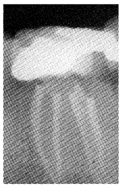
International Endodontic Journal

doi:10.1111/j.1365-2591.2011.01866.x



CASE REPORT

The use of cone beam computed tomography in the management of dens invaginatus affecting a strategic tooth in a patient affected by hypodontia: a case report

C. Durack[1,2] & S. Patel[1,3]

[1]Department of Conservative Dentistry, Dental Institute, Kings College London, London; [2]Private Practice, Dorking, Surrey; and [3]Specialist Practice, London, UK

Abstract

Durack C, Patel S. The use of cone beam computed tomography in the management of dens invaginatus affecting a strategic tooth in a patient affected by hypodontia: a case report. *International Endodontic Journal*, **44**, 474–483, 2011.

Aim To report on the use of cone beam computed tomography (CBCT) in the diagnosis and management of dens invaginatus.

Summary Chronic apical periodontitis of an invaginated maxillary lateral incisor was diagnosed in a patient suffering from hypodontia and awaiting active orthodontic therapy. Loss of the tooth would have complicated orthodontic treatment. Conventional periapical radiographs provided insufficient information about the nature of the invagination and its relation to the root canal to formulate an appropriate plan for treating the tooth. A small volume CBCT scan of the tooth revealed that the invagination and the root canal were completely separate, non-communicating spaces and that the wall of the invagination acted as an obstruction to the effective chemomechanical debridement of the infected root canal. An innovative method of accessing the infected root canal, based on information from the CBCT images, was adapted to permit its instrumentation, disinfection and filling.

Key learning points

- Teeth with dens invaginatus requiring endodontic treatment present diagnostic and technical challenges.
- CBCT can provide essential information in the management of dens invaginatus.

Keywords cone beam computed tomography, dens invaginatus, hypodontia.

Received 3 November 2010; accepted 10 January 2011

Correspondence: Conor Durack, 70 Milligan Street, Limehouse, London E14 8AU, UK (Tel.: 0044 7517988317; e-mail: conordurack1@hotmail.com).

Introduction

Dens invaginatus is a developmental dental malformation generally thought to occur as a result of an infolding of the enamel organ into the dental papilla prior to calcification. 'Dens in dente', 'dentoid in dente', 'dilated gestant odontome', 'dilated composite odontome' and 'tooth inclusion' are terms that have also been used to describe the malformation (Hülsmann 1997). However, there is a general lack of consensus on the appropriate nomenclature for the condition. For the purpose of this paper, the term 'dens invaginatus' will be adapted.

The exact aetiology of dens invaginatus is unclear. Several theories pertaining to the pathogenesis of the condition have been proposed, but there seems to be little agreement. Kronfeld (1934) suggested that the invagination occurs as a consequence of uncontrolled growth of a portion of the enamel epithelium. In contrast, Rushton (1937) proposed that continued, normal proliferation of the developing dental tissues around a portion of the enamel organ exhibiting retarded growth is responsible. External forces exerted on the developing tooth germ by the growing dental arch (Atkinson 1943) and adjacent developing tooth germs (Segura *et al.* 2002) have been suggested as causes. Trauma (Gustafson & Sundberg 1950) and infection (Sprawson 1937) affecting developing teeth have also been implicated in the aetiology of the condition. In addition, there is significant evidence suggesting a genetic component in the development of dens invaginatus (Grahnen *et al.* 1959, Ireland *et al.* 1987, Hosey & Bedi 1996, Dassule *et al.* 2000).

Numerous studies have examined the prevalence of dens invaginatus. However, direct comparison of the studies is complicated by the variations in study design, diagnostic criteria and sample size and type. Between 0.65% (Hamasha & Al-Omari 2004) and 8% (Stephens 1953) of all teeth are affected by the condition that occurs in between 1.7% (Ruprecht *et al.* 1986) and 8% of the population (Stephens 1953). Maxillary lateral incisors are the most commonly affected teeth (Grahnen *et al.* 1959, Hamasha & Al-Omari 2004). Dens invaginatus may occur bilaterally (Bäckman & Wahlin 2001, Hamasha & Al-Omari 2004) and can also occur in combination with other dental abnormalities (Bäckman & Wahlin 2001).

The clinical presentation of dens invaginatus varies. The tooth may have an outwardly normal morphology (Gonçalves *et al.* 2002). When permanent anterior teeth are affected, the invagination is always located palatally (Bishop & Alani 2008). The invagination typically occurs occlusally on posterior teeth and may be associated with a complex fissure pattern (Oehlers 1957a). The severity of the invagination can range from a pronounced cingulum/occlusal pit (Bishop & Alani 2008) to a deep infolding of the enamel reaching the apical foramen (Pindborg 1970). Other changes in the form of the affected tooth, which may occur in association with the condition include a peg or barrel shaped anatomy (Oehlers 1957b, Ridell *et al.* 2001), incisal notching and/or an increased labio-lingual or mesio-distal dimension (Khabbaz *et al.* 1995) or a prominent palatal cingulum (Oehlers 1957a, Ridell *et al.* 2001). Many invaginations are inaccessible to cleaning and may act as plaque 'traps'. As such, affected teeth are susceptible to pulpal and periodontal disease, and patients may initially present with signs or symptoms associated with pulpitis and apical or marginal periodontitis. Dens invaginatus may occur in association with other dental anomalies (Robbins & Keene 1964, Bäckman & Wahlin 2001, Sedano *et al.* 2009) and syndromes (Oncag *et al.* 1995, Hibbert 2005).

The most widely used classification of dens invaginatus was proposed by Oehlers (1957b). He described three basic forms of the anomaly. Type I is an enamel lined, minor invagination not extending beyond the amelocemental junction or the confines of the crown of the affected tooth. Type II is also enamel lined, but in contrast to type I it invades the root of the tooth remaining confined as a blind sac within the root canal. It does not communicate with the periodontal ligament but may communicate with the pulp space. Type III invaginations extend through the root and communicate with the periodontal ligament laterally (type IIIa) or at the apical foramen (type IIIb). Type III invaginations generally do not communicate with the pulp space and may be lined with enamel or cementum.

The radiographic appearance of dens invaginatus reflects, to a limited degree, the severity of the invagination. The invagination may appear simply as a radiographic representation of the occlusal or palatal pit. Other variations in radiographic appearance include a loop invagination confined within the tooth and pointing towards its apex (Gotoh *et al.* 1979), a radiolucent pocket with or without a radiopaque border (White & Pharoah 2000) or a fissure, separate from the main canal and communicating with the periodontal ligament through its own foramen to produce a 'pseudo-canal' (Gonçalves *et al.* 2002). However, it is impossible to appreciate fully the exact anatomical nature of invaginated teeth from conventional radiographic images.

Cone beam computed tomography (CBCT) is a three-dimensional imaging system designed specifically for dental and maxillo-facial use (Mozzo *et al.* 1998, Arai *et al.* 1999). A cone-shaped, pulsatile X-ray beam captures many individual basis images of a predetermined region in a single 180° and 360° sweep of the patient's head. The captured data can then be re-formatted using software to produce an accurate three-dimensional representation of the area of interest. The pulsatile nature of the X-ray beam and the use of a scanner with sophisticated image receptors operating at a relatively high kV results in a reduced radiation exposure to the patient when compared to medical CT (Patel *et al.* 2007).

The purpose of this case report is to document the treatment of a challenging case of dens invaginatus of a permanent maxillary lateral incisor in a patient affected by hypodontia and for whom orthodontic therapy was planned.

Case report

A 12-year-old Caucasian girl suffering from hypodontia was referred to the endodontic department at Guy's Dental Hospital, London for the management of a dens invaginatus of the maxillary right lateral incisor (tooth 12). The patient was in the treatment planning stage of orthodontic therapy and the treating orthodontist was keen to maintain the affected tooth as it was of strategic importance given the location and number of congenitally missing teeth.

The patient reported that the tooth had never been symptomatic. The invagination was initially identified on a dental panoramic tomograph (DPT) taken for orthodontic diagnostic purposes. The patient had an unremarkable medical history and was a regular dental attender. She was not involved in contact sports and reported no history of dental trauma.

Clinical examination revealed that the patient had a mixed dentition. Although tooth 24 was in functional occlusion, tooth 14 was not present clinically. Both teeth 13 and 53 were fully erupted in the mouth adjacent to each other. The former occupied the premolar region. The patient had a severe class II division II incisor relationship. Tooth 55 had a class II mesio-occlusal (MO) composite restoration and tooth 65 had a class II MO carious lesion. Tooth 12 had an unusual shape (Fig. 1). The cervical third of its crown was disproportionately narrower than its coronal two-thirds. It was also wider mesio-distally and had a greater clinical crown height than the contralateral tooth. The incisal edge of tooth 12 had a shallow notch. The invagination had been accessed by the patient's general dental practitioner (GDP) by the time she presented to the department of endodontics, and the palatal access cavity was restored with a temporary filling material. The

Figure 1 Labial view of the invaginated tooth 12 beside the retained deciduous canine.

restoration masked any clinical evidence of an invagination into the palatal aspect of the tooth. Tooth 12 was asymptomatic.

A DPT revealed that teeth 18, 15, 14, 25 and 28 were congenitally missing. Parallax periapical radiographs (Fig. 2) of tooth 12 revealed an associated 4–5 mm periapical radiolucency and evidence of a class II invagination (Oehlers 1957b). A periapical radiograph with a stainless steel hand file marked at 15 mm from its tip and placed in the invagination was provided by the patient's GDP. According to written notes accompanying the radiograph, the GDP was unable to negotiate the invagination beyond this point. The tip of the file appeared to correspond with a point close to the most apical extent of the invagination. However, the morphology of the invagination was not clear from the diagnostic parallax radiographs, and it was decided that a small volume CBCT scan of the tooth was justified to aid the formation of an appropriate treatment protocol based on a sound knowledge of the tooth's anatomy.

The patient and her parents were informed of the intended benefits of the CBCT scan as well as the associated risks. The estimated dose of radiation to the patient was explained and put into context and written informed consent to carry out the procedure was obtained. A small volume CBCT scan (3D Accuitomo; J Morita Manufacturing, Kyoto, Japan) of the area of interest was taken. Exposure parameters of 80 kV, 3.0 mA and 17.5 s were used. Careful examination of cross-sectional images of the invaginated tooth

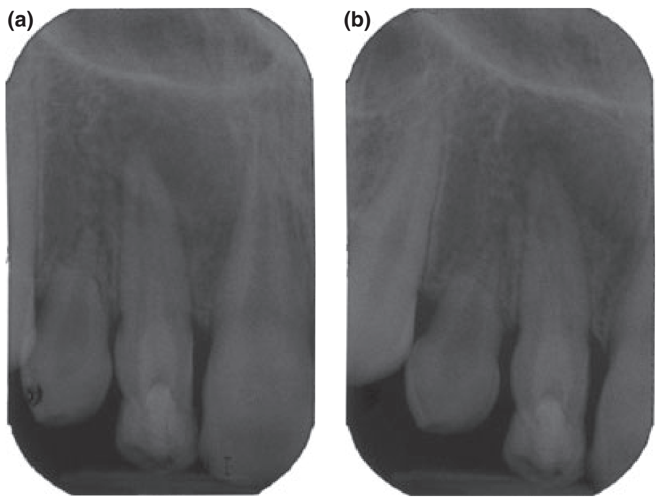


Figure 2 (a) Diagnostic periapical radiograph of the invaginated tooth 12. (b) Parallax radiograph.

in all the orthogonal planes confirmed the presence of a class II dens invaginatus (Fig. 3). The invagination penetrated and reached the apical third of the root but remained confined as a blind sac. It did not communicate with the pulp space and appeared to be entirely lined with enamel. The invagination was completely separated from the wall of the root canal throughout its entire length by a narrow width of pulp space, which encircled the infolding sac. At the apex of the invagination, the surrounding pulp space ballooned out into the walls of the root before tapering to the tooth's true apical foramen. The distance between the invagination and the root canal wall was at its narrowest at a constriction just coronal to the point that the pulp space began to balloon. The periapical radiolucency measured almost 10 mm at its greatest diameter, contrary to the apparent size of the radiolucency on the periapical radiograph.

A diagnosis of chronic apical periodontitis associated with an infected necrotic root canal system was reached for the 12. It was unclear whether the invagination was vital or not prior to it being accessed by the GDP. The treatment options were explained to the

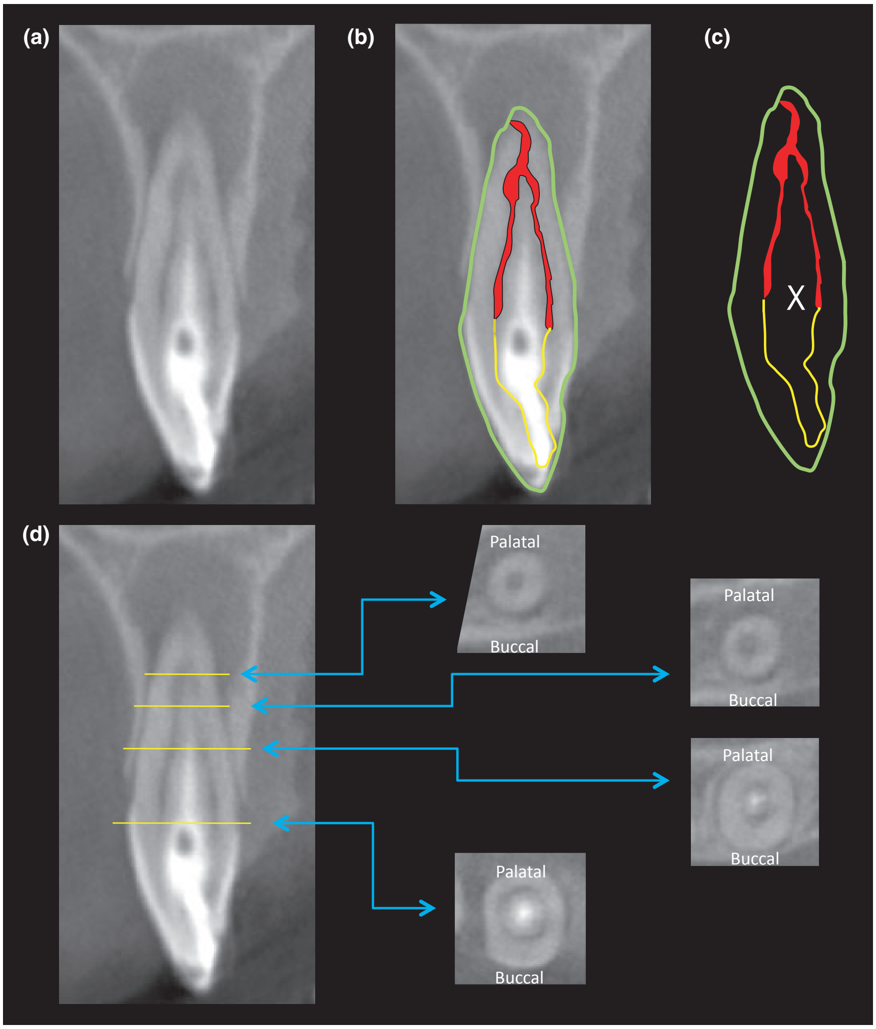


Figure 3 (a) Sagittal reformatted slice of the invaginated tooth. (b, c) Diagrammatic representation of the root canal (red), the invagination (yellow) and the outline of the tooth (green) with and without superimposition on the sagittal CBCT slice. 'X' denotes the space occupied by the invagination. (d) Axial slices at various points denoted on the sagittal section.

patient and her parents, and an informed decision was made to attempt root canal treatment of the tooth through and around the invagination. Endodontic therapy was completed over two visits under rubber dam and with the aid of a dental operating microscope (3 step entreé Dental Microscope; Global, St. Louis, MO, USA). At the first appointment, local anaesthetic was administered and the tooth was isolated using rubber dam. The temporary dressing was removed and access was gained to the invagination through the existing cavity. The most apical level of the invagination was reached easily with stainless steel (SS) hand files (Dentsply Maillefer, Ballaigues, Switzerland) 15 mm from the incisal edge of the tooth. The base of the invagination was explored with progressively smaller hand files (sizes 15, 10, 08 and 06). The walls felt smooth when probed gently, and there was no apparent breach in the integrity of what appeared to be an enamel-lined pouch. To bypass the base of the invagination, an ISO size 20 K-type ultrasonic file (Dentsply Maillefer) mounted on an ultrasound generator (Piezon Master 400, EMS, Morangis, France) was used. The file was marked with a rubber stop at a point 15 mm from its tip and introduced passively into the canal. Short bursts of energy were employed under continuous irrigation and in a controlled and careful manner to break the enamel barrier. Care was taken to maintain the alignment of the file with the long axis of the tooth. Once the enamel wall was perforated, a size 15 K-flexofile (Dentsply Maillefer) was introduced into the canal and easily passed through the newly created opening. The opening was subsequently widened using hand files (Dentsply Maillefer) so that unimpeded access to the apical terminus of the canal was possible. The provisional working length was determined from the CBCT scan and verified using an apex locator (Dentaport ZX; J Morita Manufacturing). The apical third of the root canal was then prepared with K-flexofiles (Dentsply Maillefer) using a step-back technique from the apical foramen, which was prepared to size 40. Chemomechanical debridement of the coronal two-thirds of the root canal encircling the invagination was carried out next. To achieve access to this area, a finely gritted, tapered diamond bur (556, ISO 173-016; Dentsply Maillefer) in a high-speed turbine was employed to create separate cavities immediately buccal and palatal to the entrance to the invagination (Fig. 4). Constant reference was made to the CBCT images to ensure appropriate alignment of the bur and to avoid

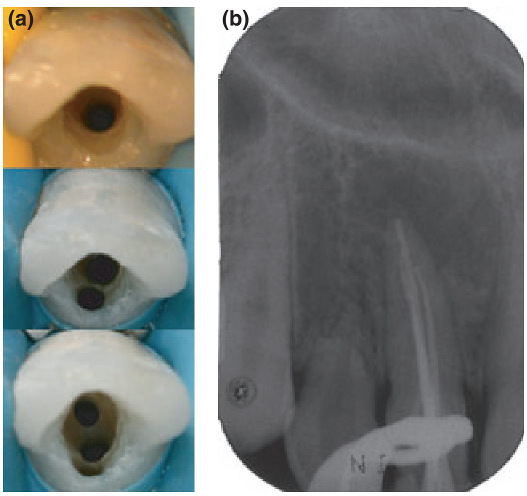


Figure 4 (a) (top) Access cavity on removal of the temporary restoration revealing the opening of the invagination; (middle) palatal channel created to gain access to the root canal system and the invagination above it; (bottom) the relationship of the bucally created channel to the invagination entrance and the palatally created channel. (b) Master gutta-percha point radiograph.

accidental perforation during this procedure. Size 10 and subsequently size 15 K-flexofiles were passively introduced into the cavities until resistance was met. A periapical radiograph was then taken with the size 15 files positioned at the points of resistance. The radiograph revealed that the file tips were located at the constriction between the invagination and the root canal wall, just coronal to the point at which the canal expands. Size 06–30 K-flexofiles (Dentsply Maillefer) were gently worked through the constriction in succession, using the balanced force technique, creating access to the apical third of the canal, beyond the invagination. The canal and invagination were continuously irrigated with sodium hypochlorite (Merck, Darmstadt, Germany) during instrumentation. The irrigant was agitated for one minute using an ISO size 15 K-type ultrasonic file (Dentsply Maillefer) mounted on an ultrasound generator (EMS). The root canal complex was dried and dressed with calcium hydroxide paste (Pulpdent Paste, Pulpdent Corporation, Watertown, MA, USA), and the access cavity was sealed with a sterile cotton pellet and IRM (Dentsply Maillefer). The treatment was completed at the second appointment, 2 weeks later. Under local anaesthetic and rubber dam, the temporary restoration was removed and the entire root canal system was irrigated and dried. A master gutta-percha cone radiograph was taken with points in each of the canal orifices (Fig. 4). The canals were subsequently dried and filled using warm vertical condensation of gutta-percha. The access cavity was restored with composite resin (Herculite® Ultra; Kerr Corporation, Orange, CA, USA). Postoperative periapical radiographs at two different angles revealed an adequately filled root canal system (Fig. 5). The patient was reviewed twelve months later. The tooth was asymptomatic, and the adjacent, permanent, maxillary anterior teeth responded normally to sensitivity testing. A review periapical radiograph of the 12 demonstrated a significant reduction in the size of the periapical radiolucency associated with the tooth (Fig. 5).

Discussion

This case provided a number of operational and treatment-planning challenges. The orthodontic care of the patient was complicated by the number and position of the congenitally missing teeth. The situation would have been compounded by the enforced

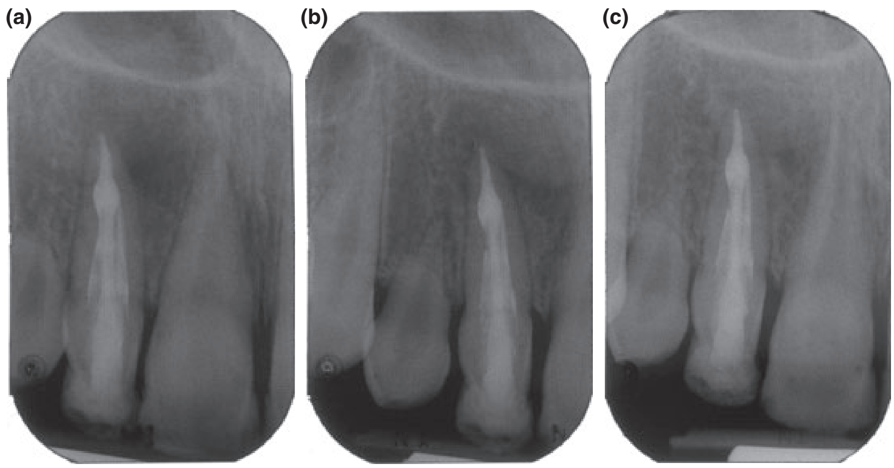


Figure 5 (a) Postoperative radiograph; note the dense root filling within the invagination (centre) and the circumferential root filling occupying the narrow root canal space around it. (b) Parallax postoperative radiograph. (c) 12 month post-treatment review radiograph demonstrating signs of significant healing.

extraction of the infected tooth 12. In that event, it may well have been necessary to accept the space resulting from the loss of the tooth and to restore the missing unit with a dental prosthesis such as a resin retained bridge and/or a dental implant. However, restoring missing anterior dental units in a patient with a class II, division II incisor relationship and with a deep overbite carries its own challenges, whatever the restorative option. Add to this the very young age of the patient and the strategic importance of maintaining the invaginated tooth became clear.

Hypodontia can occur in combination with a range of dental anomalies (Hülsmann 1997, Bishop & Alani 2008). However, the occurrence of dens invaginatus and hypodontia in the same patient is a rare event. In a cross-sectional clinical and radiographic study of 739 Swedish children, hypodontia and dens invaginatus never occurred in the same subject despite a prevalence of 6.8% for the latter in the examined cohort (Bäckman & Wahlin 2001). However, the occurrence of these two dental anomalies together have been documented in isolated case reports (Robbins & Keene 1964, Sedano *et al.* 2009).

When treating cases of dens invaginatus, especially those with more complex anatomy, it is essential to develop an appreciation of the course of the invagination and how it relates to the main canal/s of the tooth. This information is not always obvious from intraoral periapical radiographs. The limitations of conventional radiography are well documented. The diagnostic yield of this form of imaging is greatly reduced by geometric distortion (Gröndahl & Huumonen 2004), anatomical noise (Bender & Seltzer 1961, Revesz *et al.* 1974, Kundel & Revesz 1976) and the compression of three-dimensional structures on to a two-dimensional shadowgraph (Webber & Messura 1999, Patel *et al.* 2009). The CBCT scan performed in this case provided a large amount of data that were reconstructed to provide a three-dimensional representation of the invaginated tooth.

The reconstructed images allowed a true appreciation of the complex root canal anatomy and were essential in the planning of separate access strategies to the coronal and apical portions of the infected root canal system. In this case, the invagination acted as an obstruction of sorts to the adequate chemomechanical debridement of the root canal complex. By creating cavities buccal and palatal to the invagination instrumentation, irrigation and filling of the coronal root canal was achieved. It was felt that the creation of additional mesial and distal cavities would have been unnecessarily destructive.

The sodium hypochlorite (Merck) irrigant was agitated ultrasonically to allow it to penetrate the space mesial and distal to the invagination and the use of warm vertical condensation of gutta-percha ensured adequate filling of this space. It was clear from the preoperative scan that, whilst necessary, the coronal cavities would not provide adequate access to the apical portion of the canal to achieve disinfection and filling of this area. Access to the apical third of the canal was obtained separately through the invagination using an ultrasonically activated stainless steel file to breach the enamel wall. The creation of strategic orifices to assist disinfection of the tooth carried with it the very real risk of inadvertent perforation of the root canal wall. The CBCT images facilitated the appropriate positioning of these orifices and provided valuable information regarding safe cavity dimensions and angulations. The images were constantly referenced during the preparation of the cavities. Stainless steel files were chosen to instrument the canal as their physical properties mean they were less likely to deform and fracture against the hard enamel during the instrumentation procedures.

The use of CBCT as an aid in the endodontic treatment of dens invaginatus (Patel 2010) and fused teeth (Song *et al.* 2010) has been reported in the literature. However, CBCT comes with an increased radiation exposure to the patient when compared to periapical radiographs. Whenever ionizing radiation is used in medical imaging, the effective radiation dose to the patient must be as low as reasonably achievable

(ALARA), justified and optimized (Farman 2005). For this reason, a small volume CBCT scan was prescribed in this case. It is essential that the information obtained from this type of imaging will influence the treatment provided; otherwise, it cannot be justified. In this case, it is unlikely that endodontic treatment could have been as accurately planned and delivered as safely and successfully as it was without the aid of the CBCT images.

Conclusion

Dens invaginatus is a relatively uncommon condition, which can occur in conjunction with a range of other dental anomalies, but only rarely occurs with hypodontia. The endodontic treatment of dens invaginatus can be challenging because of the bizarre morphology often associated with the condition and the lack of information provided by conventional dental radiographs in the third dimension. CBCT is a useful adjunct to the clinician's armamentarium in the endodontic treatment of dens invaginatus.

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