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Detection of Radiolucencies around Endodontically Treated Teeth on Routine CT Scans

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Abstract

Purpose: This retrospective study compared computed tomography (CT) imaging to routine dental periapical radiographs in diagnosing radiolucencies around endodontically treated teeth.
Materials and Methods: Of the 244 CT scans evaluated, 104 had no teeth on the scan. On the remaining 140 scans, 353 teeth fell into the following categories: 59 maxillary molars, 30 mandibular molars, 66 maxillary premolars, 56 mandibular premolars, and 141 anterior teeth. Positive and negative predictive values were calculated, as were sensitivity, specificity, and prevalence assuming the CT scan was the test standard.
Results: For the total tooth population periapical radiograph – CT slice sensitivity was 52, specificity was 90, the positive predictive value (PPV) was 97, the negative predictive value (NPV) was 25, and the prevalence 85.
Conclusion: In the population studied, the CT scan had a greater ability to show radiolucencies that were not evident on periapical radiographs.

While not common, it is possible for patients who have had root canal therapy to have recurrent symptoms with dental periapical radiographs that show resolution of periapical pathology and a successful obturation of the canals present; however, these periapical radiographs may not reveal periapical radiolucencies that persist long after the completion of endodontic therapy. Individuals with these persistent residual or unhealed lesions may even be symptomatic. Since the dental periapical radiograph is a 2D representation of the area in question, it is possible that occult lesions may be present. Computed tomography (CT) is 3D and may reveal lesions, if present, that would not be apparent on the dental radiograph. If so, it may prove that CT scans are an adjunctive tool in diagnosis and treatment planning.[1-5]

A necrotic pulp will not trigger changes in radiographic appearance as long as the enzymes produced by the inflammatory process do not start to demineralize the cortical plate. Studies have shown that bony lesions created entirely within cancellous bone and not invading the junction between cancellous and the inner surface of cortical bone cannot be visualized on radiographs.[1-5]

Bender and Seltzer[6] showed that if artificial bone lesions were enlarged so they encroached on the junction area of the cancellous and cortical bone, they could be seen on the radiograph. It appeared that as long as the lesion was confined within cancellous bone and not encroaching on junctional trabeculae and masked by thick cortical bone, no radiographic visualization occurred. Various degrees of radiolucencies were seen when the composition of mineralized tissues varied. The higher the calcium (hydroxyl apatite crystal) content was in a given volume of tissue, the greater the absorption of the x-rays, thus, a higher potential index of opacity occurred.[7]

Most of the root apices of the anterior teeth and the bicuspids are located in or near the buccal aspect of the cortical bone. Therefore, in most of these teeth, the development of periapical lesions appears on roentgenograms because the lesions involve the cortex sooner. The distal root of a bifurcated mandibular first molar, the roots of the mandibular second molar, and most maxillary molars (particularly the palatal root) are encased in more cancellous bone. Bender and Seltzer[6] also reported that more mandibular molars than maxillary molars exhibit areas of rarefaction. This variation may exist because the maxillary molars are encased in cancellous bone. Bender[7] found that in mandibles the lowest percent of mineral bone loss (MBL) in the direct path of the x-ray beam to create a radiolucent area in cortical bone was 6.6%.

CT imaging is now commonly used in the process of treatment planning for dental implants because of the ability to capture accurate 3D imaging of potential implant sites.[8] It has also been documented that CT imaging may be more diagnostically accurate when compared to conventional 2D periapical radiography in the detection of radiolucent osseous defects.[9,10] However, there are disadvantages associated with CT imaging, such as a decreased ability to detect a defined bone/soft tissue boundary and beam hardening artifacts.[8-10] Hardening artifacts can appear if high density objects, such as metal, are present in the field of view. These artifacts can alter the image of both hard and soft tissue and can lead to misinterpretation of the peri-implant area, and possibly an inaccurate diagnosis.[8,10]

The use of digital periapical radiology has made the acquisition, manipulation, and enhancement of periapical radiographs easier, but these features have yet to prove reliable in the improvement of diagnostic efficacy.[11] Recent reviews have demonstrated the need for more studies on the diagnostic accuracy of CT imaging.[12,13]

The purpose of this study was to compare CT imaging to routine dental periapical radiographs in diagnosing radiolucencies around endodontically treated teeth.

Materials and methods

For this retrospective study, 244 existing CT scans in the departments of prosthodontics, periodontology, dental implants, and oral surgery were reviewed. Multiple calibration sessions demonstrated the consistency of the investigators to agree on the presence of radiolucencies on both the CT scan and the periapical radiographs. The presence of any radiolucencies on endodontically treated teeth were recorded as "presence of radiolucency on CT scan," and the slice number on the existing CT scan showing the presence of the radiolucency was noted. Two researchers had to agree on the presence of the radiolucency. If a disagreement arose, a third researcher adjudicated the decision. The teeth were categorized by location: maxillary molars, mandibular molars, maxillary premolars, mandibular premolars, and anterior teeth.

The existing radiographs were then evaluated to determine if the radiolucency detected on the CT scan was visible on the periapical radiograph or vice versa. If both researchers agreed on the presence of a radiolucency, it was recorded as "presence of radiolucency on periapical radiograph." If there was a disagreement, a third investigator was called in to adjudicate the decision.

Confidentiality and data storage

Approval was sought and granted by the institution's institutional review board. A unique number assigned by the investigators was used to identify each patient. The patient's chart number, assigned by the College of Dentistry at the time of subject registration, could identify each subject, and was kept in a separate file maintained by the principal investigator and available only to the study personnel.

This was done so that if a radiolucency was detected on the CT scan that was not evident on the periapical radiograph, the investigators could notify the treating dentist at the College of Dentistry of the findings. The only data collected were the results of the radiographic evaluation. No other demographic or personal data were recorded. After the radiographs were reviewed and the treating doctor notified, where appropriate, the chart numbers (patient identifiers) were erased from the database. For statistical analysis, only numerical data were conveyed to the statistician.

Data analysis

The Chi Square test was performed to determine if there was a difference between the groups. Since it was anticipated that the prevalence of periapical lesions would be low in the studied population, positive and negative predictive values were calculated, as well as sensitivity, specificity, and prevalence, assuming the CT scan was the test standard.

Results

Of the 244 CT scans evaluated, 104 had no teeth on the scan. On the remaining 140 scans, 353 teeth fell into the following categories: 59 maxillary molars, 30 mandibular molars, 66 maxillary premolars, 56 mandibular premolars, and 141 anterior teeth. Chi Square tests for the total tooth population showed a difference in the three groups: CT scan slice, CT scan panoramic view, and periapical radiograph.

The results of the combined data for all teeth, with the periapical radiograph compared to the CT scan slice and the CT scan panoramic view, are shown in Table 1. Table 2 shows the data broken down into the individual tooth groups observed compared to the CT scan slice, but care should be observed in extrapolating conclusions due the difference in N among the groups, especially the mandibular molar group. Since sensitivity is the proportion of patients with disease identified by the test, this study showed that there is a high rate of false negatives for the periapical radiographs.

Discussion

According to Eckert et al,[14] "When sensitivity is high, there is a high true positive rate and a low rate of false negatives. Hence, a negative result to a highly sensitive test is a relatively reliable indicator that disease is absent. Specificity is the proportion of patients without disease who were identified by the test. A high specificity means there are a high number of true negative results and few false positive results. When a test with a high specificity results in a positive response, there is a good chance that disease is present, because false positives are rare. Positive predictive value (PPV) can be interpreted to mean when a test result is positive, how often is the disease present; negative predictive value (NPV) can be interpreted to mean when a test is negative, how often is the disease absent."[14] So clearly, interpreting PPV and NPV is intuitively easier.

It is apparent that if a radiolucency is evident on a periapical radiograph, it will be evident on the CT scan. What is also evident is that a radiolucency evident on the CT scan is often not visible on the periapical radiograph. Infrequently, as the data show, a radiolucency showed up on a periapical radiograph but not a CT scan. Of course, care must be taken in how we as clinicians use the data, as a radiolucency does not always indicate pathology.

The prevalence of lesions in this cohort is higher than what would be expected in the general population. All of the patients who had scans were culled from those referred to the clinic for

Table 1 Data for the total population

	Sensitivity	Specificity	PPV	NPV	Prevalence
Total population PA – CT slice	52	90	97	25	85
Total population PA – CT pan	51	88	95	26	85

Table 2 Data for the individual tooth groups

	Sensitivity	Specificity	PPV	NPV	Prevalence
Maxillary molars PA – CT slice	65	75	97	17	91
Mandibular molars PA – CT slice	57	14	92	31	81
Maxillary premolars PA – CT slice	44	100	100	31	80
Mandibular premolars PA – CT slice	39	89	94	26	81
Anteriors PA – CT slice	52	92	98	22	87

major restorative issues and in need of implant therapy, so the findings of other dental problems were not unusual.

The obligation to evaluate every area in the scan is mandatory to ensure proper treatment of our patients. It was interesting to see the number of infraboney periodontal lesions evident on the scans that were diagnosed and either being treated or were already treated based on the clinical findings. We also observed some gutta percha that was not fully obturating portions of the canals but did not have a large enough sample to see if there was any significance to this. There were also unusual radiolucencies around implants that could not be classified as "scatter" and often demonstrated unusual configurations. While some of the lesions correlated with clinical manifestations requiring treatment, many did not. A protocol to initiate a study on this issue is underway. Care must be taken in trying to compare the results presented to cone beam scans currently in use in dentistry, and future studies should be done using this diagnostic modality.

Conclusions

In the population studied, the CT scan had a greater ability to show radiolucencies that were not evident on periapical radiographs.

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