SEM OBSERVATIONS OF RESECTED ROOT CANAL ENDS FOLLOWING APICOECTOMY

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Received 12 September, 2001/Accepted for Publication 5 December, 2001

Abstract

The purpose of this study was to examine the apical foramen of root apices extracted during apicotomies. A total of 25 teeth extracted from 25 patients admitted to the Department of Conservative Dentistry at Tokyo Dental College’s Chiba Hospital were used for the study. All patients were between 22 to 56 years of age at the time of the study, and each of the 25 cases was determined clinically on radiographs to be chronic apical suppurative periodontitis. Microsurgery was performed on all cases, and the extracted root apices were then observed using SEM. The results demonstrated a wide opening, greater than 350\(\mu\)m as measured along the major axis, of the apical foramen in 80% of the cases. Various characteristics indicative of resorption were observed around the apical foramen. These features included those believed to have been caused by overinstrumentation during root canal treatment as well as irregularly shaped areas presumed to be apical lesions that had enlarged and eroded. We observed a high frequency of manifestations of cementum resorption surrounding the root apices of teeth with apical lesions. Furthermore, we concluded that in the majority of cases in the present study, due to the fact that the apical foramen exceeded normal opening dimensions as a result of overinstrumentation during root canal treatment or resorption around the root apex, prolongation of the lesions had occurred in response to direct contact of microbial infectious matter and tissues surrounding the root apex over a large area. The above finding suggested that, in cases in which the apical foramen is destroyed through overinstrumentation larger than #35 or in which the apical foramen opens up to dimensions greater than 350\(\mu\)m due to pathologic resorption, surgical intervention may be indicated.

On the other hand, in 64% of the cases, an accessory canal was observed in the root apical lesion. Based on this observation, the presence of an accessory canal in the root apex may contribute to some degree to the prolongation of the lesion.

Key words: Apical foramen—SEM—Apicotomy—Microsurgical endodontics—Accessory canal

This study was published in the Japanese Journal of Conservative Dentistry 43, 852–857, 2000.
INTRODUCTION

The general indication for apicotomy is difficulty in conservation of diseased teeth using conventional root canal treatment. Recently, microsurgical endodontic techniques have come into use, and we have introduced the use of an operating microscope in to Japan\(^9\), to perform surgery. This microscope can improve the reliability of apicotomy surgery. However, questions remain as to the features in the apical foramen of a diseased tooth that indicate the need for apicotomy. Although a small number of studies into such features have been reported, the great majority of these studies have involved observation of extracted teeth, and few of these cases were conclusively diagnosed as chronic apical suppurative periodontitis on radiography. With consent from patients in cases diagnosed as chronic apical suppurative periodontitis, we performed morphological examinations of extracted root apices at surgery. We also performed apicotomies in some cases.

MATERIALS AND METHODS

The informed consent of all human subjects participating in this investigation was obtained. The test samples were 25 teeth with periapical radiolucency from patients who visited the Department of Conservative Dentistry at Tokyo Dental College Hospital. These patients were males and females between 22 and 56 years of age. Based on pre-operative radiographs, 23 samples were classified as hard-to-remove root canal post and crown prostheses. Of these, 21 samples had inadequate root canal filling and 2 samples had excess root filling. The remaining 2 samples were intractable cases with bleeding and continuous purulent discharge.

All apicotomies were performed with a microscope for endodontic microsurgery, and the root apices were carefully cut to a length of 3 mm using a #104 diamond instrument. Apices were fixed with 10% neutral buffered formalin and soaked in 10% sodium hypochlo-rite for 30 min to remove soft tissues. Samples were then immersed in 3% H\(_2\)O\(_2\) for 15 min, rinsed in running tap water in 12 h, dehydrated for 1 h each in solutions of 70–90% alcohol, and stored in 100% alcohol. Finally, samples were dried, coated with Au-Pd, examined under a scanning electron microscope (SEM) (S-800, Hitachi), and photographed.

RESULTS

The status of the extracted root apices is shown in Tables 1 and 2, and prototypes are shown in Figs. 1 to 6. The diameters of apical foramina ranged from 26 to 1,511 \(\mu\)m. However, the major axis of the apical foramen was >350 \(\mu\)m in 80% of cases.

In addition, 64% of cases displayed an accessory canal. The numbers of accessory canals in all tooth groups are shown in Table 3. In this study, irregular absorption and sharp edges were observed around the root apex in cases with the major axis of the apical foramen >350 \(\mu\)m. Absorption was most likely attributable to over-instrumentation in root canal treatment, and then further erosion with expansion of the lesion. Likewise, various degrees of absorption were observed at the cementum surface of the root apex.

DISCUSSION

The majority of studies on the apical foramen have been performed using macroscopic\(^{16,14}\) or microscopic\(^{2,4,7,13}\) morphologic examination of extracted teeth. In the present study, 25 permanent teeth were extracted at apicotomy, as a result of endodontic disease, and only the root apices were observed.

Irregular absorption at the surface of root apices was observed in this study. Various studies have reported absorption of cementum. Hess\(^5\) emphasized the need to recognize that absorption and addition may occur simultaneously in endodontic treatment, even at the root surface of the same tooth. Delazangles\(^3\) found that absorption extended toward the
apical side of the main root canal in cases of radicular granuloma identified on histopathology, and found little absorption of tooth substance associated with radicular cysts. In addition, Laslie et al.\(^8\) found that the different absorption images correlated with the histologic diagnosis.

Some studies in Japan\(^{10-12}\) have involved extracted teeth with root apices demonstrating radiolucency. According to these studies,
X-ray findings were not consistent with SEM findings, even though increased conical or patelliform absorption of tooth substance was found in cases of root apices demonstrating radiolucency, compared to cases without radiolucency. In these studies, bacterial infection was not examined in detail, but radiolucency was found in all cases, and various degrees of absorption of surfaces were observed. Absorption of cementum was found to occur with high frequency in teeth with lesions at the root apex and was also found to occur in some normal extracted teeth. Large apical foramina and absorption of the cementum around root apexes were revealed by SEM, and radiography revealed large apical foramina.

Therefore, continuous bacterial infection
was found to interfere with the curative process in most cases following excessive enlargement of the apical foramen due to over-instrumentation during root canal treatment and subsequent absorption of tooth substance around the root apex. A large apical foramen often leads to intractable pathosis due to continuous purulent discharge.

The results of the present study support these previous findings. In the present study, 80% of the teeth examined displayed an apical foramen with a major axis \( > 350 \mu m \). This suggests that an apical foramen with a major axis \( > 350 \mu m \) (due to pathologic absorption or manipulation of the apical foramen with an instrument larger than #35) may cause intractable lesions requiring surgical endodontics.

In addition, accessory canals (generally regarded as apical ramifications) were observed in 64% of the present samples. Hess\(^6\) identified accessory canals in all tooth groups and from patients of any age. Although the incidence of apical ramifications has been reported as 25% for maxillary central incisors and 31% for maxillary lateral incisors, the incidence rate of accessory canals in the present samples exceeded 40% for maxillary central incisors and 70% for lateral incisors. The incidence of accessory canals therefore seems higher for maxillary lateral incisors than for maxillary central incisors.

The complex anatomical structure of the root apex appears likely to contribute to some degree to prolongation of the lesion.

The knowledge of root canal anatomy, and of the apical area in particular, and the ability to determine root canal length accurately may represent important factors in determining the prognosis of endodontic therapy.

### REFERENCES


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Table 3  Number of accessory canals in all tooth groups

<table>
<thead>
<tr>
<th>Tooth</th>
<th>Maxillary central incisor</th>
<th>Maxillary lateral incisor</th>
<th>Other</th>
</tr>
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<tbody>
<tr>
<td>Number of cases (%)</td>
<td>4 (40%)</td>
<td>7 (70%)</td>
<td>5 (100%)</td>
</tr>
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Fig. 5  Major axis of the apical foramen \( > 1.5 \) mm, and foramina of accessory canals.

Fig. 6  Wide, almost circular, apical foramen. Foramina of accessory canals observed near the apical foramen.


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