

# A Successful Individual Endodontic Treatment of Severely Curved Root Canals in Mandibular Second Molars: A Case Report

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## Short report

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# Abstract

**Background and Overview** The incidence rate of severely curved root canals in mandibular molars is low, and the root canal treatment of mandibular molars with this aberrant canal anatomy may be visibly and technically challenging. **Case Description** A 26-year-old Chinese female patient presented with intermittent and occlusal pain in the left mandibular second molar. The patient had undergone caries for filling restoration before endodontic consultation. With the aid of cone beam computed tomography (CBCT), a large periapical radiolucency was observed, and curved root canals in a mandibular second molar were confirmed, depicting a severe and curved distolingual root. Nonsurgical treatments, including novel individual preparation skills and techniques and the use of bioceramic materials as an apical barrier, were performed, and complete healing of the periapical lesion and a satisfactory effect were achieved. **Conclusions and Practical implications** A case of a severely curved root canal in a mandibular second molar was successfully treated and reported herein. The complex anatomy of the tooth and the postoperative effect were also evaluated via the three-dimensional (3D) reconstruction of CBCT images, which accurately identified the aberrant canal morphology. Furthermore, new devices and biomaterial applications combined with novel synthesis techniques can increase the success rate of intractable endodontic treatment.

## Significance

The treatment of patients with severely curved root canals is problematic. Herein, with the guidance of CBCT, individual preparation skills and techniques and the use of bioceramic materials as an apical barrier may aid in the treatment of such severely curved teeth.

## Introduction

To date, root canal therapy (RCT) is a preferred treatment for pulpitis and periapical disease, and its success rate is closely associated with the anatomical morphology of the root canal system[1]. Being familiar with internal canal morphology is crucial for endodontists. The anatomical variations existing in the root canal system, such as curvature, may result in severe complications, such as ledge formation, apical transportation and perforation during root canal preparation, which increases the failure rates of the treatment[2]. To reduce the occurrence of these complications, a comprehensive understanding of root canal curvature models, including the degree of curvature and radius, is important. Mandibular permanent molars are the most vulnerable to dental disease, but the anatomical structure of the root canal is usually complex and substantially varied, which is considerably challenging for clinicians. According to reports, the anatomical configuration of molar roots and canals varies by nation. For example, the proportions of Spanish, Iranian and Indian people with permanent second mandibular molars that have two roots are 83%, 81.6%, 79.35%, respectively[3–5]. Most mandibular second molars have a small degree of bifurcation or have conical roots that are fused on the buccal surface and separated on the lingual surface. This fused root was coined in a C-shaped root, which is an important feature of mandibular second molars. Kim et al[6] reported that the proportion of patients with a double

root canal system in their mandibular second molars totalled 58% in Korea, while the proportion with the C-shaped type accounted for 40%, as analysed by cone beam computed tomography (CBCT) data.

CBCT was introduced as a high-resolution imaging modality in oral and maxillofacial radiology[7]. Analysing and displaying the curved root canal system in the sagittal, coronal and axial planes can allow for three-dimensional reconstruction of CBCT scans, providing high-resolution images of the root canal system to gain a better understanding of the direction of curvature. Thus, visualization of the canal anatomy can enable precise canal preparation[8] and provide clinical guidance for the diagnosis and treatment of complex and curved canals[9]. This clinical report describes three severely curved canals in the left mandibular second molar that were successfully healed with individual RCTs under dental microscope and CBCT guidance. Herein, we propose preparation techniques with ultrasound systems and dental lasers, and we find evidence that filling with bioceramic materials as an apical barrier may aid in the treatment of severely curved teeth.

## Clinical Report

A 26-year-old female patient was admitted to the Department of Endodontics..., in December 2019. She was referred for evaluation of the left mandibular second molar with the chief complaint of intermittent pain and occlusal pain in this tooth. The patient denied having a remarkable medical history or drug allergies, and she reported caries for which her dentist filled as restoration. Upon extraoral examination, no significant signs were noted. The intraoral examination revealed that the left mandibular second molar (#37) had been restored with white material (Figure 1A) and showed no signs of swelling, no response to the pulp test, and no pathological mobility. Periodontal probing around the tooth showed a pocket within physiological limits without an intraoral sinus. However, there was severe pain from percussion and palpation. The first mandibular molar had a crown and no response to the cold test or percussion and was asymptomatic. Radiographic examination showed that tooth #37 had a large periapical radiolucency encompassing both the mesial and distal regions with a size of  $11 \times 6 \times 6 \text{ mm}^3$  (Figure 1B), which was confirmed by CBCT (Planmeca Romexis, Finland) (Figure 1D, E). In addition, the root canals in tooth #37 had two roots: The mesial root had two separate canals, the distal root had an oblate canal (Figure F-G), and a large periapical radiolucency that perforated the lingual cortical plate was observed in the apical region of #37 (H-I). More importantly, all canals in both the mesial and distal roots had a sharp curvature mainly in the distal direction. Referring to the method of canal curvature, namely, the Pruett method[10], the degree of root canal curvature was measured using periapical radiographs, which showed that the curvature was mainly in the distal direction. The degree of curvature in the mesial and distal root was determined to be  $91.5^\circ$  ( $\alpha$ ) and  $105^\circ$  ( $\beta$ ) degrees, with radii of curvature of 3.2 mm ( $r_1$ ) and 3 mm ( $r_2$ ), respectively (Figure 1C), indicating that the canals were severely curved, which makes treatment difficult. According to clinical and radiographic examination, a diagnosis of chronic periapical periodontitis of #37 was reached, and a nonsurgical treatment (RCT) of the tooth was proposed and scheduled.

After discussing possible treatment options, the patient agreed to treatment for tooth #37 and signed the informed consent form. The tooth was isolated with a rubber dam, and the old fillings were removed before completely exposing the top pulp chamber. Endodontic access was completed using a diamond bur with a water spray. The entire procedure was performed under a dental microscope (ZUMAX, Suzhou, China) and with the guidance of CBCT. Three canals were identified, namely, the mesiobuccal, mesiolingual and distal canal under magnification, and a Ni-Ti file rotary system (Orodeka, PLEX, Italy) was used for root canal preparation. The preparation and process of cleaning and shaping the canals was divided into two parts: (1) During the initial stage of RCT, the orifices of the root canals were trimmed using ET18D (ACTEON®, SATELEC, France), and coronal access was obtained using #15/08 (Orodeka, PLEX, Italy). (2) For mesial root canals, after exploring and dredging the position of the canals with #08 and #10 K-files (Densply, USA), the initial working length (WL) was determined by #10 K-files at the end of the apex under magnification, which was confirmed by periapical radiographs (Figure 2A-D). Then, canals were shaped and enlarged using #15/03, #20/04 and #25/04, while for a distal root canal, the upper canal was used for the crown-down technique with #15/03, #20/04 and #25/06 according to the resistance. After that, #6 K-files was established a straight path to the apex with EDTA gel (MD-ClelCream, Meta Biomed, USA)), and the WL was determined according to the penetration of the #06 K-files and measured (referring to the point on the crown edge to the apical foramen minus 1 mm)[11]. The step-back technique, using the 0.5-mm recession method with #08, #10 and #15 K-files, was used for apex preparation to maintain the original morphology and shape of the root canal. Finally, the canal was finished with #12/03 and #15/03. A total of 20 ml of 5.25% NaOCl combined with 17% EDTA solution was used to irrigate every root canal during preparation. An ultrasound system (P5 Newtron XS, SATELEC, France) was introduced to activate the irrigant, and a photon-initiated photoacoustic streaming (PIPS) technique (Er:YAG, SSP, 2 Hz, 20 mJ, 0.15 W, LightWalkerAT, Fotona, Germany) was used to further remove the deep smear layer and eliminate any remaining bacteria in the dentin canal tubes. Finally, paper points were used to dry the canals for inspection, calcium hydroxide paste was used as filler, and then the coronal was temporarily sealed with temporary filling material (Ceivitron, Taipei, China). All operations were carried out successfully under a dental operating microscope.

The tooth was re-examined two weeks later, and the canals were copiously irrigated with 17% EDTA solution to remove calcium hydroxide paste. After cleaning with the PIPS technique and distilled water, the canals were dried with paper points. The main gutta-percha cones were selected (#25/04), and the mesial canals were filled with large taper gutta-perchas and root canal sealer iRoot® SP (Innovative Bioceramix, Vancouver, BC, Canada). However, gutta-perchas could not reach the WL point in the distal canal due to the sharp curved apex. Therefore, the vertical condensation technique was used for the apical sites, in which iRoot® BP Plus (Innovative Bioceramix, Vancouver, BC, Canada) was placed as a barrier to exert a better apical sealing effect after filling with iRoot® SP (Figure 2E). Postoperative radiographs were taken to confirm that three canals were filled compactly, especially in the curved corners. After three months of observation (Figure 3B), the patient had no spontaneous pain or other obvious abnormalities, and the tooth was restored with composite resin (Filtek Z350 XT, 3M ESPE). The patient was then referred for restorative treatment. The edge of the ceramic crown and occlusal was

checked to ensure a proper fit (Figure 2G-I), and follow-ups were recommended after one year. No pain, swelling or mobility were noted. The radiographic examination of the treated tooth confirmed the almost complete recovery of periapical radiolucency, suggesting that the periapical inflammation healed obviously at six months and one year postoperatively (Figure 3C-H).

## Discussion

Endodontic treatment failure in mandibular molars is mostly due to the complexity and diversity of root canal configurations. In this case, three mandibular molar canals, namely, the mesiobuccal, mesiolingual and distal canals, were separate and independent from each other. Interestingly, the CBCT images revealed that these canals were severely curved, showing highly rare degrees of curvature, illustrating the challenges that must be faced when dealing with the anatomical variations in canals. As studies have reported, most mandibular second molars have two roots or a fused root, with 55% having three canals [12]. Precisely understanding the positions, directions and angles of these curvature canals is important for treatment. However, diagnostic X-ray is a two-dimensional image that does not reflect the buccal and lingual curvature. Unlike radiograph images, CBCT images can sufficiently depict the original morphology such that file separation is prevented and the healing effect after treatment can be evaluated. In this study, visible three-dimensional canal models based on CBCT datasets were found to facilitate the shaping and cleaning efficiency of root canal systems. Friedland et al [13] reported the use of three-dimensional reconstructions of CBCT to efficiently and accurately observe and analyse anatomically curved canals. Hence, the precise assessment of root canal curvature is essential for guiding endodontic operations.

In this case, all the root canals were severely curved, especially the apical tip of the distal root canals (Figure 1), which was intractable to preparation and fillings. However, the small taper and flexibility of Ni-Ti files allow the original apical shape and position to be maintained [14]. In addition, files that are pre-bent into the root canal may retain more pericervical dentine and reduce dentin stress, instrument separation and other complications [15]. The crown-down technique, which can be used to access canals, recommends a wide pathway to facilitate irrigation. High concentrations of sodium hypochlorite with ultrasonic activation as a mechanochemical preparation can further eliminate infections of the lateral canals and curved apex. The use of lasers in dentistry fields confers many advantages, such as removing carious enamel and dentine and facilitating endodontic treatment and prosthetic procedures, including crown lengthening and sulcus uncovering [16]. Erbium laser-assisted working techniques in endodontic therapy can accelerate the healing processes via endodontic space decontamination and the removal of pathological tissues [17] and carious dental tissues, as well as through debridement and disinfection of periodontal tissue [18]. PIPS is a new technique that requires the use of an Er:YAG laser to activate the water molecules in irrigants to remove dentin debris and smear layers due to the positive radial effect [19, 20]. For these curved canals, PIPS can be used to clean the apical region as well as the narrow area of irregular canals (traffic and the gorge area) that the files cannot reach, which is a minimally invasive method to disinfect the tooth [21]. Great importance is attached to the ability to fill the apex of curvature since conventional canal fillings cannot seal the irregular apex. iRoot BP Plus can be used for repairs

such as pulpotomy, pulp floor perforation repair, and root perforation repair [22]. Interestingly, we filled the curved apex with iRoot BP Plus due to its good sealing ability and its capacity to absorb water from the dentinal tubules and to prevent oral fluid contamination[23]. The apical barrier using bioceramic materials in the apical regions showed good biocompatibility, was chemically bonded to the dentin, and reduced the number of microcracks generated by pressurized filling [22]. After one year of follow-up, the treated mandibular molar showed complete healing of the periapical lesion and a satisfactory effect (Figure 3G-I).

In conclusion, a thorough understanding of tooth and root canal morphology by CBCT during preoperative assessment is highly important. Exploring the root canals under magnification, making preparations with individual sequential techniques combined with new instruments such as ultrasonic activation and PIPS, and using fillings with bioceramics as an apical barrier are essential prerequisites to increase the success rate of this difficult endodontic treatment. Although the endodontic treatment of teeth with large periapical bone destruction and aberrant curved canals was difficult and intractable, nonsurgical root canal therapy was performed with novel devices and introduced skills in this case, resulting in a good prognosis in which the periapical radiolucency disappeared without any symptoms. This report also provides meaningful guidance and serves as a reference for other similar cases.

## **Declarations**

### **Ethical Approval and Consent to participate**

Written informed consent was obtained from the patient for publication of this case report and the images. A fully anonymized clinical data and in agreement with the decision of the Ethics Committee was not required.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The datasets in the study are available from the corresponding author on reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

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### **Authors' contributions**

XLJ contributed to conceptualization, writing-original draft preparation, editing, software. ZJY took responsibility for data curation, editing, methodology, advice. HZH was involved in visualization, investigation. WXZ took responsibility for supervision, methodology, validation, writing-reviewing and editing. All authors read and approved the final manuscript.

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The authors deny any conflicts of interest related to this study.

## Authors' information

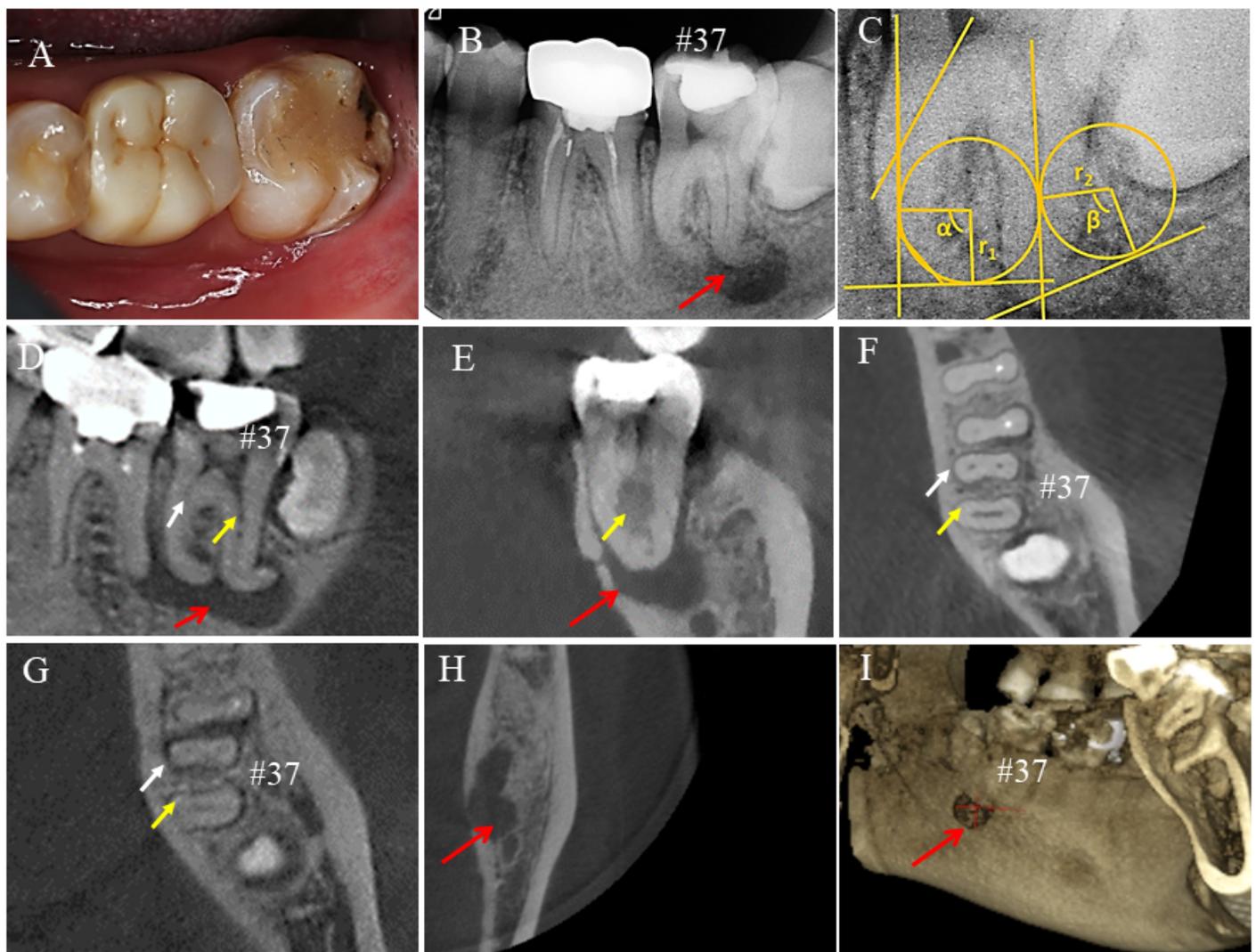
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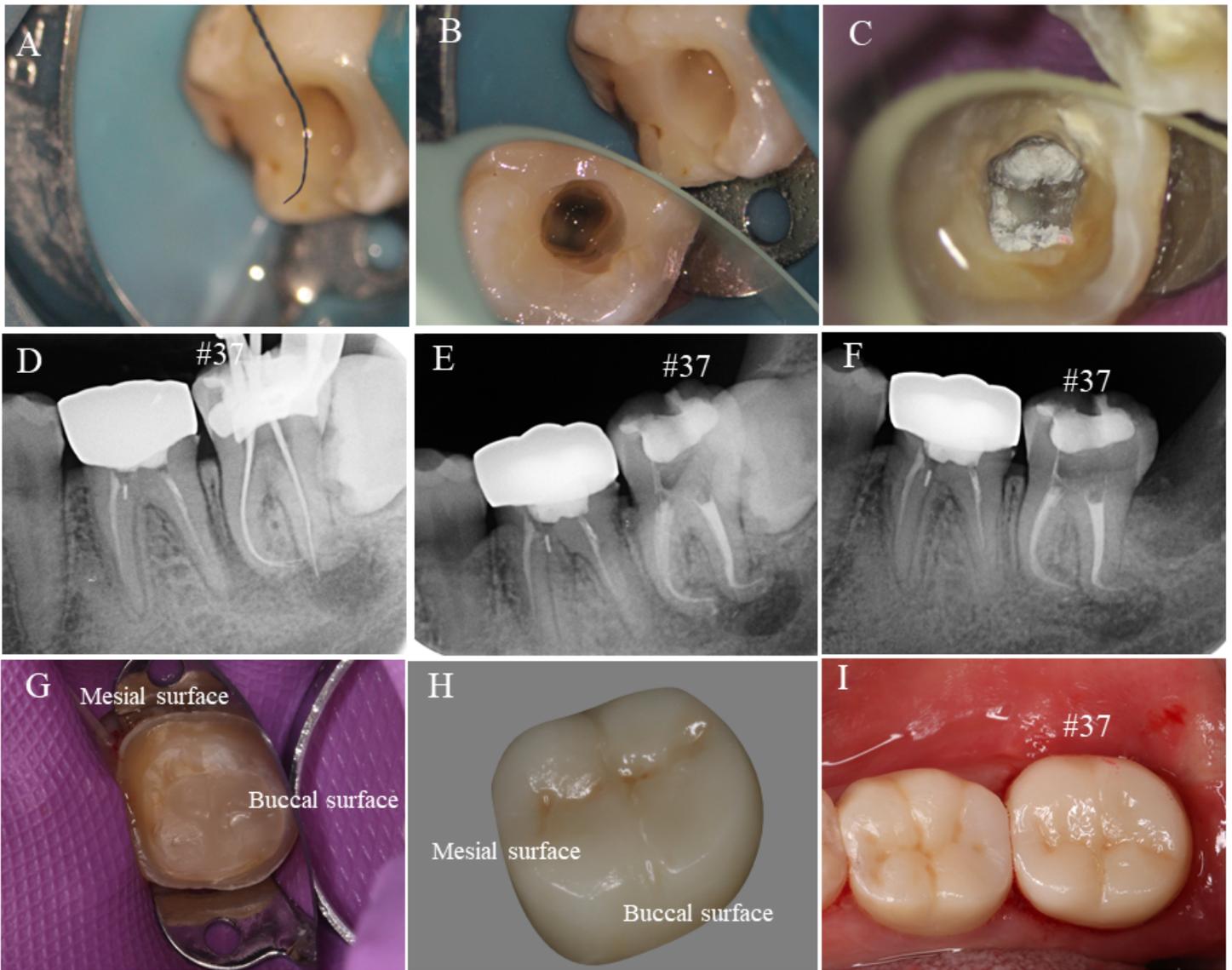
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# Figures



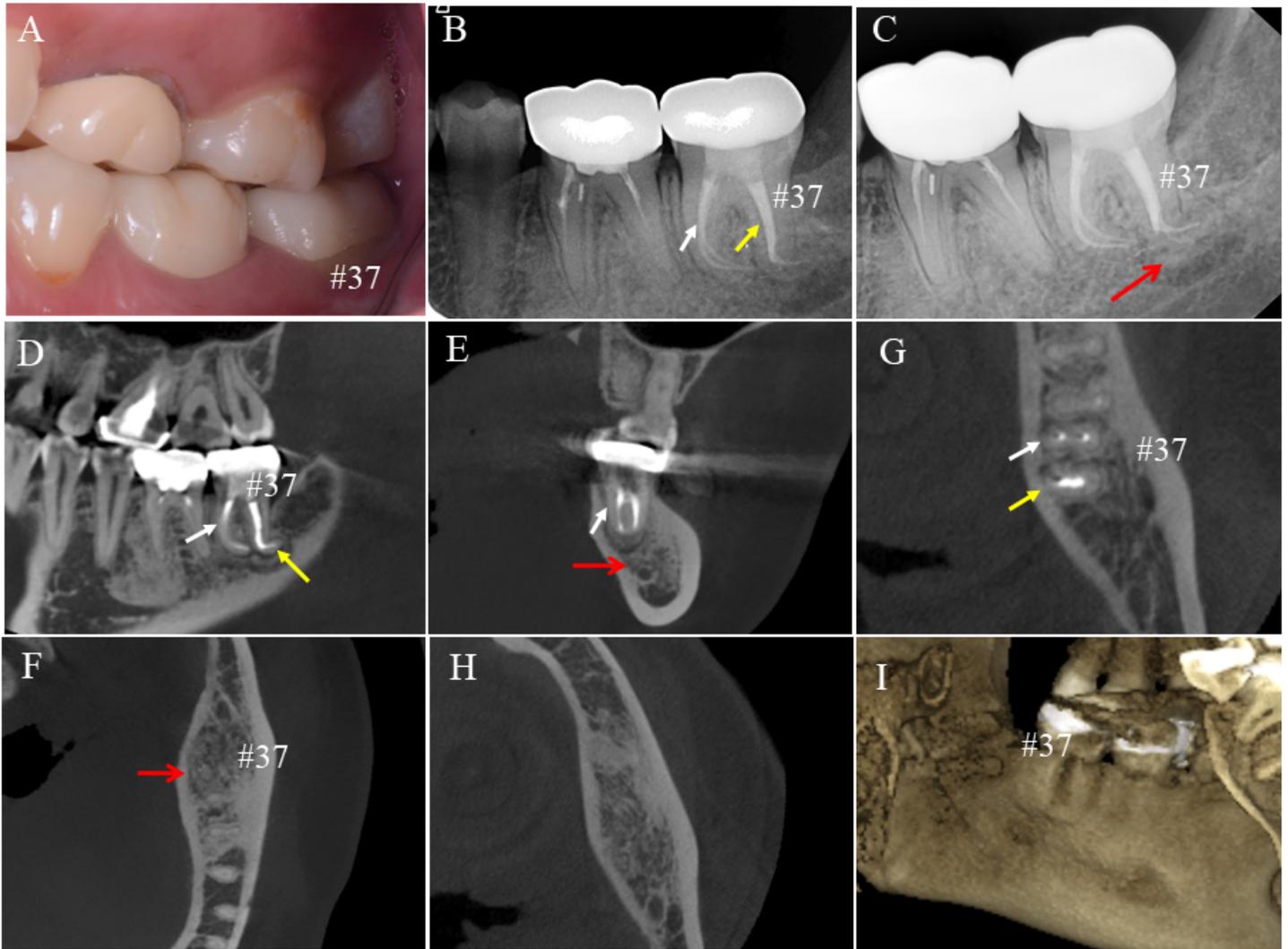
**Figure 1**

Initial clinical situation (#37). (A) Photograph of the mandibular second molar; (B) Preoperative periapical radiograph of the molar; (C) Measurement of radius of curvature and angles; (D) Sagittal, (E) coronal, and (F-H) axial dimensions obtained from CBCT. (I) The 3D reconstruction of the CBCT presenting the perforation of the lingual cortical plate. The white and yellow arrows represent the mesial root canals and a distal root canal, respectively; the red arrow shows the regions of large periapical radiolucency.



**Figure 2**

Treatment of the mandibular second molar. (A) Severe curvature of the file in the canal apex; (B) preoperative image and (C) postoperative image of the bottom medullary chamber; (D) radiograph for the working length determination; (E) final radiograph after the operation; (F) follow-up after two weeks. (G) The tooth after crown preparation; (H) The ceramic crown; (I) The occlusal surface after restoration.



**Figure 3**

(A) Occlusal situation of the left molars; (B) three-month and (C) one-year radiographic follow-up images demonstrating healing of the periapical lesion; (D-H) CBCT images from the one-year radiographic follow-up; (I) 3D reconstruction of the CBCT presenting healing of the lingual cortical plate. The white and yellow arrows represent the mesial root canals and a distal root canal, respectively; the red arrow shows the regions of periapical healing.