Field Of View And Voxel Size Considerations In Cone-Beam Computed Tomography: A Systematic Review

Syurri Innaddinna Syahraini, Bramma Kiswanjaya*****, Menik Priaminiarti*, Hanna H Bachtiar Iskandar**

**Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Universitas Indonesia*

Jl. Salemba Raya No.4, Jakarta, Indonesia. 10430

***Correspondence**:* **bramma.kiswanjaya@ui.ac.id**

Received 8 May 2023; 1st revision 15 May 2023; 2nd revision 6 june 2023; Accepted 31 December 2024; Published online 31 December 2024

Keywords:

cone-beam computed tomography; field of view; image enhancement; voxel size

ABSTRACT

Background: *Several factors must be considered when selecting the appropriate field of view (FOV) and voxel size for good image quality on Cone Beam Computed-Tomography (CBCT). The goal of this study is to identify the variables that should be taken into account when choosing the proper FOV and voxel size to obtain high image quality in accordance with the purpose of the examination.*

Method: *Articles in Q1 and Q2 journals published within the period from January 2016 to September 2021 were searched from Scopus and PubMed online using the keywords field of view/FOV in CBCT, voxel size in CBCT, and FOV and voxel size in CBCT. On the basis of the article selection criteria, 13 journals were included in the study. Also included in the study were several types of three-dimensional (3D) CBCT machines: Planmeca ProMax® 3D ProFace™, i-Cat Cone Beam 3D, Picasso Trio CBCT: Carestream unit® CS 9300 CBCT, and Accuitomo F17D 3D CBCT.*

Result: *Periodontal disease, secondary caries, fractures, external resorption, and endodontic problems are typically detected using a 0.2 mm voxel size. It is advised to utilize a 0.1 mm voxel size for root fractures with an intracanal metallic post and an anatomic isthmus in the root canal, and to use 0.3 mm and 0.4 mm voxel sizes for evaluating the implant.*

Conclusion: *It was found in the review that most of the selected studies recommended using the smallest FOV available in the CBCT unit to detect pathological conditions and important anatomical structures.*

doi: http://dx.doi.org/10.30659/odj.11.2.221-231
2460-4119 / 2354-5992 ©2024 National Research and Innovation Agency

Odonto : Dental Journal accredited as Sinta 2 Journal (https://sinta.kemdikbud.go.id/journals/profile/3200)
How to Cite: Syahraini *et al*. Field Of View And Voxel Size Considerations In Cone-Beam Computed Tomography: A Systematic Review. Odonto: Dental Journal, v.11, n.2, p.221-2310, December 2024

INTRODUCTION

The most sophisticated three-dimensional radiographic examination technique in dentistry is cone-beam computed tomography (CBCT). CBCT is performed when conventional radiographic examinations, such as periapical and panoramic radiography, cannot provide the information needed to perform diagnosis and treatment planning.[1] In general, CBCT is indicated for evaluation of impacted teeth, implant treatment planning, temporomandibular joint evaluation, orthodontic and surgical treatment simulation, diagnosis of dentoalveolar pathological conditions, nasal/paranasal sinus evaluation, and pharyngeal airway evaluation. It can also be used to evaluate craniofacial anomalies, view the root shape in complex endodontics, evaluate periodontal bone height, assess maxillofacial growth and development, and estimate age.[2] However, the radiation dose received by the patient in CBCT should be carefully considered since it is higher than that received by the patient in any other dental radiographic examination. Therefore, the justification for the patient's radiation exposure must be considered so that its diagnostic benefits will outweigh its possible risks.[1] A clinical examination should be performed before prescribing a radiographic examination, and radiographic examination must not be made a "routine" examination as it will expose patients to ionizing radiation, which may be harmful to their health.[1]

The application of the optimization principle of ALARA (as low as reasonably achievable) in CBCT can be adjusted by taking into account the size of the patient and the purpose of the examination.[1] Several CBCT systems allow for settings that can reduce image quality, including voxel size, slice thickness, spatial resolution, and scan volume/field of view (FOV).[3–6] The currently available software enables CBCT scanners to reduce radiation doses, such as by requiring a small FOV and through radiation exposure regulation and collimation.[1] The FOV depends on the X-ray beam collimation, which can limit the extent of radiation exposure to reduce the patient's unnecessary exposure and produce the best image by reducing the scattered radiation, which can reduce the image quality.[2] For radiation protection, it is crucial to reduce the FOV, especially in children.[7] The optimization strategy in CBCT, however, is concentrated on lowering the radiation dose without lowering the diagnostic accuracy.[8]

The resolution of CBCT is higher than that of conventional computed tomography (CT) because its voxel size is more isotropic. Smaller voxel sizes can provide good image quality but use higher radiation doses. This is also related to the ALARA principle; thus, the procedure chosen must be based on the lowest possible radiation dose for producing a sharp image of the structures to be evaluated.[5] On the basis of clinical and technical considerations, it was shown that a constant dose provides reasonably acceptable image quality.[9] Several factors must be considered when selecting the appropriate FOV and voxel size for good image quality on CBCT according to the purpose of the examination.[7] Such factors were investigated in this systematic literature review. The goal of this study is to identify the variables that should be taken into account when choosing the proper FOV and voxel size to obtain high image quality in accordance with the purpose of the examination.

LITERATURE REVIEW

The articles discussed in this systematic literature review were published in Q1 and Q2 journals based on SCImago journal and country rank. They were published within the period from January 2016 to September 2021 and traced from the Scopus and PubMed online databases. The keywords were field of view/FOV in CBCT, voxel size in CBCT, and FOV and voxel size in CBCT. The review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Fig. 1). Full clinical trial, meta-analysis, and randomized controlled trial manuscripts published in English were included in the review, and manuscripts with a literature review design and not related to the research purpose were excluded.

METHODS

The search yielded 104 journals from Scopus and 24 from PubMed. Of these, 17 were selected for inclusion in the study on the basis of the article inclusion and exclusion criteria. After the review of the entire manuscripts, however, four articles were found not to match the purpose of this literature review; thus, only 13 journals were finally included. The characteristics of the 13 journals are shown in Table 1. This study included several types of three-dimensional (3D) CBCT machines: Planmeca ProMax® 3D ProFace™, i-Cat Cone Beam 3D, Picasso Trio CBCT: Carestream unit® CS 9300 CBCT, and Accuitomo F17D 3D CBCT. Of the 13 articles included in the review, three discuss FOV, as shown in Table 2, while 10 discuss voxel size, as shown in Table 3. Several related articles published in Q1 and Q2 journals were also added to the Discussion section.

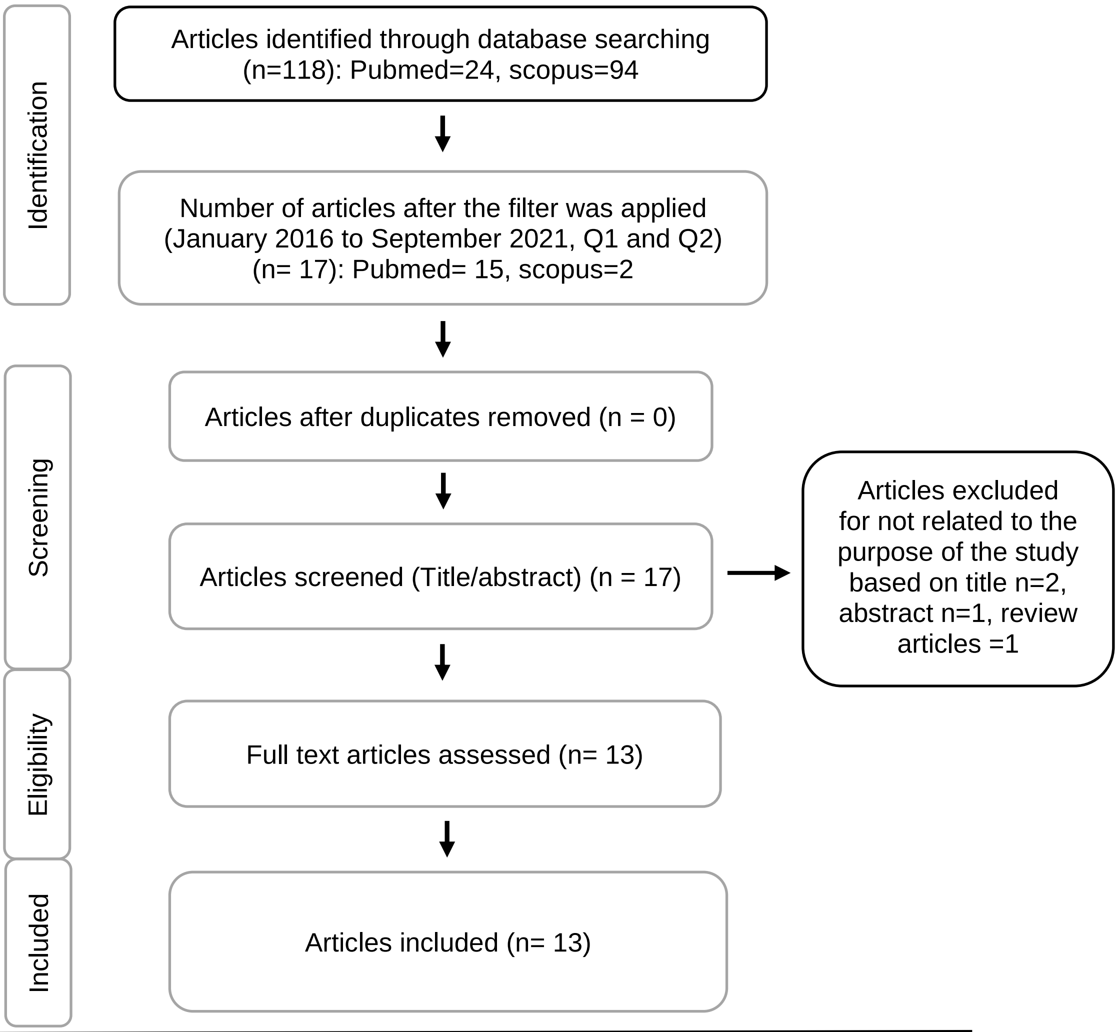

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flowchart

Table 1. Characteristics of the selected journal articles

No.	Author	Study design	Journal	Scopus index	Samples and methods
1	Ismail H Baltacioglu et al.[17]	Comparative	Dentomaxillofac Radiol (2016)	Q1	A cone-beam computed tomography (CBCT) device (Planmeca ProMax® 3D ProFaceTM; Planmeca, Helsinki, Finland) was used to scan a total of 128 premolars and molars: 100 × 90 mm field of view (FOV); 3 voxel sizes: normal resolution (0.2 mm voxel size), high resolution (0.15 mm voxel size), and low resolution (0.40 mm voxel size).
2	Carolina Carmo Menezes et al.[5]	Comparative	Angle Orthod (2016)	Q1	With an i-Cat Cone Beam 3D Dental Imaging System (Imaging Sciences International, Hatfield, PA, USA), twelve dry skulls were scanned at the following settings: 8 cm FOV, 120 kVp, 36.12 mA, and 40 s for 0.2 mm voxel size; 8 cm FOV, 120 kVp, 18.45 mA, and 20 s for 0.3 mm and 0.4 mm voxel size.
3	Larissa Pereira Lagos de Melo et al.[8]	Comparative	Oral Surg Oral Med Oral Pathol Oral Radiol (2017)	Q2	A Picasso Trio CBCT device (Vatech, E-WOO Technology Co., Ltd., Republic of Korea) was used to scan eight dry skulls with 13 M3RB at 80 kVp, 3.5 mA, 12 8.5 cm and 5 5 cm FOV, and 0.2 mm and 0.3 mm voxel sizes.
4	Solange Kobayashi-Velasco et al.[18]	Comparative	Dentomaxillofac Radiol (2017)	Q1	Eighty animal incisors were scanned with a Planmeca ProMax® 3D CBCT unit (Planmeca Oy, Helsinki, Finland): 5 × 5.5 cm FOV, 0.2 mm voxel size with 400 frames and high definition (HD) 0.15 mm with 500 frames.
5	Jean-Philippe Dillenseger et al.[10]	Comparative	Dentomaxillofac Radiol (2017)	Q1	A phantom was scanned with a Planmeca Promax CBCT unit (FOV < 50 mm, 75/100 μm voxel size) and a Newtom^{TM} CBCT unit (60–180 mm FOV, 250/300 μm voxel size).
6	Fernanda Paula Yamamoto-Silva et al.[22]	Comparative	Imaging Sci Dent (2018)	Q2	Thirty teeth were imaged using two CBCT systems: the i-CAT (8 8 cm FOV, 26.9 s scan time, 120 kVp, 5 mA, 0.125 mm and 0.2 mm voxel sizes) and Eagle 3D V-Beam (5 5 cm FOV, 32 s exposure time, 85 kVp, 5 mA, 0.1 mm and 0.16 mm voxel sizes).
7	Cemre Koç et al.[19]	Comparative	Dentomaxillofac Radiol (2018)	Q1	Forty teeth were scanned with a ProMax® 3D Max CBCT unit (Planmeca, Helsinki, Finland): 96 kVp, 1 mA, 55 × 50 mm FOV, 12 s and 15 s scan times, and 0.075 mm, 0.1 mm, and 0.2 mm voxel sizes.
8	Gül Sönmez et al.[20]	Comparative	Dentomaxillofac Radiol (2018)	Q1	A Planmeca CBCT equipment was used to scan 40 teeth in four different voxel sizes: 0.075 mm for endo, 0.1 mm for HD, 0.15 mm for HD, and 0.2 mm for normal resolution.
9	Ameera Alabdulwahid, Wafa Alfaleh[26]	Comparative	Saudi Dent J (2020)	Q2	Ten dry skulls were scanned with the Carestream unit® CS 9300 CBCT: 70 kVp, 4 mA, 0.18 mm and 0.3 mm voxel sizes, 10 cm FOV height, 5 cm FOV diameter, and 6.2 s scan time.
10	Emine ebnem Kursun-Cakmak et al.[23]	Comparative	Dentomaxillofac Radiol (2019)	Q1	An i-CAT 3D CBCT unit (Imaging Sciences International, Hatfield, PA) was used to scan four different types of implants. The scan times for the different voxel sizes were 14.7 seconds for the 0.2-0.25 mm voxel sizes and 4.8 seconds for the 0.3 mm and 0.4 mm voxel sizes.
11	Yusuke Hayashi et al.[25]	Comparative	J Oral Sci (2020)	Q2	A phantom was scanned with an Accuitomo F17D 3D CBCT unit (J. Morita Mfg. Corp., Kyoto, Japan): 90 kV, 5 mA, 360° scan, 17.5 s scan time, and 40 mm FOV for the 80 μm voxel size, and 100 mm FOV for the 250 μm voxel size.
12	Murat Icen et al.[16]	Comparative	Dentomaxillofac Radiol (2020)	Q1	A Veraviewepocs 3D R100/F40 unit (J. Morita Mfg. Corp., Kyoto, Japan) CBCT scanner was used to scan 12 dry skulls at 90 kVp, 3 mA, 10 8 cm FOV for 0.160 mm3 voxel size, and 8 8 cm FOV for 0.125 mm3 voxel size in intraoral radiography.
13	Elen de Souza Tolentino et al.[24]	Comparative	Imaging Sci Dent (2021)	Q2	Forty teeth of the M1RB were scanned with an Accuitomo® 170 3D unit (J. Morita Corp., Kyoto, Japan; 80 kVp, 6 mA, 4 × 4 cm FOV, 80 μm voxel size, and 7 s scan time) and New Generation i-Cat® (Imaging

			Sciences International, Hatfield, PA, USA; 120 kVp, 3-8 mA, 8 × 8 cm FOV, 125 µm voxel size, and 30.8 s scan time).	

Table 2. Journal articles discussing differences in the selection of the field of view (FOV)

No.	Author	Purpose	Method	Results
1	Jean-Philippe Dillenseger et al.[10]	Comparison of two-dimensional panoramic, small-FOV (less than 50 mm in diameter) CBCT and large-FOV (60–180 mm) CBCT from two different planes	A phantom was scanned with a Planmeca Promax CBCT unit (FOV < 50 mm, 75/100 µm voxel size) and a Newton™ CBCT unit (60–180 mm FOV, 250/300 µm voxel size).	The 75/100 µm voxel size and a small FOV can be used to detect small lesions such as endodontic lesions and tooth fractures and to assess the condition of the mandibular bone before implant placement, while a large FOV with a 250/300 µm isotropic voxel size is recommended for the evaluation of extensive pathological conditions such as tumor lesions or cysts in the maxilla and mandible, bone diseases such as osteonecrosis and osteomyelitis, and mandibular or maxillary fractures, and for the assessment of the implant position before installation.
2	Yusuke Hayashi et al.[25]	Accurate calculation of the corrected vertical magnification value on the panoramic view and comparison with the results of measurements made on CBCT with a small and large FOV	A phantom was scanned with an Accuitomo F17D 3D CBCT unit (J. Morita Corp., Kyoto, Japan): 90 kV, 5 mA, 360° scan, and 17.5 s scan time for a 40 mm FOV and an 80 µm voxel size and for a 100 mm FOV and a 250 µm voxel size.	The mandibular cortical width (MCW) measurement values with a panoramic view are similar to the MCWs measured using CBCT with a small FOV and CBCT with a large FOV.
3	Elen de Souza Tolentino et al.[24]	Comparison of the abilities of micro-computed tomography (as the gold standard) and of CBCT with a small and large FOV in detecting isthmuses in mandibular molars	Forty teeth of the M1RB were scanned with an Accuitomo® 170 3D unit (J. Morita Mfg. Corp., Kyoto, Japan; 80 kVp, 6 mA, 4 × 4 cm FOV, 80 µm voxel size, 7 s scan time) and New Generation i-Cat® (Imaging Sciences International, Hatfield, PA, USA; 120 kVp, 3-8 mA, 8 × 8 cm FOV, 125 µm voxel size, 30.8 s scan time).	CBCT with a small and large FOV has the same ability to detect isthmuses as micro-CT, allowing clinicians and radiologists to study the root canal anatomy and its variations even though the CBCT options are limited.

Table 3. Journal articles discussing differences in voxel size selection

No.	Author	Purpose	Method	Results
1	Ismail H Baltacioglu et al.[17]	Assessment of the diagnostic ability of CBCT in vitro, using seven different display types, to detect recurrent caries	A total of 128 premolars and molars were scanned with a CBCT unit (Planmeca ProMax® 3D ProFace™; Planmeca, Helsinki, Finland): 100 × 90 mm FOV, three voxel sizes, normal resolution (0.2 mm voxel size), high resolution (0.15 mm voxel size), and low resolution (0.40 mm voxel size).	No significant differences were found between the three voxel sizes that were used, but it is recommended that 0.2 mm (normal mode) be used, a common equipment setting for diagnostic purposes. The use of different monitors also showed no difference in assessing caries recurrence.
2	Carolina Carmo Menezes et al.[5]	Evaluation of the precision, reproducibility, and accuracy of alveolar crest height measurements on CBCT images with different voxel sizes	With an i-Cat Cone Beam 3D Dental Imaging System (Imaging Sciences International, Hatfield, PA, USA), twelve dry skulls were scanned at the following settings: 8 cm FOV, 120 kVp, 36.12 mA, and 40 s for 0.2 mm voxel size; 8 cm FOV, 120 kVp,	All the voxel sizes showed the same precision and reproducibility results. High accuracy in assessing the alveolar crest height for mandibular anterior and posterior teeth was achieved with the 0.2 mm and 0.3 mm

			18.45 mA, and 20 s for 0.3 mm and 0.4 mm voxel size.	voxel sizes while the 0.4 mm voxel size was not accurate enough to assess the lingual aspect of anterior teeth.
3	Larissa Pereira Lagos de Melo et al.[8]	Determination of the effect of CBCT acquisition parameters in evaluating mandibular third molars on the mandibular canal	A Picasso Trio CBCT device (Vatech, E-WOO Technology Co., Ltd., Republic of Korea) was used to scan eight dry skulls with 13 M3RB at 80 kVp, 3.5 mA, 12 8.5 cm and 5 5 cm FOV, and 0.2 mm and 0.3 mm voxel sizes.	Voxel size does not significantly affect image evaluation unless the contact between the teeth and the mandibular canal is assessed. A small voxel size affects the assessment of the contact between the teeth and the mandibular canal.
4	Solange Kobayashi-Velasco et al.[18]	Comparison of two small-FOV CBCT protocols with different voxel and frame sizes for diagnosing root and alveolar fractures in the maxillary canine macerate	Eighty animal incisors were scanned with a Planmeca ProMax® 3D CBCT unit (Planmeca Oy, Helsinki, Finland): 5 × 5.5 cm FOV, 0.2 mm voxel size with 400 frames, and HD, 0.15 mm voxel size with 500 frames.	The diagnosis results using normal and HD voxel sizes were similar; thus, the protocol that was chosen for root and alveolar fractures was a standard voxel size of 0.2 mm. The normal-mode protocol was chosen considering the lower radiation exposure for the patient because it produces the same picture as the HD protocol.
5	Fernanda Paula Yamamoto -Silva et al.[22]	Determination of the effect of voxel size and the accuracy of two CBCT systems in detecting vertical root fractures in the presence of intracanal metallic posts	Thirty teeth were imaged using two CBCT systems: the i-CAT (8 8 cm FOV, 26.9 s scan time, 120 kVp, 5 mA, 0.125 mm and 0.2 mm voxel sizes) and Eagle 3D V-Beam (5 5 cm FOV, 32 s exposure time, 85 kVp, 5 mA, 0.1 mm and 0.16 mm voxel sizes).	The CBCT protocol and system with a smaller voxel size and FOV can detect vertical root fractures with intracanal metallic posts in teeth.
6	Cemre Koç et al.[19]	Comparison of the accuracy of the photostimulable phosphor plate sensor with three different voxel sizes from CBCT images in detecting endodontic complications	Forty teeth were scanned with a ProMax® 3D Max CBCT unit (Planmeca, Helsinki, Finland): 96 kVp, 1 mA, 55 × 50 mm FOV, 12 s and 15 s scan times, and 0.075 mm, 0.1 mm, and 0.2 mm voxel sizes.	There were no statistically significant differences between the three CBCT images taken with different voxel sizes. CBCT images with 0.1 mm and 0.2 mm voxel sizes are considered suitable for detecting endodontic complications when needed.
7	Gül Sönmez et al.[20]	Comparison of the accuracy of linear and volumetric measurements of artificial root external resorption cavities performed using CBCT with four voxel sizes and four different software ex vivo	A Planmeca CBCT equipment was used to scan 40 teeth in four different voxel sizes: 0.075 mm for endo, 0.1 mm for HD, 0.15 mm for HD, and 0.2 mm for normal resolution.	CBCT is excellent for monitoring external root resorption with 0.1 mm and 0.2 mm voxel sizes..
8	Ameera Alabdulwahid, Wafa Alfaleh[26]	Identification of the mandibular canal by CBCT and the effect of differences in voxel size	Ten dry skulls were scanned with a Carestream unit® CS 9300 CBCT device: 70 kVp, 4 mA, 0.18 mm and 0.3 mm voxel sizes, 10 cm FOV height, 5 cm FOV diameter, and 6.2 s scan time.	No significant difference was found between the two voxel sizes in identifying the mandibular canal.
9	Emine ebnem Kursun-Cakmak et al.[23]	Determination of the effect of the implant material on the contrast-to-noise ratio (CNR) using CT and CBCT with various scan settings	Four types of implants were scanned with an i-CAT 3D CBCT unit (Imaging Sciences International, Hatfield, PA, USA), acquisition (voxel sizes: 0.2 mm, 0.25 mm, 0.3 mm, and 0.4 mm); 120 kVp, 20.27 mAs, 16 cm FOV, and 14.7 s scan time for the 0.2–0.25 mm voxel	The 0.3 mm and 0.4 mm voxel sizes are the procedures that may be used to evaluate the region close to the implant. Longer scan times are needed for greater scan resolutions, which increases radiation exposure and decreases CNR on picture quality.

			sizes and 4.8 s scan time for the 0.3 mm and 0.4 mm voxel sizes.	
10	Murat Icen et al.[16]	Comparison of the detection of periodontal defects using intraoral radiography and CBCT with different voxel sizes	A Veraviewepocs 3D R100/F40 unit (J. Morita Mfg. Corp., Kyoto, Japan) CBCT scanner was used to scan 12 dry skulls at 90 kVp, 3 mA, 10 8 cm FOV for 0.160 mm3 voxel size, and 8 8 cm FOV for 0.125 mm3 voxel size in intraoral radiography.	A smaller voxel size and a smaller FOV are effective in detecting various periodontal defects.

DISCUSSION

The FOV to be selected in CBCT depends on the purpose of the examination to be done. Dillenseger et al. found that two-dimensional panoramic, small-FOV (less than 50 mm in diameter) CBCT and large-FOV (60–180 mm in diameter) CBCT from two different units (Planmeca Promax and Newtom™) can be used for different purposes.[10] The research found that CBCT performed on a Planmeca Promax with a high-resolution protocol isotropic voxel size of 75/100 µm and a small FOV can detect small lesions, such as endodontic lesions or fractures, and can assess the condition of the mandibular bone before implant placement. Regarding the Newtom™ CBCT unit, a large FOV protocol with an isotropic voxel size of 250/300 µm is recommended for use in evaluating extensive pathological conditions such as tumor lesions or cysts in the maxilla and mandible and bone diseases such as osteonecrosis, osteomyelitis, and mandibular or maxillary fractures, and in assessing the implant position before implant placement. It is better to use CBCT with a small FOV and with a 75 × 75 × 75 mm or 100 × 100 × 100 mm voxel size, while for a broader range of pathological conditions, a large FOV with an isotropic voxel size of 250/300 um can be used.[11,12] Therefore, the study by Dillenseger et al. showed that a small FOV is more suitable for evaluating small lesions.[10]

The degree of damage to alveolar bone height was assessed in the Menezes et al. research, which employed CBCT to assess periodontal disease. It investigated the measurement of alveolar bone height and discovered that the 0.2 mm and 0.3 mm voxel sizes could be used to assess the lingual aspect of anterior teeth with high accuracy, but not the alveolar crest height for the mandibular anterior and posterior teeth.[5] This is in contrast with the research result of Damstra et al.[13] which evaluated the accuracy of bone height measurement with varying bone thicknesses in dry mandibles with 0.25 mm and 0.4 mm voxel sizes. They found no significant difference between the two voxel sizes.[13] On the other hand, a study by Sun et al. found that decreasing the voxel size from 0.4 mm to 0.25 mm might improve the linear measurement of the alveolar bone's accuracy.[14] A measurement error occurs when employing a 0.4 mm voxel size because CBCT cannot discriminate between the alveolar bone and the surrounding periodontal ligaments if a thin layer of the alveolar bone is close to or below such voxel size, making it impossible to precisely measure the height of the alveolar bone.[15] When the thickness of the bone is less than the spatial resolution of the implant image, according to a different research by Patcas et al., the bone may not show up on the tomographic image, leading to false positives.[16] Therefore, understanding these limitations is essential, especially for implant treatment planning and bone graft procedure.[17] Another study concerning periodontal disease was conducted by Icen et al., who showed that the 0.125 mm voxel size has the maximum diagnostic sensitivity and accuracy in CBCT for detecting periodontal defects. Therefore, smaller voxel sizes and FOV were found to be more effective for detecting various periodontal defects. On the basis of the aforementioned studies, it is concluded that the best voxel sizes to use for evaluating periodontal disease are 0.2 mm and 0.125 mm, which were the smallest measurements used, respectively, in the two aforementioned studies. However, when choosing the voxel size, the critical consideration is the amount of radiation that could be received by the patient.[18]

In conservative dentistry, the use of CBCT to detect secondary caries should be limited only to complex cases, when the target area cannot be evaluated or overlaps with other structures in periapical radiography. The study on secondary caries conducted by Baltacioglu et al. showed no significant differences between the three voxel sizes that were used.[19] However, it was recommended that 0.2 mm (normal mode) be selected as a standard setting for diagnostic equipment. The use of different monitors also showed no difference in assessing caries recurrence.[19] The findings of this study are also consistent with those of Kamburoglu et al.[3] and Kobayashi-Velasco et al.[20], who demonstrated that selecting the smallest FOV size of the CBCT device and a voxel size of less than 0.2 mm would provide a good-quality image for the detection of horizontal root fractures. Kamburoglu et al.[3] conducted a study using three CBCT planes with different FOV and voxel sizes. The smallest voxel size in the study was 0.076 mm, with a 50 × 37 mm FOV. To detect horizontal root fractures, it is better to assess the coronal and cross-sectional images, while the vertical root fractures should be assessed on the axial images.[3] In the case of root canal overfilling, it was found that although CBCT could provide better-quality images for detection compared to periapical radiography, such images are not statistically significantly better than those of the latter, and there is thus no statistically significant difference between the two modalities in the detection of underfilled root canals.[21] In the current review, no statistically significant differences were found between the three CBCT images taken with different voxel sizes.[21] Therefore, it is preferable to take into account the increase in radiation dosage and noise when choosing a voxel size while employing a limited FOV. When necessary, it was discovered that CBCT pictures with 0.1 mm and 0.2 mm voxel sizes were more effective at detecting endodontic problems.[21]

Trauma to the teeth can also cause external root resorption. CBCT can detect this resorption, as in the study conducted by Sönmez et al. on measuring the diameter, depth, and volume of external root resorption. No significant differences were found between the voxel sizes. When the resorption site was in the cervical area rather than in the apical area, it was found that there were statistically significant differences in the diameter and volume measurements for cervical resorption, as opposed to those for apical resorption.[22] It was concluded that CBCT with voxel sizes of 0.1 mm and 0.2 mm is perfect for measuring external root resorption when needed. Additionally, when employing smaller voxel sizes with a limited FOV, it is important to take into account the increased radiation dosage and noise.[21] Another study conducted by Vieira et al. showed that the 0.080 mm, 0.085 mm, and 0.120 mm voxel sizes yielded better results than the 0.133 mm voxel size, while there were no significant differences between the results of the three voxel sizes.[23]

Another study by Yamamoto-Silva et al. comparing the voxel sizes of 0.1 mm and 0.125 mm for the detection of vertical root fractures in an intracanal metallic post revealed a significant difference between the two.[24] While the 0.125 mm voxel size displayed higher specificity, the 0.1 mm voxel size displayed higher sensitivity and accuracy. In terms of identifying vertical root fractures based on orientation (axial, coronal, or sagittal), there was no statistically significant difference. The substantially better specificity of the aforementioned study's findings thus shown that a smaller voxel size is more effective for identifying vertical root fractures in an intracanal metallic post. [24]

In contrast to the results of the aforementioned previous studies, CBCT for implant treatment showed different results. CBCT was carried out for implant treatment at the stages before, during, and after implant placement. In the study by Kursun-Cakmak et al. on the effect of the implant material on the contrast-to-noise ratio (CNR), it was shown that the protocols that could be chosen for the assessment of the area adjacent to the implant are 0.3 mm and 0.4 mm voxel sizes because these voxel sizes provide a good diagnostic image for patients with implant restorations. The voxel sizes also have CNR values equal to or better than those of other modalities, such as CT.[25]

Several researchers have also conducted studies on anatomical structures using CBCT. Tolentino et al. studied the detection of the isthmus shape in the apical mandibular molar root canal area.[26] The results of their study indicate that there are significant differences between micro-CT and the two CBCT systems. In addition, neither CBCT system could detect multiple isthmuses to measure their lengths. This is because the average width of the apical isthmus is 0.1 mm while CBCT can detect only isthmuses with at least 0.15 mm widths. On the basis of this study's results, it was concluded that CBCT with a small FOV and CBCT with a large FOV have the same ability to detect isthmuses.[26] Hayashi et al.'s study related to anatomical structures indicating pathological conditions focused on the mandibular cortical width (MCW). It studied the measurement of MCW associated with osteoporosis using panoramic radiography and CBCT with a small and a large FOV.[27] The results showed that the MCW in CBCT with a 100 mm FOV was higher than those in panoramic radiography and in CBCT with a 40 mm FOV. However, the difference between the MCW in CBCT with a 40 mm FOV and the actual MCW was insignificant. This suggests that all of these methods are acceptable for measuring MCW in detecting osteoporosis or osteopenia.[27] Studies have also been conducted on the evaluation of the mandibular canal using CBCT. This study concluded that low-dose CBCT should be chosen for evaluating mandibular third molars[8]. A small FOV can reduce the radiation dose but does not affect image quality. Although a small voxel size helps in the assessment of the contact between the teeth and the mandibular canal,[8] it produces images with high spatial resolutions, causing the patient to receive more radiation.[28]

CONCLUSION

It was found in this systematic literature review that most of the studies reviewed recommended using the smallest FOV available in the CBCT unit to detect pathological conditions and important anatomical structures. In terms of voxel size selection, it is typically advised to utilize a 0.2 mm voxel size for identifying endodontic problems, secondary caries, fractures, and periodontal disease. A 0.1 mm voxel size is necessary for root fractures with an intracanal metallic post and an anatomical isthmus in the root canal, and 0.3 mm and 0.4 mm voxel sizes should be utilized to assess implants. However, it is important to take into account the increased noise and radiation exposure when employing a short FOV and a tiny voxel size.

ACKNOWLEDGEMENT : None

CONFLICT OF INTEREST: None

REFERENCES

1. Toilet Scarf. Clinical recommendations regarding use of cone-beam computed tomography in orthodontic treatment. Position statement by the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;116(2):238-57.
2. Kau CH, Abramovitch K, Kamel SG, Bozic M. Cone beam CT of the head and neck anatomical atlas. Springer Singapore. 2011.p.3-7.
3. Kamburoğlu K, Onder B, Murat S, Avsever H, Yüksel S, Paksoy CS. Radiographic detection of artificially created horizontal root fracture using different cone-beam CT units with small fields of view. Dentomaxillofac Radiol. 2013;42(4):20120261.
4. Hassan BA, Payam J, Juyanda B, Van Der Stelt P, Wesselink PR. Influence of scan setting selections on root canal visibility with cone beam CT. Dentomaxillofac Radiol. 2012;41(8):645-8.
5. Menezes CC, Janson G, Massaro CDS, Cambiaghi L, Garib DG. Precision, reproducibility, and accuracy of bone crest level measurements of CBCT cross-sections using different resolutions. Angle Orthod. 2016;86(4):535-42.
6. Kamburoğlu K, Murat S, Kolsuz E, Kurt H, Yüksel S, Paksoy C. Comparative assessment of subjective image quality of cross-sectional cone-beam computed tomography scans. J Oral Sci. 2011;53(4):501-8.
7. Esmaeili EP, Ilo AM, Waltimo-Sirén J, Ekholm M. Minimum size and positioning of imaging field for CBCT scans of impacted maxillary canines. Clin Oral Investig. 2020;24:897-905.
8. Lagos de Melo LP, Oenning ACC, Nadaes MR, et al. Influence of acquisition parameters on the evaluation of mandibular third molars through cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol. 2017;124(2):183-90.
9. Brasil DM, Pauwels R, Coucke W, Haiter-Neto F, Jacobs R. Image quality optimization using a narrow vertical detector dental cone-beam CT. Dentomaxillofac Radiol. 2019;48(3):20180357.
10. Dillenseger JP, Gros CI, Sayeh A, et al. Image quality evaluation of small FOV and large FOV CBCT devices for oral and maxillofacial radiology. Dentomaxillofac Radiol. 2017;46(1):1-10.
11. Laksmitarani N, Yusuf HY, Adiantoro S. Prevalence of odontogenic cyst in oral and maxillofacial surgery department of hasan sadikin general hospital: 2 years retrospective study. Odonto: Dental Journal. 2022;9(2): 290-8.
12. Siregar M, Sitam S, Lita YA, Hadikrishna I. Analysis of dentigerous cyst, ameloblastoma, and odontogenic keratocyst panoramic radiograph and cbct: a scoping review. Odonto: Dental Journal. 2022;9(1):115-30
13. Damstra J, Fourie Z, Huddleston Slater JJR, Ren Y. Accuracy of linear measurements from cone-beam computed tomography-derived surface models of different voxel sizes. Am J Orthod Dentofac Orthop. 2010;137(1):16.e1-6.
14. Sun Z, Smith T, Kortam S, Kim DG, Tee BC, Fields H. Effect of bone thickness on alveolar bone-height measurements from cone-beam computed tomography images. Am J Orthod Dentofac Orthop. 2011;139(2):e117-27.
15. Wood R, Sun Z, Chaudhry J, Tee BC, Kim DG, Leblebicioglu B, England G. Factors affecting the accuracy of buccal alveolar bone height measurements from cone-beam computed tomography images. Am J Orthod Dentofac Orthop. 2013;143(3):353-63.
16. Patcas R, Müller L, Ullrich O, Peltomäki T. Accuracy of cone-beam computed tomography at different resolutions assessed on the bony covering of the mandibular anterior teeth. Am J Orthod Dentofac Orthop. 2012;141(1):41-50.
17. Tanaka Y, Dutra V, Lin WS, Levon J, Hamada Y. Evaluation of the accuracy of buccal bone thickness measurement from cone-beam computed tomography compared with histologic analysis. J Prosthet Dent. 2021:S0022-3913(21)00499-6.
18. Icen M, Orhan K, Seker C, Geduk G, Ozlü FC, Cengiz MI. Comparison of CBCT with different voxel sizes and intraoral scanner for detection of periodontal defects: An in vitro study. Dentomaxillofac Radiol. 2020;49(5):1-7.
19. Baltacioglu IH, Eren H, Yavuz Y, Kamburoglu K. Diagnostic accuracy of different display types in detection of recurrent caries under restorations by using CBCT. Dentomaxillofac Radiol. 2016;45(6):20160099.
20. Kobayashi-Velasco S, Salineiro FCS, Gialain IO, Cavalcanti MGP. Diagnosis of alveolar and root fractures in macerated canine maxillae: A comparison between two different CBCT protocols. Dentomaxillofac Radiol. 2017;46(6):20170037.
21. Koç C, Sönmez G, Yılmaz F, Karahan S, Kamburoğlu K. Comparison of the accuracy of periapical

radiography with CBCT taken at 3 different voxel sizes in detecting simulated endodontic complications: An ex vivo study. Dentomaxillofac Radiol. 2018;47(4):1-9.

22. Sönmez G, Koç C, Kamburoğlu K. Accuracy of linear and volumetric measurements of artificial ERR cavities by using CBCT images obtained at 4 different voxel sizes and measured by using 4 different software: An ex vivo research. Dentomaxillofac Radiol. 2018;47(8):20170325.
23. Vieira HT, Vizzotto B. Diagnostic efficacy of different cone-beam computed tomography scanning protocols in the detection of chemically simulated external root resorption. 2020;130(3):322-7.
24. Yamamoto-Silva FP, Siqueira CF de O, Silva MAGS, Fonseca RB, Santos AA, Estrela C, Silva BS de F. Influence of voxel size on cone-beam computed tomography-based detection of vertical root fractures in the presence of intracanal metallic posts. Imaging Sci Dent. 2018;48(3):177-84.
25. Kursun-Cakmak EŞ, Kocasarac HD, Bayrak S, Ustaoğlu G, Noujeim M. Estimation of contrast-to-noise ratio in CT and CBCT images with varying scan settings in the presence of different implant materials. Dentomaxillofac Radiol. 2019;48(8):4-9.
26. Tolentino E de S, Amoroso-Silva PA, Alcalde MP, Yamashita FC, Iwaki LCV, Rubira-Bullen IRF, Duarte MAH. Comparison of limited- and large-volume cone-beam computed tomography using a small voxel size for detecting isthmuses in mandibular molars. Imaging Sci Dent. 2021;51:1-8.
27. Hayashi Y, Ito M, Imanishi Y, Watanabe K, Matsumoto K, Arai Y, Honda K. Use of experimental phantoms to determine the accuracy and reliability of mandibular cortical width measurements by panoramic radiography and cone-beam computed tomography. J Oral Sci. 2020;62(3):303-7.
28. Alabdulwahid A, Alfaleh W. Identification of mandibular canal in cone-beam computed tomography plane with different voxel sizes. Saudi Dent J. 2020;32(8):403-9.