Chronic Apical Periodontitis with Calculus-like Mineral Deposit on the Root Apex: A Case Report

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Abstract

We report a case of a large calculus-like mineral deposit on the root apex as persistent apical periodontitis. The patient was a 54 years old male who presented with persistent gingival fistula at the maxillary right lateral incisor. An apicoectomy was performed because of post-endodontic gingival fistula and the calculus was excised completely. Then the fistula was closed. The resected calculus-like deposit, the supra-gingival and sub-gingival calculi from the same patient were examined byscanning electron microscopy under which the surface morphologies are different: fibrous calcified mass; flaky calcified mass and spherical calcified mass and infrared spectroscopy which showed the characteristic functional groups of the three specimens been exactly same but the waveforms varied. The tooth presents with a palatal additional root on radiograph. Free mineral ions and mineral salts may have accumulated via the fistula at the root apex and led to mineralization of the dental plaque and inflammatory tissues and formation of the special minerals.

Key Words: Additional root, Chronic periapical periodontitis, Dental calculus, Lateral incisor, Mineralization

Introduction

Apical periodontitis is an inflammatory destructive condition that occurs in periapical tissues. After an antigen infiltrates pulp tissues, the infection spreads through the root canal system to the apex via the apical foramina. This process induces specific immune responses in vivo, leading to inflammatory cell infiltration, destruction of apical tissues, and resorption of the alveolar bone [1]. Common causes of this disease are pulp necrosis-related pulp infection, trauma, and endodontic treatment [2]. Conventional root canal treatment is an effective way to preserve a diseased tooth, as it aims to eradicate the effects of pathogens in the root canal system on the periapical tissues and to eliminate the cause of persistent inflammation.

Chronic Periapical Periodontitis (also known as chronic apical periodontitis, CAP) is a chronic inflammation of the periapical tissues caused by persistent interradicular infections and pathogenic stimuli. CAP is characterized by the formation of the destruction of alveolar bone and inflammatory granulation tissues. CAP lesions present as periapical granulomas, chronic periapical abscesses, periapical cysts, periapical condensing osteitis and sinus tract [3]. CAP is sometimes asymptomatic, but when present, the signs symptoms may include sinus tract and discomfort on percussion, and lack of pulp vitality being a common indication. Radiographs show low-density areas of different sizes adjacent to root apex, 90% of which can be attributed to CAP-associated periapical cysts [4].

Dental calculus is usually a kind of mineralized or mineralizing bacterial plaque, and it is found in the form of deposits that are accumulated on the surfaces of teeth or restorations. In the case of periapical granulomas, chronic periapical abscesses and periapical cysts, if unconventional calcium deposition occurs, the resulting mineralization reaction leads to abnormal outcomes such as calcification and ossification, which may further form small calculus-like mineral deposits on the apical root surface. Dental calculus consists of minerals that form the inorganic components and an organic matrix. The mineral found in calculus is usually calcium phosphate [5]. Supragingival calculi contain 37% (v/v) minerals and sub gingival calculi contain 58% (v/v) minerals [6]. The organic component of dental calculus is mainly an acquired pellicle. Dental calculi usually deposited on the surfaces of teeth or restorations being difficult to clean, and deposition in the alveolar bone on the root apex is found in a few cases and therapy failures have been reported in most of the cases [7-10]. Large dental calculus deposits can be observed on radiographs.

A case of Chronic Periapical Periodontitis (CAP) associated with a large calculus-like deposit on the apical root surface with a tapered additional root in the mesial-palatal direction is reported. In this case,a post-endodontic gingival sinus that existed with the involved tooth. Part of the root apex and calculus-like calcium deposit on the apical root surface were resected by apicoectomy, and the resected calcium deposit as well as the supragingival and sub gingival calculi were examined under a Scanning Electron Microscope (SEM) and Infrared (IR) spectroscope. Soft-tissue lesions healed following the surgical treatment, and the involved tooth was capable of normal chewing function.

Case report

The patient was a 54-year-old man who attended for recurrent inflammation of a maxillary right anterior tooth over two years period. Although the patient had received Root Canal Treatment (RCT) in another hospital six months pervious, he experienced recurrent inflammation and a persistent fistula was present. Clinical examination showed a dental restoration and no developmental abnormalities at the lingual side of the maxillary right lateral incisor. The percussion findings were negative. A sinus tract was observed at the labial surface of the tooth, and pus was able to see under pressing the area. The degree of tooth mobility was I, and the probing depth was approximately 2 mm. Oral hygiene was poor, with supragingival calculus (Calculus index was 2), pigmentation

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being observed, and full-mouth gingival recession of 2–4 mm. A radiograph (*Figure 1a*) showed that the maxillary right lateral incisor had root canal filling with the material under well condition; further, there was a high-density area below the root apex in the bellow direction and a large low-density area in the periapex. According to the above observations, the patient was diagnosed with CAP of the maxillary right lateral incisor; however, we did not exclude other possible diagnoses such as the presence of an additional root of the maxillary right lateral incisor and periapical foreign material of the maxillary right lateral incisor. The patient denied systems disease history, blood examination and liver function examination and kidney function examination were normal, no smoking, good nutrition. No families had any calculus except dental calcium.

The treatment plan was full-mouth scaling plus an exploratory gingival flap surgery. After one week of full-mouth scaling, routine sterilization and draping were performed. Under magnifier, a full-thickness gingival flap from the upper maxillary right canine to the left incisor was raised with the patient under local anesthesia in order to expose the surgical area. During surgery, a large area of calculus-like calcium deposit was observed around one-fourth area of the apex of the maxillary right lateral incisor. The calculus-like calcium deposits below the tooth apex were massive. On the labial surface, the alveolar bone was resorbed to the root apex but palatal alveolar bone being not destroyed, and the resorption lesion on the periapical alveolar bone was approximately 10 mm × 9 mm × 7 mm. Apicoectomy was performed to resect granulation tissues and no additional root being seen, then prepare the root apex, this was followed by filling with an Ag-Hg alloy, rinsing and hemostasis, wound suture with a 5-0 silk thread, and placement of a drainage tube (*Figures 1b–1d*). Then a periapical radiograph of the maxillary right lateral incisor was taken. The radiograph showed that about 3 mm of the apex had been resected and filled (*Figure 1e*).

Following normal clinical procedure, the patient was re-examined to remove stitches one week after surgery; the

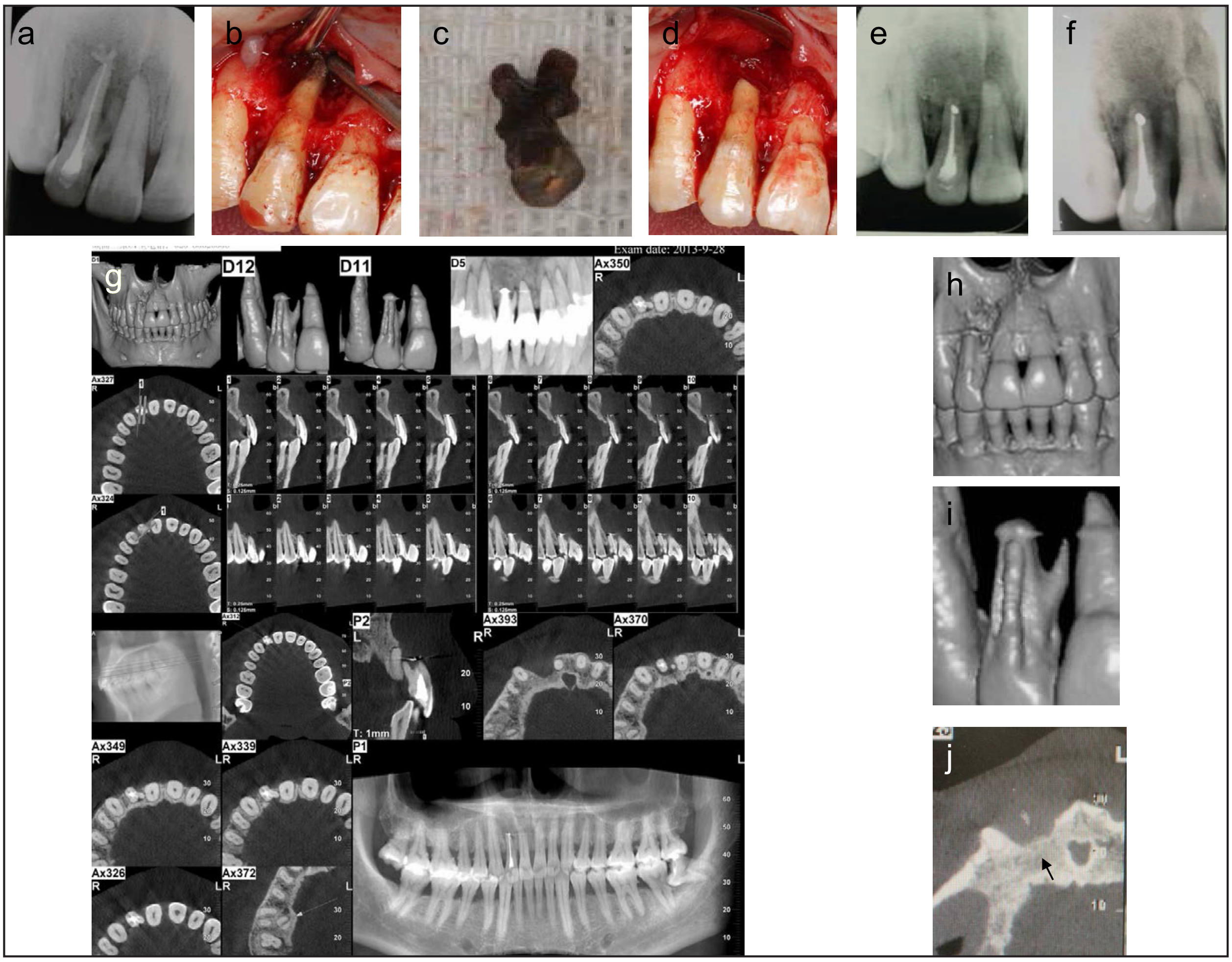

Figure 1. *(a) A periapical radiograph showing the maxillary right lateral incisor before flap operation. The high-density area below the root apex in the mesial direction, and a large low-density area in the periapex can be seen. (b) Exposure of the involved tooth during apicoectomy. (c) The resected root apex, with massive calculus-like calcium deposits (background grid, 0.86 mm each). (d) Oral view after root resection and retrograde filling, during surgery. (e) A periapical radiograph of the involved tooth after retrograde filling, after surgery: about 3 mm of the apex was resected and filled. (f) A periapical radiograph of the involved tooth eight months after surgery, showing increased density of the periapical alveolar bone and reduced size of the low-density area. (g) CBCT images of the involved tooth eight months after surgery; three-dimensional reconstruction showed the presence of a palatal additional root with an unclear root canal; segmented scan showed a periodontal alveolar bone under restoration (segmentation distance: 0.125 mm; thickness: 0.25 mm). (h) Local amplification of the CBCT image showing the partially restored alveolar bone, shrunken area of the bone defect, and rough bone surface in the tooth root apex. (i) Tapered additional root at the palatal side of the maxillary right lateral incisor. (j) Local enlargement of the bone defect cavity (size, approx. 3.5 mm × 10.34 mm), showing that the density of the cavity was slightly higher than that of the surrounding tissues; in addition, organized reaction of blood clots and ossification repair can also be seen. The arrows indicate the rough bone surface with partial bone formation.*

fistula's internal opening appeared to be closed. Then to avoid trouble for the additional root not being filled, root canal treatment was performed again, but unfortunately root canal filling material could not reach the additional root. Eight months later, the patient was re-examined and the fistula was observed to be closing with no clinical symptoms; a further periapical radiograph of the maxillary right lateral incisor showed that the size of the periapical lesion had decreased while the bone density had increased (*Figure 1f*). Cone-Beam CT (CBCT) images (*Figures 1g–1j*) showed that the bone defect in the maxillary right lateral incisor was beginning to in filling, and an unclear canal of the tapered additional root was present on the mesial-palatal side.

The calculus-like calcium deposit obtained as well as the supragingival and subgingival calculi from the same patient were examined by IR spectroscopy and SEM. Specimens were rinsed with double-distilled water three times and then air dried. Images were taken under a stereomicroscope (*Figures 2a–2c*). Part of the specimens was porphyrized to make tablets and then scanned in the wavelength range of 200–4,000 cm^{-1} using a NEXUS 670FT-IR spectrometer (Nicolet, USA) (*Figures 3a–3c*). The remaining of the specimens was dried at the critical point and surface-sprayed with gold, and then examined using a Sirion 200 field-emission scanning electron microscope (FET, USA) (*Figures 4a–4f*).

IR spectroscopy data showed that the specimens of the calculus-like calcium deposit as well as the supragingival and subgingival calculi had the characteristic PO_4^{3-} peaks at wave numbers 1037 and 588 cm^{-1}, CO_3^{2-} peaks at 1435 and 871 cm^{-1}, -C=O-NH_2- peak at 1640 cm^{-1}, -CH_2- peaks at 2919 and 2852 cm^{-1}, and OH^- peak at 3439 cm^{-1}. The characteristic functional groups were exactly the same; however, the waveforms varied due to differences in the contents of the characteristic functional groups formed in different environments. SEM images showed that calculi deposited at different sites had various surface morphologies: the periapical calculus-like deposit was observed as a fibrous calcified mass; the supragingival calculus was observed as a flaky calcified mass; and the subgingival calculus was observed as a spherical calcified mass.

Discussion

There are several causes of persistent periapical lesions with a protracted healing after conventional root canal treatment:

1. Many studies demonstrate that the root canal isthmus and apical derivatives are common causes [11]; that is, residual pathogens in the apex of the root canal induce persistent intraradicular infection [12].

2. Pathogens are colonized on the root surface or the periapex. The presence of extraradicular biofilms causes extraradicular infections [13-15].

3. Root canal filling material or other exogenous substances that are placed beyond the apical foramen may cause foreign-body reactions [16,17].

4. Accumulation of endogenous cholesterol crystals may irritate periapical tissues. The body cells are unable to eliminate the local accumulation of cholesterol crystals, and a massive accumulation of cholesterol crystals in inflamed periapical tissues may interfere with the periapical healing after conventional root canal treatment.

5. True cystic lesions can also contribute to persistent periapical lesions [18]. It is believed that the radicular cyst is formed by inflammatory proliferation of epithelial cells in the inflamed periodontal ligament, since the existence of pathogenic stimuli may cause secondary infection.

6. Periapical granulomas or periapical lesions may undergo scar-like healing [19]. A periapical scar probably develops because precursors of soft connective tissue colonize both the root tip and periapical tissue; this may occur before the appropriate cells, which have the potential to restore various structural components of the apical periodontium, are able to colonize the area.

7. Root fractures or root cracks are formed [16]. The presence of numerous bacteria in the fracture or cracks may lead to extraradicular periapical infection, and subsequently sinus formation. The case reported, the cause may be both the calculus-like deposit causing foreign-body reactions and pathogens. In cases of refractory apical periodontitis, the intraradicular pathogenic infection should first be eliminated or reduced by non-surgical root canal treatment; then, the extraradicular infection sources and associated lesion tissues should be resected by surgical endodontic treatment (apicoectomy), in order to promote healing of the periapical lesions. Surgical root canal treatment is required for healing in 5% of apical periodontitis cases.

Apical deposition of calcium salts is a unique and rare form of mineralization. Deposits at the root apex however affect the healing of periapical lesions. Dental calculus is usually a kind of mineralized or mineralizing bacterial plaque and sediment, and it is found in the form of deposits that are accumulated on the surfaces of teeth or restorations. Inorganic salts from the saliva or gingival crevicular fluid are resorted and deposited, thereby forming the calculus. There are two kinds of calculi, supragingival and subgingival calculi. In the present case, apical calculus-like mineral deposition occurred, and it may be special repair and reconstruction of the periapical tissues affected by chronic inflammation. To date, few studies have reported CAP lesions with a protracted course due to the presence of calculus-like calcium deposit on the root apex surrounded by the alveolar bone; further, treatment failures have been reported in most of the cases, in which it was found that the deposit was not calculus. IR spectroscopy and SEM

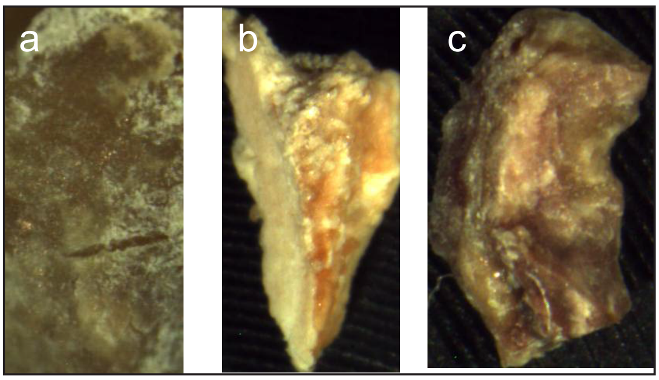

Figure 2*. Stereomicroscopic images (magnification, 10×) of (a) calculus-like calcium deposit on the root apex with distinctive shading and a surface crack; (b) supragingival calculus, showing the distinctive attachment surface and the free surface; and (c) subgingival calculus, showing an irregular shape, an uneven surface, and a dark red color.*

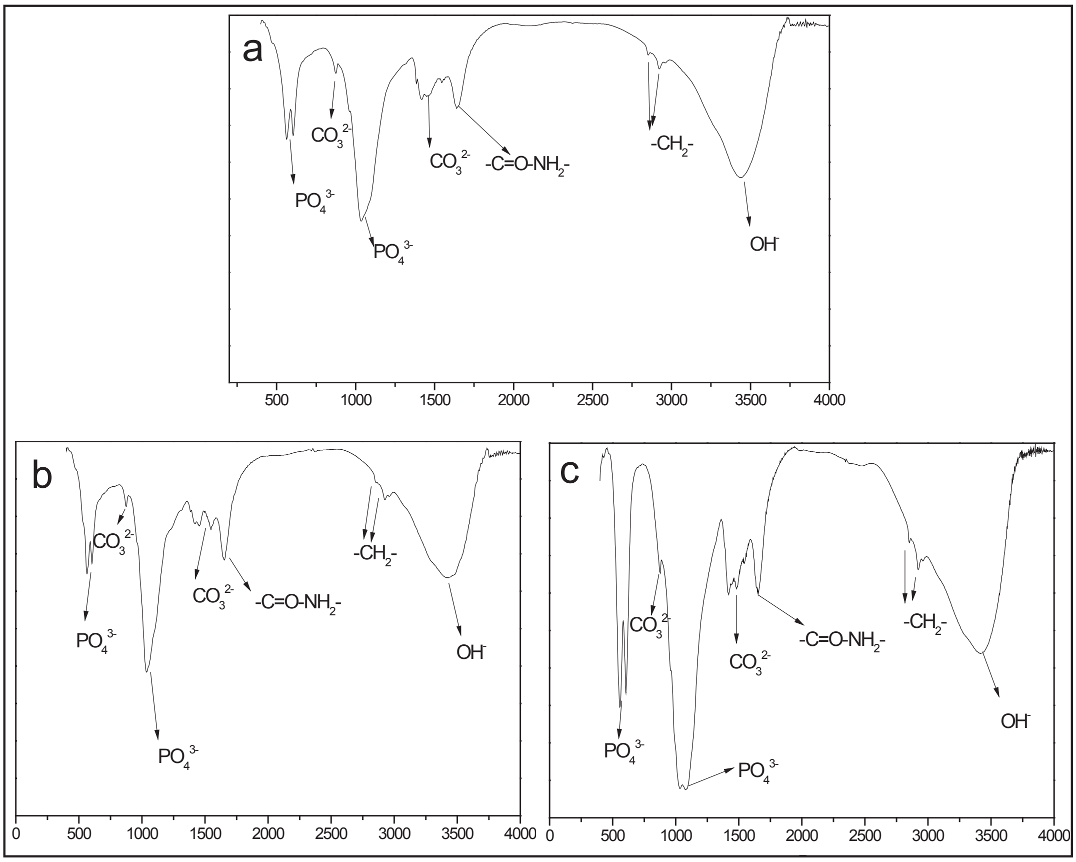

Figure 3. *Infrared spectrographs of (a) the calculus-like calcium deposit at the root apex; (b) the supragingival calculus; and (c) the supragingival calculus. Abscissa represents the peak value of characteristic functional groups: OH^-, 3439 cm^{-1}; -CH_2^-, 2919 cm^{-1} and 2852 cm^{-1}; -C=O-NH_2-, 1640 cm^{-1}; CO_3^{2-}, 1435 cm^{-1} and 871 cm^{-1}; PO_4^{3-}, 1037 cm^{-1} and 588 cm^{-1}.*

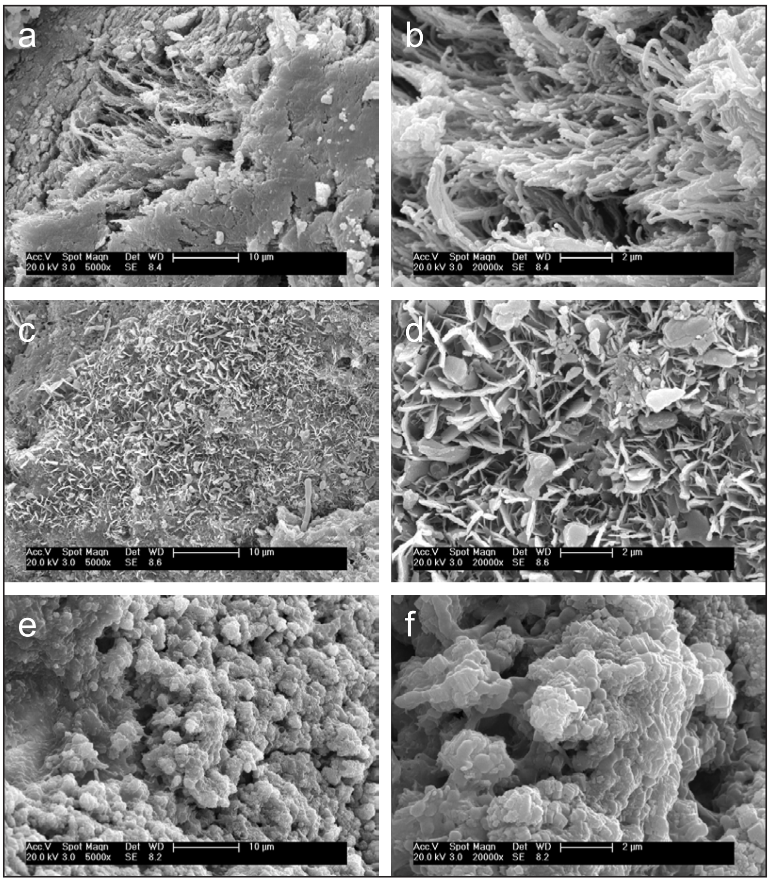

Figure 4. *Scanning electron microscopy images of (a, b) the calculus-like calcium deposit at the root apex showing a regular filamentous mineralized deposit in the uncompressed surface area (a, 5000×; b, 20000×); (c, d) supragingival calculus, showing a foliate mineralized deposit on the surface in a regular shape but in irregular directions (c, 5000×; d, 20000×); and (e, f) subgingival calculus, showing an irregular massive mineralized deposit on the surface (e, 5000 ×; f, 20000×).*

are relatively reliable means for determination of calculus composition. Because of the limited size of the specimens in this case, they could only be examined by IR spectroscopy and SEM. The inorganic components of the calculus-like deposit on the apical root, as well as the supragingival and subgingival calculi, are similar. Further, they also contain some organic components. With tooth eruption, saliva proteins rapidly and selectively are absorbed onto the enamel surface to form an acquired enamel film, called the acquired pellicle.

Thereafter, different oral microbes adhere and settle on the enamel pellicle, promoting maturation of the plaque biofilm. Inorganic salts such as calcium and phosphorus from the saliva or gingival crevicular fluid are further adsorbed onto the pellicle to form mineralized and bacteria plaques, thereby forming the calculus. The organic component of dental calculus is mainly an acquired pellicle. IR spectroscopy data from this study showed that the three types of calculi contained the same organic components. This indicates that the calculus-like deposit on the apical root may have an organic pellicle layer that can adsorb inorganic components, similar to an erupted tooth with an acquired enamel film. In the case of erupted teeth, salivary proteins are selectively adsorbed onto the enamel surface and constitute the major component of acquired pellicles, whereas organic pellicles of the periapical calculus may be formed by humoral proteins. The three types of calculus specimens share similar components that correspond to the same functional groups, despite the difference in the contents of these functional groups, that is, different molecular compositions. In the IR spectra, the position, shape, and intensity of an absorption band reflect the characteristics of the molecular structure, while the absorption intensity is related to the molecular composition or the content of specific functional groups. There are obvious differences in the position and intensity of the wave number between some of the major groups of the absorption bands of the three specimens, but the three specimens have similar shape. The main cause of this phenomenon is the mutual replacement and commutation of anionic groups in the calculus. The result of this study could indicate that the three types of calculi were located at different sites; that is, the colloid-crystal balance in their environments was different. Moreover, the composition of the elements and the ions and their different location in the calculus may have also contributed to the difference between the three types of calculi.

In the present study, SEM images showed that different parts of the calculus had various morphologies under different environmental conditions and the calcifications were of different shapes: filamentous, needle-like, spherical, foliate or fan-like aggregates. In the present study, there may be two sources for the formation of the calculus-like mineral deposits on the root apex of the CAP tooth

1. Long-term periapical lesions led to bone resorption around the root apex and formation of the bony lacuna (inflammatory granulation tissue replaces bone); thus, the root apex was exposed to an infectious environment. Additionally, persistent root canal infection and fistula enabled the root apex to connect with the oral cavity through a potential corridor, the sinus. Bacteria inhabiting the root canal and the mouth invaded periapical tissues thus form a bacterial plaque on the apical surface. The process and principle underlying bacterial colonization at a different site from the bacterial plaque are uniform. Previous the dental plaque on an apical surface by SEM and found it similar to marginal periodontal plaque. Free mineral ions accumulate at the root apex via demineralization of the root canal wall and absorption of periapical bone tissue; this together with the accumulation of mineral salts from the saliva (via a fistula) leads to mineralization of the dental plaque and inflammatory granulation tissue formation of high-density mineral deposit. Apical calculus-like deposits may be a type of special repair mechanism for chronic periapical periodontitis. Generally, saliva is the mineralization source of supragingival calculus, whereas serum, gingival crevicular fluid, and periodontal pocket fluid provide mineralization sources for subgingival calculus. For the calculus-like mineral deposit on the root apex in our case, the mineralization sources may have included saliva, serum, and periodontal pocket fluid; the waveforms from the IR spectrogram in our case are between those of supragingival and subgingival calculi.

According to the IR spectrograms, the apical and subgingival calculi shared similar characteristic functional groups and peak density.

2. Alternatively, the calculus-like mineral deposit may have been formed due to overfilled of the root canal plus the persistence and mineralization of root filling material in the root apex. However, the likelihood of this is small because the sinushad been present fortwo years, while the rootcanal fillingwas performed only 6 months before surgery; thus, formation of such a large area of calculus-like mineral in a short time as a result of root canal filling would have been unlikely.

In the CAP-involved tooth, a high-density area on the medial surface of the tooth root was confirmed by CBCT to be an additional root. However, this may not have been related to the sinus, which was closed after the apicoectomy. The additional root was relatively close to the palatal side and thus was not probed during apicoectomy. Only a few studies (mainly case reports) have documented morphological variations in the root canal system and root structure [20,21], and morphological variations in the tooth root are rare. Hertwig's Root Sheath (HERS) is the inducer and regulator of root formation and plays a role in regulating the size, shape, and number of tooth roots. HERS is involved in the entire developmental process of the human tooth root. In the case reported, rootdevelopment of the maxillary right lateral incisor might be affected by internal and external factors, which led to abnormal fusion of HERS and thus the formation of the palatal additional root. However, the exact mechanism of this aberrance remains unclear.

Conclusion

1. In this case of chronic apical periodontitis, it is believed that free mineral ions and mineral salts may have accumulated via the fistula at the root apex and led to mineralization of the dental plaque and inflammatory granulation tissues and formation of large high-density minerals, the special extraradicular periapical foreign material led to the persistent and protracted course of sinus.

2. The probability of the lesion healing was increased significantly after apicoectomy.

3. In this case the size (4.3*3.2mm) and special spot (on the root apex surrounded by the alveolar bone) of the apical deposition of calcium salts were unique and rare.

4. Apical deposition of calcium salts as a kind of special substances initiating foreign reaction leading to persistent periapical lesions is a rare occurrence, and is possibly a hitherto unknown cause of chronic periapical periodontitis.

5. The presence of a palatal additional root in the lateral incisors is very rare.

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