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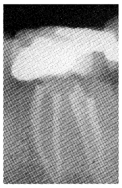

CASE REPORT

A new cone beam computerized tomography system for use in endodontic surgery

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Abstract

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Aim To present a newly developed cone beam computerized tomography system (3DX Micro-CT) and its application in endodontic surgery.

Summary Cone beam CT has attracted considerable attention as a new diagnostic imaging technique in dentistry. The assessment of fractured endodontic instruments and the planning of endodontic surgery present challenges that conventional radiography cannot meet successfully. In this report, the value of the 3DX cone beam computerized radiography system is illustrated by the case of a fractured endodontic instrument protruding into the maxillary sinus.

Key learning points

- Cone beam CT is helpful for diagnosis and treatment planning in endodontic surgery.
- Hemisection is an important treatment alternative to save at least a part of the tooth.

Keywords: computerized tomography, endodontic surgery, fractured instrument, three-dimensional image.

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Introduction

Various radiographic imaging techniques are available to visualize anatomical and pathological details. Although periapical and panoramic radiography produce acceptable details in the mesial-distal direction, the observation of details in the bucco-lingual dimension is inadequate. Three-dimensional computerized tomography (CT) is used for the diagnosis and treatment planning of periapical pathosis (Cotti *et al.* 1999, Hamada *et al.* 2005). However, conventional CT devices are large, expensive and expose the

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patient to relatively high doses of radiation (Vannier *et al.* 1997, Fortin *et al.* 2002). The advantage of using the cone beam CT system known as 3DX multi-image Micro-CT (Morita Co., Kyoto, Japan) is that it requires significantly lower radiation doses than conventional CT systems (Arai *et al.* 1999). Hashimoto *et al.* (2003) reported the superiority of the 3DX Micro-CT in the display of dental hard tissues whilst substantially decreasing the dose to the patient.

Teeth with fractured instruments extending into the maxillary sinus might be an aetiological factor for sinusitis (Rud & Rud 1998). An attempt to remove instruments from such cases is often undertaken, however, teeth not responding to conventional therapy or for which a root canal retreatment is not possible require surgical intervention. When a surgical approach is chosen, the precise extent of the fractured instrument should be known, as well as its relation to the root and neighbouring anatomic structures, such as the maxillary sinus. In this case report, 3DX Micro-CT was used for diagnosis and treatment planning. Based on the 3DX Micro-CT findings, endodontic surgery including hemisection was the treatment of choice, which resulted in removal of the fractured instrument.

Case report

A 38-year-old female patient was referred to the Endodontic Department at Nihon University School of Dentistry, for evaluation and treatment of her maxillary right first molar (tooth 16). She complained of mild soreness from tooth 16, especially when the tooth was in function. Her medical history was noncontributory. The dental history revealed that root canal treatment and a post-retained crown had been performed 5 years previously (Fig. 1). Tooth 16 was slightly tender to percussion and palpation. The gingival probing depths were within normal limits. A periapical radiograph showed a fractured instrument, which appeared to extrude into the maxillary sinus (Fig. 2). The findings were confirmed by panoramic radiography (Fig. 3). However, conventional dental radiographic detection is difficult or inaccurate, especially when the fractured instrument is located toward the buccal or lingual aspect of the complex root. A 3DX Micro-CT picture was thus ordered to confirm the diagnosis (Fig. 4a,b,c). The 3DX Micro-CT was developed as a limited cone beam CT device for practical use, enabling three-dimensional imaging of the hard tissues of the maxillofacial and ear and nose regions. The exposure factors for 3DX Micro-CT were 80 kVp, 2 mA and 17 s. The image data were quantified on a two-dimensional screen measuring 240 pixels in the vertical direction by 320 pixels in the

Figure 1 Preoperative clinical photograph of tooth 16.

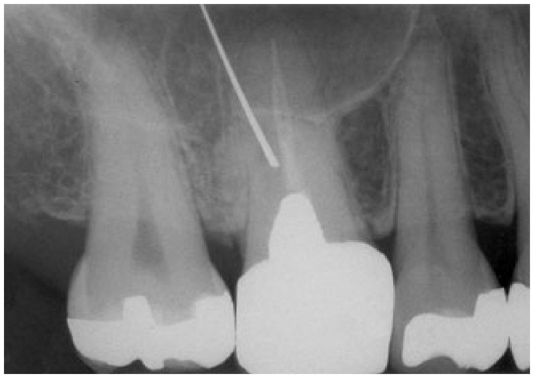

Figure 2 Preoperative periapical radiograph showing a well-defined fractured instrument.

Figure 3 Preoperative panoramic radiograph showing a fractured instrument in the maxillary sinus.

horizontal direction, with each pixel quantified at eight bits, and stored in a computer. The image reconstruction took approximately 2 min and the distances between the images were 1 mm. The imaging area was 30 mm (240 voxels) in height and 40 mm (320 voxels) in diameter, with each voxel consisting of a square with sides of 0.125 mm in length. As the small voxel was cubic in shape, the resolution of the images was high and was the same in any direction. Sections parallel to the dental arch (sagittal sections), perpendicular to the dental arch (coronal sections) and horizontal (axial) sections are produced with a slice width of 1 mm at an interval of 1 mm. The 3DX Micro-CT helped to evaluate the exact position of the fractured instrument and its spatial relationship to maxillary sinus. A sagittal section and an axial section revealed the fractured instrument between the buccal roots (Fig. 4a,c). Furthermore, an axial section showed root filling material in the palatal root canal. Measurement of the object can be easily performed at any site by using a scale shown on the left side of the image. A coronal section of dental arch showed the 13.3 mm length of the fractured instrument protruding into the maxillary sinus (Fig. 4b).

After removing the metal crown, inspection of the pulp chamber floor revealed three root canal orifices and an iatrogenic perforation (Fig. 5). The fractured instrument was located inside the perforation. Initially, the orthograde removal of the instrument from the perforated site was attempted, but failed. The patient was scheduled for surgical removal of the fractured instrument. It was decided that the first molar would receive a hemisection because the fractured instrument was estimated to be too difficult to reach and locate.

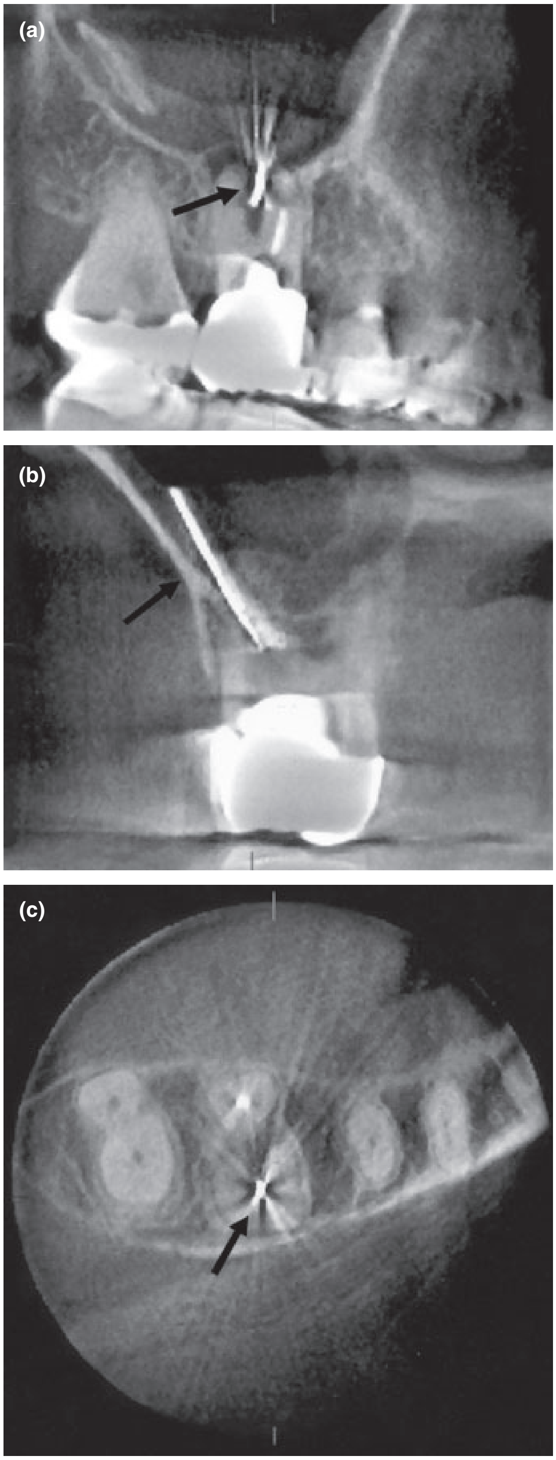

Figure 4 3DX images in (a) sagittal plane, (b) coronal plane and (c) axial plane showing a fractured instrument.

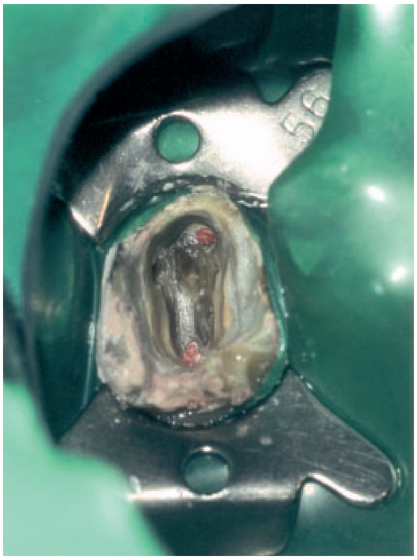

Figure 5 Photograph revealing root canal orifices and perforated site.

Following an intrasulcular incision extending to both adjacent teeth, a full mucoperiosteal flap was raised. A diamond bur in a high-speed handpiece was used to separate the roots. The bur was run in a withdrawing motion, first mesially and then distally, whilst the area was constantly irrigated with saline solution. The buccal roots with the fractured instrument were removed (Figs 6 and 7). The socket was curetted to remove granulation tissue, overhanging dentine and the remaining tooth was contoured to avoid a dentine shelf or residual ledge. The flap was repositioned and sutured. The patient returned 1 week later with no symptoms or signs and the sutures removed. Because of the inadequate root canal filling, the residual palatal root was filled 4 months later with gutta-percha and root canal sealer (Canals; Showa Yakuhin, Tokyo, Japan) using the lateral condensation method.

The patient was reexamined periodically for postoperative care (Figs 8 and 9). Three years after surgery the area appears clinically and radiographically healthy and the remaining root has been restored with a porcelain crown (Fig. 10).

Figure 6 Photograph showing extracted area following hemisection procedure.

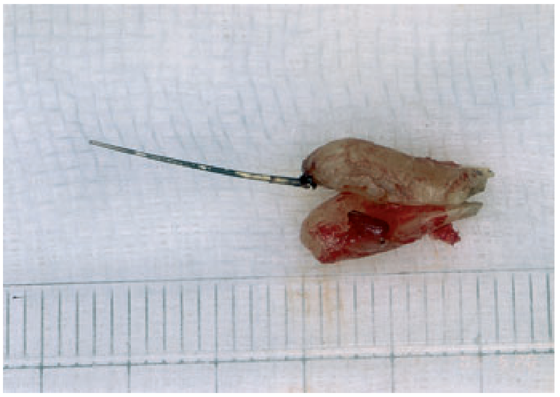

Figure 7 The resected tooth and the removed fractured instrument.

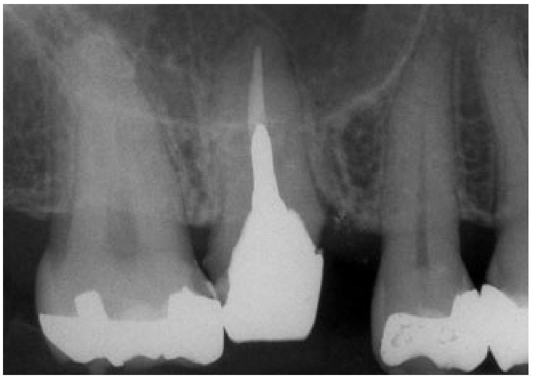

Figure 8 Radiograph 6 months after hemisection.

Figure 9 Clinical view of remaining abutment tooth at 6 months recall.

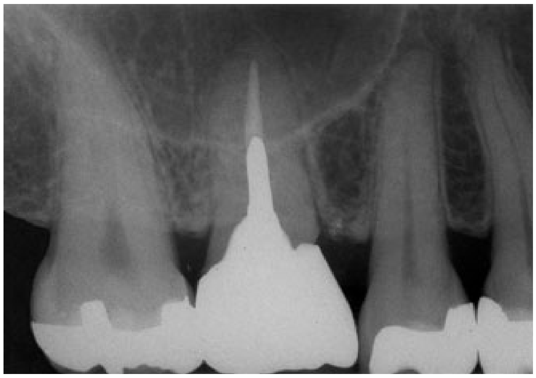

Figure 10 Three-year follow-up radiograph of maxillary first molar. A porcelain crown has been placed.

Discussion

One of the main problems in root canal retreatment is the removal of the root filling material. The retrieval may be difficult, but is essential for successful retreatment. Fractured instruments are tedious to remove and may reduce the chances of successful retreatment (Friedman & Stabholz 1986). The position of the fractured instrument has an influence on prognosis. The prognosis is poorer when the instrument is broken near the apex (Fors & Berg 1986). In this report, a perforation was detected in the pulpal floor, and the fractured instrument was located at the perforated site and protruded into the maxillary sinus. An attempt to remove fractured instruments is necessary in such cases. Prior to attempting instrument removal careful clinical and radiographic diagnosis is mandatory. The preoperative radiograph should be examined regarding the length and the location of the fractured instrument. Because of the recent progress of computer technology, three-dimensional reformatting has become possible by using serial two-dimensional CT images, allowing location and morphology to be examined three dimensionally. Thus the exact position of the fractured instrument can be accurately determined, decreasing differences in the interpretation amongst individual observers.

The cone beam CT system is a new type of imaging apparatus that may have advantages over conventional CT. This CT system has facilitated the examination of smaller parts of the dentomaxillofacial area (Rigolone *et al.* 2003, Araki *et al.* 2004). Arai *et al.* (1999) set out to develop a compact CT apparatus for dental use that was under the name of Ortho-CT. This limited cone beam CT became available on the market in 2000 under the name 3DX (Arai *et al.* 2000). The 3DX Micro-CT images in this case enabled detailed information concerning the size of the fractured instrument and its precise spatial relationships to the maxillary sinus to be obtained. With the transverse information from the 3DX Micro-CT, the fractured instrument was detected between two buccal roots and not in the palatal root. The true extent of the fractured instrument and the involvement of maxillary sinus could have been decisive in selecting a proper treatment. 3DX Micro-CT images can be printed out at actual size, and by using a scale shown on the left side of the image can be measured. Therefore, the fractured instrument length was determined. With proper knowledge of the three-dimensional interrelation of the fractured instrument and maxillary sinus a safer surgical intervention can be performed. The radiation doses are always of concern, and obviously a decrease of radiation without a decrease in image quality is desirable. The skin doses from the 3DX Micro-CT were less than that generated with rotational panoramic radiograph (Iwai *et al.* 2000), approximately 1/400 lower than those from the multidetector CT (Hashimoto *et al.* 2003). This is a strong advantage in clinical applications.

Management of a case with a fractured instrument involves either an orthograde or a surgical approach. In many cases, however, the orthograde approach is a better alternative than surgical intervention. The orthograde removal of the fractured instrument from the perforated site was attempted, but failed. A surgical approach may be compromised if removal of instruments from the tooth is impossible. Periapical surgery (Block & Lewis 1987), intentional replantation (Fors & Berg 1986) or hemisection are the recommended treatment options if surgical treatment is required. In this case, the decision was made to continue root canal treatment in an attempt to conserve the tooth and remove the instrument from the perforated site. Accordingly, the affected tooth was separated, the palatal root was retained using a hemisection procedure. Hemisection is defined as the division of a tooth in half and removal of the unwanted, diseased portion, together with its roots. It has remained a treatment option when other measures cannot overcome periodontal, pulpal or other problems associated with one root in case of mandibular molars, and one or two roots in case of maxillary molars (Erpenstein 1983). Thus it was confirmed that hemisection is the treatment of choice where it is not possible to treat one part of the tooth by conventional root canal treatment because of perforation and a fractured instrument.

Conclusions

This case illustrates an application of 3DX cone beam computerized radiography system in planning endodontic surgery.

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