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ORIGINAL ARTICLE

A comparison of the use of cone-beam computed tomography and panoramic radiography in the assessment of pre-eruptive intracoronal resorption

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ABSTRACT

Objective: This study aimed to investigate the prevalence of pre-eruptive intracoronal resorption (PIR) using cone beam computed tomography (CBCT) and panoramic radiography and to compare the findings of these imaging techniques.

Methods: This retrospective study consisted of 733 patients who had at least one unerupted tooth and had undergoneimaging with both three-dimensional (3D) CBCT and two-dimensional (2D) panoramic radiography. In all the images, the number of teeth with intracoronal resorption, affected tooth type and number, and size and location of the PIR defects were recorded. The McNemar test was used to compare the prevalence of PIR in the CBCT and panoramic images.

Results: Fewer PIR defects were detected in the panoramic images (3.1% of the patients) than in the CBCT images (9.5% of the patients) ($p < .001$). According to the CBCT images, the distribution of PIR defects was as follows: third molars (59.5%), canine teeth (11.4%), second molars and premolars (7.6% for both), supernumerary teeth (5.1%), second molars (3.8%), central incisors (2.5%), and first premolar and primary second molar teeth (1.5% for both). According to the scoring classification system for PIR defects, PIR 1 defects were the most common (65.8%), followed by PIR 3 (24.1%) and PIR 2 (10.1%). Of these defects, 69.6% were located in the central aspect of the crown. Ectopically positioned teeth showing intracoronal resorption accounted for 51.9% of the cases of PIR.

Conclusions: CBCT detected more cases of PIR than panoramic radiography. The mandibular third permanent molar was the most commonly affected tooth.

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Introduction

Pre-eruptive intracoronal resorption (PIR) is a developmental defect of the teeth that results in a well-circumscribed and abnormal radiolucent area within the coronal dentin of unerupted teeth.[1–3] PIR is an uncommon condition, which is typically detected as an incidental finding during routine radiographic examinations of unerupted teeth.[1,2,4] In general, PIR defects have been reported only within the dentin, although the enamel may be included in advanced cases.[2,5] Such defects are usually located on the mesial or central aspects of the crown, close to the dentino-enamel junction. Although PIR can extend to various depths of dentin, it rarely involves the pulp.[6,7] The etiology and factors associated with the initiation of the resorptive process remain unclear.[1,2] However, some suggested that PIR was associated with local factors, such as chronic apical inflammation and ectopic eruption, or systemic factors, including herpes zosters.[8,9]

PIR defects are classified as 1, 2, or 3, according to the size of the defect.[1] In PIR 1 defects, the resorption is less than one-third of the dentin thickness. In PIR 2 defects, it is between one-third and two-thirds of the dentin thickness. In PIR 3 defects, the resorption extends to more than two-thirds of the dentin thickness. PIR accounts for the majority of occult carries.[10] In general, PIR defects are observed as carious lesions on radiographs of erupted permanent teeth of children and young adults. Due to their rapid rate of progress, these lesions may lead to pain of unknown etiology, pulpal pathosis, and acute dental abscesses on unerupted teeth.[6,11,12] Thus, radiographs of all developing permanent teeth should be checked for PIR defects.[13] The recommended treatment options for PIR include restoration of the defect, root canal treatment, and tooth extraction to avoid progression of the resorptive process.[1,8]

The radiologist's experience, radiographic quality, imaging method, and awareness of the manifestation of PIR may influence the diagnosis of PIR. As conventional radiographs provide only a two-dimensional (2D) view of teeth and adjacent structures, they might not detect relevant information in orthogonal planes.[14]

Recently, cone beam computed tomography (CBCT) has been used to evaluate the morphology of teeth.[15] CBCT is a practical tool for noninvasive and three-dimensional (3D) reconstruction imaging by clinicians in dentistry applications and morphological analyses.[16] There have been only a few

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single case descriptions of PIR defects and some studies of the prevalence of PIR using panoramic or bitewing radiographs.[1,2,4,6,7,11] One study used CBCT imaging, but this study had a small sample size.[17] To the best of our knowledge, no studies have compared the use of CBCT and panoramic radiography to assess the prevalence of PIR defects. Thus, the purpose of this study was to investigate the prevalence of PIR defects in a large Turkish population using CBCT and panoramic radiographs and to compare the findings of the imaging techniques.

Materials and methods

The initial sample in this retrospective study consisted of 2127 patients aged 7–72 years. After excluding patients who did not have at least one unerupted teeth, the final sample consisted of 733 (334 males, 399 females) patients who had undergone both CBCT and panoramic radiography (orthopantomographs [OPGs]). The data were obtained from the archives (October 2012–July 2015) of the Department of Oral and Maxillofacial Radiology at Izmir Katip Celebi University, Izmir, Turkey. This study was approved by the local ethics committee of Izmir Katip Celebi University. The CBCT images and OPGs had been taken for several clinical indications (e.g. an impacted tooth, orthodontic reasons, possible pathosis [odontogenic cysts or tumors], a supernumerary tooth, or a temporomandibular joint disorder). The patients provided informed consent prior to the radiography and CBCT examinations, and the study was performed according to the principles of the Helsinki Declaration. Only the researchers had access to the acquired data. This study consisted of randomly selected patients, so there was no choice about age or gender. As it was important to differentiate PIR lesions from routine posteruptive carious lesions, only unerupted teeth that had not emerged into the oral cavity were assessed.

The inclusion criteria were as follows: (1) patients who had at least one unerupted toothbelow the cemento-enamel junction of an adjacent tooth or completely covered by bone, (2) good-quality images, (3) patients for whom both CBCT and OPG images were available, and (4) CBCT images have 12 cm $\times$8 cm FOV. An unerupted tooth with an incorrect eruption path was defined as ectopically positioned.[1] The exclusion criteria were: poor-quality CBCT images due to image artefacts (e.g. movement artefacts or beam hardening), incomplete records, patients with evidence ofskeletal asymmetries, relevant drug consumption, dental pathology (amelogenesis imperfecta, dentinogenesis imperfecta, and hypophoshatemic rickets), and syndromic and congenital disorders.

An experienced radiologist performed the image acquisition process, according to the manufacturer's recommended protocol, and the minimum exposure time necessary for adequate image quality was used. In each case, the field of view was 12 $\times$ 8 cm. The scanning times were 14–18 sec, the collimation height was 13 cm, and the exposure time was 3.6 s. With this device, the tube potential (kVp) and tube current (mA) were automatically determined from the scout views by the CBCT machine. All the images were obtained using a NewTom 5G CBCT machine (NewTom 5G; QR, Verona, Italy). The CBCT images were analyzed with NNT software using a Dell Precision T5400 workstation (Dell, Round Rock, TX). In the dental imaging of each patient, the voxel size was adjusted to 0.15 mm, and the slice thickness was 1.0 mm.

The panoramic images were obtained using an OP300 (Scanora/Instrumentarium, PaloDEx Group, Tuusula, Finland) instrument, equipped with a digital complementary metal oxide semiconductor sensor. Proprietary ADC technology automatically optimizes the panoramic exposure levels for each patient during every acquisition, resulting in a patient-specific dosage. The OP300 multilayer feature provides five panoramic images with only one scan and all five images were analyzed in the present study.

Information on the orodental, medical (syndromes and systemic diseases), and demographic characteristics of the patients was obtained from the clinical records. Two dentomaxillofacial radiologists (O.D. and E.Y.) with 7 years of experience in CBCT and OPG imaging evaluated the patients' records and radiographs. They carefully evaluated the axial, cross-sectional, multiplanar reformatted, and 3D reformatted images of the patients to determine the existence of PIR and associated local factors (ectopic eruption and apical inflammation of the primary tooth). The number of unerupted teeth, number of teeth showing intracoronal resorption, location of each radiolucent defect (both mesiodistal and buccopalatal direction), affected tooth type, and number of each tooth type were recorded.

The PIR defects were classified according to the classification system of Seow.[1] However, in contrast to this system, which considers only the mesiodistal dimension, the present study investigated the resorption in all three dimensions (axial, coronal, and sagittal) and calculated the ratio of the resorption volume to the entire crown volume. According to the modified PIR classification system, the volume of the resorption area was estimated and compared with that of the whole dentin of the entire crown. Using this modified 3D system, PIR was classified as follows:

- PIR 1: less than one-third of the dentin volume of the entire crown
- PIR 2: between one-third and two-thirds of the dentin volume of the entire crown
- PIR 3: more than two-thirds of the dentin volume of the entire crown

Cohen's kappa test was used to calculate the interexaminer reliability between the two observers. Intraexaminer agreement was evaluated by repeating the measurements one week after the first examination. The intraexaminer kappa value was 0.91. Pearson's correlation analysis and the χ^2 test were used to evaluate the association of PIR with age and gender. The McNemar test was used to compare the presence of PIR on the CBCT images and OPGs. The data were analyzed using SPSS for Windows (version 18.0, SPSS Inc., Chicago, IL) statistical software. A value of $p < .05$ was regarded as statistically significant.

Table 1. Number of PIR defect on CBCT and OPG.

	No of PIR defect teeth		
	OPG (*n*) (%)	CBCT (*n*) (%)	*p*
Maxilla	13 (46.4)	35 (44.3)	<.05
Mandible	15 (53.6)	44 (55.7)	

Results

On the CBCT images, PIR was observed in 70 of the 733 (9.5%) patients. In this study, 4096 unerupted teeth were evaluated, and 79 teeth showed intracoronal resorption, giving a prevalence of 1.93%. The mean age of the patients was 20.2 years (range, 7–65; mean for males, 21.4; for females, 19.2). There were 29 (41.4%) females and 41 (58.6%) males with intracoronal resorption. According to Cohen's kappa test, the interexaminer agreement between the two assessments by the observers was high: $k = 0.912$ and $p < .001$ for the CBCT images and $k = 0.868$ and $p < .001$ for the panoramic images. Tables 1 and 2 show the localization of the PIR defects. Intracoronal resorption was detected in both the maxillary and mandibular regions. Thirty-four (43%) of the affected teeth were located in the maxillary region, and 45 (57%) were located in the mandibular region. As shown in Table 1, no associations with gender and age were detected ($p > .05$). Table 3 illustrates the location, tooth type, and size of the PIR defect, in addition to local and systemic factors according to gender. Of the 79 CBCT cases of PIR, the locations of the defects were as follows: 47 (59.5%) in third molars, 9 (11.4%) in canines, 6 (7.6%) each in second molars and premolars, 4 (5.1%) in supernumerary teeth, 3 (3.8%) in second molar teeth, 2 (2.5%) in central incisors, and 1 (1.5%) in first premolar and primary second molar teeth (Figure 1). No lateral incisor was affected.

Of the defects, 69.6% were located in the central aspect of the crown, followed by the distal (21.5%) and mesial (8.9%) aspects. In 65 of the 70 subjects with PIR, only one tooth was affected. Two subjects had two affected teeth, two had three affected teeth, and one had four affected teeth. More than half of the teeth with defects (52%) were in an ectopic position.

On the panoramic radiographs, PIR was observed in 23 of the 733 (3.14%) patients. As shown in Table 1, according to the McNemar test, the detection of PIR was lower on the panoramic radiographs ($n = 12$, 3.1%) than on the CBCT images ($n = 52$, 9.5%) ($p < .001$). There were 12 PIR 1 defects, 4 PIR 2 defects, and 7 PIR 3 defects detected on the panoramic radiographs vs. 52, 8, and 19, respectively, on the CBCT images. Figures 2 and 3 show examples of the CBCT images and panoramic radiographs of the PIR defects.

Discussion

The diagnosis of PIR at an early stage is important to limit the extent of the resorptive lesion and prevent its progression into the dental pulp. The reported prevalence of teeth affected by PIR ranges from 0.7% [8] to 8.1%.[18] The different cohorts studied, variations in the diagnostic techniques used, and diagnostic difficulties may explain the wide variation in the reported prevalence. The present study detected PIR in 9.5% of the patients evaluated using CBCT, which was slightly higher than the results of previous studies.[1,7,18,19] The increased prevalence may be explained by the use of high-resolution 3D radiography in the present study, whereas previous studies used 2D radiography, which has several limitations. A recent study using CBCT reported that the prevalence of PIR was 15.1%.[17] The discord between the findings of that study and the present one may be explained by the different method used to score the PIR and the sample size. Studies that used panoramic radiographs reported that the prevalence of PIR was 0.7% [8] and 1.55% [9] in Turkish dental patients. In the present study, the prevalence of PIR defects in the panoramic radiographs and CBCT images was 3.1% and 9.5%, respectively. The relatively high prevalence (3.1%) of PIR defects in the panoramic radiographs was within the range reported in the literature.[1,7–9,18] Table 3 shows the sizes of the PIR defects determined by panoramic radiography and CBCT imaging. As can be seen, the sizes of the defects observed on the panoramic radiographs differed from those detected on the CBCT images. The superior imaging ability of CBCT could explain the high frequency of PIR defects found in the present study.[14]

Some previous studies reported PIR in maxillary and mandibular permanent and supernumerary teeth.[1,7,9,18] In the present study, we found no difference in the prevalence of intracoronal resorption between the genders, in accordance with the findings of a previous study.[8] Another study found that PIR was most common in mandibular second molars, followed by maxillary second premolars, maxillary central incisors, and maxillary canines.[9] PIR was also reported to be common in mandibular first premolars, maxillary second molars, and mandibular second premolars but not in third molars and maxillary first premolars.[18] The majority of PIR defects have been observed in maxillary third molars, followed by mandibular third molars, maxillary canines, mandibular canines, supernumerary teeth, and maxillary premolars.[8] In the present study, the mandibular third molar was the most common PIR site, followed by maxillary third molars, maxillary canines, and mandibular second molars. No PIR defects were detected in lateral, maxillary second molars, or mandibular central teeth. The mean age of the samples in the various studies, geographical or racial differences, radiological technique used, or unknown local factors may explain the different reported prevalence of PIR defects in the literature.

A number of theories have been proposed to explain PIR, the aetiology of which is controversial and unclear. According to an early study, PIR was due to infection of the periapical areas of primary teeth overlying their permanent successors, with the infection adversely affecting ameloblasts of the developing permanent tooth and causing hypoplastic enamel.[20] However, this theory does not explain lesions in permanent molars, which have no overlying primary teeth. It also does not explain the presence of defects in 60 teeth (four of which were supernumerary teeth) without precursory primary teeth in the present study or the presence of defects in similar cases reported in previous studies.[4,8,9,11]

Table 2. Summary of clinical and radiographic findings in male and female patients with intracoronal resorption.

Female									Male							
		Affected tooth			CBCT	OPG	Medical			Affected tooth			CBCT	OPG	Medical	
Case No.	Age	Maxilla	Mandible	Location	Defect score	Defect score	factors	Local factors	Age	Maxilla	Mandible	Location	Defect score	Defect score	factors	Local factors
1	54	8	–	Central	1	0	Hypertension	Ectopic	30	–	8	Distal	1	0	–	–
2	46	–	8	Central	1	0	–	–	10	–	5,7	Mesial, central	1	1, 0	–	–
3	14	–	8	Central	1	1	–	Ectopic	40	3	–	Central	1	0	–	Ectopic
4	13	–	8	Central	1	0	–	–	14	Supernumerary	–	Cental	3	0	–	Ectopic
5	60	8	–	Distal	1	0	Astma	Ectopic -	15	–	7	Central	3	3	–	–
6	15	–	8	Central	1	0	–	–	29	–	8	Central	1	1	–	Ectopic
7	14	3	–	Central	3	1	–	Ectopic	65	8	–	Distal	1	0	Diabet	–
8	15	1	–	Mesial	2	1	–	Ectopic	43	3	–	Central	1	0	–	Ectopic
9	23	–	8	Central	1	0	–	–	16	8	8	Central	1	0, 1	–	–
10	13	–	8	Central	1	0	–	Ectopic	17	8	–	Central	1	0	–	–
11	35	6	–	Distal	3	0	–	–	29	–	8	Central	1	0	–	Ectopic
12	15	8	–	Central	2	2	–	–	34	–	8	Central	1	1	–	Ectopic
13	13	3	–	Mesial	1	0	–	Ectopic -	11	–	7	Central	1	0	–	–
14	17	–	8	Central	1	0	–	–	15	8	–	Distal	1	0	–	Ectopic
15	17	–	8	Central	1	0	–	–	41	8	–	Central	2	0	–	–
16	35	–	8	Central	2	1	–	Ectopic	46	Supernumerary	–	Distal	3	3	astma	Ectopic
17	12	–	7	Central	1	0	–	–	44	–	8	Central	1	0	–	Ectopic
18	39	3	–	Central	3	2	–	Ectopic	12	6,6	6,6	Central	3	3	–	–
19	44	8	–	Central	1	0	–	–	15	8	–	Central	1	0	–	Ectopic
20	16	8	–	Central	1	0	–	Ectopic	15	–	8	Central	1	0	–	–
21	17	–	8	Central	1	1	–	–	14	3	–	Mesial	1	0	–	–
22	21	Supernumerary	–	Central	3	0	–	Ectopic -	13	–	8	Central	1	1	–	Ectopic
23	8	1	–	Central	3	0	–	Ectopic	15	–	8	Central	1	0	–	–
24	13	–	8	Central	1	0	–	–	14	–	8	Central	1	0	–	Ectopic
25	45	8	3,8	Central	3,3,2	3,3,2	–	–	9	primary molar	–	Central	3	2	–	–
26	48	8	–	Central	3	3	hypertension	Ectopic	9	–	5, 7, 5	Distal	1	0	–	–
27	30	Supernumerary	–	Central	2	1	–	Ectopic	12	–	8	Distal	1	0	–	Ectopic
28	28	–	8	Central	1	0	–	–	14	–	8	Central	1	0	–	Ectopic
29	35	–	8	Distal	1	1	–	Ectopic	45	–	8	Central	1	0	–	Ectopic
30	13	8	–	Central	1	0	–	–	13	–	7	Central	1	3	–	–
31	36	3	–	Central	3	3	–	Ectopic	45	–	8	Central	1	0	–	Ectopic
32	40	4	–	Central	1	0	–	Ectopic	40	–	8	Central	1	0	–	–
33	13	8	–	Central	1	0	–	–	9	–	5	Distal	1	0	–	–
34	54	8	–	Central	3	2	diabet	Ectopic	39	3	–	Central	1	0	–	Ectopic
35	–	–	–	–	–	–	–	–	15	–	8	Central	1	0	–	Ectopic
36	–	–	–	–	–	–	–	–	16	–	8	Distal	1	0	–	–

Defect Score 1: the resorption is less than one-third of the dentin thickness, Score 2: between one-third and two-thirds of the dentin thickness, Score 3: more than two-thirds of the dentin thickness.

According to another theory, PIR was attributed to pressure-induced local damage to the protective layer of a tooth caused by an abnormal tooth position, resulting in resorptive cells easily reaching the dentinal layer of the tooth and causing resorption.[7] In the present study, in almost half the patients with PIR defects, the teeth showed ectopic eruption, supporting this theory. However, a previous study found no association of PIR defects with medical conditions.[1] The small percentage of medical conditions (hypertension, asthma, and heart disease) in the present study sample was not representative enough to predict an association of PIR defects with any medical condition. Further studies are needed to shed light on this issue.

The differential diagnosis of PIR defects includes dental caries. As the radiographic views of both PIR defects and dental caries are similar in erupted teeth, it may be difficult or impossible to differentiate PIR defects from dental caries. However, a PIR defect can be distinguished from a carious lesion by a well-defined border and abnormal radiolucent area in the coronal dentin of the unerupted tooth.[1]

PIR occurs in the coronal section of the tooth.[11] All previous studies used the Seow [1] classification system to determine the prevalence of each type of PIR, with PIR 1 defects (50–85%) being the most common, followed by PIR 2 (25–39.3%) and PIR 3 (3–40%) defects.[8,9,18] Similar to the previous studies, PIR 1 defects were the most common type (65.8%) in the present study.

In a previous study by Al-Batayneh et al.,[18] all the subjects had only one affected tooth, pointing to a role for local etiologic factors. This finding was in accordance with that of other studies,[8,18] although some authors [4,7,21] reported more than one affected tooth in the same individual. In the present study, of the 42 subjects with PIR, 37 cases had one affected tooth, four had two affected teeth, and one had three affected teeth. The difference in the prevalence of PIR defects may be related to systemic factors, multiple local factors, unknown etiologic factors, and radiological techniques.

The Seow [1] classification is based on a 2D radiographic image. Therefore, it may underestimate the complexity and true extent of the defect. As reported earlier, 2D radiographs provided limited information in endodontic epidemiological surveys and clinical outcome studies.[14–16]

Table 3. Demographic analysis, prevalence and localization of intracoronal resorption on CBCT.

	Intracoronal resorption		
Gender	Present (*n*) (%)	Maxilla (%)	Mandible (%)
Male	43 (54.4)	15 (34.9)	28 (65.1)
Female	36 (45.6)	20 (55.5)	16 (44.5)
Total	79 (100)	35 (44.3)	44 (55.7)

$p > .05$ for genders.

Figure 1. Number of each tooth affected PIR defects.

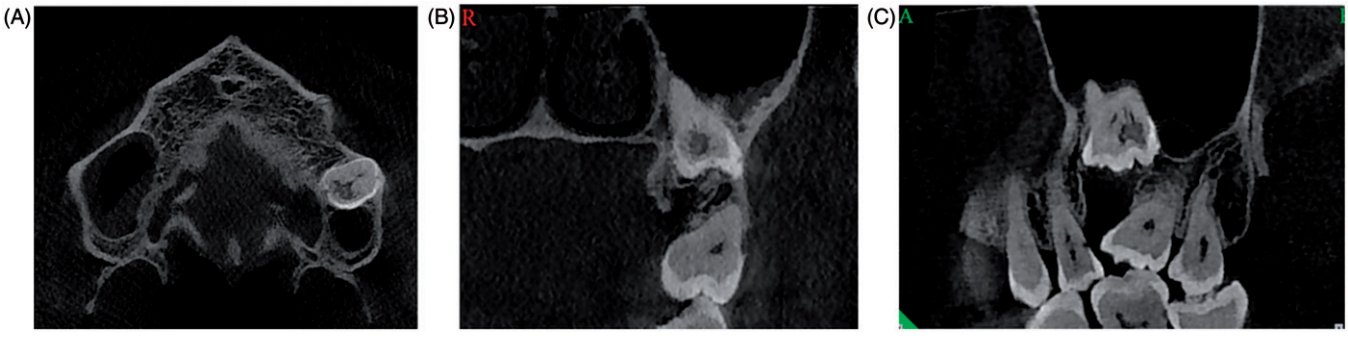

Figure 2. CBCT images; axial (A), coronal (B) and sagittal (C) of the unerupted teeth with PIR defects.

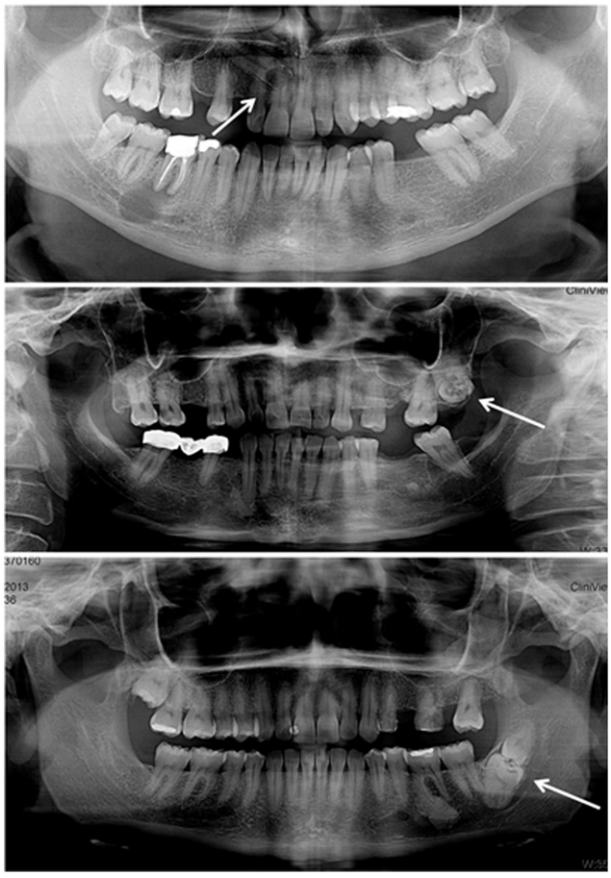

Figure 3. Examples of PIR defects (arrows) on OPGs.

The maxillary molar and premolar crowns of unerupted teeth are usually not as well defined as their mandibular counterparts on panoramic radiographs, and earlier studies that used 2D imaging may have missed defects in these teeth.[1,7,9,19] This is the first study to use both CBCT imaging and panoramic radiography to determine the presence of PIR.

Although CBCT scanning has advantages in crown and root canal anatomy investigations, according to current recommendations, the decision to use CBCT scanning should depend on whether the benefits outweigh the risk of the relatively higher radiation dose of CBCT compared with conventional radiographs. Thus, CBCT should be reserved for selected cases when conventional imaging fails to provide definitive information about complex endodontic conditions.[22]

In conclusion, CBCT detected more cases of PIR than panoramic radiographs. The prevalence of PIR defects on the CBCT images was 9.5% by subjects and 1.95% by teeth examined. The mandibular third permanent molar was the most commonly affected tooth, and the majority of the subjects had only one affected tooth.

Disclosure statement

The authors declare that they have no conflict of interest.

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