Successful root canal treatment of an atypical mandibular canine with a boomerang-shaped root and canal system with a large periapical lesion—A case report with 9-year follow-up

Abstract

Aim: This report describes an atypical mandibular canine with a single boomerang-shaped root and root canal system with a large periapical lesion managed by root canal treatment.

Methods: The chief complaint of a 16-year-old male was acute pain and an abnormal sensation in the right mandibular canine (#27). The clinical examination revealed that tooth #27 had an unusual coronal morphology. The buccal aspect of the tooth resembled that of a normal canine but was significantly broader than expected. On the lingual aspect of the crown, however, there was an unusual cusp-like structure with ridges that was slightly less prominent than the buccal incisal tip. The intraoral periapical radiographs revealed a complex root with an obvious cow horn-shaped canal mesially and distally, but with the suggestion of a root structure joining the mesial and distal extensions. A large periapical lesion was present, Computed tomography revealed the presence of a single root and canal system shaped like a boomerang. Root canal treatment was performed, and the patient was followed-up for 9 years.

Results: Following root canal treatment, the patient had no symptoms, no mobility, no periodontal pockets, or root resorption. At 9 years, the cone beam computed tomography images confirmed that satisfactory healing of the periapical tissues had occurred.

Conclusion: The mandibular right canine had a unique boomerang-shaped root and canal system. Effective shaping and cleaning of the complex canal shape plus thermoplastic root filling aided the successful healing of the periapical lesion.

Key words: Anomalies, c-shaped canal, canal morphology, mandibular canine, root canal treatment

Statement of Clinical relevance

This report describes a rare morphoanatomical variant of a mandibular canine with a single boomerang-shaped root and a root canal system with a large periapical lesion that was successfully managed with root canal treatment.

Introduction

Due to the anatomical complexity of teeth, clinicians frequently have difficulty locating root canals, as well as cleaning, shaping and filling them[1,2]. It is therefore mandatory for clinicians to have a thorough knowledge and understanding of the normal anatomy as well as uncommon developmental anomalies of teeth, roots, and root canals in order to undertake a range of endodontic procedures, including root canal treatment and surgery[1,3].

The mandibular canine usually has a single root and canal; however, anatomic variations do occur, but their prevalence differs among populations and races[4]. Dental anomalies are craniofacial abnormalities of the form, function and position of teeth, bone and tissues of the jaw and mouth that are usually congenital and are expressed as an isolated finding or part of a syndrome[5,6]. Mandibular canine anomalies encompass a range of deviations from their normal development, eruption time and position in the arch, and can be characterized based on their shape, number of roots or canals, size, and structure of either the crown/ root or both. The anomalies can be either unilateral or bilateral[7].

Fusion of teeth is defined as "the union of two or more separately developing tooth germs at the dentinal level, yielding a single large tooth during odontogenesis, when the crown is not yet mineralized"[8] and is more prevalent in the primary dentition ranging between 0.5-2.5%[9], with a higher prevalence in the anterior region. Supernumerary teeth are defined as excess teeth in comparison to that of the normal series and have been attributed to the localized hyperactivity of the dental lamina[10]. The prevalence of supernumerary teeth has been reported to be 8.2-10 times more in the maxilla in comparison to the mandible[11]. Fusion between permanent teeth and supernumerary teeth can result in a very broad anomalous crown structure with a groove between them[12]. Among the fused primary tooth anomalies observed in a Turkish population, the most common was fusion of mandibular canines to lateral incisors which was reported to be 68% (34 teeth out of 50)[13].

Talon cusps are another anomaly observed in maxillary and mandibular anterior teeth that are characterized by an extra cusp arising from the cingulum area that extends at least up to half the distance between the cementoenamel junction (CEJ) to incisal edge.

The talon cusp usually consists of enamel, dentin and a pulp horn[14]. A cone beam computed tomography (CBCT) study reported that the prevalence of talon cusps in mandibular canines in Caucasians was 3%[15].

In endodontics, conventional intraoral periapical radiographs are an essential diagnostic instrument for evaluating root and canal configurations. However, standard dental radiographs do not always reveal the complex morphology of the root canal system. In this situation, CBCT scans can provide more comprehensive images on root and canal anatomy[16]. Additionally, CBCT images are also useful in detecting apical periodontitis, which cannot always be diagnosed on periapical radiographs[17].

Endodontic treatment of teeth with anomalies will vary depending on the specific anomaly and the extent of tooth and bone destruction. A thorough understanding of the complexity of the canal system through three-dimensional (3D) imaging with computed tomography will also aid in selecting the appropriate management option and guide the clinician through the various stages of the selected clinical treatment[18,19]. This report describes a rare morphoanatomical variation of a mandibular canine with a single boomerang-shaped root and root canal system with a large periapical lesion detected using CBCT imaging. The tooth underwent root canal treatment and was monitored for 9 years.

Case Report

In 2014, a 16-year-old Caucasian male was referred to the outpatient maxillofacial service of Vall d'Hebron University Hospital, Barcelona, Spain, with the chief complaint of sharp pain and abnormal sensation from the right mandibular canine (#27). The patient had suffered multiple episodes of severe pain and swelling in relation to #27 for 2 years and had visited many dentists with no relief of symptoms. The patient gave a history of multiple courses of antibiotics, failure of an attempted extraction, and the placement of a surgical drain to relieve the symptoms. The patient's medical status was classified as ASA-I.

Pre-operative clinical findings

Clinical examination revealed a total of 14 teeth in the mandible (excluding the third molars). Teeth #26 and #27 were rotated with abnormal coronal morphology (Fig. 1A). The buccal aspect of #27 resembled the morphology of a normal canine but was broader than expected. However, an unusual predominant cusp-like structure with ridges on the lingual aspect of the crown was present, which was slightly less pronounced than the buccal incisal tip. Thus, the mandibular canine had an occlusal table with a buccal tip and a lingual cusp with a small cusp-like projection between them. The lingual tooth structure was wider mesiodistally than the buccal surface of the crown.

A fluctuant swelling extended mesially from the symphysial region to the distal border of the tooth #29 and was approximately 5 cm in length. No periodontal pocket or mobility was present. Tooth #27 was tender to percussion as well as palpation; pulp sensibility testing was negative.

Pre-operative periapical radiographic findings

Intraoral periapical radiographs revealed a complex root and canal structure with what appeared to be a cow horn-shaped root canal system (Fig. 1B); however, there was the suggestion of a faint root structure joining the mesial and distal extensions. Loss of lamina dura and bone loss was evident on the distal aspect of the root, contributing to a PAI score of 4^{20}. The root of #26 appeared to have been displaced mesially to accommodate the broad anomalous root structure. Owing to the complex and varied crown and root anatomy associated with extensive periapical swelling, computed tomography was planned to aid in diagnosis and treatment planning.

Pre-operative CT images

Computed tomography images were acquired preoperatively using a Philips Brilliance iCT 256 device operated at 80KV, and DLP 58 mGy. A follow-up CBCT image with 8 X 8 cm FOV (Ortophos XG 3D, Dentsply Sirona, Sirona Dental systems, Bensheim, Germany, 0.16voxels, 70KVP, 8 mA) was acquired 9 years after treatment.

Axial sections: The images from the crown, down to the CEJ revealed an anomalous canine with a prominent cusp-like structure projected from the CEJ on the lingual surface. Two arm like extensions from the buccal surface encompass this accessory cusp like anomaly (Fig. 2A), giving the appearance of an occlusal table of 8 mm buccolingually and 7.3 mm mesiodistally. In the root sections, a single canal is observed from the cervical region to

the apical sections which is broad coronally and is visualized as a boomerang-shaped canal which flattens into a thin C-shape canal in the apical region (Fig. 2B-E). Teeth #28 and #29 have invaginations on the buccal surface of the roots (Fig. 2E) as well as a C-shaped canal patterns in the more apical axial sections with two distinct apical foramina. Loss of periapical bone is observed from the mesial aspect of #25 to the mesial aspect of #28 (Fig 2F). The lesion had perforated the buccal cortical plate at multiple sites and was 25 mm mesiodistally and 15 mm buccolingually in the axial section (Fig. 2F).

Sagittal and coronal sections: The lingual cusp like structure in the coronal aspect as well as height and width of the periapical lesion are best visualized in these sections (23 mm height and 11 mm width) (Fig. 2G and H), In the coronal section, 2 cow horn-like root extensions which contain the mesial and distal extensions of the boomerang-shaped canal can be visualized (Fig. 2I and J).

Diagnosis

The 3D model confirms the tooth anatomy (Fig. 2K) and reveals the size of the periapical lesion as well as multiple perforated buccal cortical plate (Fig. 2L and M). A diagnosis of an anomalous mandibular canine with a necrotic pulp and boomerang-shaped root and root canal with a chronic periapical abscess was made. Various treatment options were discussed with the patient and his parents. As a consequence of the complexity of the anatomical variation, a multi-visit root canal treatment was agreed. The patient's assent as well as consent from the parent were obtained prior to the procedure.

Treatment

A buccal infiltration was administered to the patient using 3.6 mL of 4% articaine with 1:100,000 epinephrine (Artinibsa; Inibsa, Barcelona, Spain). The local anesthetic solution was delivered using a side-loading carpule syringe fitted with 27-gauge needle. Under dental dam isolation an access cavity was prepared under a microscope (OPMI Pico, Carl Zeiss), initially with a round bur and then with a Start x 2 ultrasonic tip (Dentsply Maillefer, Ballaigues, Switzerland). The access was modified to a triangular shape to ensure enhanced visibility / access to the complex root canal anatomy (Fig. 3A). Working length was determined using an apex locator (Root Zx Mini, Morita, Kyoto, Japan) and confirmed using radiographs. The canal was cleaned and shaped with the principles used for a C-shaped canal pattern. The canal was enlarged using the ProTaper Gold system up

to size F3 (Dentsply Maillefer, Ballaigues, Switzerland) and disinfected with 3 ml of 3% sodium hypochlorite between instrumentation with a 30-gauge side-vented needle (Max I Probe, Dentsply Rinn, York**)**. The final irrigation was performed using passive ultrasonic agitation and a size 20 Irrisafe tip (Satelec Acteon, Mérignac, France), alternating between 17% EDTA and 3 % NaOCl. After drying the canals with absorbent points, a calcium hydroxide intracanal medicament (Calcicur, Voco GmbH, Cuxhaven, Germany) was placed and agitated inside the canals with a medium size 25/0.04 EndoActivator tip (Dentsply Sirona, Ballaigues, Switzerland) in an attempt to spread the medicament over the canal walls and within the lumen of the complex canal shape. The access cavity was restored with reinforced zinc oxide eugenol cement (IRM; Dentsply-Caulk, Milford, DE).

The patient was seen again after 14 days, when the pain, swelling, and abnormal sensation had resolved. The canals were filled with gutta-percha points (Autofit, Analytic Endodontics, Glendora, CA) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) using the continuous wave condensation technique with down-pack (System B unit, Sybron Endo, Orange, CA) and backfill (Obtura II unit, Obtura Spartan, Fenton, MO). Buchannan pluggers were used for final vertical compaction (n#1 and 2) (Fig. 3B). The coronal access was restored with a resin composite (Filtek Z250, 3M ESPE, St. Paul MN).

Follow-up

The patient was recalled at 3 months, 6 months, and 12 months and then annually for 9 years (Fig. 3C). Over this period, the patient was asymptomatic, with no pain, swelling, or tenderness to percussion. No mobility, periodontal pocket, or root resorption was evident at any time point during the follow-up period. A CBCT scan at 9 years demonstrated advanced bony healing in the periapical region (Fig. 4A-J). The reformation of the complete buccal cortical plate is evident in the various sections of the CBCT as well as in the 3D rendered image (Fig. 4K). No root resorption or crestal bone loss is observed. A reduction in the volume of periapical radiolucency from 2.461cm^3 to 55mm^3 was observed at 9 years.

Discussion

Morphoanatomic variations of teeth with complex root canal patterns can pose challenges while performing root canal treatment. Lack of knowledge of root canal anatomy prior to the treatment can lead to iatrogenic errors such as missed canals[21], strip perforations in danger zones[22], instrument fracture[23], incomplete disinfection, and poor canal shaping and filling[24], which can ultimately affect the long-term treatment outcome.

The disturbance of morpho-differentiation during odontogenesis, which is influenced by both local and systemic factors, may result in dental anomalies[5]. The anomalies are expressed either as an individual finding or are associated with a syndrome[5]. Variations can be observed such as alterations in the shape, contour, number, and size of teeth. This case report is the first of its kind to describe a rare anomaly of the mandibular right canine, with altered size and shape of both the crown and root. The exact category of variation could not be confirmed due to the absence of any previous literature; however, a few possible explanations are offered based on the appearance of the tooth.

The presence of an extra cusp-like structure on the lingual aspect is similar to a talon cusp, which is also observed as a macrodontia of the crown. However, the root had a curved, boomerang-shape that contained a canal of a similar outline[25]. The outward folding of the inner enamel epithelium as well as dental papilla hyperplasia [26] can lead to the development of talon cusps. The occurrence of a talon cusp is common in maxillary incisors but rare in mandibular teeth[27]. The presence of a larger talon cusp is categorized as type 1 or true talon[28]. The talon cusp usually has enamel and dentin structures associated with a pulpal extension in the larger talons, a feature that can be observed in this mandibular canine.

Another interesting theory that could be considered with regards to the rare anomaly described in this report is that there could be a fusion of the mandibular canine to a lingually placed double tooth. This fusion could have contributed to the formation of a large crown as well as a boomerang-shaped canal. Sachdeva et al reported a mandibular central incisor associated with a talon cusp fused to a supernumerary tooth[29].

The literature provides diverse approaches to managing complex root canal anatomy; however, there are no guidelines for endodontic management of such complex

variations. The boomerang-shaped root canal anatomy was cleaned and disinfected using passive ultrasonics, and a calcium hydroxide medicament was placed for 2 weeks which resulted in complete resolution of the paresthesia. The use of passive ultrasonic irrigation and sodium hypochlorite has been reported to reduce the accumulated hard tissue debris by 64 to 77% in C-shaped canals[30] and 62% in oval canals[31].

A clinical study reported a significant reduction of bacteria and negative cultures in up to 88.7% of patients after inter appointment calcium hydroxide medication placement as an adjunct to 17% EDTA and 5.25% NaOCl irrigation[32]. Thus, in the present case, substantial bony healing occurred, which could be attributed to the thorough disinfection of the canals.

A continuous wave of obturation technique was reported to perform better in comparison to vertical compaction in mesial canals of molars with an isthmus[33]. Despite the presence of a large periapical lesion and complex root anatomy, successful healing was observed at 9 years (Fig. 4K). Special attention must be paid to the disinfection of such complex anomalies as well as the use of computed tomography and magnification to aid in proper management and treatment.

The strength of the case documentation is the use of 3D imaging, which aided in thorough management planning and treatment of the complex anatomy of the mandibular canine. Along with disinfection using passive ultrasonic irrigation and intracanal medicaments, and thermoplastic canal filling, aided the successful healing of the periapical lesion. The main limitation is that the etiology that led to the variation in crown, root and canal anatomy could not be defined. Genetic or advanced molecular assessments can be performed to comprehend the etiology of such anomalies so that their pathogenesis could be comprehended and managed appropriately[5].

Conclusion

In this case report, an unusual mandibular canine tooth anatomy with a single boomerang-shaped root and root canal system with a large periapical lesion is presented. The case supports the use of 3D imaging, sufficient cleaning, and thermoplastic obturation of the complex canal system, all of which contributed to the successful healing of the large periapical lesion.

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Figures Legends

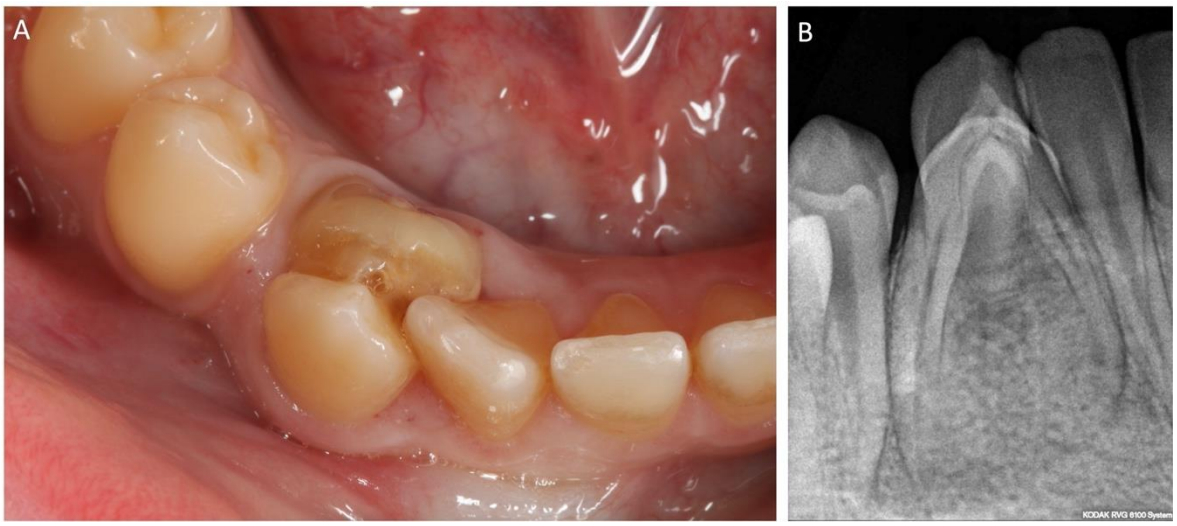

Figure 1. (A) Clinical image of tooth #27 reveals a relatively normal buccal surface and incisal tip but with a large, unusual cusp-like structure lingually and a broad occlusal table. Mesio-distally, the lingual cusp-like structure is wider than the buccal structure. There is a smaller cusp-like projection in the center of the occlusal table. (B) Periapical radiograph of tooth #27 reveals a root structure resembling an atypical inverted cow horn-shaped root and canal pattern but with the suggestion of an indistinct root structure between the mesial and distal extremities. Coronally, the buccal tooth structure is superimposed over the lingual cusp.

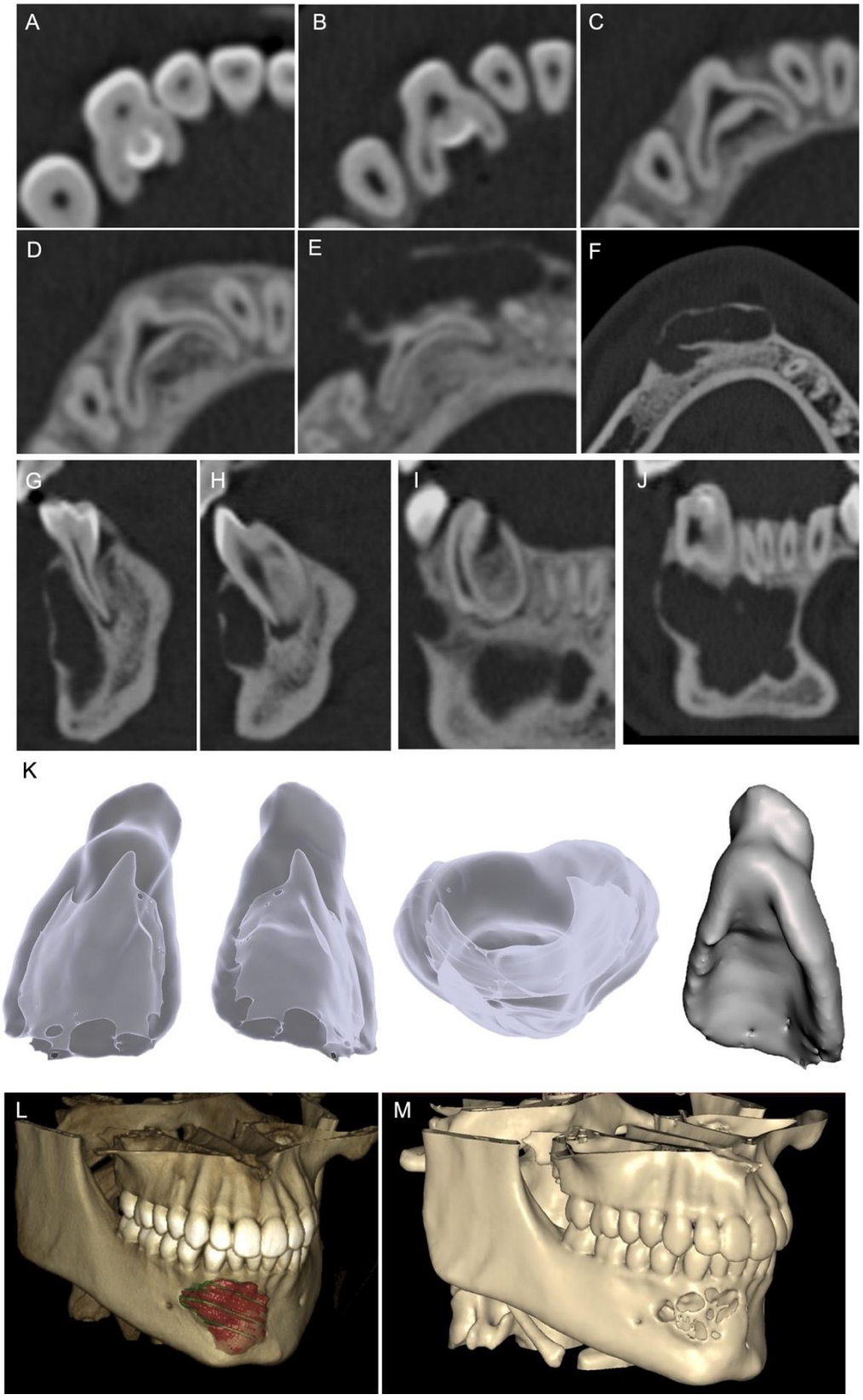
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Figure 2. (A) An axial radicular section in the cervical region demonstrates a central canal and two fin-like extensions of the root, that give a boomerang like appearance to the root canal. (B-D) Buccal evagination of the root surface. (E, F) Large periapical lesion with multiple perforated buccal cortical plate. (G, H) Sagittal sections reveals the fin-like extensions gradually merge with the main central canal. (I, J) Coronal sections demonstrate 2 horn-like radicular extensions that merge with the main crown of the canine. (K) 3D rendering of the image showing the atypical crown and root morphology of tooth #27. (L, M,) 3D rendered images reveal the size of the periapical lesion as well as multiple perforations on the buccal cortical plate.

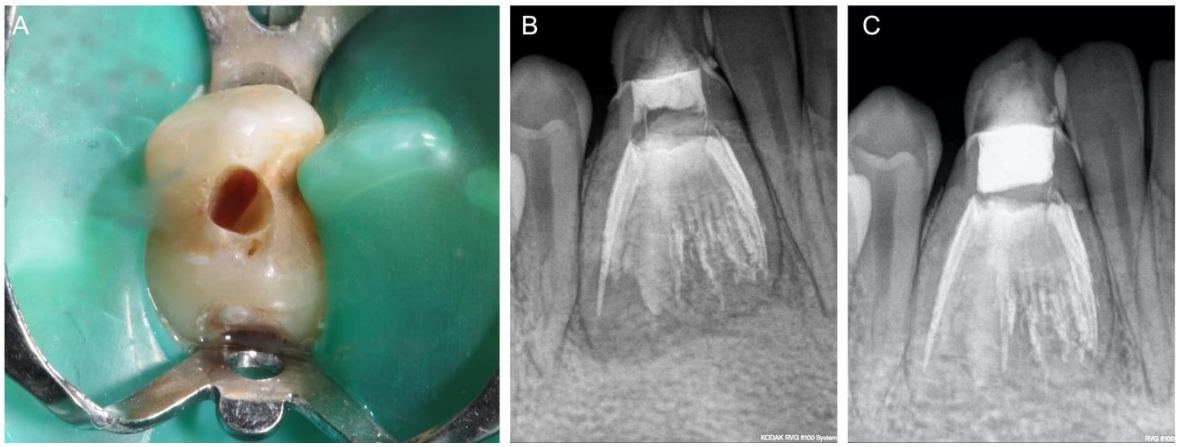

Figure 3. (A) Access opening. (B) Periapical radiograph immediately following root filling. (C) Periapical radiograph after 9 years.

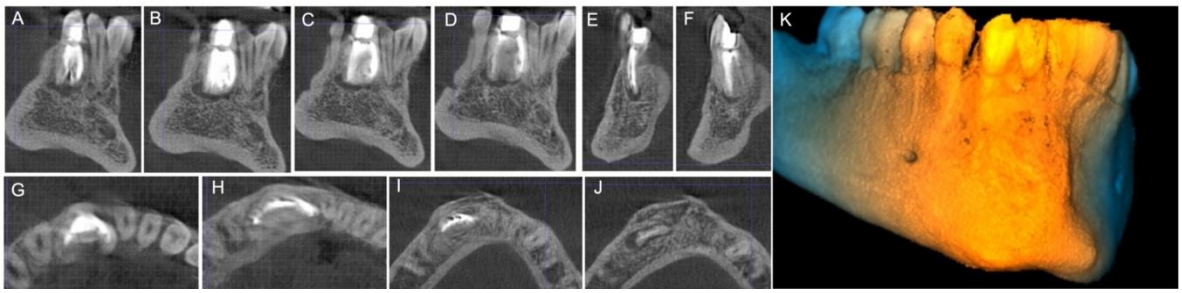

Figure 4: CBCT images at the 9-year follow-up. (A-D) Coronal sections buccal to lingual showing the curved canal extending gradually to the lingual side and ending as a cow horn-shaped canal pattern which correlates to the intra-oral periapical radiograph. Advanced periapical healing is observed. (E, F) Sagittal section demonstrating the main canal extending lingually along with a healing periapical lesion. (G-J) Axial sections coronally showing the filled boomerang-shaped canal gradually reducing in size to the apical section. Complete formation of the buccal cortical plate is observed. (K) 3D rendered image showing advanced bony healing as well as the complete buccal cortical plate.