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Agreement between cone beam computed tomography images and panoramic radiographs for initial orthodontic evaluation

Pisha Pittayapat, DDS, MSc,[a,b] Guy Willems, PhD,[c] Ali Alqerban, DDS, MSc,[c] Wim Coucke, PhD,[d] Rejane Faria Ribeiro-Rotta, PhD,[e] Paulo Couto Souza, PhD,[f] Fernando Henrique Westphalen, PhD,[f] and Reinhilde Jacobs, PhD[a]

KU Leuven and University Hospitals Leuven, Leuven, Belgium; Chulalongkorn University, Bangkok, Thailand; Scientific Institute of Public Health, Brussels, Belgium; Federal University of Goiás, Goiás, Brazil; Pontifical Catholic University of Paraná, Curitiba, Paraná, Brazil

Objective. The aim of this study was to compare the agreement between cone beam computed tomography (CBCT) and panoramic radiographs for initial orthodontic evaluation. This study was not meant to test differences between imaging modalities or to indicate superiority of one technique.

Study Design. Thirty-eight subjects with both panoramic and CBCT images were retrospectively collected. Eight observers answered 14 observational questions. The observation was repeated after 4 weeks.

Results. CBCT images yielded better agreement between 2 observer groups (orthodontic residents and radiologists) and better inter- and intraobserver agreement. The agreement between panoramic radiographs and CBCT scans was moderate.

Conclusions. If CBCT is *a priori* present in a case with justified indications, it has the potential to provide valuable diagnostic information for initial orthodontic evaluation and extra information for treatment planning. The moderate agreement between panoramic and CBCT images may indicate that the nature and amount of information gained from both imaging sources is deviant. (Oral Surg Oral Med Oral Pathol Oral Radiol 2014;117:111-119)

Panoramic radiography has been used as an essential diagnostic tool in dentistry for more than half a century.[1-3] Although with several limitations, such as geometric distortion and superimposition of anatomic structures,[4-7] panoramic radiographs are still generally used in orthodontic treatment planning, in oral surgery, and in almost all dental specialties for overall screening.

Three-dimensional (3D) computed tomography (CT) images were introduced to dentistry in the 1990s, but in view of the high radiation dose, their use has been rather controversial and not widely accepted. However, since the introduction of the first cone beam computed tomography (CBCT) systems,[8] 3D imaging has started to play an increasingly important role in oral health care diagnostics. The technology of this device has been continuously developing, offering dentists spatial visibility of anatomic structures and pathology with a better image quality and also with a relatively lower radiation dose than the multi-slice CT.[9]

Although different guidelines and selection criteria may exist in various countries, orthodontists often seem to request a panoramic radiograph and a lateral cephalogram for initial treatment planning. Additional information about tooth eruption state, angulation of the teeth, and overall dental, periodontal, and condylar condition is often added to the clinical evaluation based on analysis of the panoramic radiograph. This type of radiograph is also used to follow up orthodontic treatment progress as well as to visualize treatment outcome and prognosis of wisdom teeth if present.[10] In particular indications, conventional radiographs seem to offer insufficient information to make a diagnosis, illustrating the need for a low-dose CBCT for specific orthodontic comprehensive care, such as cases of canine impaction, root resorption, supernumerary teeth, and airway-related problems.[11,12] The radiation burden by CBCT, however, remains a major concern, especially in children. Studies have been conducted on different CBCT devices and different protocols to evaluate radiation

Statement of Clinical Relevance

Although CBCT scans still cannot replace panoramic radiographs, the present study might suggest eliminating the need for a further panoramic image if a recent CBCT scan of both jaws is already available.

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[a]Oral Imaging Center, OMFS-IMPATH research group, Department of Imaging and Pathology, Faculty of Medicine, University of Leuven.
[b]Radiology Department, Faculty of Dentistry, Chulalongkorn University.
[c]Orthodontics, Department of Oral Health Sciences, KU Leuven & Dentistry, University Hospitals Leuven.
[d]Department of Clinical Biology, Scientific Institute of Public Health.
[e]Department of Oral Medicine, School of Dentistry, Federal University of Goiás.
[f]School of Dentistry, Pontifical Catholic University of Paraná.

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dose to the patients. Dosimetric studies found that the amount of radiation dose is strongly related to the size of the field of view (FOV) and imaging parameters (e.g., resolution, rotation, milliamperage).[13,14] The latter information is crucial to apply the ALARA (as low as reasonably achievable) concept in children.

Several studies have tested the reliability of panoramic radiography for orthodontic-related issues, and some have contrasted its reliability with that of CBCT. Results show that panoramic radiographs are often unreliable in diagnosing canine impaction, third molar impaction, mesial angulation of the roots, root contact, root resorption, and supernumerary teeth. In contrast, CBCT scans could offer more reliable information and may lead to a different diagnosis and treatment plan for these specific conditions.[15-24]

In a previous study, the ability of panoramic views generated from CBCT scans was compared with that of conventional digital panoramic radiographs. The results suggested that the reformatted panoramic views from some CBCT scans may be able to offer equal diagnostic quality compared with the digital panoramic images commonly used in dental practices.[25] The next step would be to examine whether the full CBCT dataset has equal diagnostic quality compared with conventional digital panoramic radiographs. If the patient's preexisting CBCT data can provide orthodontists all necessary information for orthodontic treatment, then extra conventional 2D radiographs will not be required anymore, making an additional panoramic radiograph unnecessary. Patients' datasets will be more compact, and the radiation dose can be reduced.

There is only a little evidence from the literature that indicates whether CBCT data can offer better diagnostic potential, lead to improved orthodontic treatment planning, and offer orthodontists the same amount of information as they usually require from conventional panoramic radiographs.[26]

The aim of this study is to compare the agreement between observers for CBCT and digital panoramic radiographs related to initial orthodontic evaluation in the situation where CBCT images are *a priori* requested by the orthodontist for justified indications. This study was not meant to test differences or indicate superiority of 3D imaging in general or CBCT imaging more specifically. This study was aimed to evaluate the suitability of CBCT for initial orthodontic evaluation, when a CBCT scan was indicated and *a priori* taken for some specific indication.

MATERIALS AND METHODS

Samples

Thirty-eight patients (13 males and 25 females; age range, 8-25 years; mean age, 13.2 years; standard deviation [SD], 4.2 years) were retrospectively selected from the hospital orthodontic database (Oral Imaging Center, Katholieke Universiteit Leuven, Leuven, Belgium). The selection criteria were (1) that patients had a panoramic radiograph and additional CBCT images after a panoramic radiograph had been taken (the CBCT was specifically indicated for patients with root resorption cases and for treatment planning when dealing with impacted canines); (2) that both types of images were taken within an average time interval of 3 months (range, 0-11.5 months; SD, 3.7 months); (3) that no significant pathology of the maxillofacial region (benign or malignant tumor, cleft lip or cleft palate, trauma) was present; and (4) that no significant asymmetry of the face was observed. The study protocol (reference number, ML6960) was approved by the UZ Leuven Medical Ethics Committee. The authors have read the Helsinki Declaration and have followed the guidelines in this investigation.

Imaging modalities

Panoramic radiographs were acquired from a standard digital panoramic device with charge-coupled device sensor (Veraviewepocs 2D, J. Morita, Kyoto, Japan). The panoramic settings were selected depending on each patient (64 kilovolt peak [kVp]; 8.9 milliampere [mA]; 7.4 sec; pixel size, 0.144 mm; image size, 30 × 15 cm). The images were collected from the hospital picture archiving and communication system by being exported as TIFF files (Tagged Image File Format).

The CBCT scans of each patient were taken with 3D Accuitomo 170 (J. Morita) (FOV, 140 × 100 mm; high-fidelity (Hi-Fi) mode, 90 kVp, 5 mA; scan time, 30.8 sec; voxel size, 0.25 mm). All datasets were exported as DICOM files (Digital Imaging and Communications in Medicine standard).

Image evaluation

Eight observers (5 second-year orthodontic residents and 3 dentomaxillofacial radiologists with more than 5 years' experience) were initially introduced to an instruction and calibration session. Detailed instructions and definitions of all questions were given to all observers. The observers made an observation of 3 cases. Then the answers were checked and calibrated by the main author. All of them participated at the first observation session, and 5 observers (orthodontic residents) repeated the evaluation after a 4-week interval. Both observation sessions were performed under standardized conditions: dimmed ambient light, with 20-inch, 2-megapixel clinical review display (MDRC-2120; Barco NV, Kortrijk, Belgium).

During the observation, images from the patients were divided into 2 groups and then randomized within the group, and they were also re-randomized for the

Fig. 1. Panoramic radiograph of a 10-year-old boy from group 1.

second session. In group 1, panoramic radiographs were shown to observers on the ImageJ software, version 1.45s (National Institutes of Health, Bethesda, MD, USA) (Figure 1). In group 2, the entire volumes of CBCT images were shown on the OnDemand3D software, version 1.0.8.0408 (Cybermed; Seoul, South Korea) (Figure 2). In both groups, the observers had the possibility to use all tools available in the software, including the panoramic curve tool in the OnDemand3D application.

Questionnaire

Observers answered 14 questions related to initial orthodontic evaluation. The detailed questions and answer options are shown in Table I. The tooth numbering system used in the questionnaire was the FDI World Dental Federation notation (e.g., 13 is a maxillary right canine).

Statistical analysis

Statistical analysis was performed with R software for Windows, version 2.14 (R Development Core Team, Foundation for Statistical Computing, Vienna, Austria). Agreements were assessed using Fleiss κ statistics. Data were assessed on the following aspects:

- Agreement between the radiologist group and the orthodontic resident group
- Agreement between digital panoramic radiographs and CBCT images
- Interobserver agreement
- Intraobserver agreement

RESULTS

Agreement between observer groups

A high agreement was found between the orthodontic resident group and the radiologist group. The agreement was higher in the CBCT image group than in the panoramic group, with the Fleiss κ being 1.0 and 0.9 ($P < .0001$), respectively.

Agreement between 2 imaging modalities

A moderate agreement for all observers (Fleiss κ, 0.5; $P < .0001$) was observed when comparing the 2 image modalities (group 1, panoramic; group 2, CBCT).[31] The Fleiss κ was slightly higher in the orthodontic resident group (0.54) than in the radiologist group (0.45) ($P < .0001$).

More detailed results of the questionnaire per question and the frequency of all answers given to all questions are shown in Table II. It was found that for question 10 (localization of the upper right canine), the agreement between the 2D and 3D modalities was only slight (Fleiss κ, 0.2; $P < .0001$).[31] Other questions that received fair agreement (Fleiss κ, 0.2-0.4) were questions 4, 5, and 6 (apical area of frontal, middle, and posterior region), 11 (angulation of the upper right canine), 12 (root resorption of the upper right lateral incisor), and 14 (impaction risk of third molars).

Intra- and Interobserver agreement

The intraobserver agreement was substantial and was slightly better for the CBCT than the panoramic images (Fleiss κ, 0.71 and 0.65 ($P < .0001$), respectively). Moderate agreement was found in the interobserver analysis. The Fleiss κ tended to be higher for the CBCT (0.5) than for the panoramic images (0.4) ($P < .0001$).

DISCUSSION

The present study found only a moderate agreement between CBCT images and digital panoramic radiographs when questions related to the initial orthodontic evaluation had to be answered.

In this study, panoramic and CBCT images of the patients were collected retrospectively. The patients were selected from the database of patients who had images from both modalities taken. The patients included in this study had CBCT scans acquired in the clinic according to the treating doctor's specified exposure parameters. The patients were not intentionally overexposed for this study. The patients often had problems with impacted canines or third molars, thus the population of this study was not distributed to people with normal oral condition. Although patients with oral and maxillofacial tumor, cleft lip and cleft palate, and trauma were discarded, there still might have been some potential bias to this study.

As the results have shown, a high agreement was found between the 2 observer groups, and the agreement was higher when visualizing the CBCT images compared with the panoramic images. This was not unforeseen, because the CBCT images should offer more precise and realistic volume data when comparing with the panoramic images that are actually 2D shadows of the jaws. Evaluation of the dentomaxillofacial region on

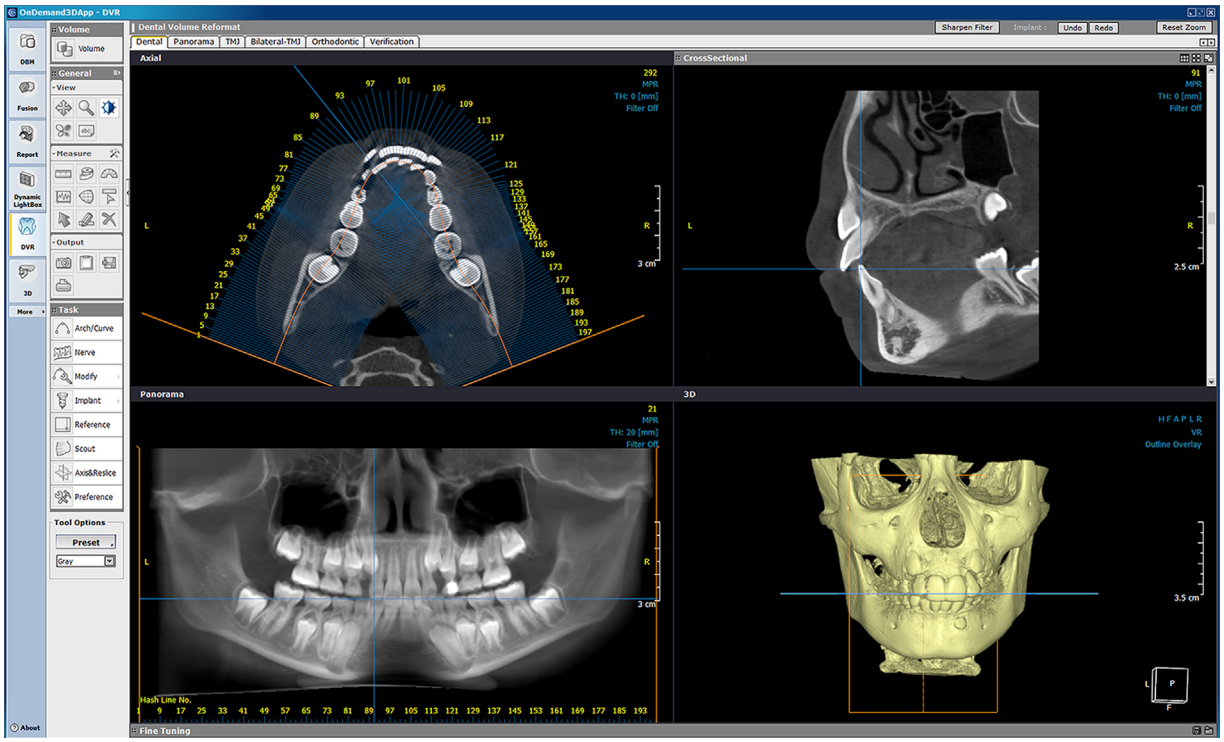

Fig. 2. The CBCT image of the same patient as in Figure 1, viewed on the OnDemand3D software. During the observation, the observers could view the entire CBCT volume in axial, coronal, and sagittal slices and could potentially draw a panoramic curve to create a reformatted panoramic view, as shown in this Figure. The thickness of reformatted panoramic views could be adjusted. This Figure shows a reformatted panoramic view with a 20-mm thickness. (*CBCT*, cone beam computed tomography.)

CBCT images should give more reliable answers to the questions. This supports the fact that both inter- and intraobserver agreement were higher in the CBCT group.

Questions were raised when comparing the 2 image modalities, because only a moderate agreement was observed. The Fleiss κ was slightly higher in the orthodontic resident group. This implied that there were some points for which panoramic and CBCT images resulted in different answers to the questions, or, to put it another way, they provided different information. The agreement was then inspected closely to see which questions had less agreement, and the results are shown in Table II.

Some questions showed low or slight agreement (e.g., for question 10, Fleiss $\kappa = 0.2$; $P < .0001$) (see Table II). In question 10, the observers were asked to localize the upper right canine. In all cases, the canine could be localized in the CBCT images, but in the panoramic radiographs, the observers could only localize in 72.3% of the cases, and in reality, the judgment of the location may not always be the true location, because the panoramic radiographs provide only 2D aspects and do not show the real buccopalatal dimension (see Table II). The results of this study are similar to previous evidence on managing canine impaction.[19,20,28]

Studies found that 3D imaging was advantageous in the management of impacted canines[28] and that the CBCT was more sensitive than conventional radiography for canine localization.[19] The findings from Botticelli et al.[20] indicated that CBCT increased precision in the localization of the canines and improved the estimation of the space conditions in the arch. The latter resulted in a difference in diagnosis and treatment planning from the 2D imaging approach.[20]

Some questions showed fair agreement (Fleiss κ, 0.2-0.4).[31] These were questions about apical area (questions 4, 5, and 6), angulation of the upper right canine (question 11), root resorption of the upper right lateral incisor (question 12), and the impaction risk of third molars (question 14). Some questions (especially questions 4, 5, and 6) are indeed rather subjective and cannot be truly objectified. Therefore, they probably had a large influence on the level of agreement. On the other hand, the authors decided to include these questions because they are often asked by orthodontists during the initial evaluation.

Questions 4 to 6 asked the observers to evaluate the space at the apical areas. As mentioned, the nature of these questions is rather subjective, and in this study, true distance measurements could not be performed as a gold standard; therefore, it was impossible to verify

Table I. Questions related to the initial orthodontic evaluation, answered by the observers

	Questions	*Description*	*Answers*
Q1	Are all permanent teeth present?	All permanent teeth including both teeth and tooth buds.	1 Yes/2 No/3 Unidentified
Q2	Is the sequence of eruption in upper left and upper right side symmetrical?	The same sequence of eruption applied for both left and right side of the upper jaw or not.	1 Yes/2 No/3 Unidentified
Q3	Is the sequence of eruption in lower left and lower right side symmetrical?	The same sequence of eruption is applied for both left and right side of the lower jaw or not.	1 Yes/2 No/3 Unidentified
Q4	Is the anterior apical area (root spacing) optimal?	The space in the area between the mesial surface of the upper right and left canines is adequate for normal eruption or not. Yes—The space is optimal and adequate. Reduced—The space is slightly reduced. This will determine the treatment plan to gain more space. Severe—The space is severely reduced. This will determine the treatment plan to gain more space and will determine whether there is a need for tooth extraction.	1 Yes/2 Reduced/3 Severe/4 Unidentified
Q5	Is the middle apical area (root spacing) optimal?	The space in the area from the mesial surface of the upper canine to the mesial surface of the first molar is adequate for normal eruption or not. The answers are as in Q4.	1 Yes/2 Reduced/3 Severe/4 Unidentified
Q6	Is the posterior apical area (root spacing) optimal?	The space in the area from the mesial surface of the upper first molar to the distal surface of the upper third molar is adequate for normal eruption or not. The answers are as in Q4.	1 Yes/2 Reduced/3 Severe/4 Unidentified
Q7	Is the path of eruption of tooth 13 optimal?	The optimal path of eruption is when the upper canine replaces the primary canine vertically without deviating to the mesial or distal side.	1 Yes/2 No/3 Unidentified
Q8	Is the path of eruption of tooth 23 optimal?	The optimal path of eruption is when the upper canine replaces the primary canine vertically without deviating to the mesial or distal side.	1 Yes/2 No/3 Unidentified
Q9	Is there impaction risk of tooth 13 and tooth 23?	Impaction is defined as a suboptimal path of eruption, for example, the canine has not erupted when the dental age is more than 13 years, complete canine root formation occurs without eruption, or there is insufficient mesiodistal space.	1 Yes/2 No/3 Unidentified
Q10	Can the upper right canine (tooth 13) be localized?	Localization of the upper right canine in relation to the dental arch.	1 Buccal/2 Middle/3 Palatal/4 Unidentified
Q11	What is the angulation of the upper right canine (tooth 13) to the midline?	The angle is formed by a line on the midline bisecting the jaw in two and a line through the cusp and the apex bisecting the canine along its long axis (Figure 3).[19,27-30]	1 Category A: 0°-22.5° to the midline 2 Category B: 22.6°-45.0° to the midline 3 Category C: 45.1°-67.5° to the midline 4 Category D: 67.6°-90.0° to the midline
Q12	Is there pathologic root resorption at the upper right lateral incisor (tooth 12)?	Detection of a resorption defect on the upper right lateral incisor root.	1 Yes/2 No/3 Unidentified
Q13	Is there impaction risk of premolars and molars?	The impaction risk is classified when the path of eruption is not optimal, complete root formation occurs without eruption, or there is insufficient mesiodistal space.	1 Yes/2 No/3 Unidentified
Q14	Is there impaction risk of third molars?	The impaction risk is classified when the path of eruption is not optimal, complete root formation occurs without eruption, or there is insufficient mesiodistal space.	1 Yes/2 No/3 Unidentified

Q, question.

Table II. Agreement between group 1 panoramic and group 2 CBCT per question for all observers and frequency of all answers in percentage with standard error

		Fleiss κ	P	*Image modality*	*% Answer 1, (SE)*	*% Answer 2, (SE)*	*% Answer 3, (SE)*	*% Answer 4, (SE)*
					Yes	No	Unidentified	
Q1	Are all permanent teeth present?	0.6	<.0001	Panoramic	55.6, (1.2)	39.1, (1.0)	5.3, (0.4)	
				CBCT	54.3, (1.3)	44.7, (1.1)	1.0, (0.2)	
Q2	Is the sequence of eruption of upper left and upper right side symmetrical?	0.6	<.0001	Panoramic	46.7, (1.2)	32.9, (1.0)	20.4, (0.8)	
				CBCT	39.8, (1.3)	43.8, (1.2)	16.4, (0.8)	
Q3	Is the sequence of eruption of lower left and lower right side symmetrical?	0.6	<.0001	Panoramic	53.0, (1.2)	16.4, (0.8)	30.6, (1.0)	
				CBCT	48.7, (1.3)	19.7, (0.9)	31.6, (1.0)	
					Yes	Reduced	Severe	Unidentified
Q4	Is the anterior apical area of the upper jaw optimal?	0.3	<.0001	Panoramic	58.5, (2.8)	31.9, (3.4)	8.9, (2.6)	0.7, (0.8)
				CBCT	71.1, (2.6)	23.0, (3.3)	4.9, (2.0)	1.0, (1.0)
Q5	Is the middle apical area of the upper jaw optimal?	0.2	<.0001	Panoramic	48.4, (2.9)	36.8, (3.4)	11.8, (2.8)	3.0, (1.7)
				CBCT	74.7, (2.5)	24.0, (3.5)	1.0, (1.0)	0.3, (0.6)
Q6	Is the posterior apical area of the upper jaw optimal?	0.4	<.0001	Panoramic	31.2, (2.7)	45.7, (3.2)	16.5, (3.1)	6.6, (2.3)
				CBCT	37.5, (2.8)	49.7, (3.3)	9.9, (2.7)	2.9, (1.7)
					Yes	No	Unidentified	
Q7	Is the path of eruption of tooth 13 optimal?	0.4	<.0001	Panoramic	56.9, (1.2)	34.2, (1.0)	8.9, (0.6)	
				CBCT	43.4, (1.3)	48.0, (1.2)	8.6, (0.6)	
Q8	Is the path of eruption of tooth 23 optimal?	0.6	<.0001	Panoramic	40.8, (1.2)	52.3, (1.1)	6.9, (0.5)	
				CBCT	47.0, (1.3)	46.4, (1.2)	6.6, (0.5)	
Q9	Is there impaction risk of tooth 13 and tooth 23?	0.5	<.0001	Panoramic	76.0, (1.0)	20.7, (0.8)	3.3, (0.4)	
				CBCT	72.7, (1.1)	25.0, (1.0)	2.3, (0.3)	
					Buccal	Middle	Palatal	Unidentified
Q10	Can tooth 13 be localized?	0.2	<.0001	Panoramic	4.9, (1.2)	51.3, (2.9)	16.1, (2.7)	27.7, (3.6)
				CBCT	15.8, (2.1)	59.5, (3.0)	24.7, (3.5)	0.0, (0.0)
					0°-22.5° to M	22.6°-45.0° to M	45.1°-67.5° to M	67.6°-90.0° to M
Q11	What is the angulation of tooth 13 to the midline?	0.3	<.0001	Panoramic	79.0, (2.3)	17.4, (3.2)	3.6, (1.8)	0.0, (0.0)
				CBCT	68.1, (2.7)	25.3, (3.4)	6.3, (2.3)	0.3, (0.6)
					Yes	No	Unidentified	
Q12	Is there any pathologic root resorption at tooth 12?	0.3	<.0001	Panoramic	10.5, (1.8)	65.5, (2.8)	24.0, (3.5)	
				CBCT	10.9, (1.8)	81.9, (2.3)	7.2, (2.4)	
Q13	Is there impaction risk of premolars and molars?	0.5	<.0001	Panoramic	28.6, (1.1)	67.8, (1.0)	3.6, (0.4)	
				CBCT	20.4, (1.0)	76.3, (1.0)	3.3, (0.4)	
Q14	Is there impaction risk of third molars?	0.4	<.0001	Panoramic	67.8, (2.7)	9.8, (2.3)	22.4, (3.5)	
				CBCT	61.9, (2.8)	12.8, (2.5)	25.3, (3.5)	

CBCT, cone beam computed tomography; *M*, midline; *SE*, standard error; *Q*, question.

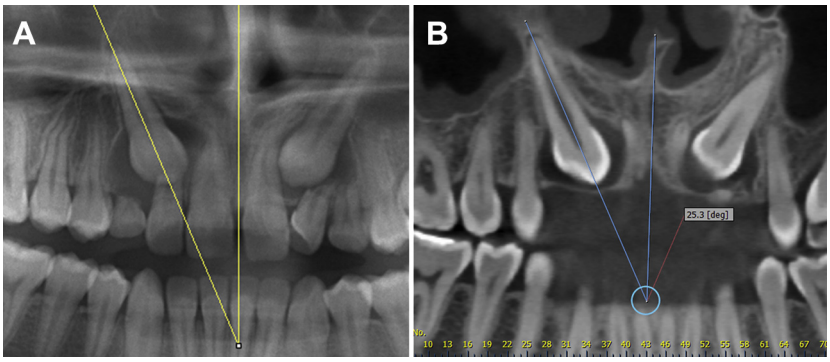

Fig. 3. The angular measurement performed in question 11 on a panoramic radiograph (A) and on a CBCT image (B). The angle was formed by a line on the midline bisecting the jaw in two and a line through the cusp and the apex bisecting the canine along its long axis. (*CBCT*, cone beam computed tomography.)

which answers were correct for each case. It is expected that 3D CBCT scans will give the answer that is closer to the real situation than panoramic radiographs, which have more distortion from their image geometry. However, in this study, only the agreement between the 2 imaging modalities could be tested.

To be able to answer question 11, the observers had to use the angular measuring tools, in both the ImageJ and the OnDemand3D software (Figure 3), and then select the angle categories from 1 to 4 (see Table II). However, the image geometry of the panoramic radiograph might influence the angular measurements. Patient positioning in the panoramic radiographic machine can influence the occlusal plane or the smile curve of the panoramic radiographs and therefore can result in only a fair agreement between the 2 imaging modalities.[21,32] The results of the present study were also supported by the results from Alqerban et al.[19] in 2011, who reported a significant difference in upper canine angulation to the midline between a digital panoramic radiograph and a medium-FOV CBCT.[19]

In question 12, the observers were asked to report any pathologic root resorption on the upper right lateral incisor. Fair agreement was found (Fleiss κ, 0.3). In the panoramic group, 24.0% of all the answers were categorized as "unidentified," in contrast to only 7.2% in the CBCT group (see Table II). This may be explained by the fact that in panoramic radiographs, the observers can only visualize the teeth in 2 dimensions. Superimposition of the anatomic structures and teeth might camouflage any root resorption in panoramic images, contrary to the situation in CBCT images, where the observers can look for the presence of root resorption on every side of the tooth. This result should be read with some caution. When root resorption was severe, it was obvious in both panoramic radiography and CBCT. In contrast, when it came to mild resorption cases, studies found that CBCT is more sensitive than panoramic radiography.[15,16]

So far, several articles related to root resorption and 3D imaging have been published.[15,16,19,33-35] Before the introduction of CBCT, studies compared conventional panoramic radiography with CT. Such comparisons found lower reliability of panoramic radiography for diagnosing incisor root resorption associated with impacted canines.[33,34] When looking at the CBCT devices, studies also found that CBCT scans were more accurate than panoramic radiographs for detecting root resorption.[15,16,19] In the study by Dudic et al.,[16] it was found that "no resorption" was observed more in panoramic radiographs than in CBCT, but mild resorption cases were observed more in CBCT, in agreement with the results of the present study.[16]

Results from another study by Alqerban et al.[35] indicated that high image quality was important for detecting root resorption, and the CBCT systems had high accuracy in the detection of the severity of root resorption.[35]

The question related to the impaction risk of third molars (question 14) showed fair agreement (Fleiss κ, 0.4; $P < .0001$). The reason might be the nature of the question, which was rather subjective. Another reason might be the age of the patients included in this study. The mean age was approximately 13 years; neither the jaws nor the third molars were fully developed, and for this reason, it was difficult to answer whether there was an impaction risk of the third molars. As a prediction, this resulted in fair agreement.

Although several studies have found additional value in CBCT, a systematic review on the use of CBCT in orthodontic treatment published in 2012 had interesting findings.[26] It was found that there is still limited evidence that CBCT offers better diagnostic potential or leads to improved treatment planning and a more predictable or superior treatment outcome than conventional imaging modalities. Only some specific studies on airway diagnostics provide sound scientific data suggesting that CBCT can add value.[26] There is little

evidence to support a role of CBCT in the initial orthodontic evaluation.

The present study did not aim to establish the superiority of any imaging modalities but instead was trying to evaluate whether both imaging modalities offer the essential information needed for an initial orthodontic diagnostic evaluation. The study did not aim to compare the observers' reply to the real case findings (clinical standard). Even though this could be regarded as a limitation, this study has found that the cone beam computed tomography showed its ability to give all necessary information for initial orthodontic evaluation. With moderate agreement between 2D and 3D imaging modalities, it suggested that the information gained from CBCT scans might not be similar to the information usually gained from panoramic radiographs. In the observation of the detailed results, CBCT offered a greater depth of information about the patient's condition. Further studies should be performed on the accuracy of the radiographic findings, by comparing CBCT and panoramic radiography with a gold standard and by evaluating whether the differential findings using 2D vs 3D imaging modalities could influence treatment planning and treatment outcome in orthodontic treatment.

Radiation to the patients

The present study was a retrospective study, and all images were acquired before data collection. Both CBCT and panoramic images were referred by orthodontists with justified indications. The radiation dose received from CBCT is strongly related to FOV size and also dependent on the exposure.[13,14] For children it is crucial that dental CBCT examinations should be fully justified over conventional radiography. New guidelines and recommendations on CBCT for dental and maxillofacial radiology are now available and should be followed.[36] One recently published set of recommendations by the American Academy of Oral and Maxillofacial Radiology[37] stated that CBCT in orthodontic treatment should be justified on an individual basis, based on clinical presentation, and the position statement should be periodically revised to reflect new evidence. A proper radiation regimen is highly recommended, and it is emphasized to keep the radiation dose to the patient as low as reasonably achievable.

CONCLUSIONS

In this questionnaire-based study, moderate agreement on initial orthodontic evaluation was found between CBCT images and panoramic radiographs. This does not mean that the information received from CBCT images is either incorrect or unreliable; rather, it simply means that it deviated from the information gained from panoramic radiographs. If a priori present, CBCT imaging has the potential to provide valuable diagnostic information for initial orthodontic evaluation and also to add extra information for orthodontic treatment planning. Yet proper justification and the ALARA concept should be meticulously followed.

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Reprint requests:

Pisha Pittayapat
Oral Imaging Center, OMFS-IMPATH research group
Department of Imaging and Pathology
Faculty of Medicine
University of Leuven
Kapucijnenvoer 33
3000 Leuven
Belgium.
p.pittayapat@gmail.com