Cone Beam Computed Tomography in Endodontics

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Introduction

Conventional (both chemical and digital) radiography renders a three-dimensional (3-D) anatomical structure two dimensionally with inherent distortions. This limitation poses a steep learning curve for novice operators to interpret information from the resulting images. In many incidences, it becomes a matter of guesswork even to the experienced user, like the relationship of the maxillary molars with the maxillary sinus.

Cone beam computed tomography (CBCT) has been used in dentistry since 1998. Unlike medical CT, which captures the image in slices, CBCT data are captured in a 3-D pixel unit called voxel. As these voxels are isotropic, the object is accurately measured in different directions. This enables the rendering of geometrically undistorted images of the maxillo-facial skeletal structure and allows viewing at different angles.

In addition to providing higher resolution image, CBCT has a much reduced radiation dosage than medical CT. The exposure, at about three to ten times the radiation of a digital panoramic radiograph, is more comparable to routine diagnostic imaging with panoramic and periapical radiography. CBCT is available with different fields of view (FOV) to suit different applications. In endodontics, a machine with limited FOV should suffice. CBCT has become a routine tool in oral surgery and especially implant dentistry. With increasing affordability of the computer and less expensive CB X-ray tube, CBCT will have enormous potential in endodontics. The following case reports illustrate some of these endodontic applications.

Case Reports

Case 1 - C Shaped Mandibular Second Molar Teeth

Approximately 42% of fused-root mandibular second molars of Hong Kong Chinese patients might be associated with a C-shaped root canal system. This common anatomical variation presents a challenge to root canal treatment. The difficulties include locating and cleaning of the canal system, and instrumentation mishaps. Periapical radiograph alone is not adequate to distinguish c-shaped root canal pattern from fused roots with separate canals.

This Chinese patient had what looked like a two-rooted 47 (Fig 1a). Symptoms persisted despite instrumentation of both canals (Fig 1b). The case was referred and treated under the operating microscope, which revealed the c-shaped canal pattern (Fig 1c). The symptom was relieved after completion of treatment (Fig 1d). If a pre-operative CBCT were taken, a couple of treatment visits could be saved.

Fig 1e shows another case with c-shaped root canals in both 37 and 47.

Summary

The advantages of CBCT includes:
1. Three dimensional rendition
2. Geometrically accurate images
3. Increased sensitivity and specificity for caries, periodontal and periapical lesions
4. Patient comfort - no intra-oral placement of film or sensor.
5. Soft tissue rendition

Disadvantages:
1. Increased radiation
2. Expensive
3. Inferior resolution
4. Beam scatter and hardening by high density materials cause artifacts
5. Dentist/DSA needs to be computer savvy

Fig 1a Tooth 47 appeared to have conical root with 2 root canals.
Fig 1b Both canals identified and cleaned
Fig 1c C-shaped canal pattern revealed under the operating microscope
Fig 1d Final obturation of the c-shaped canal system
Fig 1e CBCT showing c-shaped canal pattern in both 37 and 47
Case 2 - Extra Root/Canal

This patient complained of persistent discomfort from tooth 24 despite apparently satisfactory root canal treatment. The periapical radiograph revealed satisfactory root canal fillings without periapical change (Fig 2a). As the pain radiated to the cheek and zygoma area, a CBCT was taken to check for missing root canal and possible sinus problem.

The CBCT revealed an untreated MB root canal (Fig 2b). The symptom was relieved after retreatment was performed (Fig 2c).

Maxillary molars, particularly the MB roots, present problems frequently. The MB2 canal should be considered as the norm rather than the exception. They are revealed readily with the CBCT (Fig 2d).

Case 3 - The "Hidden" Radioluencies

The CBCT gives improved sensitivity and specificity in diagnosis of periapical lesions over conventional radiographs. The analyses of diagnostic methods showed that apical periodontitis was detected more frequently when CBCT was used, compared with periapical radiograph.

This patient complained of persistent poorly located discomfort from his lower right posterior teeth. Tooth 47 was heavily restored but responsive to pulp tests. The tooth appeared normal on periapical radiograph (Fig 3a). No crack tooth was suspected in the region and the opposing dentition. There was hesitation to remove the filling for further investigation due to the potential cumulative pulpal injury from repeated operative procedure.

A CBCT revealed a periapical lesion that was not evident on the periapical radiograph (Fig 3b). Root canal treatment was instituted. The pulp was confirmed necrotic on opening. The treatment was completed uneventfully and the pre-operative symptom was cured (Fig 3d). The confronting post-operative problem is whether CBCT will be required for periodic reviews. This will imply high radiation and cost. A radiologist will be consulted.

Case 4 - Cervical Resorption

This patient was referred by his general dentist for the management of the two non-vital upper central incisors. The teeth suffered traumatic injury more than 20 years ago and became discoloured over the last few years. Both teeth did not respond to pulp tests. The periapical radiograph showed there was pulpal sclerosis, together with small periapical lesions with both teeth (Fig. 4a). There were radiolucent lesions in the root of 11. It was difficult to determine the nature of the resorptive lesions.

A CBCT was acquired and revealed multiple resorptive lacunae inside the pulp chamber of 11 (Fig. 4b). The diagnosis was cervical resorption of 11 and internal resorption of 21.

Treatment of 11 would be challenging due to the co-existence of cervical resorption and total pulpal sclerosis. Substantial tooth tissue has to be removed to gain access to these lacunae. The surgical procedure would be traumatic and destructive. As the tooth has been asymptomatic over these many years and the resorption process was slow, the patient decided not to take treatment but to keep the tooth under periodic reviews. The root treatment of 21 was completed uneventfully (Fig 4c).
Case 5 - Internal Resorption

This patient presented with buccal and lingual sinuses at tooth 36. The periapical radiograph showed radiolucent patches in and around the mesial root (Fig 5a). The CBCT revealed extensive root perforations due to internal resorption (Fig 5b, c, d). The prognosis of the tooth was poor and it was extracted.

Case 6 Pre-surgical Assessment for Apicectomy

This patient was referred by her general dentist for the management of a deteriorating periapical lesion at 36. The tooth was root filled to a high standard under rubber dam isolation a few years ago. However, the periapical lesion increased in size, together with the emergence of a buccal discharging sinus (Fig 6a, b).

It would be less likely to achieve a successful outcome if conventional retreatment was attempted in failed cases with technically satisfactory treatment8. An apicectomy with retrograde filling was planned, as the case could be infected by more resistant bacteria/fungi, or suffering from an extra-radicular infection9, a radicular cyst10, 11, or a foreign body reaction12. Furthermore the possibility of apical root fracture13 could be explored at the same time.

The periapical radiographs showed the mental foramen was in close proximity with the mesial root and the periapical lesion. A CBCT was acquired to provide a geometrically accurate assessment of the relationship between them and the ‘space’ available for surgical manipulation14 (Fig 6c). It would also show any potential missed canal.

After apicectomy and curettage, an anastomosis between the mesial canals was identified. It was prepared with endosonics and retrofilled with MTA (Fig 6d). The patient experienced minimal mental paraesthesia, which recovered completely six weeks after surgery. The case is under active review.

Other Related Applications

Simon et al15 claimed that the CBCT could distinguish between periapical granuloma and radicular cyst in 13 out of 17 cases. However, this has not been substantiated by others.

CBCT is superior to conventional radiography for the diagnosis of horizontal root fractures16, and is proved valuable for real-time assessment in maxillo-facial trauma diagnosis and treatment17. The resolution of the CBCT is low at 2 lines per mm (lpmm)18 compared with conventional (chemical and digital) intraoral periapical film with 15-20 lpmm19. This is not adequate to reveal except the more extensive vertical root fractures (VRF) (Fig 7).
This lack of resolution, however, does not affect the superiority of CBCT in the assessment of periodontal regeneration, caries and bone lesions. The image on the scan is well demarcated and provides better sensitivity and specificity than conventional radiograph. However the scatter and beam hardening could significantly affect the image occasionally (Fig 8).

Conclusion
The CBCT is a valuable adjunct to the endodontists' armamentarium. The learning curve is not steep and variability of clinical interpretation is low. However it is a sophisticated tool, requiring special skills for operating the machine and the image manipulation afterwards. Like any equipment in the digital age, continuous evolution and refinement is anticipated. Extra hidden expenses in depreciation and upgrades have to be added to the initial installation cost.

In conclusion the CBCT is a useful tool for the diagnosis and management of endodontic problems. Its use is becoming increasingly popular but some machines are better suited for endodontic purposes than others. The operators should consider their specific needs before making the move to acquiring one in the office.

References