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Diagnostic imaging of chronic inflammatory periapical lesions

Dimitar Yovchev[1], Janet Kirilova[2]

1. Department of Imaging and Oral Diagnostic, Faculty of Dental Medicine, Medical University, Sofia, Bulgaria
2. Department of Conservative Dentistry, Faculty of Dental Medicine, Medical University, Sofia, Bulgaria

Abstract

The Imaging methods are an integral part in diagnostics and follow up of the osteolytic changes in chronic inflammatory periapical lesions. The review examines the opportunities of the main imaging methods applied in everyday practice for visualizing these changes - intraoral radiographs, panoramic tomography, and cone beam computed tomography. Their advantages and disadvantages in the diagnostic process are discussed. Due to the availability of different imaging methods for diagnosing the changes in the periapical region and the associated with them specific features, including differences in the received dose, finding the appropriate one, and minimizing the dose is a challenge.

It can be overcome only if the advantages and disadvantages of the imaging methods are well known.

Keywords: intraoral radiographs; panoramic tomography; cone beam computed tomography (CBCT); apical granuloma; radicular cysts.

Introduction

The diagnostic imaging methods, medical history, clinical examination, and other no imaging diagnostic methods (electropulp and thermal tests) are essential for the final diagnosis (1).
The imaging methods for diagnosing the osteolytic changes around the root apex include intraoral radiographs, panoramic tomography, and cone beam computed tomography (CBCT).

In many cases, an accurate diagnosis based only on imaging methods is not possible due to the non-specific characteristics of the findings. For example, an oval radiolucent periapical shadow with a distinct border can be seen in chronic localized periodontitis (granuloma), and also in the case of a radicular cyst, the immature focus of periapical cemental dysplasia (stage I), etc.
Imaging studies can reveal essential information for the treatment (conservative and surgical) of chronic apical lesions: thickening of the sinus mucosa in chronic sinusitis, presence and course of a fistula, features of the root canal system, proximity of critical anatomical structures, etc.

Imaging characteristics of the different chronic inflammatory periapical lesions

The osteolytic changes in the area at the root apexes, according to the imaging findings (location, shape, size, and border of the radiolucency), are usually classified into one of the following diagnoses: chronic apical periodontitis (granuloma), periapical abscess (with or without fistula) or a cyst (29).
The periapical granuloma is visible radiographically as an oval radiolucent shadow with a sharp border interrupting the dental alveolus's cortical plate (lamina dura) (29) Fig. 1.

Fig 1. Digital intraoral radiograph of tooth 25 in a patient with chronic apical localized periodontitis (d.d. small radicular cyst). Additional findings: missing part of the crown of tooth 25 and caries in the crown of tooth 24.

The radicular cyst has radiographic features similar to periapical granuloma - an oval or well-defined pear-shaped radiolucency with an osteosclerotic rim, usually < 1 cm in diameter, and an interrupted lamina dura (29, 32, 34). Fig 2.

Fig 2. An intraoral radiograph of a patient with a radicular cyst.

Due to the similarity of the radiological of finding the periapical granuloma and the radicular cyst, it is not always possible to distinguish them accurately using radiographic methods and the available clinical data (24, 30).
Juerchott et al. established that the differentiation between radicular cysts and granulomas in vivo can be reliably provided by magnetic resonance imaging (MRI) (26).
Occasionally the chronic inflammation in the apical region presents as condensing osteitis. The radiographic finding includes a homogeneous radiopaque shadow in the area at the root apex due to marked osteosclerosis and a slightly widened periodontal ligament space in some cases (30).

In the case of periapical abscess in the acute phase, a minimal widening of the periapical periodontal ligament space and intact cortical plate (lamina dura) are found (30, 31).
In a periapical abscess with chronification and formation of an osteolytic defect filled with pus, the imaging finding includes the destruction of the cortical plate and the presence of a radiolucent shadow with an irregular border (blurred in case of exacerbation) in the region of the periapex (29,31,32).
Although it is less often, the osteolytic changes in the apical root region can also be due to other conditions. They expand the differential diagnosis, including periapical cemental dysplasia (stage I), foreign body reaction (incl. around extruded root canal filling material), keratocyst, traumatic cyst, ameloblastoma, cholesterol granuloma, fibrous dysplasia, osteomyelitis, tuberculosis, primary and secondary malignant neoplastic processes etc.
Regarding differential diagnosis, some other conditions, such as periapical fibrous connective tissue (periapical scar), and osteoporotic bone marrow defect, should also be considered.

Discussion

Intraoral radiographs are a largely available and inexpensive method to visualize the changes around the root apex at a lower dose (compared to panoramic tomography and CBCT). The use of digital sensors significantly reduces the dose compared to film radiography – a significant advance because more than one intraoral radiograph are required during endodontic treatment.
The image quality of intraoral radiographs is essential for successful diagnosis. It depends on various factors: optimal choice of exposure parameters (exposure duration (< 1 s), electrical current (varying between 3.5 - 8 mA), voltage (ranging between 60 kV and 70 kV)), focal spot size (varying from 0.4 mm to 0.7 mm), movement of the object during the exposure and applying of correct radiographic technique.
The intraoral radiographs have some limitations, including two-dimensional images, varying degrees of geometric deformation, and a small area covering. To see larger lesions around the apex, another X-ray or applying of another imaging method is required.
Other disadvantages of intraoral radiography are the discomfort for the patient related to the rigidity and size of some sensors; sensor positioning errors; ability to manipulate the image (2); superimposition of anatomical structures over the examined lesion leading to poor visibility or invisibility of the lesion (3).
Using intraoral radiography, difficulties can be encountered to establish the remodeling or destruction of the cortical layer or to determine the anatomical relationship between the lesion and the maxillary sinus, mandibular canal, etc. (4, 5).
If the periapical lesion is located only in the spongy substance and the cortical layer is not affected, the lesion can not be easily detected (6, 7, 8, 9).

Panoramic tomography (PT) provides an image of both jaws (an advantage vs intraoral radiographs).
In order to increase the sensitivity and specificity of the diagnosis in apical lesions the panoramic tomography is often combined with intraoral radiographs (10, 11).
The deformity of the panoramic tomography image should also be considered evaluating the progression, regression, or stationing of osteolytic changes at the apex (12).
The anatomical variations of the jaws, and the incorrect positioning of the patient can be related to incomplete including of some structures in the focal layer. This can result in blurred and distorted image (13).
Another imaging modality is the ***Cone Beam Computed Tomography (CBCT)***. This method has advantages such as: obtaining reconstructed images in different planes at high resolution (reaching in some

devices up to a voxel size of 0.076 mm), three-dimensional images, a lower dose (compared to MDCT), a possibility of accurate measurements (linear and volumetric), etc. (Fig.3).
Delicate anatomical structures such as mandibular incisive canals, lingual vascular canals, and accessory mental foramina (usually < 1 mm in diameter) can be distinguished by the method (14, 15, 16).
CBCT can visualize obliteration in the dental pulp, root canals and ramifications in the root canal system, the presence and course of the middle medial root canal in the lower molars, and other less common variations of the root canal system.

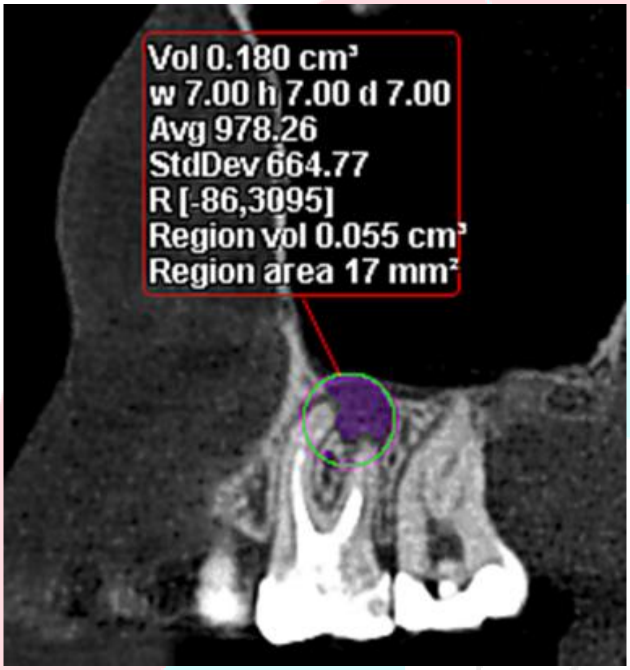

Fig. 3. Sagittal CBCT slice shows chronic localized periodontitis at the apices of the vestibular roots of tooth 26 with a measured lesion volume – 0.055 cm^3.

CBCT also allows visualization of periapical lesion borders and proximity of the lesion to important anatomic structures (e.g., maxillary sinus) – information that cannot be obtained sufficiently from intraoral radiography or panoramic tomography (17,18). The method can detect lesions located between the roots or behind them.
According to van der Borden et al. and Okada et al., CBCT can detect 20-39% more periapical lesions than two-dimensional radiographic methods (19, 20).
CBCT has a limited ability to differentiate soft tissues (poor soft tissue contrast), lower resolution compared to intraoral radiography, and a relatively higher effective dose compared to conventional radiographs, which can reach up to 40 times the dose in panoramic tomography (21, 22).
The dose of CBCT varies widely among available devices and it is also influenced by the chosen parameters of the examination (21).
The application of CBCT in endodontics should be carefully considered on a case-by-case basis and done after a detailed clinical examination, including an analysis of the available radiographs (21).
When CBCT examination in endodontics is required, only a small field of view (FOV, <5 cm) with a high-resolution examination is applicable. This minimizes the effective dose and improves spatial resolution (21).
A factor affecting the image quality of CBCT is the presence of scattering and beam hardening artifacts from high-density structures (posts, metal restorations, gutta-percha, etc) (21).
To reduce motion artifacts, stable patient positioning is mandatory (21).
Artifacts can make difficult assessments of crown fit and root canal fillings' quality (24, 25).

Magnetic resonance imaging (MRI). There are also studies about the opportunities of MRI in diagnosing osteolytic changes at the apex, indicating that the method can provide more detailed characteristics of these lesions (26, 27, 28).
MRI has some advantages (among them the absence of ionizing radiation) and has similar to CBCT diagnostic value in detecting changes at the root apex (26, 27, 28).
Some authors suggest combining CBCT and MRI for a more precise diagnosis of complex periapical pathological conditions (17).

MRI has some limitations: it cannot be used in patients with retainers or orthodontic brackets made of ferromagnetic alloys; the high price; a long time to prepare the patient, the duration of the examination itself; not applicable for patients with electronic devices implanted in the body (in case if they are not compatible with MRI), etc. (17, 28).

A helpful starting point for choosing an imaging method for diagnosing periapical lesions are the recommendations developed by the European Association of Endodontics, the American Association of Endodontists, the American Academy of Oral and Maxillofacial Surgery, etc. (21, 33).

The updated 2016 position of AAE (American Association of Endodontists) and AAOMR (American Academy of Oral and Maxillofacial Radiology) with recommendations for the use of CBCT in endodontics stated that intraoral radiographs should be considered as the method of choice for imaging in endodontics (33).

For patients with nonspecific clinical signs and symptoms related to untreated or endodontically treated teeth, CBCT with limited FOV should be considered as a modality of choice (33).

The European Society of Endodontology (ESE) published a position for the application of CBCT; the method should be considered in cases where the lower dose of conventional radiography does not provide enough information for the diagnosis (17).

CBCT is a method of choice in the initial treatment of teeth where extra canals and complex morphology are expected, such as mandibular anterior teeth, maxillary and mandibular premolars, molars, and dental anomalies (33).

The AAE and AAOMR recommend using CBCT in endodontics, stating that limited FOV CBCT is the method of choice for pre-surgical planning to localize the root apex and visualize proximity to adjacent anatomic structures (33).

Conclusion

It can be concluded that, due to the availability of different imaging methods for the diagnosis of the changes in the periapical region and the associated with them specific features, including differences in the received dose, finding the appropriate method, and minimizing the dose is a challenge.

It can be overcome only if the advantages and disadvantages of the imaging methods are well known.

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Corresponding author:
Janet Kirilova,
Department of Conservative Dentistry, Faculty of Dental Medicine, Medical University, Sofia;
1, St. Georgi Sofiiski blvd., 1431 Sofia, Bulgaria.
Tel: +359 888343396, E-mail: janetkirilova@gmail.com