The thick slice technique: a virtual periapical radiograph

Dr. Richard S. Kahan explores the benefits of using advanced CBCT techniques in radiographic comparison and illustrates its use in a clinical case

Accuracy in endodontic diagnosis has always lacked total objectivity due to the limitations in both the sensitivity and specificity of our clinical and radiographic special tests (Mejare, et al., 2015; 2012; Petersson, et al., 2012). The limitations of conventional two-dimensional radiography have been well documented, and the relatively recent introduction of limited volume cone beam computerized tomography (CBCT) in endodontics has significantly increased our ability to accurately visualize periradicular pathology through slices (Venskutonis, et al., 2014; Abella, et al., 2012), without the limitations imposed by surrounding hard tissues.

Further clinical benefits include the ability of CBCT to accurately visualize the anatomical complexities of the root canal system (Zhang, et al., 2011), to appreciate the extent of resorptions (Kamburoglu, 2011), to observe the effects of vertical root fractures (Metska, et al., 2012), and to understand treatment failure through untreated anatomy. These factors significantly enhance diagnosis, treatment planning, and clinical activity.

Using this enhanced knowledge in clinical endodontics can offer endodontists opportunities to provide patients with a greater degree of treatment predictability, and aids decision-making at the initial stages without the need for invasive procedures. Extending the use further can allow minimally invasive endodontics to treat challenging problems, such as those described in the article “Endodontics in 3D – a clinical series” (2014). This involves the continuous use of the scan during treatment utilizing head-up treatment displays.

Richard S. Kahan, BDS, MSc (Lond), LDS RCS (Eng), is a specialist endodontist working in Harley Street, London, and the former director of endodontic courses at UCL Eastman CPD. He has lectured widely on endodontics and technology, and set up the Academy of Advanced Endodontics to teach the fundamentals of endodontic treatment to GPs and master classes for specialists.

Educational aims and objectives
This clinical article aims to demonstrate an advanced CBCT technique in a clinical case using a time-shifted comparative virtual periapical radiograph created by a thick slice technique.

Expected outcomes
Endodontic Practice US subscribers can answer the CE questions on page 39 to earn 2 hours of CE from reading this article. Correctly answering the questions will demonstrate the reader can:
• See the use of virtual periapical radiographs from limited volume CBCT scans in successful endodontic diagnosis.
• Realize the potential difficulty in endodontic diagnosis regarding the comparison of radiographic imaging over time.
• Recognize the thick slice technique.

Advanced techniques in time-shifted endodontics
Beyond these novel uses of the technology, further derivations can be made using advanced post-processing techniques, fully utilizing the increased information gathered through the scan, and further justifying the increased radiation.

A particular area of difficulty in endodontic diagnosis is the comparison of radiographic imaging over time. The ability to determine whether radiolucency is increasing or decreasing in size is constantly in demand to determine the success or failure of endodontic treatment and the diagnosis of pain.

This can translate further to diagnosis and treatment planning in the presence of an asymptomatic radiolucency associated with endodontically treated teeth. This common clinical conundrum can present itself on routine radiography, and the impulse to retreat should be tempered with an initial search for historical imaging of the area to try and determine whether the lesion has changed in size over time.

The difficulties in achieving a precise comparison are well recognized, according to Wu, Shemesh, and Wesselink (2009). Beyond the subjectivity in determining the presence and size of a radiolucency with inter- and intra-observer variation, the geometry of the image and the physical difficulty of lining up the X-ray over an extended time period is more than likely to produce inaccuracies. A radiolucency projected at different horizontal and vertical angulations will appear as different sizes.

Bearing in mind all of these limitations in radiographic comparison, along with the inability to visualize up to 50% of periapical lesions using standard radiography (Venskutonis, et al., 2014), it is not surprising that our success-failure statistics are likely to be inaccurate.

Those currently quoted will almost certainly be a victim of the data “garbage in, garbage out” principle (GIGO) (López, et al., 2014).

The thick slice technique
A single limited volume CBCT scan can provide a baseline image that can be used both prospectively and retrospectively for comparison to a standard periapical radiograph taken at any horizontal and vertical projection achieved in the mouth.

Increasing slice thickness
The process involves the production of a virtual periapical radiograph from a limited volume CBCT scan by increasing the thickness of the coronal slice equal to, or larger than, the hard tissues imaged by a routine
periapical radiographic projection. This will produce a virtual periapical radiograph (Figures 1A-2B).

Adjustments in the horizontal and vertical planes

Adjustments need to be made to match the angulation of the central X-ray beam in both horizontal and vertical planes (Figures 3A-6B). This can be done through rotation in the axial and coronal planes and visual comparison with the true periapical radiograph.

The correct angulations can be judged by the relative positions of two objects to one another on the radiograph. Tooth and root morphology, restorations, and root filling materials can be effective markers. The resolution of the virtual periapical radiograph is inferior to standard radiography, and further post processing to increase the contrast (reducing the number of grayscales) is necessary.

Clinical case report

A 41-year-old female patient who had fractured her jaw 10 years previously was referred by a specialist endodontist for a limited volume CBCT scan in order to help investigate and find the source of nonspecific pain in her lower left quadrant. Both clinical and radiographic tests were inconclusive.

The LL6 had been endodontically retreated 1 year previously. The tooth had been root treated 2 years previously by a general dental practitioner and had never felt right. The re-root filling appeared satisfactory, but the periapical review radiograph showed apical radiolucencies at both mesial and distal roots. Without a common alignment of the historical radiographs with the review radiographs, the possible healing signs observed could not provide the diagnostic confidence to rule out the LL6 as the source of the pain. The LL7 did not respond.

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to vitality testing but had only a shallow restoration. The question was whether the LL6 should be retreated once again, other teeth investigated, or a referral made for atypical facial pain.

Four periapical radiographs were provided, one preoperative (Figure 7), one postoperative (Figure 8), and two review radiographs at different angles (Figures 9A and 9B).

A 4 x 4 cm limited volume CBCT scan of the lower left posterior quadrant was taken using a Morita Veraviewepocs 3D, imaging the LL5 to the LL7. A metal plate was screwed into the buccal cortical plate below the mesial root of the LL7. The LL6 had been root treated with all three canals filled to the radiographic apex. A small radiolucency was associated with the mesial root apex together with widening of the periodontal ligament (PDL) space around the distal root apex. The LL7 had a small occlusal restoration with minimal depth. The pulp chamber and the coronal third of the root canals showed significant sclerosis, and there was very definitive widening of the PDL space around the mesial root apex (Figure 10, arrowed). The LL5 showed no signs of any periradicular pathology.

A virtual periapical was produced using the thick slice technique within the One Volume Viewer imaging software and then compared to the postoperative view taken 1 year previously. Horizontal angulation was judged through the relative positions of the mesiobuccal and mesiolingual root fillings (Figure 11). The vertical angulation was judged using the distance of the distal root apex of the LL7 to the metal plate (Figure 12).
A diagnostically acceptable comparative virtual periapical radiograph was created (Figure 13). The radiolucencies at both mesial and distal roots certainly appeared to be smaller. Furthermore, the widening seen at the apex of the LL7 appeared more pronounced in the virtual periapical than the radiograph taken a year earlier.

The analysis was able to confirm healing at the LL6 and suggested a deteriorating pulpal issue at the LL7 with severe sclerosis and PDL widening. Without further clinical evidence and testing, this would not be a definitive diagnosis, but it was able to increase diagnostic confidence.

Conclusion

Limited volume CBCT scanning is a powerful diagnostic tool with particular benefit to endodontists. The increased radiation dose needs to be well justified, and it is up to the clinician to use all of the high-quality data captured for the benefit of the patient. Through careful and thoughtful processing, a single CBCT scan can be used together with standard radiography, not only for direct reporting at one instance in time, but also retrospectively as demonstrated in this article, and prospectively, for reviewing treatment carried out following a scan.

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REFERENCES