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## Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology

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**Objective.** To compare intraoral periapical radiography with 3D images for the diagnosis of periapical pathology.

**Study design.** Maxillary molars and premolars and mandibular molars with endodontic problems and examined with periapical radiographs and a 3D technique (3D Accuitomo) were retrospectively selected and evaluated by 3 oral radiologists. Numbers of roots and root canals, presence and location of periapical lesions, and their relation to neighboring structures were studied.

**Results.** Among 46 teeth, both techniques demonstrated lesions in 32 teeth, and an additional 10 teeth were found in the Accuitomo images. As regards individual roots, 53 lesions were found in both techniques, and 33 more roots were found to have lesions in Accuitomo images. Artefacts were sometimes a problem in Accuitomo images. In 32 of the 46 cases, all observers agreed that additional clinically relevant information was obtained with Accuitomo images.

**Conclusions.** A high-resolution 3D technique can be of value for diagnosis of periapical problems. (*Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007;103:114-9)

Intraoral radiography is the technique commonly used to establish whether periapical disease is present. For treatment-planning purposes, however, considerably more information is required. The extent of the lesion must also be known, as well as how many roots and root canals there are in an affected tooth, which root or roots are affected, and whether a lesion at one root is connected to that at another. When periapical surgery is contemplated, knowledge about the relation between root apices and between a lesion and neighboring anatomic features is essential. The relation to the maxillary sinus and the mandibular canal is particularly important.

In intraoral radiography the 3-dimensional object is compressed into a 2-dimensional image from which the observer has to mentally recreate the 3 dimensions. This can be difficult even when more than a single radiograph is used. Of particular concern is the background pattern that features on either side of the struc-

tures of interest give rise to and the contrast between a lesion and its surroundings. When the background pattern is complex, structures of interest become less easy to perceive than when it is less complex.<sup>1</sup> Thus, the findings of, e.g., Bender and Selzer,<sup>2,3</sup> Schwarz and Foster,<sup>4</sup> Lee and Messer,<sup>5</sup> and Wallace et al.<sup>6</sup> that lesions confined to the cancellous bone can be difficult to detect, as well as those of Shoha et al.,<sup>7</sup> Scarfe et al.,<sup>8</sup> and Marmary et al.<sup>9</sup> that the size of periapical lesions is often underestimated in periapical radiographs, are not surprising. The latter demonstrated that periapical lesions do not have to erode the lingual or buccal cortical bone plate to become detectable but did not discuss whether this had to do with loss of bone trabeculae close to the cortical bone responsible for much of the background pattern. In periapical radiography the use of 2 or more radiographs, obtained with different irradiation geometry, can improve the accuracy with which periapical lesions can be detected.<sup>10</sup> The use of more than 1 radiograph is of course inestimable when there is a need to display the roots of a tooth with as little superimposition onto each other as possible and when root fractures are suspected. Best possible periapical radiographs are obtained when the paralleling technique is used.<sup>11</sup> This is, however, not always possible, e.g., in the upper molar regions where, owing to anatomic conditions, there is the greatest need for 3-dimensional information. Therefore, periapical intraoral radiographs may be quite sufficient in many areas and less so in others, depending on the diagnostic problems and the anatomic conditions.

Three-dimensional (3D) information of teeth and

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jaws can be gleaned from computerized tomography (CT). Tachibana and Matsumoto<sup>12</sup> investigated the usefulness of CT in endodontics, and later it was shown to provide diagnostic information not evident from periapical intraoral radiographs.<sup>9,13</sup> However, the technique is expensive, can yield high radiation doses, and is not readily available in the dentist's office. Lately, so-called cone-beam CT, also called digital volume tomography, has been developed for the dental market. Several machines are now commercially available of which 1 (3D Accuitomo, J Morita Mfg. Corp., Kyoto, Japan) is specifically made to display small parts of the jawbone with an image field size similar to that of ordinary dental films.<sup>14</sup> A single 360-degree scan collects projection data for image reconstruction from a cylinder with a height of 30 mm and a diameter of 40 mm. From this volume, tomographic slices of widths from 0.125 to 2.0 mm can be displayed in 3 perpendicular planes. New slices can be made in any desired direction, making it possible to see, e.g., a particular root in all its 3 dimensions. Digital volume tomography generally yields considerably lower effective doses than CT,<sup>15</sup> particularly when just a small volume is examined.

Given the conceivable limitations of intraoral periapical radiography for the diagnosis of apical periodontal disease, we considered it of interest to assess whether and how the information obtained by means of limited cone-beam CT, in our case the 3D Accuitomo, differs from that obtained by intraoral periapical radiography.

## MATERIAL AND METHODS

### Patients

Among all patients referred to the Clinic of Oral and Maxillofacial Radiology at the Public Dental Health Service, Göteborg, Sweden, between April 2003 and July 2004, we identified 36 patients in whom the referring dentist specifically had asked for detailed information about anatomy and pathology and who fulfilled the following criteria:

Clinical and/or radiographic findings (in periapical radiographs) of a periapical lesion.

Maxillary premolar or maxillary/mandibular first or second molar.

Examined with 2 intraoral periapical radiographs and 3D Accuitomo.

Among the patients, 23 were women and 12 men, with a mean age of 50 yrs (range 16-80 yrs). In 9 patients, 2 teeth were analyzed and in 1 patient 3 teeth, yielding a total of 46 teeth. The distribution of tooth types is shown in Table I.

**Table I.** Distribution of tooth types (n) evaluated and number of teeth with periapical lesions diagnosed per technique

Jaw	Tooth type (n)	Periapical radiographs	3D Accuitomo
Maxilla	Premolar (9)	8	8
	1st molar (18)	14	17
	2nd molar (7)	4	7
Mandible	1st molar (7)	5	5
	2nd molar (5)	1	5
Total	(46)	32	42

### Radiographic techniques

Two intraoral periapical radiographs were obtained with a parallelling technique and a horizontal angle difference of about 10 degrees using an Oralix DC (Gendex Corporation, Milwaukee, WI) dental x-ray machine operating at 65 kV and 7.5 mA. Focus-film distance was 22 cm and exposure time between 0.32 and 0.5 s, depending on tooth type. F-speed films (Kodak Insight; Eastman Kodak, Rochester, NY) were used and processed in an automatic processor (AP 200 Processor; PLH Medical, Watford, England). The radiographs were evaluated against a light box of constant luminosity with the aid of an x-ray viewer providing 2× magnification.

The Accuitomo examinations were made with the tooth to be examined in the center of the volume. Operating parameters were 2.0-4.0 mA, 80 kV, and exposure time 17.5 s. From the reconstructed volume the "sagittal" slices (1 mm thick) were placed parallel to the horizontal axis of the alveolar process. This means that new slices for each specific root were not performed. The images were analyzed on a Dell Workstation PWS 350 and a Dell monitor (size 18 inches) with Trinitron tube, 1024 × 768 pixels.

### Evaluation of the radiographs

Three specialists in oral and maxillofacial radiology analyzed all radiographs together. First, the intraoral ones were evaluated and, after at least 2 wks, all Accuitomo images. In case of disagreement the observers had to reach consensus. At a later occasion the observers did a direct comparison between intraoral radiographs and Accuitomo images. For each case it was noted whether additional information was obtained with the Accuitomo images relative to the intraoral ones and what type of information it was.

A periapical lesion was defined as a periapical radiolucency in connection with the apical part of a root exceeding at least twice the width of the periodontal ligament space. In the Accuitomo images the lesion had to be visible in more than 1 of the image planes.

Parameters analyzed are shown in Table II. In both

**Table II.** Parameters scored in periapical radiographs and 3D Accuitomo

Parameter	Technique	
	Periapical radiographs and 3D Accuitomo	Only 3D Accuitomo
Number of:		
roots	X	
root canals (unfilled and filled)	X	
roots involved in lesion	X	
Presence of:		
root canal post	X	
periapical lesion	X	
Size of lesion	X	buccal-palatal dimension
Effect on or perforation of cortical bone plate	X	
Distance between:		
lesion and mandibular canal/ maxillary sinus	X	
apex and mandibular canal	X	
Expansion of lesion into maxillary sinus	X	
Apical-marginal communication	X	
Marginal bone level	X	

types of images the presence and location of a lesion in relation to the root(s), cortical bone, maxillary sinus, and mandibular canal were studied and number of roots and root canals with and without filling or post assessed. In the upper jaw the distance between the root apices/lesions and the inferior border of the maxillary sinus and in the lower jaw that between the apex/lesion and the upper border of the mandibular canal were evaluated. In the periapical radiographs, measurements were made with a ruler and in the Accuitomo images with the inbuilt measurement tool. In Accuitomo images the lesion size was measured in all 3 dimensions and in periapical radiographs in 2. An apical-marginal communication was considered present when the periodontal ligament space, from the marginal bone crest to the apex or the periapical lesion, was twice its normal width or more.

## RESULTS

Of all 46 teeth analyzed, 41 (89%) had been endodontically treated, of which 23 (56%) had a post in one or more root canals. In the periapical radiographs, 2 premolars were assessed to have 2 roots whereas only 1 was seen in the Accuitomo images, 3 maxillary molars were assessed as having 2 roots and 3 also found in the Accuitomo images. With respect to root canals, 124 were found in the periapical radiographs and 12 (10%) more in the Accuitomo images (7 in maxillary

and 5 in mandibular molars). The maxillary sinus was assessed as being situated between the buccal and palatal roots in 7 teeth in periapical radiographs and in an additional 4 in the Accuitomo images.

In the same 32 teeth, periapical lesions were diagnosed in both periapical radiographs and Accuitomo images. For distribution of tooth type and number of teeth with periapical lesion diagnosed per technique, see Table I. In the Accuitomo images, however, 10 more teeth with periapical lesions were found. The sizes of lesions, as measured in Accuitomo images, that were not detected in periapical radiographs are shown in Table III. When the presence of periapical lesions was related to individual roots rather than teeth, lesions were found at the same roots, in both techniques, in 53 cases. At an additional 33 roots, lesions that were not visible in the periapical radiographs were found in the Accuitomo images. Erosions, or perforations, of the buccal and/or the palatal/lingual bone plate at the level of the apices were noticed 9 times more often in Accuitomo images than in periapical radiographs. In the latter images, lesions at 13 teeth were seen to expand into the maxillary sinus, whereas the same finding was made at 18 teeth in Accuitomo images. In 11 cases this observation was made at the same teeth with both techniques. Thickening of the mucous membrane in the maxillary sinus was seen more than 4 times as often in Accuitomo images (30 cases) than in periapical images (7 cases).

The mean distance, as measured in periapical radiographs, between the apex of mandibular molars and the upper border of the mandibular canal was 2.5 mm (range 0-6.0 mm;  $n = 8$ ). In 4 cases the canal was outside of the imaged area. In corresponding Accuitomo images the mean distance was 2.8 mm (range 0-5.0 mm;  $n = 8$ ). The mean distance between periapical lesions and the mandibular canal was 2.0 mm (range 0-4.0 mm;  $n = 6$ ) in periapical radiographs and 2.1 mm (range 0-5.0 mm,  $n = 6$ ) in corresponding Accuitomo images.

Apical-marginal communication was seen at the same 4 teeth in both types of images and at an additional 5 teeth in Accuitomo images. In both techniques the distance between the marginal bone level and the used reference point ranged between 1.0 and 2.0 mm. The distance could not be assessed at 2 teeth in periapical radiographs, owing to overlapping, and at 11 teeth in Accuitomo images. In those images the most common reason was artefacts from metallic root canal posts, crowns, or fillings.

When both techniques were analyzed together, all observers agreed that the Accuitomo images in 32 (70%) cases provided clinically relevant additional information not found in the periapical radiographs. In 3

**Table III.** Tooth type and size (in mm, as measured in 3D Accuitomo) of periapical lesions undetected in periapical radiographs

Jaw	Tooth type	Root involved	Height	Mesiodistal	Buccolingual
Maxilla	1st molar‡	p§	9.6	13.3	11.3
		mb	3.3	2.3	4.0
		db	0.9	5.2	3.4
	1st molar	db	4.4	4.0	3.0
		mb	1.0	1.8	2.0
	1st molar	mb*	0.8	2.0	2.5
	2nd molar‡	(mb, db, p§)†	9.6	13.3	14.3
	2nd molar	(mb, db, p)†	4.5	6.0	13.0
	2nd molar	p*	1.7	1.9	3.1
	Mandible	2nd molar	d*	2.9	2.8
2nd molar		m*	1.0	1.0	1.0
2nd molar		m*	1.0	2.0	2.0
2nd molar		m*	0.5	2.0	2.0
Mean value			1.0	2.8	4.4

p, palatal root; mb, mesiobuccal root; db, distobuccal root; d, distal root; m, mesial root.

\*Other roots without lesion.

†One lesion.

‡Shown in Fig. 1.

§Fusion of lesions at adjacent teeth.

more cases this was the opinion among 1 or 2 of the observers. The additional information consisted of better visualization of the anatomy of roots and root canals, improved understanding of the location of lesions and of the relation between lesions and the maxillary sinus, and a more accurate appreciation of lesion size.

**DISCUSSION**

The results suggest that 3D imaging of teeth and surrounding bone may be of value in cases of endodontic problems, not least when related to multirouted teeth. There are several reasons for this. When using tomographic slices, rather than images in which an entire volume is compressed into a 2D image, the problem of superimposition of unrelated structures onto the features of interest decreases. In periapical radiography, especially in the maxillary molar region, the irradiation geometry often cannot become optimal, e.g., owing to a low palatal vault. An irradiation geometry with the x-ray beam coming too much from above results in a superimposition of the maxillary zygomatic process and the zygomatic bone onto the roots as well as a distorted image of them. When roots diverge they become displayed with different degrees of distortions in periapical radiographs, and when they are close together they cannot always be separated from each other even if several radiographs are taken. When using appropriate tomographic techniques it is possible to look at each root separately. Slice angles can be chosen so that the frontal and sagittal slices, respectively, become parallel with the longitudinal axis of the root and, therefore, the axial slices perpendicular to it. These factors

make the superiority of high-quality tomographic techniques over conventional radiography obvious.

The decrease of the negative influence on the detectability of lesions caused by a complex background pattern,<sup>1,16</sup> or too much unaffected mass on either side of them,<sup>6,17,18</sup> may be the main reason why 10 teeth with periapical lesions that were undetected in periapical radiographs were found in the Accuitomo images. Most were small (Table III), which gives further credence to this explanation. Surprisingly, however, 3 large lesions were undetected in periapical radiographs. They involved the entire alveolar process in the buccopalatal direction, had perforated the cortical bone, and expanded into the maxillary sinus (Fig. 1). In 2 of these cases there was also a thickening of the mucous membrane along the sinus floor. Lack of a well defined border of the lesions might have led to the false negative diagnoses made from the periapical radiographs.

In the planning of apical surgery, knowledge of the location of the maxillary sinus or the mandibular canal can be essential. The divergence and location of roots in the alveolar process and the relation between the sinus cavity, roots, and lesions may influence the surgical approach. It has previously been shown that cone-beam CT examination helped in the treatment planning and conduction of endodontic surgery of first maxillary molars.<sup>19</sup> We found more affected roots with the Accuitomo technique than with intraoral radiography and more lesions that expanded into the maxillary sinus. This lends support to the conclusions drawn by Rigolone et al.<sup>19</sup>

The mandibular canal was seen more often in 3D

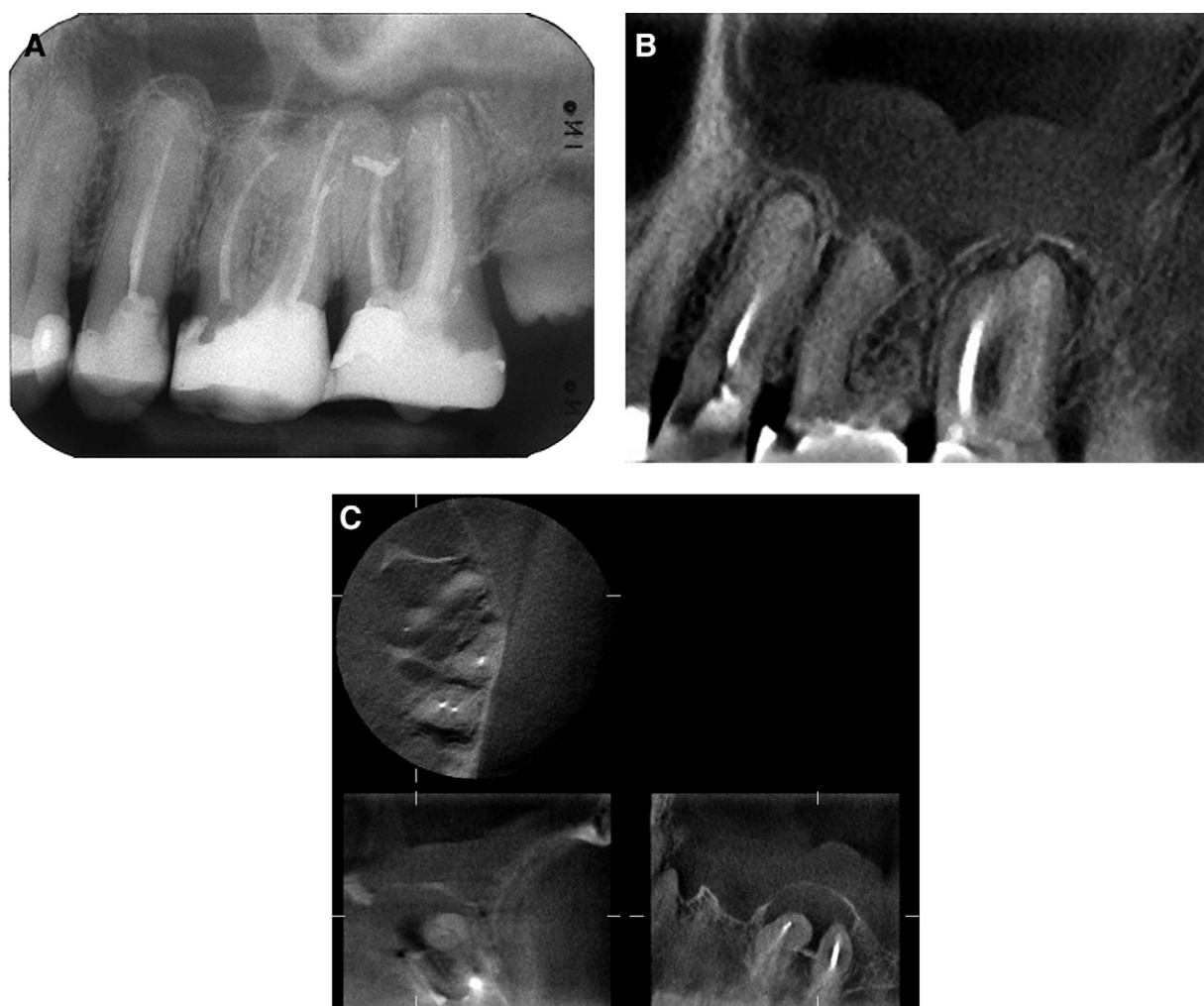


Fig. 1. The lesions of the first and second maxillary molar were not detected in the periapical radiographs (A), but were clearly visible in the Accuitomo images (B, C). C, The lesion at the second molar is seen in 3 perpendicular planes. The 4 white markers in each image indicate the relation between reconstructed planes. Axial and frontal views show the perforated palatal bone plate. The expansion of the lesion into the maxillary sinus at the palatal roots of first and second molar is shown in the sagittal view. B, Thickening of the mucous membrane along the sinus floor above the buccal roots is seen in the sagittal view.

Accuitomo than in periapical radiographs. In the latter the perceived relation between the mandibular canal, root apices, and periapical lesions can vary owing to the inclination of the roots within the jaw and the irradiation geometry. Velvart et al.<sup>13</sup> noted that CT was more accurate in determining the distance between roots and the mandibular canal than periapical radiography, which could be misleading. They also remarked that 3D imaging was of great help in apical surgery, because it could be better planned.

When metallic objects are present in either the tooth of interest or an adjacent one, artefacts can make evaluations difficult in Accuitomo images. In some cases they made it impossible to measure the marginal bone level. Periapical radiographs were then of great help.

The artefacts arise owing to problems in the reconstruction algorithm when handling the transition between metal and tissue. A similar problem is well known in conventional CT.

The effective dose of 2 periapical radiographs in the molar regions has been reported to be 0.01-0.02 mSv,<sup>20</sup> and, according to Iwai et al.,<sup>15</sup> it is 0.006-0.012 mSv when using the Accuitomo technique.

In this study, films were used for the intraoral technique. Unlike film images, digital images can be manipulated to make them better suited for different diagnostic tasks. In vitro, it has been shown that observers were somewhat better in detecting lesions confined to the lamina dura and the cancellous bone when digital images were used as opposed to film images.<sup>21</sup> As regards lesions

involving the cortical bone, no difference was found between film and digital images.<sup>22</sup> However, contradictory results<sup>6,18</sup> have been reported. It should be noted that digital intraoral techniques do not differ from nondigital methods with respect to superimposition of anatomic structures onto features of diagnostic interest.

Other tomographic methods have been used in endodontic diagnosis. Tammissalo et al.<sup>23</sup> used conventional spiral tomography (Scanora) and found it better than periapical radiography in detecting periapical lesions in the premolar and molar regions. Tuned-aperture CT is a method yielding 3D information based on a series of intraoral radiographs taken from different directions.<sup>24</sup> It has been shown to be an effective tool to visualize osseous healing in rabbits<sup>25</sup> and root fractures.<sup>26</sup> So far, however, the technique is not commercially available.

We conclude that in selected cases, e.g., when there is no detectable pathology in periapical radiographs although clinical tests indicate so, or when endodontic surgery is planned for multirrooted teeth, additional radiographic examination using a 3D technique, such as the 3D Accuitomo, should be considered.

## REFERENCES

- Kundel HL, Revesz G. Lesion conspicuity, structured noise, and film reader error. *Am J Roentgenol* 1976;126:1233-8.
- Bender IB, Selzer S. Roentgenographic and direct observation of experimental lesions in bone: I. *J Am Dent Assoc* 1961;62:152-60.
- Bender IB, Seltzer S. Roentgenographic and direct observation of experimental lesions in bone: II. *J Am Dent Assoc* 1961;62:708-16.
- Schwartz SF, Foster JK. Roentgenographic interpretation of experimentally produced bone lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1971;32: 606-12.
- Lee S-J, Messer HH. Radiographic appearance of artificially prepared periapical lesions confined to cancellous bone. *Int Endod J* 1986;19:64-72.
- Wallace JA, Nair MK, Colaco MF, Kapa SF. A comparative evaluation of the diagnostic efficacy of film and digital sensors for detection of simulated periapical lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;92: 93-7.
- Shoha RR, Dowson J, Richards AG. Radiographic interpretation of experimentally produced bone lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1974;38:294-303.
- Scarfe WC, Czerniejewski VJ, Farman AG, Avant SL, Molteni R. In vivo accuracy and reliability of color-coded image enhancements for the assessment of periradicular lesion dimensions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999;88:603-11.
- Marmary Y, Koter T, Heling I. The effect of periapical rarefying osteitis on cortical and cancellous bone. A study comparing conventional radiographs with computed tomography. *Dentomaxillofac Radiol* 1999;28:267-271.
- Brynnolf I. Roentgenologic periapical diagnosis. One, two or more roentgenograms? *Sven Tandlak Tidskr* 1970;63:345-50.
- Forsberg J, Halse A. Radiographic simulation of a periapical lesion comparing the paralleling and the bisecting-angle techniques. *Int Endod J* 1994;27:133-8.
- Tachibana H, Matsumoto K. Applicability of x-ray computerized tomography in endodontics. *Endod Dent Traumatol* 1990;6:16-20.
- Velvart P, Hecker H, Tillinger G. Detection of the apical lesion and the mandibular canal in conventional radiography and computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;92:682-8.
- Arai Y, Honda K, Iwai K, Shinoda K. Practical model "3DX" of limited cone-beam x-ray CT for dental use. In: Lemke HU, Vannier MW, Inamura K, Farman AG, Doi K, editors. *Computer assisted radiology and surgery*. Amsterdam: Elsevier; 2001. p. 713-18.
- Iwai K, Arai Y, Hashimoto K, Nishizawa K. Estimation of effective dose from limited cone beam x-ray CT examination. *Jpn Dent Radiol* 2000;40:251-9.
- Revesz G, Kundel HL, Graber MA. The influence of structured noise on the detection of radiologic abnormalities. *Invest Radiol* 1974;9:479-86.
- Bender IB. Factors influencing the radiographic appearance of bone lesions. *J Endod* 1982;8:161-70.
- Paurazas SB, Geist JR, Pink FE, Hoen MM, Steiman HR. Comparison of diagnostic accuracy of digital imaging by using CCD and CMOS-APS sensors with E-speed film in the detection of periapical bony lesions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;89:356-62.
- Rigolone M, Pasqualini D, Bianchi L, Berutti W, Bianchi SD. Vestibular surgical access to the palatine root of the superior first molar: "low-dose cone-beam" CT analysis of the pathway and its anatomic variations. *J Endod* 2003;29:773-5.
- Ekestubbe A, Thilander-Klang A, Lith A, Gröndahl H-G. Effective and organ doses from scanography and zonography: a comparison with periapical radiography. *Dentomaxillofac Radiol* 2004;33:87-92.
- Yokota ET, Miles DA, Newton CW, Brown CE Jr. Interpretation of periapical lesions using radiovisiography. *J Endod* 1994;20:490-4.
- Kullendorff B, Nilsson M, Rohlin M. Diagnostic accuracy of direct digital dental radiography for the detection of periapical bone lesions: overall comparison between conventional and direct digital radiography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996;82:344-50.
- Tammissalo T, Luostarinen T, Vähätalo K, Tammissalo EH. Comparison of periapical and detailed narrow-beam radiography for diagnosis of periapical bone lesions. *Dentomaxillofac Radiol* 1993;22:183-7.
- Webber RL, Horton RA, Tyndall DA, Ludlow JB. Tuned-aperture computed tomography (TACT™). Theory and application for three-dimensional dento-alveolar imaging. *Dentomaxillofac Radiol* 1997;26:53-62.
- Nair MK, Seyedain A, Agarwal S, Webber RL, Nair UP, Piesco NP, et al. Tuned aperture computed tomography to evaluate osseous healing. *J Dent Res* 2001;80:1621-4.
- Nair MK, Nair UP, Gröndahl H-G, Webber RL, Wallace JA. Detection of artificially induced vertical radicular fractures using tuned aperture computed tomography. *Eur J Oral Sci* 2001;109:375-9.

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