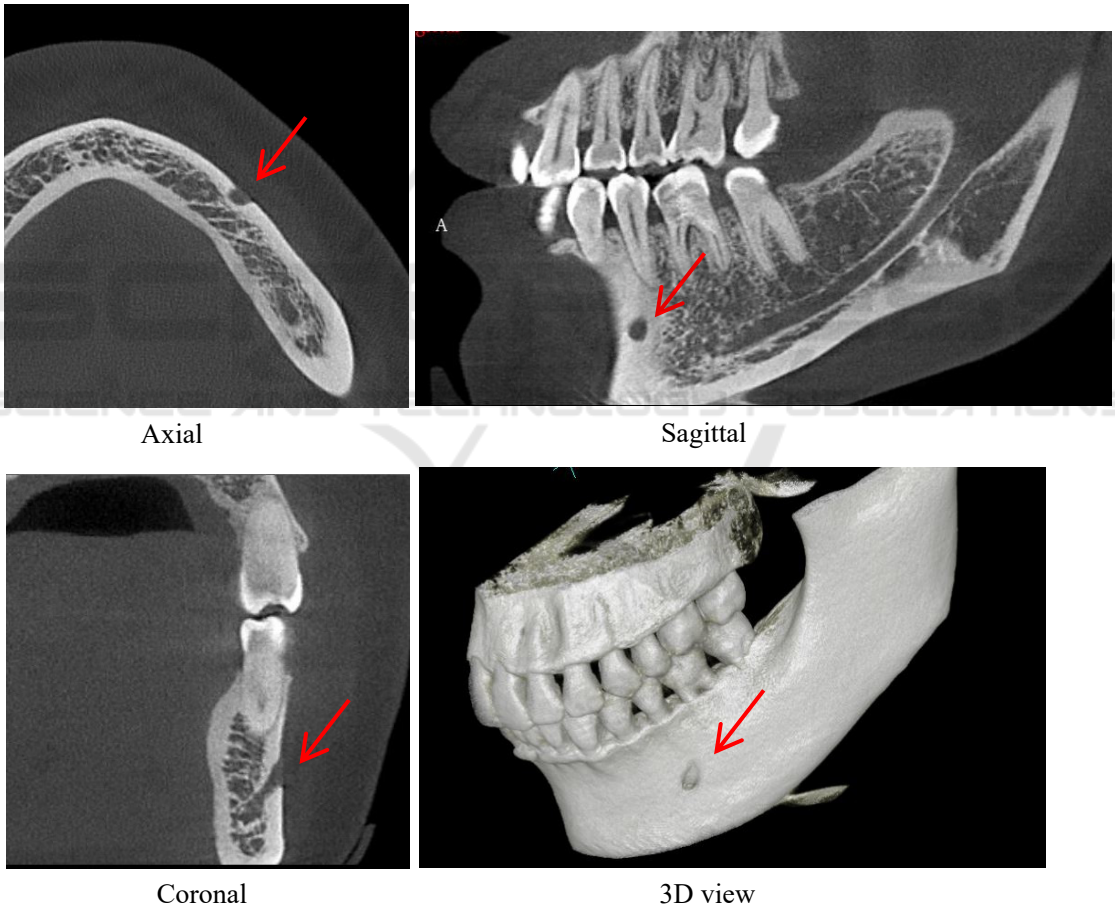

Figure 1: Anterior opening of the mandibular canal (mental foramen).

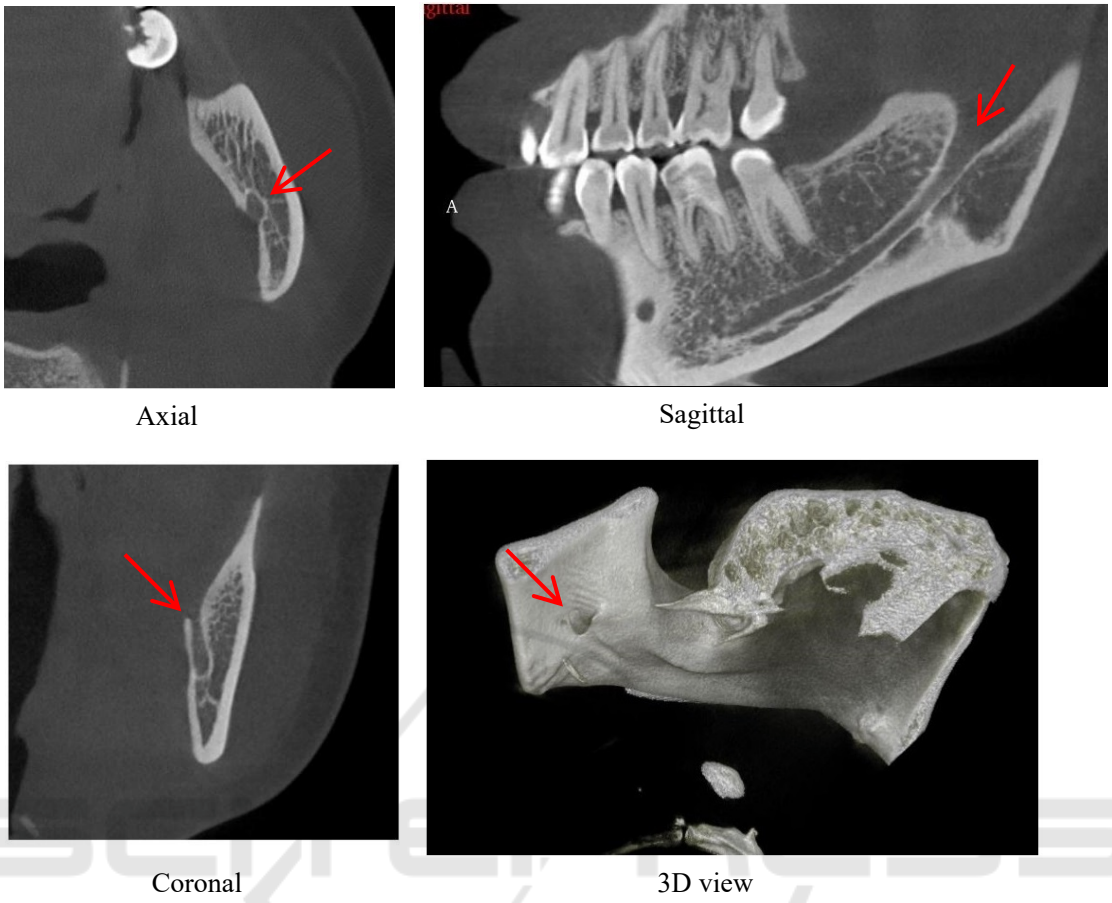

Figure 2: The posterior opening of the mandibular canal (mandibular foramen).

All imaging data were measured and analyzed by 2 imaging professionals, and the distance-related quantitative values were measured 3 times and averaged.

Statistical processing SPSS 20.0 statistical software package was used to analyze the data, and the selected specimens were strictly judged to control selection bias. The Kappa test was used to test the consistency of the measurement analysis results of the two physicians: Kappa value greater than 0.8 and less than or equal to 1.0, almost completely consistent; Kappa value greater than 0.6 and less than or equal to 0.8, highly consistent; Kappa value greater than 0.4 and less than or equal to 0.6, moderately consistent ; Kappa value greater than 0.2 and less than or equal to 0.4, general consistency; Kappa value greater than 0 and less than or equal to 0.2, extremely low consistency. Wilcoxon paired signed rank was used for difference analysis, and $P<0.05$ was considered statistically significant.

3 TEST RESULTS AND DISCUSSIONS

3.1 Whether the Mandibular Neural Canal Can Be Clearly Observed and the Position Can Be Accurately Determined

The four CBCT devices selected in this study can clearly observe the shape and position of the mandibular neural canal in patients, and classify them according to the position of the mandibular neural canal. The evaluation of the clarity and position of the mandibular neural canal by the two physicians was "almost identical", and there was no significant difference in the evaluation ($P>0.05$). Among the selected samples, 24.5% had the mandibular canal in the high position, 44.5% had the mandibular canal in the middle, and 30.75% had the mandibular canal in the low position.

Table 1: Mandibular neural canal definition and location distribution.

	able to observe clearly			unable to observe clearly
	high	middle	low	
Equipment 1	25%	43%	32%	0 %
Equipment 2	24%	44%	32%	0 %
Equipment 3	24%	46%	30%	0 %
Equipment 4	26%	45%	29%	0 %
average value	24.5%	44.5%	30.75%	0 %

3.2 Whether the Mandibular Neural Canal Can Be Completely Observed

The four CBCT devices selected in this study have significant differences in the imaging field sizes. Among them: Device 1 has the largest field of view, which can cover almost the entire skull below the brow bone; Device 2 has a field of view that covers the complete mandible and includes the temporomandibular joint; Although the field of view of Device 3 and Device 4 can completely cover the entire dentition, because the field of view is too small to show the entire mandible in the field of view. The four CBCT devices selected in this study have significant differences in the imaging field sizes. Among them: Device 1 has the largest field of view and can cover almost the entire head below the brow bone; Device 2 has a field of view that covers the complete mandible and includes the temporomandibular joint. The field of view of device 3 and device 4 can completely cover the entire dentition, but due to the small field of view, the entire mandible cannot be displayed in the field of view, nor the entire mandibular neural canal.

Because each device can clearly observe the mandibular neural canal, the imaging field of view is a key factor in determining whether the entire neural canal can be completely observed. The diametrical field of view is particularly critical. Device 1 and Device 2 have a large enough field of view diameter, so that the mandibular neural canal can be completely distributed within the field of view diameter, so that the entire mandibular neural canal can be observed, which is more conducive to the safety of mandibular implant surgery. Due to the limited field of view, device 3 and device 4 can also meet the needs of mandibular implant surgery, but cannot fully display the second half of the mandibular neural canal, and their clinical application scope is limited to a certain extent.

Table 2: Imaging integrity of the mandibular neural tube.

	Imaging field of view Diameter (cm) x Height (cm)	Mandibular canal imaging complete
Equipment 1	23 x 18	√
Equipment 2	15 x 12	√
Equipment 3	8 x 8	x
Equipment 4	8.8 x 8	x

3.3 Discussion

The early observation and study of the three-dimensional topography of the mandibular neural canal mainly used spiral CT, especially the high-resolution scanning mode (HRCT) in spiral CT. The main observation items include the precise position of the buccolingual, the height of the alveolar ridge, and the contour of the bone plate. This information can be summarized as the location, orientation, and surrounding tissue of the mandibular neural canal (Bai, 2008; Liu, 2014; Ge, 2003). In the impact data of spiral CT, MPR images are mostly used for observation, especially the sagittal images of the posterior teeth. Although these methods can better complete the preoperative observation of the mandibular neural canal, the general equipment is relatively expensive, and the spiral CT needs to be shared with other departments, which limits the clinical application.

With the popularization of oral CBCT equipment, especially the convenience and high precision of oral CBCT scanning, more and more physicians use CBCT to observe and study the mandibular neural

canal. And it can completely cover the anatomical information of the original spiral CT. The clear observation of the mandibular neural canal in CBCT can be applied in many clinical directions, such as mandibular implant surgery, mandibular deformity correction, impacted tooth extraction, mandibular fracture treatment, etc. (Ye, 2013; Li, 2017; Li, 2019).

This study compared the application effects of various CBCTs of different specifications in the clinical observation of the mandibular neural canal. Studies have shown that the four selected CBCT devices with conventional performance can clearly and accurately observe the shape and position of the mandibular neural canal, which can meet the needs of various clinical applications such as mandibular implant surgery. But the field of view of these CBCT products varies greatly, ranging from 23x18(cm) to 8x8(cm). The huge difference in the size of the field of view results in a fundamental difference in the integrity of the mandibular neural canal imaging, and the small field of view will lead to the inability to completely observe the position and direction of the entire neural canal. According to clinical experience, the length of the mandibular neural canal in adult patients is generally 7 to 9 cm. In addition, the incisors are generally required to be completely displayed in the field of view during CBCT scanning. At the same time, a small error in the positioning of each patient is considered. Therefore, the diameter of the task CBCT field of view should not be Less than 12 cm, in order to calmly observe the complete direction of the mandibular neural canal. This study suggests that CBCT can be well applied to the observation of the mandibular neural canal, but to observe the complete position and orientation of the mandibular neural canal, a CBCT device with sufficient field size should be used.

4 CONCLUSION

This study shows that the selected mainstream CBCT equipments can obtain the clear image of the mandibular canal. But, when the field of view is 8 cm or below, the mandibular canal cannot be observed intactly. Therefore, if the intact mandibular canal needs to be observed, the CBCT device with a field of view which is large enough should be choosed. The diameter of the field of view should be given special attention.

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