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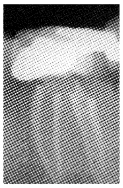

CASE REPORT

The use of limited cone beam computed tomography in the diagnosis and management of a case of perforating internal root resorption

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Abstract

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Aim To describe the use of cone beam computed tomography (CBCT) in the diagnosis and management of a maxillary lateral incisor with perforating internal root resorption (IRR).

Summary Root resorption is the loss of dentine or cementum as a result of osteoclastic cell action. IRR occurs exclusively as a result of pulpal inflammation. Until very recently, the diagnosis of internal and external resorptive defects has been limited to the information obtained from conventional radiographic techniques. This case report describes the use of CBCT in the diagnosis and treatment planning of a case of perforating IRR. Emphasis is given to the modifications made to the treatment procedures in view of the additional information obtained from the CBCT data.

Key learning points

- Internal root resorptive defects may perforate the external root surface, and this may not be detectable using conventional radiographic techniques; consideration of this should be made during diagnosis and treatment planning.
- CBCT provides additional relevant information on the location and nature of root resorptive defects when compared with that provided by conventional radiographs.
- CBCT findings may modify treatment planning, as well as the techniques that may be employed during both non-surgical and surgical endodontic treatment.

Keywords: cone beam computed tomography, diagnosis, internal root resorption, management, mineral trioxide aggregate.

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Introduction

Root resorption is the loss of dentine or cementum as a result of osteoclastic cell action (Patel & Pitt Ford 2007). Resorption can be broadly categorized according to its location, as internal or external. The cells responsible for resorption, whether it is internal or external, have been described as osteoclasts, odontoclasts and dentinoclasts (Gunraj 1999).

Internal root resorption (IRR) occurs exclusively as a result of pulpal inflammation, whereas the various types of external resorption have differing aetiology. As cementum protects the external root surface from resorption, the predentine and odontoblast layer appear to prevent the pulpal dentine from resorption. However, pulpal inflammation might lead to loss of the predentine and odontoblast layer and allow clastic resorption of the internal dentine (Patel *et al.* 2010). It has been demonstrated that inflamed pulp tissue is necessary for IRR to be initiated and maintained (Wedenberg & Lindskog 1985).

Clinically, differentiating between IRR and external cervical resorption (ECR) is often challenging, particularly in the absence of clinical manifestations such as the classical 'pink spot' appearance, localized gingival inflammation or an osseous defect (Gulabivala & Searson 1995). In these cases, radiographic signs might be the only indication of a resorptive process. Most commonly, IRR is seen as a clear expansion of the root canal outline, with smooth, well-demarcated margins. Also, the root canal outline is continuous with that of the resorptive defect. Conversely, with ECR the root canal outline is usually discernible within the resorptive defect. IRR is characterized by the lesion maintaining its position relative to the root canal space when two parallax radiographs are taken. However, with ECR the lesion alters its position relative to the root canal space when the X-ray beam is shifted.

Traditionally, the diagnosis of internal root resorptive and external cervical resorptive defects has been limited to the information obtained from conventional radiographic techniques, whether film-based or digital. The main limitation of these techniques is that a two-dimensional image can only provide limited clinical information with respect to three-dimensional structures. In particular, radiographic imaging is unable to reveal the location and nature of a resorptive defect, or the thickness of the remaining root canal dentine, particularly in the bucco-lingual plane. Superimposition of various anatomical structures and image distortion is a further limitation resulting in limited diagnostic yield from conventional radiographic techniques (Patel *et al.* 2007, de Paula-Silva *et al.* 2009).

Recently, the innovation of cone beam computed tomography (CBCT) in dentistry offers an imaging modality capable of providing a three-dimensional unobscured view of dentoalveolar anatomy (Cotton *et al.* 2007, Patel 2009). CBCT has also been shown to provide geometrically reliable images when compared to traditional radiographic techniques (Sonick *et al.* 1994, Marmulla *et al.* 2005).

Cone beam tomographic scanners have been developed from medical computed tomography (CT) scanners for specific maxillofacial and dental use (Mozzo *et al.* 1998, Arai *et al.* 1999). CBCT acquires three-dimensional volumetric data of much smaller regions than medical CT. The field of view for one such limited cone beam tomographic scanner is only 30×40 mm, which is equivalent to a small periapical radiograph (3D Accuitomo; J Morita Corporation, Osaka, Japan). CBCT acquires all image data with a single sweep of the scanner, as opposed to medical CT imaging which uses multiple slices to compose a three-dimensional image. The single rotation, sensitive flat panel detector helps reduce the overall dose, resulting in a significantly lower effective dose with CBCT. In fact, the effective dose for a 3D Accuitomo scan might be equivocal to that of 2–3 plain film periapical radiographs (Arai *et al.* 2001, Loubele *et al.* 2009).

The hard tissue resolution of CBCT approaches that of conventional medical CT imaging. CBCT also offers the clinician the option of viewing the acquired images in various formats. With respect to resorptive lesions of the dental hard tissues, CBCT provides the clinician with a vast amount of relevant anatomical information. The size, shape and dimensions of the resorptive lesion can be established. In particular, the buccolingual anatomy of the lesion can be determined. With CBCT, accurate determination of periapical bone lesions is achievable. Three-dimensional imaging also aids the clinician with the localization of anatomical structures such as the inferior alveolar neurovascular bundle (Velvart *et al.* 2001), mental foramen and maxillary sinus (Rigolone *et al.* 2003).

This case report describes the use of CBCT in the diagnosis and combined non-surgical and surgical management of perforating IRR in a maxillary lateral incisor (tooth 12).

Report

A healthy 39-year-old male patient was referred by his general dental practitioner to the Endodontic Postgraduate Unit for management of tooth 12. The patient reported an acute episode of pain and facial swelling approximately 1 month prior to his referral. This was managed by the patient's general dental practitioner with a week-long course of systemic antibiotics. At the time of consultation, the patient reported slight pain on pressure to tooth 12. According to the patient, the tooth was crowned over 10 years previously. There was no history of trauma.

Clinically, tooth 12 was restored with a porcelain-bonded crown; the margins of which were defective (Fig. 1a). There was no evidence of labial or palatal erythema, swelling or sinus tract formation. However, there was tenderness to axial percussion of tooth 12 and also digital palpation of the mucosa palatal to the apex of the tooth. It was not possible to perform pulp sensibility testing on tooth 12 because of the presence of the crown; whilst both tooth 11 and tooth 13 gave positive responses. No evidence of attachment loss was apparent on periodontal examination of the maxillary anterior teeth. Radiographic examination using a paralleling technique revealed a periradicular radiolucency associated with tooth 12 (Fig. 1b). There was a clearly demarcated ballooning of the root canal in the apical third. The crown margins were defective, and there were also mesial caries evident in tooth 13. A diagnosis of chronic apical periodontitis associated with a necrotic pulp, and IRR, was made for tooth 12.

To assess the nature, location and severity of the resorptive lesion, a limited CBCT of the region associated with tooth 12 was prescribed. Following verbal and written consent being obtained, a limited CBCT scan of this region was carried out (3D Accuitomo 80; J Morita Manufacturing, Kyoto, Japan) with exposure parameters of 80 kV, 3.0 mA and 17.5 s. Following analysis of the axial, sagittal and coronal slices, it was evident that there

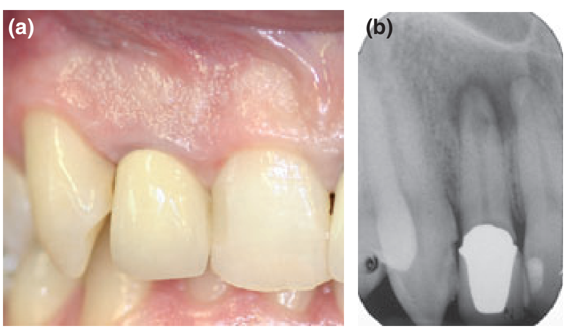

Figure 1 (a) Clinical view showing preoperative status of crowned tooth 12. (b) Preoperative radiograph of tooth 12 demonstrating periradicular radiolucency and internal root resorption.

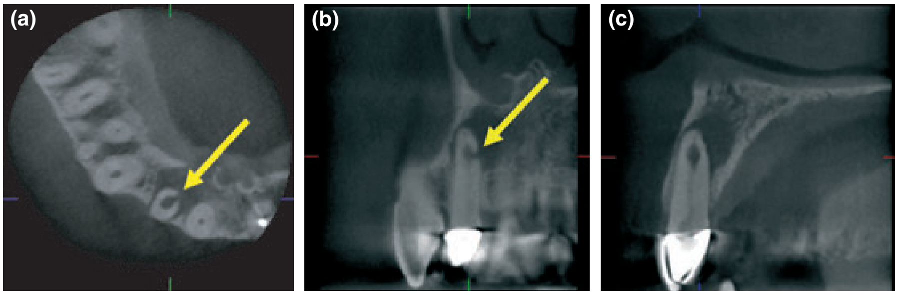

Figure 2 Selected cone beam computed tomography images of tooth 12; (a) axial slice demonstrating palatal perforation (yellow arrow), (b) coronal slice shows location and size of perforating resorptive defect (yellow arrow) as well as the extent of the periradicular lesion, (c) further slice does not disclose perforation but clearly demonstrates 'classical' appearance of internal root resorption.

was obvious IRR of the root canal which perforated the apical third of the canal palatally (Fig. 2a–c). The perforation could not be determined from the preoperative radiograph but was clearly visible on the CBCT images. The periradicular lesion associated with tooth 12 was found to be extensive, extending apical and palatal to the root perforation.

The patient was advised of the findings of the special investigations, and the various treatment options were discussed. The patient was advised of the potential technical difficulties and prognosis of the endodontic treatment. In particular, the problem of effectively disinfecting and sealing the resorptive defect was conveyed. In view of this, the patient was advised that a combined non-surgical and surgical approach would almost certainly be required. The patient gave consent for the proposed treatment.

Following administration of local anaesthetic, and the taking of a putty index of tooth 12, the crown was sectioned and removed. Rubber dam was applied, and the field was disinfected with sodium hypochlorite 1% w/v (Adams Healthcare, Leeds, UK). The root canal was accessed, and the coronal portion of the canal was flared with Gates Glidden drills, sizes 2–4 (Dentsply Maillefer, Ballaigues, Switzerland), after which initial instrumentation was carried out with K-Flexofiles (Dentsply Maillefer). Working-length determination with an apex locator was not possible because of the presence of the resorptive perforation. Accurate undistorted measurements were obtained from the CBCT scan, demonstrating the level of the perforation and apex as 18 and 22 mm, respectively. Paper points were used to confirm the level of the perforation. Using a combination of the working length obtained from the CBCT and paper points, the working length was confirmed as 22 mm. This was verified with a diagnostic radiograph. Copious irrigation with sodium hypochlorite solution was performed throughout the procedure. As the CBCT scan had revealed the presence of a palatal perforation, the 27-gauge irrigating needle was pre-measured to ensure that there was no inadvertent extrusion of irrigants into the periradicular tissues. Furthermore, the vent of the irrigating needle was orientated buccally to further ensure safe irrigation. The sodium hypochlorite solution was gently agitated with a pre-measured gutta-percha point, ensuring that the point was kept short of the level of the perforation. The use of ultrasonically energized instrumentation/irrigation was considered unsafe in this case because of the presence of the perforating defect. The root canal was irrigated with 17% EDTA solution (Guy's Hospital Dental Formula, Guy's and St Thomas's NHS Foundation Trust, London, UK) for 2 min, which was activated manually as previously described.

After a final rinse of sodium hypochlorite, the root canal space was dried with paper points. Filling of the root canal space and perforation was carried out with mineral trioxide aggregate (ProRoot MTA; Dentsply Tulsa Dental, Tulsa, Oklahoma, USA), which was

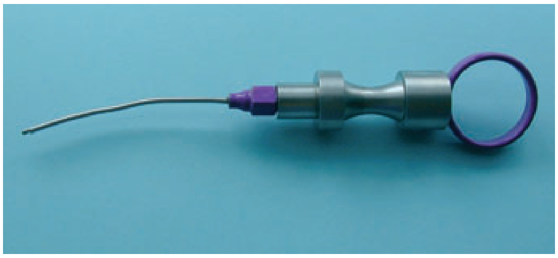

Figure 3 A Dovgan carrier was used to deliver MTA into the root canal space.

delivered into the root canal space using a Dovgan carrier (Vista Dental, Racine, Wisconsin, USA) (Fig. 3). The MTA was initially compacted incrementally using Machtou hand pluggers (Dentsply Maillefer). Following every few increments of MTA, the material was further compacted by applying short bursts of ultrasonic energy to a DG16 probe which was kept in contact with the MTA. Once approximately 5–6 mm of MTA had been compacted into the root canal, a radiograph was taken to verify the quality of the filling. MTA was chosen as the filling material in view of the presence of the perforation, as well as to facilitate the subsequently planned surgical procedure. The root canal filling was completed using thermoplasticized gutta-percha (Obtura; Sybron Endo, Orange, CA, USA) and root canal sealer (Kerr Pulp Canal Sealer EWT; Kerr Corporation, Orange, CA, USA).

To facilitate post-placement and subsequent restoration, the coronal root canal space was cleaned using an ultrasonically activated file with abundant irrigation; the root canal walls were inspected to ensure there were no remnants of gutta-percha or sealer. The canal was rinsed with alcohol to sequester any free eugenol from the root canal sealer. As a yellow D.T. Light-Post (Recherches Techniques Dentaires, Saint Egreve, France) was found to fit well in the root canal, no post-space preparation was necessary. The post and post-space were then etched, washed and dried. A resin cement (RelyX Unicem Self-Adhesive-Resin Cement; St. Paul, MA, USA) was then introduced into the root canal using a dedicated elongated delivery tip, until the entire post-space was filled. The post was then seated fully into the root canal and the excess cement removed. The cement was light-cured whilst maintaining gentle axial pressure on the post. The tooth and post were etched and rinsed, after which, a light-cured bonding agent (OptiBond Solo Plus; Kerr Corporation, Orange, CA, USA) was applied, lightly air-dried and cured. A light-cure composite core was then built-up incrementally (Herculite XRV; Kerr Hawe, Bioggio, Switzerland). The mesial caries were removed from tooth 13, and the cavity was restored with composite (Herculite XRV; Kerr Hawe). The rubber dam was removed from the teeth, after which crown preparation of tooth 12 was completed at the same visit. An acrylic provisional crown was constructed. A postoperative radiograph was taken (Fig. 4a). Arrangements were made to carry out surgical endodontic treatment 2 weeks later. However, at this appointment the patient felt his symptoms had completely resolved and declined surgery, requesting a follow-up appointment at a later stage. Therefore, it was decided to restore the tooth definitively, and so a full coverage all-ceramic crown was constructed and fitted 3 weeks later. At the appointment to fit the crown, the patient confirmed that he had not experienced any problems.

The patient was reviewed 1 year after the completion of root canal treatment. At the time of review, the patient had been symptom free until approximately 2 weeks prior to the appointment, when he had noticed slight tenderness to pressure associated with tooth 12. On clinical examination, tooth 12 was mildly tender to axial percussion and there was also some tenderness of the palatal mucosa adjacent to the apex of the tooth.

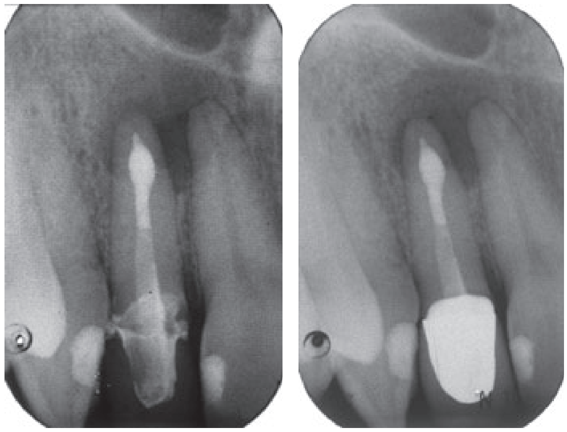

Figure 4 (a) Postoperative radiograph taken following completion of root canal treatment, placement of fibre post, composite core and provisional crown, (b) follow-up radiograph taken 1 year after the completion of root canal treatment. The periradicular lesion has not changed in size.

Radiographic examination using a paralleling technique revealed no change in the size of the periradicular radiolucency associated with tooth 12 (Fig. 4b).

A diagnosis of chronic apical periodontitis associated with a previously root treated tooth was reached for tooth 12. The cause of post-treatment disease was most likely due to infection remaining in the inaccessible regions of the root canal space and resorptive lesion. The patient was advised of the diagnosis, and the various treatment options were discussed. The patient decided to proceed with surgical endodontic treatment of tooth 12 and accordingly gave verbal and written consent. The CBCT images were again used to treatment plan the surgical endodontic procedure. Analysis of the image data allowed the procedure to be planned in three dimensions.

Preoperatively, the patient rinsed with chlorhexidine gluconate 0.2% w/v (Chlorhexidine Gluconate Antiseptic Mouthwash; Ecolab, Leeds, UK). Local anaesthesia was achieved with infiltrations of 2% lidocaine hydrochloride with 1 : 80 000 adrenaline (Lignospan Special; Septodont, Saint-Maur-des-Fossés, France). A modified Luebke-Ochsenbein flap was atraumatically reflected and retracted. Periradicular access was aided by the existing perforation in the labial cortical plate. It was not necessary to enlarge this access. The periradicular soft tissue lesion was excised and stored in 10% formalin solution for histopathological examination. The root-end was resected using a cutting-through approach at approximately 6 mm from the apex using a long tapered diamond bur (Diatech Dental Inc, Sacramento, CA, USA) in a surgical turbine handpiece. Local haemostasis was achieved using gauze dampened with 1 : 1000 adrenaline (Adrenaline Injection 1 in 1000; Hameln Pharmaceuticals Ltds, Gloucester, UK) for 5 min. The root-end was inspected using micro-mirrors (Hu-Friedy, Chicago, IL, USA) and an operating microscope (Carl Zeiss, Oberkochen, Germany). It was not necessary to prepare a root-end cavity as the existing orthograde MTA root filling was well compacted and no voids were evident. A postoperative radiograph was taken to confirm that the root-end had been adequately resected (Fig. 5a). The repositioned flap was held in position using interrupted polyamide sutures (Ethilon 5-0 PC-3; Ethicon Inc, Johnson & Johnson Company, Somerville, NJ, USA). The patient was given standard post-surgical supportive therapy instructions. Non-steroidal anti-inflammatory drugs were prescribed to be taken as necessary. No antibiotics were prescribed. The patient was initially followed up 5 days after surgery when the sutures were removed. The patient stated that he did not require

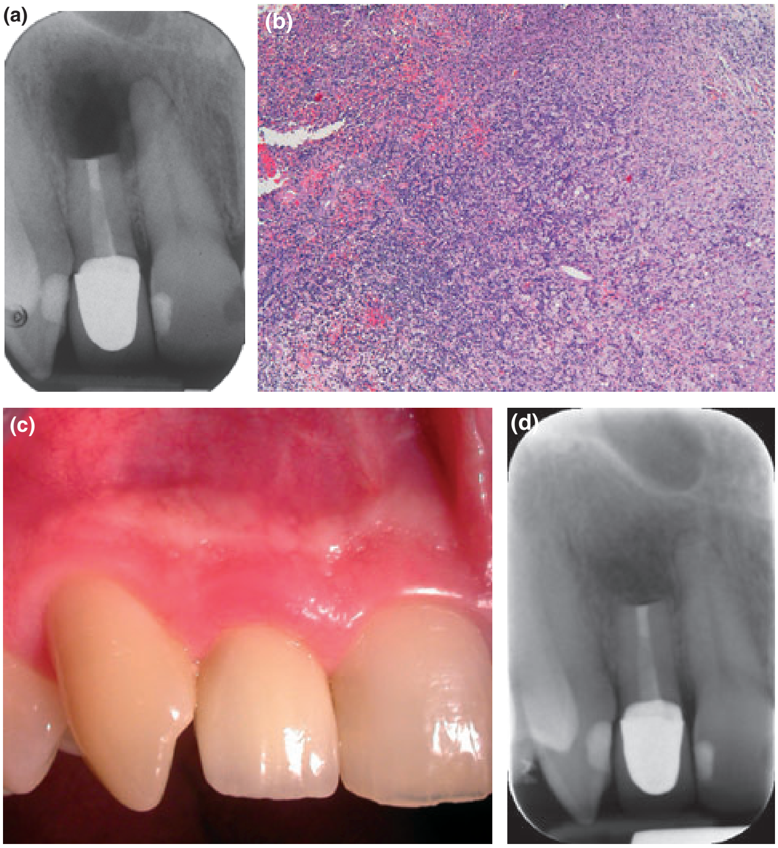

Figure 5 (a) Postoperative radiograph taken immediately after surgical endodontic treatment. (b) Routine histological section stained with Haematoxylin and Eosin showing layered infiltrate in the granuloma. Top left is centre of the lesion dominated by neutrophils, the middle portion reveals neutrophils and the right side of the lesion shows foamy macrophages. (c) Clinical appearance 1 year after the completion of treatment. (d) Review radiograph shows evidence of bony healing.

any analgesics. Histological examination confirmed the diagnosis of chronic apical periodontitis (Fig. 5b).

At the 1-year follow-up appointment, the patient did not complain of any symptoms. Clinical examination was unremarkable (Fig. 5c). Radiographic examination revealed a reduction in the size of the periradicular radiolucency with evidence of bony infill (Fig. 5d).

Discussion

Cone beam computed tomography was shown to be extremely useful in the diagnosis and management of this case of perforating IRR. CBCT has also been shown to be a useful diagnostic tool in the management of ECR (Patel & Dawood 2007), demonstrating superior accuracy when compared to digital intraoral radiography in the detection and management of resorption lesions (Patel *et al.* 2009). In this case, by carrying out the scan before any intervention, it was possible to accurately assess the nature, location and extent of the resorptive lesion.

The limited CBCT scanner used in this case was the 3D Accuitomo scanner. The exposure time for the scan with this machine is 18 s or less, but the dose is delivered in intermittent pulses giving an actual equivalent exposure time which is shorter than this.

The effective dose from the CBCT scan used in this case was in the same order of magnitude as a conventional radiograph (Arai *et al.* 2001, Lofthag-Hansen *et al.* 2008). With the low effective doses, and the additional relevant information provided, the use of CBCT scanners is justified when managing complex endodontic problems such as resorption or in cases requiring surgical management (Cohenca *et al.* 2007, Low *et al.* 2008).

The CBCT scan facilitated the diagnosis of the perforating resorption defect that could not be determined with conventional radiographs. This information meant that greater care was taken during root canal irrigation. As the exact location of the perforation had been determined preoperatively, the position and orientation of the side-venting irrigating needle tip could be controlled to minimize the risk of inadvertant extrusion of sodium hypochlorite solution. Passive ultrasonic irrigation of sodium hypochlorite was not employed in this case as a result of the perforation determined by the CBCT scan. Instead, the treatment protocol was modified so that gentle manual dynamic agitation of the irrigating solution was performed using a pre-measured gutta-percha point kept short of the level of perforation.

The information obtained from the CBCT scan also influenced the method of root canal filling used. Warm vertical compaction of gutta-percha might often be chosen as the technique of choice for the filling of cases of IRR. In this case, however, because of the perforation, there would have been significant extrusion of root filling material had this technique been employed. Therefore, MTA was used here as inadvertant extrusion would not be a problem as the material provides a highly biocompatible interface with the periradicular tissues. Also, as surgical endodontic treatment had been scheduled at the treatment planning stage, the use of MTA reduced the probability of needing to place a root-end filling at the time of surgery.

Guidelines advise that root canal treatment should be reviewed for up to 4 years (European Society of Endodontology 2006). However, it has been suggested that post-treatment disease should be diagnosed and treated surgically or non-surgically within 2 of the previous treatment (Wu & Wesselink 2005). This case report corroborates this by demonstrating that post-treatment disease can be diagnosed in a timely manner.

It is frequently recommended that at least 3 mm of the root-end should be resected (Gutmann & Harrison 1991, Stropko *et al.* 2005, Kim & Kratchman 2006). This is because most root canal ramifications, which might harbour microbes, are within this region (Vertucci 1974, De Deus 1975, Wada *et al.* 1998). However, in this case, CBCT identified the exact location and extent of the internal resorptive lesion. CBCT also accurately identified a pathological perforation palatally, 5 mm from the apex of tooth 12. This information could not have been obtained from radiographs or direct visualization during surgery. A radical root-end resection was necessary to ensure all of the infected dental tissue was removed. CBCT aided correct management of this case, i.e. performing the root-end resection below the level of the perforation.

When exposing patients to ionizing radiation, it is essential that the dose must always be kept As Low as Reasonably Achievable (Farman 2005). Each exposure must be justified whilst every radiographic view, and therefore, patient radiation dose, must be optimized. To minimize the radiation dose, the smallest field of view compatible with the clinical situation should always be prescribed (Patel & Horner 2009).

Conclusion

This case report demonstrates the benefits of utilizing CBCT in the assessment and management of perforating internal root resorption. The application of this technique provides the clinician with high quality, undistorted, geometrically accurate three-dimensional imaging. With the development of purpose-built dental limited CBCT scanners, low-dose imaging provides the clinician with a valuable diagnostic and treatment planning tool.

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Disclaimer

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