PR31

Diagnostic Accuracy of Cone Beam Computed Tomography for Evaluation of Canal Lumina

Charles Maupin[a] DDS, Nadia M. Chugal[a] DDS, MS, MPH, Ting-Ling Chang[c] DDS, Gerald Longhurst[a] DDS, Mo Kang[a] DDS, PhD, Stuart White[b] DDS , PhD, Sotirios Tetradis[b] DDS, PhD.

[a] Division of Clinical Specialties, Section of Endodontics, UCLA School of Dentistry, Los Angeles, CA
[b] Division of Diagnostic and Surgical Sciences, Section of Oral and Maxillofacial Radiology, UCLA School of Dentistry, Los Angeles, CA
[c] Division of Advanced Prosthodontics, Section of Removable Prosthodontics, UCLA School of Dentistry, Los Angeles, CA

INTRODUCTION

Cone Beam Computed Tomography (CBCT) utility and relevance to the practice of endodontics is reported with increasing frequency. Consequently, studies are needed to evaluate diagnostic efficacy of CBCT for variety of endodontic applications.

Ability to localize and negotiate all canals within a tooth is essential for rendering successful endodontic treatment and for ensuring long term successful outcome. In the process, it is necessary to minimize risks and untoward sequelae associated with treatment of challenging teeth. For example, calcified canals may pose diagnostic and treatment challenge (Fig 1). The attempt to locate calcified canals may result in significantly increased chair time for both the patient and the practitioner. Despite improved magnification technologies it may be difficult to locate and negotiate them. In the process, excessive tooth structure may be removed (Fig 2) and the tooth or a root may be at risk of untoward sequelae (perforation).

Figure 1. Periapical radiogram of tooth #30 with calcified canals

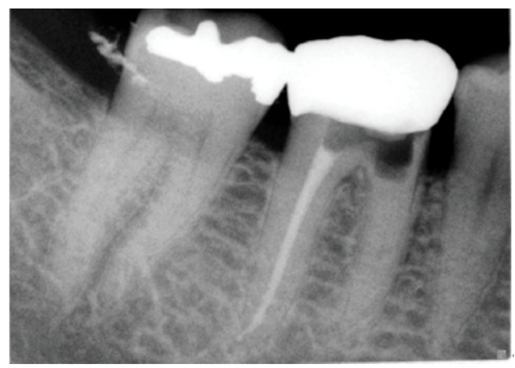


Figure 2. Tooth #30 destruction as a result of search for calcified canal(s)

The new imaging technologies such as CBCT show great promise to ascertain, before endodontic treatment is commenced, if the root canal lumen is present in a tooth that appears calcified on periapical (PA) radiograph, and if the tooth is amenable to conventional endodontic treatment.

An earlier study reported that root canal lumina were detected in an average of 98% of the roots using CBCT and 64% of roots using PA radiographs. Therefore, conventional projection radiography is not sufficiently diagnostic for determining with certainty if the canal lumen is present (Chugal et al 2008, 2009).

We hypothesize that distance of the canal lumen origin relative to the reference point such as CEJ, is significantly shorter when evaluated by cone-beam computed tomography (CBCT) compared to PA radiographs.

OBJECTIVE

The purpose of this study was to compare CBCT and conventional radiography for their ability to detect root canal lumen, localize lumen origin and determine lumen diameter.

ACKNOWLEDGEMENTS

This study was supported by the Section of Endodontics and Section of Oral and Maxillofacial Radiology. We wish to thank Brian Lozano for poster design and graphics and Dr. Kenneth Trabert, Dr. Suman Bathina and Dr. Gregory Kolber for technical assistance.

MATERIALS AND METHODS

Forty three teeth/roots (n=43) were selected from an existing collection of 1,500 extracted teeth at the UCLA School of Dentistry, and were therefore exempt from IRB requirement (UCLA IRB Exemption #:00.01.007.06.).

Screening test:: Extracted teeth from the collection were screened for the presence of calcified canals by means of digital radiography. Teeth appearing to have at least partially calcified canals were selected for the study.

Gold Standard: The teeth were examined by microCT and scored for presence of any canal lumen. These scores served as the gold standard. The root portions of the sample teeth were imaged with microCT (µCT40; Scanco Medical, Bassersdorf, Switzerland) to establish the degree of calcification of the canal space (lumen). The teeth were scanned with an isotropic resolution of 20 µm using 70 kVp and 114 µA, 200 ms integration time, and 0.36 degree stepping rotational angle for 500 projections over 180 degrees. The total scanning time was approximately 3 hours per specimen. Canals were three-dimensionally reconstructed and evaluated for volume, surface area, thickness (diameter).

Experimantal Model: Two imaging systems were compared for their ability to detect root canal lumen: CBCT images (3DX Accuitomo, J. Morita, Kyoto, Japan), and periapical F-speed film radiographs (PA). The test teeth were mounted in a dry sagittally-sectioned mandible and CBCT scans were made at 70kVp and 2.0 mA and resolution of 125 µ, (Fig 3). Periapical radiographs were also made in straight on as well as with 20-degree mesial and distal shifts at 70kVp, 15 mA and 10 pulses.

Figure 3. The test teeth were mounted in a dry sagittally-sectioned mandible and CBCT scans and periapical radiographs were made

Image Evaluation: The CBCT and PA radiographs were evaluated by two oral and maxillofacial radiologists and three endodontists and scored for presence of any canal lumen in each root. The PA images were evaluated in straight on (bucco-lingual), mesial shift and distal shift views *(Adopted from by Reit and Gröndahl 1983)*, (Table 1). The CBCT images were evaluated dynamically in the axial, sagittal and coronal planes according to same criteria. If canal lumen was present in any view, it was classified as present. The observers were blinded to the results of the MicroCT analysis.

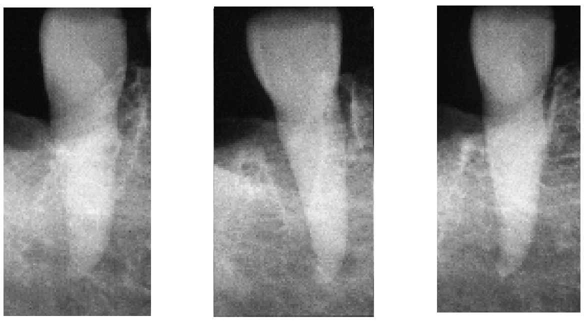
Table 1. Classification of image evaluation (Adopted from Reit and Grondhal 1983).

1.Definitely yes present
2.Probably yes present
3.Unsure/Cannot determine
4.Probably not present
5.Definitely not present

Data Analysis: Level of agreement was summarized by computing frequencies of agreement within observers and then by computing the means across observers. The level of agreement between techniques were compared with Chi-square tests and paired t-tests across observers and with McNemar's test within observers.

RESULTS

Figure 4. MicroCT image of specimen #M



Bucco-Lingual **Mesial Shift** **Distal Shift**

Figure 5. Periapical radiographs of specimen #M demonstrate calcified canal (no lumen visible) according to all 5 evaluators in bucco-lingual, mesial shift and distal shift views

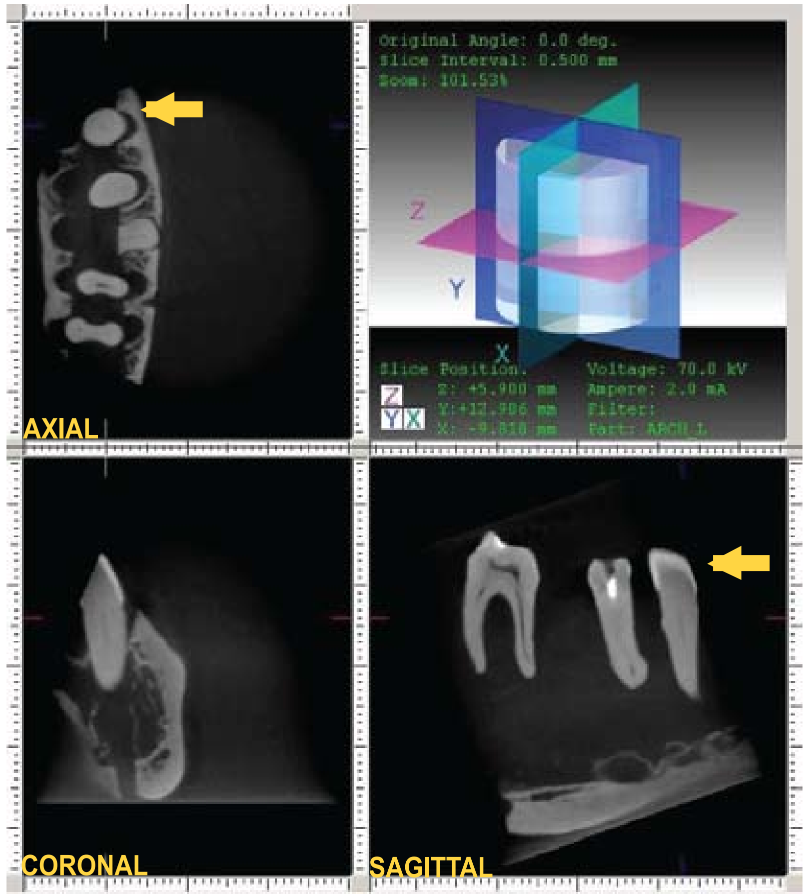


Figure 6. Cone-beam computed tomograph of specimen #M demonstrates visible canal lumen in axial, coronal and sagittal planes

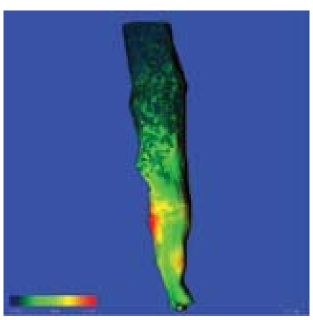
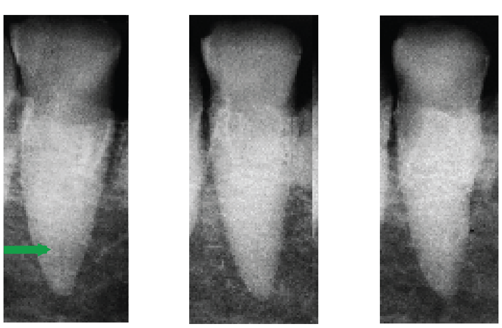


Figure 7. MicroCT image of specimen #N.



Bucco-Lingual **Mesial Shift** **Distal Shift**

Figure 8. Periapical radiographs of specimen #N demonstrate canal lumen visible at apical extent of bucco-lingual view, uncertain presence on mesial shift view and no lumen discernible on distal shift view

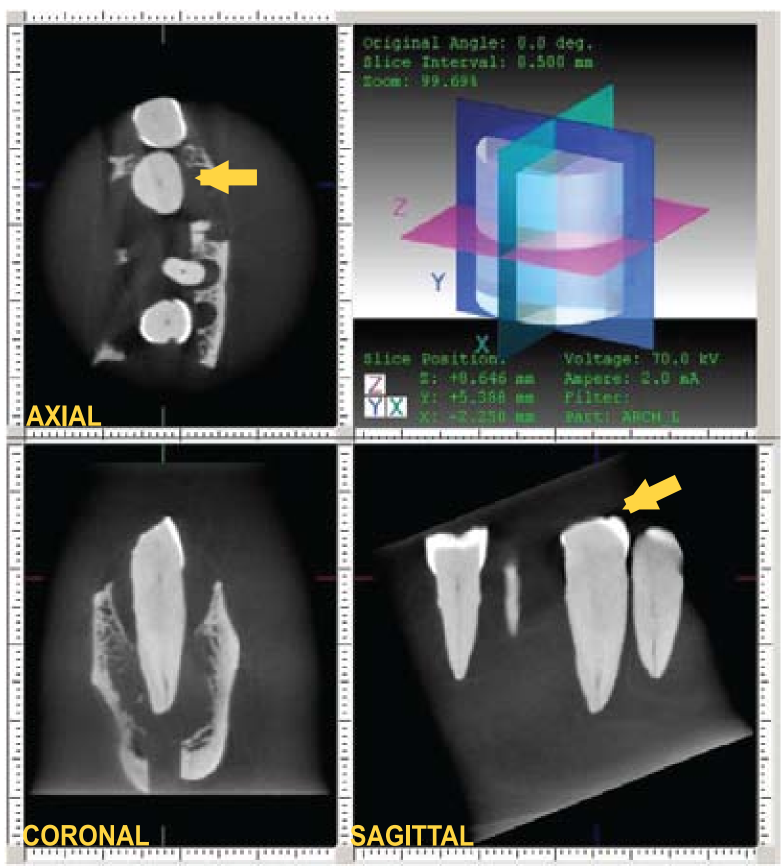


Figure 9. Cone-beam computed tomograph of specimen #N demonstrates visible canal lumen in axial, coronal and sagittal planes

We did not find any canal lumen to be completely calcified by MicroCT (Fig 4) despite the fact that canals appeared calcified on PA radiographs (Fig 5). The prevalence of canal lumina as identified by MicroCT as standard reference was therefore 100%. The reported percent agreement between MicroCT and CBCT in identifying canal lumina was 98.6% (Chugal et al 2008), (Fig 6). Therefore, there is no statistically significant difference between MicroCT and CBCT imaging systems. The percent agreement in identifying canal lumina between CBCT and PA radiographs was 69.5% and between MicroCT and PA radiographs was 69%, an average agreement across 5 observers.

We evaluated the distance of canal origin from a reference point (CEJ), on MicroCT scans (Fig 7) and PA radiographs (Fig 8). Since MicroCT and CBCT have almost perfect agreement we did not expect and did not observe any difference between MicroCT and CBCT values (Fig 9). The detection distance (in mm) of the canal lumen origin from the CEJ was significantly shorter on MicroCT scans compared to PA radiographs (Fig 10), ($p<0.05$).

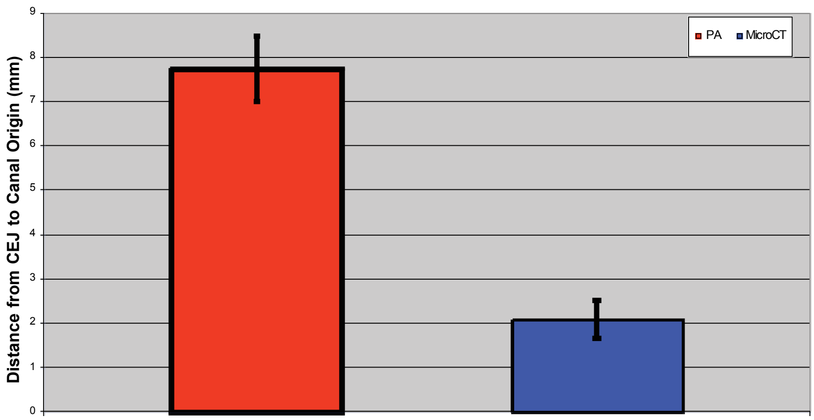


Figure 10. The distance of the canal origin from a reference point (CEJ) was significantly shorter on MicroCT scans than on periapical radiographs, $p<0.05$

Based on MicroCT data, 90% of canal origins are located within 5 mm of the CEJ compared to 28% on PA radiographs (Table 2). This finding has significant clinical implications.

Figure 2. Distance from CEJ to Canal Origin, in mm, as percent of total sample size, for MicroCT and periapical (PA) radiographs.

Distance from CE	MicroCT Scans	PA Radiographs
≤3 mm	72%	17%
≤4 mm	86%	21%
≤5 mm	90%	28%

DISCUSSION

The present study compared the efficacy of CBCT and PA radiography in detecting origin of root canal compared to MicroCT standard reference (gold standard). The results of this study demonstrate that CBCT images present high accuracy for detection of root canal origin. The average distance from reference point is significantly shorter compared to distance observed on PA radiographs and demonstrates much smaller variability compared to PA radiographs.

CONCLUSION

Compared to the MicroCT gold standard, the utility of CBCT to identify and localize canal lumen was superior to PA radiography.