

Digital Orthopantomography vs Cone Beam Computed Tomography—Part 2: A CBCT Analysis of Factors Influencing the Prevalence of Periapical Lesions

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ABSTRACT

Aim: Cone beam computed tomography (CBCT) is the most refined and affordable method available today for the examination of an incoming patient for different dental pathologies. The aim of this paper is to evaluate the significance of some factors influencing the prevalence of apical periodontitis.

Materials and methods: An orthopantomography (OPT) and CBCT scan of the dental arches were examined for each of the selected 45 patients. The presence of apical periodontitis (AP) was compared for CBCT and OPT examination. Sensitivity, specificity, predictive values, and accuracy were calculated for CBCT, using OPT as a reference. The impact of protective/risk factors on the development of AP was examined.

Results: CBCT showed higher sensitivity (250%), predictive values (111%), accuracy (111%), and specificity (101%) than OPT. It was found to have higher sensitivity in all the dentition areas, especially where empty anatomical spaces or more radiotransparent structures have a strict relationship with the tooth apex and periapical structures like upper front area, premolar areas, and, especially, in the upper molar area. The prevalence of AP increased from 16 to 17% in the case of insufficient conservative restoration or 25% in the case of microleakage, 35–42% in the case of prosthetic restoration, 56–67% for posts, and 60 and 85%, respectively, for inadequate endodontic treatment and missed canals.

Conclusion: CBCT plays a decisive role in the evaluation of molar areas and in the endodontic treatment planning, when a close relationship between the apex and important anatomical structures exists. Different risk factors with different relevance are identified.

Clinical significance: As CBCT-examined results show, coronal restorations are moderate-risk factors, while insufficient endodontic treatments and posts are high-risk factors for the development of AP.

Keywords: Apical lesion, CBCT, Cohort study, Digital orthopantomography, Radiographic assessment.

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INTRODUCTION

Cone beam computed tomography (CBCT) is a method introduced approximately 15 years ago to visualize three-dimensional (3D) images of individual tooth or complete dentition, surrounding skeletal or periodontal tissues and to create 3D images of the area to be examined.¹

CBCT can be a powerful tool in endodontic diagnosis, treatment planning, and follow-up, offering the opportunity to see the current pathosis affecting the apexes and the real state-of-the-art of their treatments, bypassing the disturbances created by surrounding tissues.

CT scans showed full reliability for the reproduction of the tooth inner anatomy and a technical evolution and refinement, the micro CT scan, is today currently used in endodontic research.^{2,3}

In the following decades, the morphology of the canal system was studied using both the described techniques and other innovative ones, as well as in other disciplines.^{2–6}

The knowledge of anatomy and conditions of the root canal system allows the clinician to better detail treatment alternatives or the presence and extension of an apical lesion. It could be useful in making the patient aware of his clinical status, predicting a prognosis, and supporting him in taking a more informed decision about his personalized treatment plan.⁷

Even if CBCT presents radiation doses that must be taken into consideration, when we select the diagnostic tool, clinical studies comparing the presence of periapical lesions in root-filled teeth with CBCT and periapical radiographs show that CBCT identifies at least 20% more lesions than periapical radiographs.^{7–11}

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Since OPT fails to detect an important number of untreated radiolucencies, as demonstrated for periapical radiographs, its capacity in identifying the outcome of root canal therapies is questionable. Nevertheless, CBCT is currently not recommended, due to radiological considerations, for routine assessment of the outcome of root canal treatment, but its use is justified in research to provide a more objective indication of the outcomes.¹

CBCT in fact produces images of the endodontic spaces, offering not only 3D assessment of the region of interest, but also generating images with a sufficient spatial resolution to allow detailed assessment of the tooth and the surrounding bone.

Moreover, if CBCT is not currently suggested as routine assessment to evaluate the outcome of root canal treatment,¹ its use could surely be justified as a second-level examination to provide a more objective and sound examination.

Root canal treatment and retreatment studies show variable success rates of 28–97.7% in different studies.^{12–15} Some studies have limitations like the use of inexperienced operators,¹⁶ others considered low recall rates.^{17,18}

However, the fact that a single radiograph is two-dimensional is a major factor limiting its diagnostic ability.¹⁹ Other factors influencing the outcome in recognizing apical lesions are scanners themselves, the region of the jaw being scanned, superimposition or proximity of anatomical structures, exposure settings of the CBCT scanner, exposure time, size of the field of view (FOV), and the energy/potential (kV).^{20,21} The effective dose is also dependent on the region of the oral cavity being scanned.^{20–22}

The aim of this research is to perform a retrospective standardized study to evaluate the significance of some factors influencing the prevalence of apical periodontitis using CBCT in evaluating the presence of periapical lesions in a sample of 1,060 teeth.

MATERIALS AND METHODS

Forty-five patients, 20 males and 25 females, aged between 19 years and 54 years, were randomly selected from our archive (University Milano Bicocca—Department of Dentistry, Monza, Italy) between 2013 and 2018. For each patient, a radiographic examination (CBCT) was evaluated.

From a theoretical pool of 1,440 teeth (from the 45 patients examined), only 1,060 teeth were present, while the other 380 teeth had previously been extracted or lost. One hundred and sixty-five teeth showed periapical lesions on CBCT. Patients with previous orthodontic treatment, impacted teeth, teeth with an immature apex, and residual roots were excluded from the sample.

CBCT scans were acquired with a Sirona Orthophos XG 3D hybrid imaging device (Sirona Dental), with an 8 × 8 cm FOV, under the operating conditions of 85 kV and 7 mA. The high definition mode used for this study provided for a 360° rotation of the X-ray source and a scan time of 14.4 seconds with a continuous exposure. This allowed acquiring 500 individual images and reducing the resolution from 160 to 100 μm, thus, obtaining detailed, high-resolution volumes for the evaluation of the smallest structures. The X-ray dose for the 8 × 8 cm FOV was 136 to 191 μSv.

Risk factors that can cause apical periodontitis were analyzed

The prosthetic rehabilitation of the tooth has been analyzed in terms of the presence of posts and/or prosthetic crowns; the crowns have been classified into single crowns and bridges. The presence of caries, fillings, and endodontic treatment was noted. The quality of the canal treatment was evaluated by CBCT: in addition to identifying the presence of any untreated canals, the distance between the apical end of the root canal filling and the radiological apex was measured for each canal, and if this distance was more than 2 mm, the filling was considered inadequate. Finally, the presence of the Schneiderian membrane and the presence of the inferior alveolar canal at less than 2 mm from the dental apices were annotated.

The results of the radiographic evaluation have been reported in frequency tables for the presence of apical lesions and for the other risk factors.

For each patient, an OPT made in the previous 2 months was also evaluated to compare detection rates.

RESULTS

The prevalence of apical periodontitis was found to be 15.6%, as 165 periapical lesions were identified on a total of 1,060 teeth included in the study.

CBCT identified two and a half times the number of apical lesions identified by OPT in the same group of patients (Table 1).

When the endo-conservative condition of each tooth was evaluated, it was observed that

- 37% of the endodontically treated teeth had apical lesions, while 63% appeared healthy;
- if the length of the root canal filling was not adequate, 59% of the teeth had apical lesions, while the remaining 41% showed no signs of apical periodontitis;
- when an endodontically treated tooth had an untreated canal, teeth with apical lesions rose to 85%, while the remaining 15% showed no sign of apical periodontitis;
- 17% of teeth with adequate coronal obturation had apical lesions, while 83% appeared healthy;
- 25% of teeth with caries or with an infiltrated reconstruction had signs of apical lesions, as opposed to the remaining 75%.

When the prosthetic rehabilitation of the teeth was considered, it was observed that

- 42% of the crowned teeth had apical lesions, while 58% appeared healthy;
- bridge anchor crowns had a 30% probability of having periapical lesion;
- if the prosthetically restored tooth also had a post, in 53% of cases, this showed apical lesion, while in 47%, it appeared healthy (Fig. 1).

Of the 143 endodontically treated teeth, 94 (66%) had a satisfactory canal obturation, while the remaining 49 (34%) had inadequate apical extension filling. In the first group, 35 teeth had an apical lesion and 59 had healthy apices; in the second group, 29 presented an apical lesion and only 20 teeth had a healthy apex (Fig. 2).

Untreated canals were classified by the position and type. Twenty-eight untreated canals located in 20 teeth were identified, of which 2 (10%) were upper first premolars, 4 (20%) were upper or lower second molars, and 14 (70%) were upper first molars (Fig. 3).

The most unidentified and consequently untreated canal of the first upper molar was found to be the second canal of the mesiobuccal root (MB2), with 50% of all untreated canals and 74% of the superior first molar untreated canals, while the distal (D) and mesiobuccal canal (MB1) were not treated in the remaining 21 and 5% of cases, respectively.

Table 1: Revealed lesions in different dental positions by OPT and CBCT and percentage of lesions identified by CBCT compared to OPT

	All	Superior arch	Front teeth	Premolars	Molars	Inferior arch	Front teeth	Premolars	Molars
CBCT	165	92	15	37	40	73	11	18	44
OPT	66	24	8	10	6	42	7	13	22
Percentage	250.0	383.3	187.5	370.0	666.7	173.8	157.1	138.5	200.0

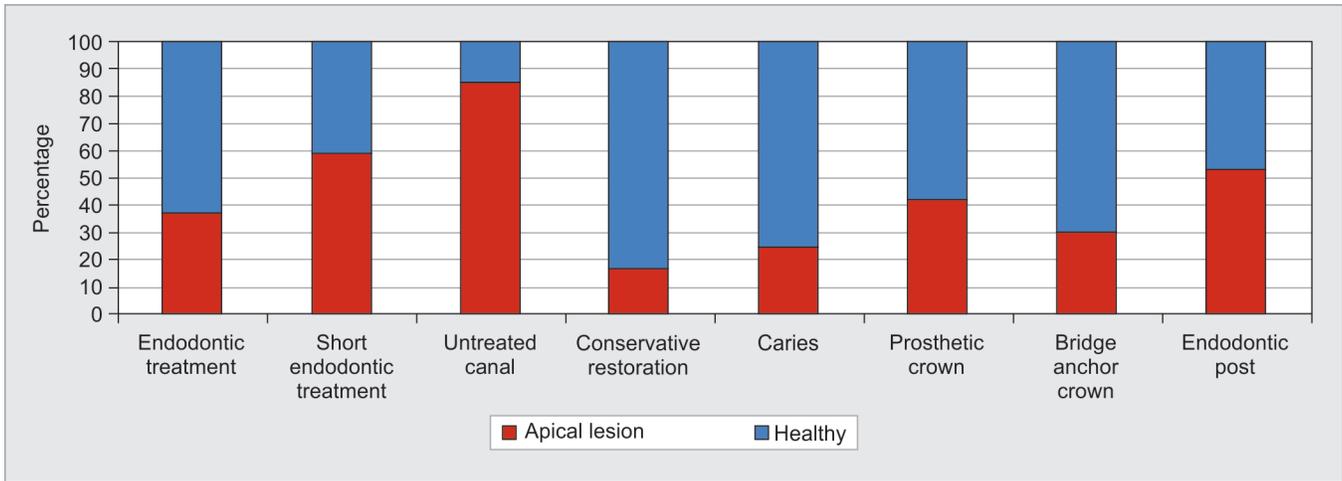


Fig. 1: Percentages of pathological and healthy apices in the different risk categories considered in this study

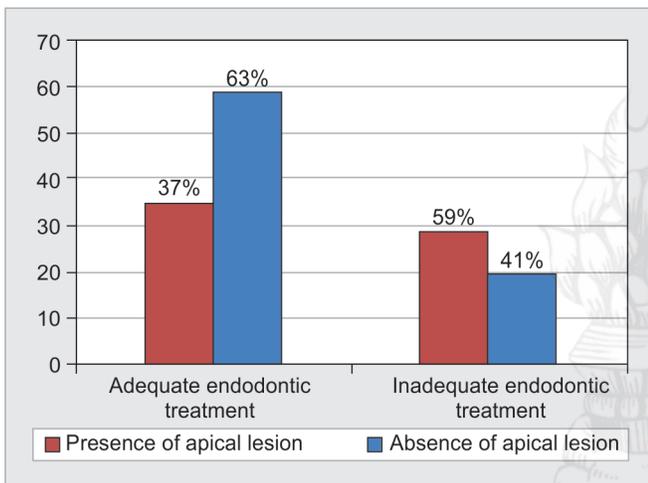


Fig. 2: Frequency of distribution of endodontic treatments evaluated in terms of root canal obturation length

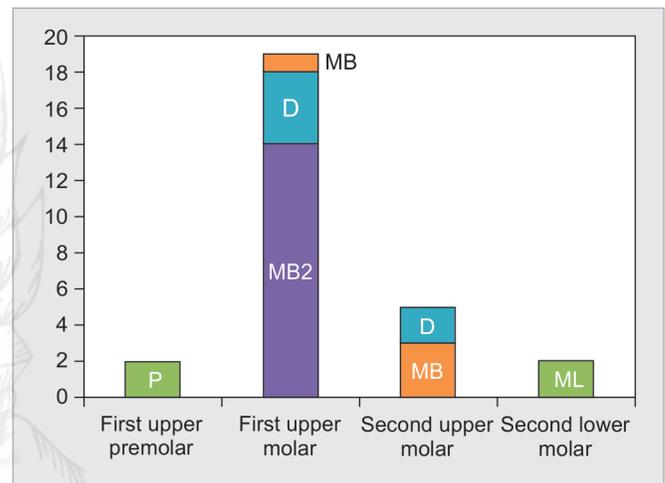


Fig. 3: Frequency of distribution of untreated canals divided by the type of tooth

The most frequently untreated canals in second superior molars were the mesiobuccal (60%), whereas the distal canals were less frequently missed (40%).

The mesiolingual canal was the only one that could be missed in the second inferior molar and similarly the palatal canal for the first superior premolar.

Subsequently, the relationship between the development of apical lesions and the presence of an endodontic treatment in teeth that had to be prosthetically rehabilitated was evaluated. Teeth presenting both apical and coronal seals had 48% probability of having an apical lesion. Lower percentages were obtained when the endodontically treated tooth was exposed in the oral cavity without any prosthetic restoration (39%). On the contrary, if the prosthetically treated tooth had not undergone any endodontic treatment, the risk of incurring a periapical lesion was 26%.

The ability of the two radiographic methods to intercept the carious processes was investigated, too. The presence of 143 caries detected by orthopantomography was confirmed when the CBCT was examined. However, 87 additional radiolucent areas were identified using CBCT and 27 were visible only on the OPT. Frequently, it was impossible to detect radiolucent lesions on the OPT because

of the superimposition of radiopaque structures, such as prosthetic crowns and adjacent teeth in the case of dental crowding.

DISCUSSION

Validity of the Diagnostic Test

CBCT showed much higher sensitivity (250%), higher predictive values and diagnostic accuracy (111%), and similar specificity (101%) compared to OPT for the diagnosis of apical lesions (Table 2).

Endodontic Treatment Quality

Outcome studies,²³⁻²⁵ agree that treatments in which the obturation material reaches 0–2 mm from the radiographic apex are associated with a greater likelihood of success compared to short treatments (more than 2 mm from the radiographic apex) or long ones (extruded material).

Table 2: Summary table of sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy of CBCT when compared to those of digital orthopantomography

Sensitivity	Specificity	Ppv	Npv	Accuracy
250%	101%	111%	111%	111%

Actually, we found that the probability to find signs of periapical lesions is 37% in the case of teeth with adequate treatment, while it reaches 59% for teeth in which the root canal filling does not present an adequate extension in a 3D perspective. The finding that the probability of complete resolution of the apical pathology is significantly higher for adequately extended treatments confirms the fact that the elimination of apical lesions strongly depends on the quality of instrumentation and root canal obturation procedure.²⁴

The prevalence of untreated infected canals in endodontically treated teeth is 12%, while Karabucak et al.²⁶ found a higher value (23%).

The tooth with the highest incidence of missed canals is the maxillary left first molar, with 50% of all untreated canals, followed by the right one, with 18%. It seems that the endodontic treatment of the left superior side of dentition is easier for the right-handed operator and that the visibility is superior to that in the contralateral side. Lower or similar percentages were obtained for the superior first premolar (7%) and for the superior (18%) and inferior (7%) second molars.

Missed canals have an 85% probability of showing signs of an apical lesion (Figs 4 and 5). The properly treated canal is devoid of pulp residues, it is dry and disinfected and it represents an unfavorable environment for bacterial survival.²⁷

However, in cross-sectional studies based on retrospective radiographic information, it is not possible to discern a persistent lesion from a recent onset lesion or from an incomplete healing lesion (scar tissue).^{23,28} Therefore, the prevalence of apical lesions in endodontically treated teeth could be the result of an overestimation.

Posts

In our study, we observed that the presence of an endodontic post significantly increased the risk of developing a periapical lesion, regardless of the type of prosthetic restoration. This question has been rarely debated in the literature and previous findings are contradictory, but our results are clear: the probability of the presence of an apical lesion increases by 25% if a post is used for prosthetic rehabilitation. It seems that the post, although it has a modulus of elasticity similar to that of dentin, predisposes the tooth to micro-fractures and post-debonding due to the discharge of occlusal forces.²⁹⁻³¹



Fig. 4: Axial section of CBCT showing the untreated MB2 canal that was invisible on OPT



Fig. 5: The untreated MB2 canal on OPT

Apical and Coronal Seal

It was observed that teeth with both an endodontic treatment and a prosthetic restoration had a higher risk (48%) of having apical lesions compared to the teeth with the endodontic seal alone and protected only by a composite restoration (39%). Teeth that had been rehabilitated with a prosthetic restoration without root canal treatment had a further lower probability of presenting apical lesions (26%): this is due to the initial unfavorable condition, rather than by an effective operative risk. In fact, only healthy teeth can be prosthetically rehabilitated without endodontic treatment, while endodontically treated teeth were teeth with a greater risk of developing periapical pathology or frankly pathological teeth from the beginning. Apical lesions in endodontically treated teeth could also be the result of the healing process.

The unexpected discrepancy between teeth with corono-apical seal and those with only endodontic seal is due to the presence of posts, in the first of these groups, which are risk factors for root fractures and bacterial infiltration.

Coronal Restoration

When the prevalence of apical lesions was investigated for prosthetically restored teeth, it was observed that the single crown is associated with a higher risk of lesion development (42%) compared to the restorations involving adjacent teeth (30%). It seems that the single prosthetic restoration predisposes the abutment to a greater risk of coronal infiltration, lack of coronal seal and, therefore, to a consequent risk of endodontic failure. Conversely, the increased extent and surface of multiple restorations is the determining factor in the neutralization of some of the mechanical forces that tend to dislocate the prosthetic reconstruction. Single crowns are more exposed to transverse or rotational forces, contrasted only by the presence of cement.

However, possible confounding factors have been analyzed. Some authors (Maddalone et al.³² and Ivanović et al.³³) signaled posts as the predisposing factor to root fractures. Actually, posts in bridge crowns were found to be fewer than posts in single crowns (25 and 8%, respectively), but, when we excluded the teeth with posts and considered only the teeth without posts, the discrepancy between single crowns and bridges did not change. The same result was obtained when the second possible confounding factor, i.e., the endodontic treatment quality, was

examined. Therefore, since we did not find real confounding factors, the observed discrepancy between single crowns and bridges was connected to the superior exposure of single crowns to dislocating forces.

The literature contains very few studies^{34,35} which investigated the effects of caries and tooth partial reconstruction on periapical health.

In our study, teeth with adequate restorations had signs of apical periodontitis in 17% of cases, regardless of the material used, while infiltrated reconstructions and carious lesions were associated with apical lesions in 25% of cases. Therefore, the presence of an adequate restoration does not represent a high-risk factor for apical health, if the instrumentation and root filling procedures are correctly performed.

Although the beam-hardening artifacts due to the presence of radiopaque materials (enamel, filling materials, and prosthetic restorations) are limiting factors in the identification of caries, Orthophos XG 3D has already shown, in a previous study,³⁶ a much higher sensitivity and specificity than other devices for this specific purpose.

CONCLUSION

CBCT shows a superior diagnostic accuracy in all the dental areas and it plays a strategic role in the diagnosis of apical lesions of the maxillary arch, especially in the molar area, where the minimum sensitivity was observed for OPT and in the lower molar area, where the accuracy is poor. CBCT also has an important role in the endodontic treatment planning, both surgical and nonsurgical, when the probability of incurring accessories canals or a complex root canal system is high. Moreover, it provides essential support in the identification of endodontic failures, like in the detection of previously missed canals.

Our study has also pointed out that the insufficient extension of root canal filling, the presence of missed canals, and posts are important risk factors for the development of apical pathologies, whereas the coronal restorations represent moderate risk factors (Fig. 1).

CLINICAL SIGNIFICANCE

CBCT could be useful in identifying hidden periapical lesion and it is an important diagnostic tool, especially when posts, inadequate restorations, and caries are present or missed canals are suspected.

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