Clinical Research

Application of Multiplanar Computed Tomography and the OsiriX Imaging Software for Precise Analysis of Dens Invaginatus in the Maxillary Third Molar

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Abstract: Dens invaginatus is a deep surface invagination of the dentin that is lined by enamel and is easily affected by dental caries, thus resulting in pulpitis and apical periodontitis. This report presents an image analysis of rare dens invaginatus of the maxillary third molar in a 23-year-old man. A radiographic examination showed a radiopaque structure in the dilated roots and a radiolucent area around the root. Tooth extraction and cystectomy were performed. The histological findings showed the tooth to have type III dens invaginatus. This report discusses the application of multiplanar computed tomography (CT) imaging and the free image analysis software (OsiriX) to achieve a more precise evaluation of dens invaginatus.

Key words: Dens invaginatus, Multiplanar CT, Image analysis software, OsiriX

Introduction

Dens invaginatus is a deep surface invagination of the crown or root that is lined by enamel, and the radiographic findings make it appear as if there is a second tooth on the surface. Dens invaginatus is easily affected by dental caries, thus resulting in pulpitis and apical periodontitis because of the deep invagination, which offers conditions favorable for the growth of bacteria. Dens invaginatus often occurs in the permanent upper lateral incisors, followed by the upper central incisors, premolars, and canines, and less often, in molars. This report describes an image analysis of dens invaginatus in the maxillary third molar by multiplanar computed tomography (CT) and the free image analysis software (OsiriX) in order to achieve a more precise evaluation of dens invaginatus.

Materials and methods

Case presentation

A 23-year-old man presented at the Department of Dentistry and Oral Surgery, University of Fukui Hospital with a primary complaint of spontaneous pain in his upper right third molar. A clinical examination revealed caries in the occlusal surface of the upper third molar. Electronic pulp testing revealed the upper right second molar to be vital while the third molar was non-vital. Slight percussion pain was observed in the third molar; however, there was no redness or swelling in the peripheral gingiva. A panoramic radiograph (Fig. 1) and axial CT showed a radiopaque structure in the dilated roots of the upper right third molar. A radiolucent area was also observed around the root. There was no penetration finding between the apical radiolucency and the right maxillary sinus. A clinical diagnosis of dens invaginatus of the upper right third molar and radicular cyst was made based on these findings. Temporary endodontic treatment of the affected third molar was performed for pain relief, before extraction. Extraction of the affected upper right third molar and a cystectomy were performed under general anesthesia. The buccal alveolar bone was removed with a chisel, the upper right third molar was extracted, and apical granulation tissue was extirpated. No perforation to the maxillary sinus was observed. The wound was closed by nylon sutures after saline irrigation. The patient’s postoperative course was uneventful. Informed consent was obtained from the patient before
histological evaluation and image analysis. This study was ethically approved by the institution.

**Examination materials**

The surgically extracted maxillary third molar was processed for histological examination. The removed tooth was fixed in 10% formalin solution. The fixed tooth was mesio-distally divided into 2 pieces; decalcified sections and undecalcified ground sections. One-half of the material was then decalcified in 10% ethylenediamine tetraacetic acid (EDTA) solution. The specimen was hydrated, and then dehydrated in an ascending series of ethanol and then was embedded in paraffin. Thin sections were cut and stained with hematoxylin and eosin (HE). The other half of the material was dehydrated in an ascending series of ethanol and then was embedded in methyl methacrylate. Several thick undecalcified sections were obtained using a diamond saw under running water and they were ground to a final thickness of 100 µm. The ground sections were thereafter observed under light microscopy.

**Image analysis**

Axial CT images were reconstituted to multiplanar CT images (sagittal and coronal) for the analysis. Furthermore, the Osirix imaging software, which runs on the Macintosh operating system version 10 (Mac OS X) as a free software program with a DICOM viewer, was used, to obtain more precise information of the extracted third molar from the preoperative CT images.

**Results**

**Macroscopic and microscopic examination**

The extirpated materials included a tooth with abnormally exaggerated roots (1.5-fold larger than the crown) and granulation tissue in the open apices (Fig. 2A). The lesion was composed of a cementum-like hard tissue mass accompanied by the roots, resembling a cemental hyperplasia associated with chronic inflammation (Fig. 2B).

The histological observation revealed the solid mass in the root area to be composed of dentin and enamel (Fig. 3A). A ground section demonstrated stripes of Retzius and dentinal tubules in the invagination (Fig. 3B). Enamel matrices were observed around the dentin of the invagination in the corresponding HE section (Figs. 3C and D). These findings suggested the lesion to be an invagination from the crown, and the diagnosis of type III invaginatus was made based on these findings.

**Image analysis**

An axial CT image (Fig. 4A) showed a concentric circular root with a pulp cavity and a radiopaque structure in the center of the root. A coronal CT image (Fig. 4B) showed an inverted tooth-like radiopaque structure between the dilated buccal and palatal roots. Radiopacification was observed in the right maxillary sinus. A sagittal CT image (Fig. 4C) showed similar findings to the coronal image.

The reconfiguration of the three-dimensional image showed a barrel-shaped tooth and a radiopaque area in the central part of the tooth (Fig. 5A). The root of the extracted third molar was larger than the crown, and it was bowl-shaped (Fig. 5B). These images obtained using the Osirix software program were consistent with type III dens invaginatus.

**Discussion**

Dens invaginatus is a deep surface invagination of the dentin that is lined by enamel.1 It has also been called “dens in dente”.1,4,5) The reported incidence of “dens invaginatus” ranges from 0.04% to 10% in Europe and U.S.,1, 6, 7) Meanwhile, the incidence is reported to range from 0.01% to 0.1%, making it extremely rare in Japan.8)

The maxillary incisor region, particularly the maxillary lateral incisors, is the most common location of dens invaginatus, while it occasionally occurs in the posterior teeth.9) Its occurrence in deciduous teeth and mandibular permanent teeth is extremely rare.9) There are no apparent gender differences in the incidence of this condition.2,10)

Dens invaginatus is easily affected by dental caries, and results in pulpitis and apical periodontitis because of the presence of a deep pit or sulcus that can provide a favorable environment for the growth of microorganisms.1,7)

The most popular classification of dens invaginatus was proposed by Oehlers.1,12) The Oehlers’ classification defines type I as an enamel-lined minor invagination occurring in the confines of the crown and not extending beyond the cemento-enamel junction.13) Type II consists of an enamel-lined form which invades the root, but ends as a blind sac with or without communication with the pulp.13) Type III describes an invagination penetrating the root to the apical area and forming a second foram in the apical or periodontal area.13) The invagination is often located near the lingual tubercle in the incisors, and occlusal surface in the molars. The current extracted dens invaginatus tooth was diagnosed to be type III based on Oehlers’ classification.

It is important to select the appropriate treatment plan according to the observed variations in the invagination. Various treatment methods have been proposed for dens invaginatus based on the Oehlers’ classification, including conservative restorative procedures, nonsurgical endodontic treatment, endodontic surgery, and intentional replantation or extraction. Conservative therapy is indicated for type I and some type II forms. Endodontic therapy is indicated for most type II form, while endodontic surgery is indicated for type III. Intentional replantation is indicated only in cases where combined endodontic-surgical treatment fails. Extraction is indicated when the invaginated tooth causes an...
aesthetic or functional disturbance. Extraction is the last choice of treatment. Temporary endodontic treatment of the affected third molar was performed in the present case for pain relief. However, it was too difficult to perform endodontic therapy alone because of the complicated pulp and root canal morphology. The affected dens invaginatus of the upper third molar region, especially with type III invagination, would have been difficult to treat by endodontic therapy alone, and early extraction of the tooth was thought to be better to relieve the patient of the unpleasant symptoms. The affected third molar was therefore extracted.

A histopathological examination of the undecalcified ground sections from this patient showed that the enamel of the crown was partly defective, and no pulp tissue was found because of the pulp treatment. The dentin and enamel of the deep invagination were revealed to be upside-down, and there was a cyst in the tooth apex.

It is difficult to diagnose dens invaginatus by the clinical morphology of the tooth. Therefore, the radiographic examination is important to diagnose this condition and select the treatment.
Dental and panoramic X-ray findings revealed the presence of crown-like hard tissue in the pulp of the present case. This “tooth within a tooth” phenomenon is a characteristic finding.\textsuperscript{4, 14, 15} However, conventional radiographic examinations, such as in panoramic or dental radiographs, often show that the invaginated region tends to overlap the lingual pit and cusp. Therefore, it is often difficult to diagnose the morphology of the dens invaginatus by conventional radiographic examination, and it is also impossible to figure out the stereoscopic shape of the invaginated region of the tooth based on conventional X-ray films. On the other hand, CT examination provides two-dimensional cross-sectional images. Therefore, CT examination is important to obtain more precise morphological information about the affected tooth. An expensive graphic reconfiguration software program is generally required to make three-dimensional images from CT images. Free software programs for the analysis of CT images have also recently become popular.\textsuperscript{3, 16} OsiriX is one of the free DICOM viewers for the analysis of CT and MR images, and it provides a lot of image information similar to what is obtained using the professional DICOM viewer. OsiriX was used to reconstitute the three-dimensional CT imaging of dens invaginatus from the preoperative CT data in the current case. The analysis yielded sophisticated three-dimensional images of the dens invaginatus and a cross-sectional view with high calcification of the internal tooth were obtained from the OsiriX software. Therefore, OsiriX can provide information not only about the three-dimensional structure, but also the internal structure of organs. Therefore, free image analysis software, such as OsiriX, can be a powerful tool for clinicians to diagnose various diseases in the oral and maxillofacial region.

References