The practice of endodontics is currently in a period of rapid evolutionary advancement. This article is the first in a 3-part series that will outline the areas of endodontics that have received the most revolutionary improvements. This first article illustrates cone beam computed tomography (CBCT) and its impact on our ability to 3-dimensionally diagnose and treat complex root canal systems. The second article will review the recent advances in disinfection that have brought us closer to our goal of completely disinfecting the root canal system. Finally, the third article in this series will illustrate recent advances in our ability to provide a precise and consistent 3-dimensional (3-D) seal of the entire root canal system from the apex to the cavosurface.

INTRODUCTION

CBCT has enabled the practitioner to evaluate endodontic anatomy and disease in a new way.1 Adding the third dimension in radiographic evaluation has helped close the gap in radiographic interpretation.2 Our ability to 3-dimensionally view and manipulate individual anatomy that we encounter in clinical practice has vastly increased our efficacy in diagnosis.3-5 Furthermore, the ability to render these images at such a microscopic level helps guide successful treatment. This capability to noninvasively and accurately visualize the patient’s teeth in such a way is remarkable, considering where we were just 10 short years ago.

The following cases provide examples of the impact that CBCT technology is having on improving the success of endodontic diagnosis and treatment.

LESIONS OF ENDODONTIC ORIGIN

CBCT has been paramount in our ability to evaluate and diagnose the presence and extent of endodontic disease.3-5 The following cases exhibit the benefit that CBCT has to reveal lesions of endodontic origin (LEOs) for the clinician as well as the patient.

Lesions of Endodontic Origin: Case 1

In this case, the general dentist sent the patient to the endodontist for additional evaluation of a possible radiolucency in the lower anterior (Figure 1a). The presence of a lesion was subject to interpretation on the 2-dimensional (2-D) digital image. This interpretive limitation of 2-D images has been well-known for almost 40 years.6 In this case, comprehensive pulpal testing was also compromised by the patient, who manifested obvious, hyper-

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Figure 1a. The digital periapical radiograph leaves the presence of a lesion of endodontic origin open to interpretation.

Figure 1b. Three-dimensional (3-D) cone beam computed tomography (CBCT) has the ability to more clearly illustrates the osseous changes present occurring in response to the extension of pulpal breakdown by product’s from necrotic tissue into the periradicular tissues.

Figure 2a. A unique location for a radiolucent lesion can be seen on the initial digital periapical radiograph.

Figure 2b. The CBCT 3-D rendering aided in diagnosis as it clearly illustrated a lateral portal of exit in the center of this osseous defect.

Figure 2c. The lateral portal of exit was instrumented with a sharp J curve of a stiff No. 15 hand file.

Figure 2d. The postoperative digital radiograph illustrated that the lateral system was sealed.

Figure 2e. The surgical microscope directly correlates what was preoperatively noted with CBCT.
Lesions of Endodontic Origin: Case 2

CBCT was valuable in the diagnosis of the unique appearing radiolucent lesion in the following case (Figure 2a). When the patient presented for evaluation and treatment of this radiolucent lesion, comprehensive pulp testing was done. Tooth No. 28 was verified to be nonvital. Although very suggestive of a lateral LEO, the definitive diagnosis that this lesion’s origin was due to extension of endodontic disease emanating from No. 28 was not yet made. The midroot, cystic appearing lesion did not have periapical involvement. Upon CBCT evaluation, a lateral portal of exit could be seen in the center of this osseous defect (Figure 2b). This aided in the diagnosis of a LEO.9,10 The information granted by the CBCT also impacted the efficacy of treatment as the infected lateral system was more easily located and opened with a sharp f-curve of a stiff No. 15 hand file (Figure 2c). We know that the ability to locate and physically instrument intricate areas of the root canal system increases successful disinfection.11 The postoperative digital image illustrates that the upward facing lateral canal was successfully sealed (Figure 2d). After nonsurgical treatment had been completed, surgical intervention was done due to the appearance and size of the lesion. When the radicular cyst (confirmed histologically) was removed, correlation between what CBCT illustrated preoperatively and what could be visualized directly through the surgical microscope was accomplished (Figure 2e).

MICROFRAC TURES

CBCT has greatly helped with the question of the elusive microfracture’s presence as well as its extent, both of which are significant factors related to treatment planning. The case below illustrates this challenging question related to a patient that presented with the classic “cracked tooth syndrome.”

The patient had intermittent hyperemic sensitivity as well as pain upon release from occlusion. With a 3-D evaluation made possible by CBCT, the clinician can better evaluate the presence and extent of microfractures. In this case, close evaluation of axial slices enabled the clinician to verify a microfracture was present (Figure 3a). Additional slices suggested that the microfracture was limited to the coronal tooth structure, as there were no signs of osseous changes in the periapical attachment. After treatment was initiated, the extent of the microfracture was further verified under the microscope (Figure 3b). The successful outcome to eliminate the patient’s symptoms and to retain the tooth with full coverage was confirmed at the one-year follow-up appointment (Figure 3c).

VERTICAL ROOT FRACTURES

The following 2 cases illustrate the ability of CBCT to help close the gap in estimating the presence of vertical root fractures (VRF).

Vertical Root Fractures: Case 1

When the patient presented for evaluation of generalized discomfort in the lower right, a 2-D image was taken (Figure 4a). Clinical findings were suggestive of a VRF. However, it was because of the benefit of CBCT that the patient and clinician felt more at ease in proceeding with the extraction of this tooth. CBCT was able to verify and illustrate for the patient the classic 3-D presentation of the changes in surrounding tissue in association with a VRF (Figures 4b and 4c). Upon removal of this hopeless tooth, granulomatous tissue could be seen along the mesiobuccal root (Figure 4d). The VRF was confirmed when the tooth was scaled for direct assessment (Figure 4e).

Vertical Root Fractures: Case 2

The second VRF case illustrates the ease of CBCT to show a straight buccal VRF. This is an obvious limitation of 2-D radiographs. A digital periapical radiograph was taken when the patient presented with a minor localized swelling near the buccal of tooth No. 28 (Figure 4f). Clinically, the probing and presentation of the periodontal tissues suggested that a VRF was present. However, the patient desired more definitive information before extracting the tooth and losing the long spanning bridge. Initial disassembly was undertaken to both eliminate the post’s impact on scatter in CBCT and for initial microscopic evaluation. Upon the post removal, the...
REVOLUTIONARY ADVANCES...

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The ability in accessing the location and extent of resorptive defects has been greatly enhanced with CBCT. The case illustrated here shows the typical dilemma when a 2-D image is sent for assessment of a resorptive defect (Figure 6a). The endodontist is asked by the general dentist to evaluate the resorptive defect and educate the patient about its presence. Ultimately, the objective is to provide comprehensive treatment (ie, the number goes up). When clinicians can visualize complex pulpal anatomy with CBCT, they can confidently and conservatively locate it under the microscope. With utilization of this new technology incomplete endodontic treatment can be a thing of the past.

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ASSESSMENT OF THE SECOND Mesiobuccal Canal in Maxillary Molars

Comprehensive treatment of the entire pulp system dictates endodontic success. Figures 5a and 5b illustrate the common challenge that arises as the result of a second mesiobuccal system in maxillary molars. It has been shown that 2 canals are present in the maxillary first molar 95% of the time and 93.7% of the time is second molars. Stropko also showed the impact that technology and experience have on our ability to provide comprehensive treatment (ie, the number goes up). When clinicians can visualize complex pulpal anatomy with CBCT, they can confidently and conservatively locate it under the microscope. With utilization of this new technology incomplete endodontic treatment can be a thing of the past.

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TREATMENT OF COMPLEX PULPAL SYSTEMS

The following case illustrates the benefit of CBCT in directing treatment when complex pulpal systems are encountered in clinical practice. When endodontic treatment was started on the infected maxillary 3-rooted premolar below difficulty was encountered in negotiating the buccal roots. Evaluation of the axial slices enabled the clinician to see how the buccal roots sharply separated (Figures 8a and 8b). It was noted that the canals are separated horizontally over 2.5 mm in less than 0.5 mm. Knowledge of how the canal starts as one and then splits into 2 canals, like a saddle on a horse, directed treatment. With this knowledge, conservative lateral exploration in this fragile area of furcal danger was safely accomplished (Figures 8c and 8d).

CLOSING COMMENTS

CBCT is revolutionizing the specialty of endodontics. Our ability to visualize the vast spectrum of anatomic variations in 3-D has aided in this modern era of endodontics. However, as the old saying goes, “With great power comes great responsibility.” In this new era of endodontics, the successes of our outcomes are very visible. There is value in pushing the envelope in all phases of endodontics that may improve successful outcomes so that we remain at the forefront of treatment options available to patients.

The goal of this article was to highlight areas of the endodontic practice that have been significantly impacted by CBCT. However, several areas were not covered. The ability to analyze the location of periapical anatomical structures of interest such as the sinus and neurovascular structures also holds value particularly in surgery. Existing root canal therapy can better be assessed including missed anatomy, transporta-

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CBCT eliminates angular errors such as overlapping, foreshortening, and elongating. Finally, it is difficult to illustrate the full benefits of CBCT in this 2-D venue. The benefit of being able to fluidly manipulate these 3-D computerized images cannot adequately be described in this 2-D venue.

Future Directions

The future of CBCT is bright, as many things are possible with this technology. The future of CBCT is bright, as many things are possible with this technology. C B C T images and aid in endodontic surgery. Preoperative CBCT images will be able to translate to intraoperative digital images giving valuable information to the clinician during treatment. Continued development in this software will one day allow the clinician to journey down the complexities of individual pulpal systems prior to entering the case clinically. These 3-D annotated models will be generated by CBCT and will be available to the practitioner at the click of a button."

References