Case Report

Diagnosis and Endodontic Management of Fused Mandibular Second Molar and Paramolar with Concrescent Supernumerary Tooth Using Cone-beam CT and 3-D Printing Technology: A Case Report

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Received 31 March, 2015/Accepted for publication 25 May, 2015

Abstract

Supernumerary teeth in the molar area are classified as paramolars or distomolars based on location. They occur frequently in the maxilla, but only rarely in the mandible. These teeth are frequently fused with adjacent teeth. When this occurs, the pulp cavities may also be connected. This makes diagnosis and planning of endodontic treatment extremely difficult. Here we report a case of a mandibular second molar fused with a paramolar, necessitating dental pulp treatment. Intraoral and panoramic radiographs were obtained for an evaluation and diagnosis. Although the images revealed a supernumerary tooth-like structure between the posterior area of the mandibular second molar and mandibular third molar, it was difficult to confirm the morphology of the tooth root apical area. Subsequent cone-beam computed tomography (CBCT) revealed that the supernumerary tooth-like structure was concrescent with the root apical area of the mandibular second molar. Based on these findings, the diagnosis was a fused mandibular second molar and paramolar with a concrescent supernumerary tooth. A 3-dimensional (3-D) printer was used to produce models based on the CBCT data to aid in treatment planning and explanation of the proposed procedures to the patient. These models allowed the complicated morphology involved to be clearly viewed, which facilitated a more precise diagnosis and better treatment planning than would otherwise have been possible. These technologies were useful in obtaining informed consent from the patient, promoting 3-D morphological understanding, and facilitating simulation of endodontic treatment.

Key words: Paramolar — Fused tooth — Concrescent tooth — Cone-beam CT — 3-D printing technology

Introduction

Supernumerary teeth in the molar area are classified as paramolars or distomolars based on location. Paramolars frequently occur on the mesiobuccal side of the maxillary
second and third molars, but are rare in the mandible. Diagnosing and endodontically treating such teeth is extremely difficult, as the dental pulp in such cases is frequently connected with that of the molars.

Here we describe how intraoral and panoramic radiography was supplemented with 3-dimensional (3-D) models constructed based on data obtained from cone-beam computed tomography (CBCT) to treat a fused mandibular second molar and paramolar with concrescent supernumerary tooth. A follow-up examination was also scheduled. Written informed consent was obtained from the patient for inclusion in this study.

Case Report

The patient was a 16-year-old boy who was referred to the Department of Conservative Dentistry at the Tokyo Dental College Chiba Hospital for the treatment of a mandibular right second molar. A partial vital pulpotomy had already been performed on this tooth by a local dentist at this point. The patient had visited his local dentist with the chief complaint of a cold-sensitive mandibular right second molar (#47). Panoramic and occlusal axis radiography was performed as a paramolar was noted on the mesiobuccal side of the mandibular right second molar and deep caries was present in the cuspal crest area (Figs. 1 and 2). Palpation revealed exposure of the pulp in the carious area, making it necessary to treat the pulp in the paramolar. After removing caries from the cuspal area of the paramolar under local anesthesia, a pulpotomy was performed: the dental pulp within the paramolar was partially removed and calcium hydroxide (Calcipex II: Nippon Shika Yakuhin, Shimonoseki, Japan) applied to the surface of the remaining pulp. Glass ionomer cement was then used to fill the remaining cavity. No symptoms were observed at a follow-up examination 7 days postoperatively. Moreover, no further clinical symptoms were noted for a period of 3 weeks until the patient visited our hospital for a more detailed evaluation of the fusion between the

Fig. 1 Preoperative panoramic radiograph from referring general practitioner

Fig. 2 Preoperative occlusal intra-oral radiograph of mandibular right molar area from referring general practitioner
Paramolar and mandibular right second molar.

The first visual examination at our hospital revealed caries in the fissure area on the occlusal surface side between the paramolar tubercle and mandibular right second molar (Fig. 3). On further examination of this area...
with an explorer, the patient complained of slight pain. Probing revealed that the circumferential gingival depth was less than 3 mm. The boundary between the paramolar and mandibular right second molar was unclear on inspection and palpation using an explorer. It was decided that 3-D imaging was needed to allow a proper evaluation of the complicated morphology of the diseased tooth. After obtaining consent from the patient and his parents, CBCT (Veraviewepocs 3D: Morita, Kyoto, Japan) was conducted.

The CBCT images (Figs. 4 and 5) revealed independent pulp cavities in the coronal area of the paramolar and mandibular right second molar. However, these pulp cavities were connected in the root area. Calcium hydroxide applied to the paramolar reached this area, which was located at the center of the root of the mandibular right second molar (Figs. 4-c and 5-d). A supernumerary tooth was noted on the distal side of the mandibular right second molar, and a horizontally impacted third molar was present in the distal area of the supernumerary tooth. Even with panoramic (Fig. 1) and intraoral radiographs (Fig. 2), it was difficult to detect the continuity between the supernumerary tooth and mandibular right second molar due to overlapping of the anatomical structure. On CBCT, no low-density lines suggesting a boundary between the supernumerary tooth and the mandibular right second molar were noted, except in the root apical area (Fig. 5-g). Furthermore, there was no continuity between the dentin and dental pulp in the root apical area, which strongly suggested that the cementum was concrescent. Based on these imaging findings, the diseased tooth was diagnosed as a mandibular second molar with a fused paramolar and concrescent supernumerary tooth.

The results of imaging, the diagnosis, and the treatment plan for caries in the fissure area were explained to the patient and his parents. Composite resin restoration was

![Fig. 5 Panel of axial CBCT sections](image-url)
subsequently performed in the carious area after obtaining consent. Next, a 3-D printer was used to produce models of the tooth and jaw bone based on the CBCT data to enable us to explain the proposed treatment plan for the submucosal supernumerary tooth and third molar.

The apparatus and software used to produce the 3-D models of the tooth and jaw bone and subsequent treatment were as follows:

1. A region of interest was established and binarization of images performed by using a medical imaging application (Volume Extractor 3.0, i-Plants Systems, Iwate, Japan).

2. Computer-aided design (CAD) data were generated to produce models.

3. Three-dimensional models of the tooth alone and of the tooth and jaw bone were fabricated using a 3-D printer (Value3D MagiX MF-2000, MUTOH Industries LTD., Tokyo, Japan, Fig. 6) based on the CAD data.

No symptoms were noted and the diseased tooth was positive on an electric vital pulp test.

Fig. 6 3-D models fabricated by 3-D printer “Value3D MagiX MF-2000”

a. Mesiobuccal view of tooth and jaw bone model, b. Occlusal surface view of tooth and jaw bone model, c. Lingual view of model with lingual cortical bone partially removed. Third molar can be observed on distal side of supernumerary tooth, d. Occlusal surface view of model c, e. 3-D model of mandibular second molar, paramolar, and supernumerary tooth. Buccal view, f. NiTi rotary files were inserted into each root canal as path-finding simulation.

Fig. 7 Intraoral radiograph and photograph at follow-up examination 5 months postoperatively
at the follow-up examination 5 months after filling was performed. The cuspal crest area of the paramolar was restored with composite resin after obtaining an intraoral radiograph (Fig. 7). The condition of the supernumerary tooth, horizontal impaction, and predicted eruption of the mandibular third molar on the distal side of the supernumerary tooth were explained to the patient and his parents using the 3-D models of the tooth and jaw-bone (Figs. 6-a–d). The difficulty of root canal treatment of the mandibular second molar due to the complicated morphology of the dental pulp was also explained using 3-D models of the tooth (Figs. 6-e, f). As regards the treatment plan for the mandibular second molar, it was explained that the dental pulp was to be conserved, while continuing monitoring for further developments. Providing information in conjunction with CBCT images and 3-D models allowed the patient to understand the anatomy of the area surrounding the diseased tooth and the necessity of continued follow-up.

This study was conducted in accordance with Rules on Ethical Conduct of Tokyo Dental College after obtaining written informed consent from the patient and his parents.

Discussion

An abnormal tooth number is classified as supernumerary teeth or hypodontia, with the incidence of the former being lower than that of the latter. Supernumerary teeth frequently occur in the anterior tooth area, whereas the rate of occurrence in the molar area is low. Tochihara reported that the incidence of supernumerary teeth in the molar area was 0.06% in Japanese. It was also reported that those in the mandibular molar area accounted for 6.57%. Supernumerary teeth in the molar area are classified as distomolars or paramolars based on location. The term “distomolar” is used to indicate supernumerary teeth in the distal area of the third molar. Therefore, the cone-like supernumerary tooth observed between the second and third molars in the present case could not be classified as a distomolar, and was therefore considered to be extremely rare.

Paramolars are supernumerary teeth occurring on the mesiobuccal side of the molars. Paramolars are frequently fused with the molars, and are classified as paramolar tubercles. In previous studies, supernumerary teeth in the molar area were classified based on the dentition of dental stone models or 2-D radiographic diagnosis. This suggests that the supernumerary teeth in these earlier reports were not clearly classified as being concrescent with molars or fused with molars or paramolar tubercles.

In the present case, CBCT imaging clearly confirmed that the diseased tooth comprised a fused paramolar and molar. There have only been a few clinical case reports in which CBCT imaging was performed to aid in the diagnosis and treatment of mandibular paramolars. In each case, it was reported that a paramolar and a molar were fused, and that their dental pulp was connected. In the present case, also, no independent root apical foramen was noted in the fused paramolar, and the connection of the dental pulp was confirmed in the area 5 mm from the apical side of the C-shaped root canal of the molar. This allowed 3-D confirmation that the dental pulp treatment had been performed within the paramolar.

Pioneered by Arai et al., the use of CBCT in dentistry has markedly changed diagnostic procedures in the dental field. This has provided various advantages in making diagnoses in the field of endodontics. It is now possible to clearly identify points requiring attention in non-surgical endodontic treatment of teeth with a general morphology and to anatomically detect the cause of treatment failure because CBCT can be used to obtain a precise understanding of the 3-D structure of the teeth and dental pulp. There have been many reports on the usefulness of CBCT in the diagnosis and treatment-based management of teeth with a complicated morphology. In the present case, too, it was possible to clearly distinguish morphological differences...
between the fusion of a molar and a para-
molar and concrescence of a molar and a
supernumerary tooth. All of this provides
evidence for the usefulness of CBCT in
understanding teeth and dental pulp with
atypical morphologies.

However, CBCT has some limitations:
it only allows observation of multi-planar
reconstruction images on a computer screen,
which means that it can only provide 2-D
information on the curvature of the tooth
root and changes in the root diameter. To
overcome this shortcoming, however, it is
possible to produce 3-D models fabricated
based on these images, which allows various
types of measurement and treatment simu-
lation. This can then be applied to actual
endodontic treatment. Although there have
been some reports on the use of 3-D model-
ing of dens in dente using a 3-D printer
in endodontic treatment training9), to our
knowledge, there have been no reports on
the application of this technology to diag-
nosis and treatment simulation in teeth and
jaw bones with a complicated morphology, as
in the present case.

In the present study, the CAD data on the
teeth and jaw bone were generated from
CBCT images using a medical imaging con-
struction application (Volume Extractor 3.0),
and the 3-D printer used to produce models
was a low-price personal printer (MF-2000).
Although the price of the printer itself and
materials for molding was low, its molding
resolution was close to that of the spatial reso-
lution of CBCT7). This allowed 3-D models to
be produced much more economically than
would be possible with printers aimed at the
higher end of the professional market.

The molding system itself can produce a
range of models. Here, 3-D models of the
teeth and jaw bone and those of the teeth
alone were produced at the actual and dou-
bled sizes, respectively. Cutting and removing
the jaw bone area from the 3-D models of
the teeth and jaw bone allowed the fused
tooth, concrescent tooth, and third molar in
the jaw bone to be viewed 3-dimensionally in
detail. Moreover, these models also helped
in explaining the complicated morphology
involved to the patient together with the need
for continued postoperative follow-up, which
aided in obtaining informed consent.

To generate 3-D models of the teeth alone,
it was necessary to separate the CBCT images
of the teeth from the jaw bone manually
using Volume Extractor 3.0. This was because
the periodontal ligament space, which is the
boundary between the tooth root around
the root apex and the alveolar hard line, was
partially unclear on the CBCT images.

The 3-D models produced through this
manipulation reproduced the morphology
of the dental pulp cavity, permitting direct
observation of the morphology of the root
canal. Furthermore, insertion of a file into
the root canal confirmed the connection
between the root canal of the paramolar
and that of the mandibular second molar.
This simulation revealed that any endodontic
treatment undertaken would be extremely
difficult. Certainly, the limited spatial resolu-
tion of CBCT and modeling resolution of the
MF-2000 meant that the models produced
would not replicate precisely the fine contours
of the root canal. However, reproducibility
was sufficient to allow a 3-D understanding
of the complicated morphology involved. In
addition, insertion of a NiTi rotary file to
further establish the path in each root canal
was performed smoothly (Fig. 6-f).

Some earlier studies have reported a
pulpectomy in fused teeth comprising a
paramolar and a molar in which CBCT was
used2,11). In the present case, the dental pulp
in the tooth root of the paramolar area was
removed up to the position corresponding
to the fusion boundary of the molar, and
calcium hydroxide was applied to the wound
surface of the dental pulp. We believe that
the present case supports the importance of
conserving the dental pulp in the complicated
C-shaped root canal region of the mandibular
second molar by performing treatment cor-
responding to a partial pulpotomy of the
molar dental pulp.

The present results confirm that employing
CBCT and 3-D modeling for diagnosis and
treatment planning in such difficult endodontic cases offers advantages in both terms of ease of use and economics. It is speculated that the use of such procedures will spread in the future with the further development of software and hardware aimed at 3-D modeling.

In the present report, a 16-year-old boy was treated for a fused mandibular second molar and paramolar with a concrescent supernumerary tooth. Evaluation using CBCT and modeling with a printer markedly facilitated a 3-D understanding of the complicated morphology of the region involved. This, in turn, allowed simulated treatment to be carried out and informed consent to be obtained with greater ease.

References


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