

Original

## Endodontic surgery failure: SEM analysis of root-end filling

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**Abstract:** This study investigated the quality of root-end filling in cases of periapical lesions persisting after endodontic surgery. Ten patients requiring extraction of an endodontically treated tooth were included. The root-ends of extracted teeth were examined by scanning electron microscopy. Defects at the interface between the root-end filling and cavity margin were classified as ideal, imperfect (some marginal disruption) or inadequate (continuous marginal disruption involving >30% of the interface). Four cases were scored as imperfect, and six were scored as inadequate. A defective apical seal could favour continuous leakage of surviving bacteria and their by-products from the infected root canal system to periapical tissues, thereby sustaining inflammation. (J Oral Sci 53, 393-396, 2011)

Keywords: endodontic surgery; scanning electronic microscope; root-end filling.

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### Introduction

According to a recent meta-analysis by Tsesis et al. (1), the success rate of modern endodontic surgery is 91.6%, while the failure rate is 4.7%, with 3.7% of cases being classified as uncertain healing. The prognosis of periapical surgery in different studies is influenced

by several factors; different surgical procedures and materials, radiographic and clinical evaluation, patient demographics and systemic condition, and local factors such as teeth involved and their anatomy, quality of previous root canal treatment and quality of coronal restoration (1-3).

The most significant outcome predictors for endodontic surgery were investigated in a recent study on re-surgery that evaluated the main causes for failure of the first surgical treatment (4). In this study, the surface of the apical root to be resected was examined intra-surgically by means of an surgical microscope at  $\times 26$  magnification in order to determine the condition after the previous endodontic surgery. Five possible causes of failure were identified. Among these, the most common cause was no root-end filling, while the presence of a gap between the root-end filling and dentin was found to be the second cause of failure (4).

The aim of the present prospective study was to investigate, using a scanning electronic microscope (SEM), the quality of root-end filling as a possible cause of periapical lesions persisting after surgical treatment.

### Materials and Methods

Patients requiring extraction of a tooth treated by endodontic surgery were recruited over a five-year period from a university dental clinic and from a private practice setting.

### Patient selection and inclusion criteria

The following criteria were adopted for tooth selection: all patients had been previously subjected to endodontic surgery, performed with a modern technique and using zinc oxide EBA reinforced cement (Super

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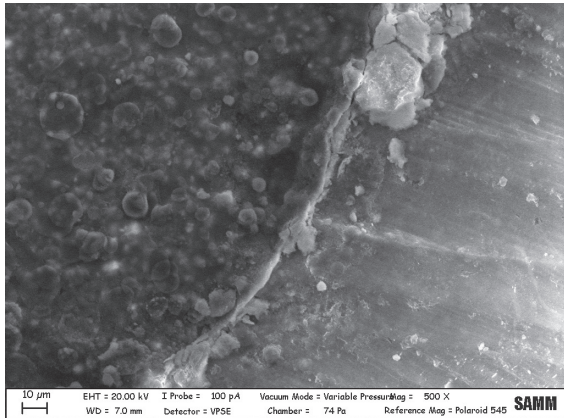


Fig. 1 Example of an ideal root-end surface without gaps between the root-end filling and cavity margin. Magnification  $\times 500$ .

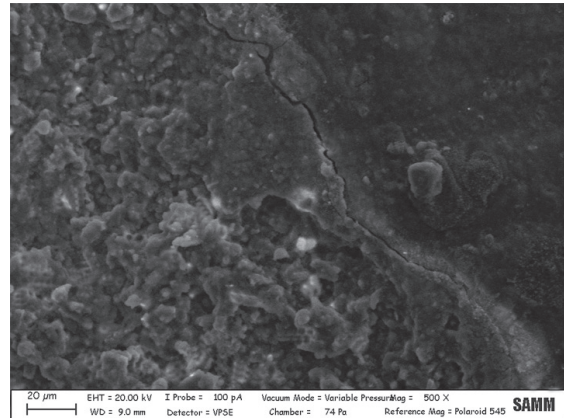


Fig. 2 Example of an imperfect root-end filling, with a small marginal disruption. Magnification  $\times 500$ .

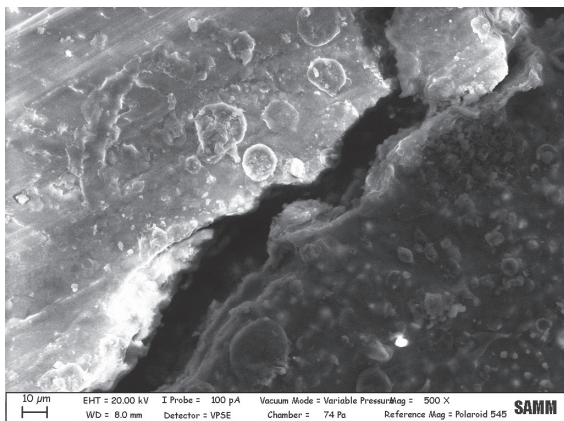


Fig. 3 Example of an inadequate root-end filling, with a large gap between the filling and cavity margin. Magnification  $\times 500$ .

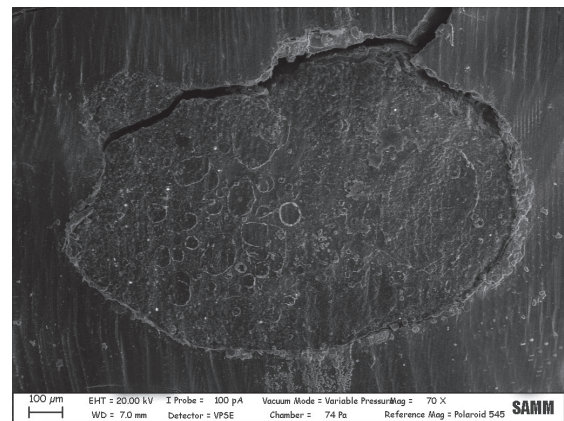


Fig. 4 Inadequate root filling showing a marginal disruption involving more than 30% of the circumferential cavity margin. Magnification  $\times 70$ .

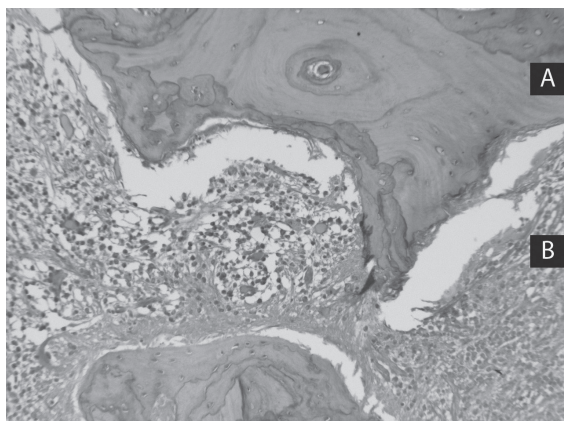


Fig. 5 Bone resorption and intratrabecular inflammatory infiltration. A: bone; B: infiltration.

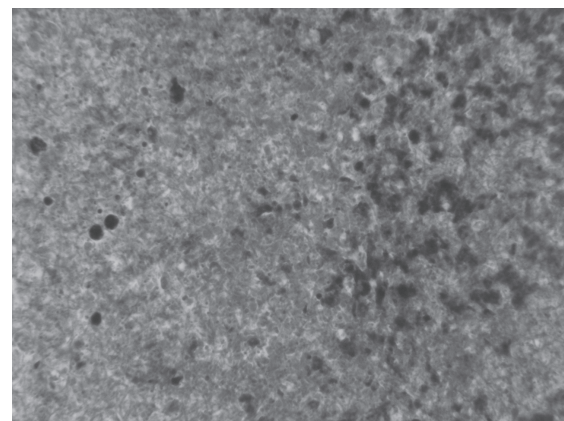


Fig. 6 Bacterial colony (dark stains on right side) within an enucleated periapical lesion.

Seal; Ognà Pharmaceuticals, Milan, Italy) as the root-end filling material; a persistent periapical lesion of strictly endodontic origin was present for at least one year after endodontic surgery (1); endodontic re-surgery was considered unfeasible; adequate definitive restoration

was present, with no clinical evidence of coronal leakage; adequate radiographic image of root-end filling cement was present (i.e., 2 to 3 mm in length and apparent three-dimensional filling); the patient did not have general medical contraindications for oral surgical procedures

(i.e., all patients had a rating of 1 or 2 according to American Society of Anesthesiologists criteria).

The following situations were excluded: teeth with pathoses associated with vertical root-fractures, and molar teeth.

Based on these criteria, 10 consecutive patients were included in the study. Each patient provided written information with regard to the surgical procedure and the subsequent analysis of the extracted tooth, and a consent form was signed if they agreed to the procedure.

Tooth extraction was performed with the patient under local anesthesia consisting of articaine chlorhydrate 4% and adrenaline 1:100,000 (Alfacaine N; Weiment Pharma, Rastat, Germany). A full-thickness mucosal flap was raised, and the tooth was carefully luxated using small elevators. Extraction of the mobilized tooth was performed with forceps; thus, a minimal amount of mechanical trauma was applied to the surrounding bone and to the tooth. Degranulation of the socket was immediately performed after extraction of the involved tooth. Samples of granulation tissue were collected for histologic analysis.

Soon after the extraction procedure, an impression of the resected root surface was obtained with polyvinylsiloxane material (Exaflex; GC Corporation, Tokyo, Japan) applied using a syringe. After 10 min, the impression was removed from the root surface and checked for imperfections under a surgical microscope at  $\times 15$ -30 magnification. In cases of imperfection, the impression was taken again until no visible imperfection was present. A positive model was then manufactured from the impression using epoxy resin. The resin was left to cure at room temperature for a minimum of 3 days. Finally, the positive models were mounted on individual stubs.

SEM evaluation was performed with a Zeiss Evo 50-EP (Carl-Zeiss, Oberkochen, Germany). To minimize artifacts, sputtering was avoided. Specimens were coded for blind evaluation, photographed at  $\times 30$  to  $\times 70$ , and independently evaluated by two examiners. Any disagreement was resolved jointly by a further evaluation of the sample under higher magnification ( $\times 500$ ) until a consensus was reached.

### Outcome variables

The root-end surface was observed for root-end filling adaptation to the cavity margin. Any defects at the interface root-end filling material/cavity margin were scored as follows: ideal, filling material is perfectly adapted (Fig. 1); imperfect, 1 to 3 small marginal disruptions and/or fracture involving the margins (Fig. 2); inadequate,

presence of a large continuous marginal disruption involving no less than 30% of the circular profile of the cavity (Figs. 3 and 4).

### Results

All the root-end fillings showed gaps between the material and canal walls. Four were scored as imperfect, and six were scored as inadequate. Among the latter, one showed a root-end fracture involving the marginal cavity.

Histological analysis of granulation tissue from the lesions within the surrounding bone (when feasible) demonstrated typical characteristics of periapical granuloma in all cases (Fig. 5). Absence or minimal presence of scar tissue was always observed, as well as presence of moderate to severe inflammation. Bacterial infiltration of the granulation tissue was observed in 4 out of 10 cases (Fig. 6).

### Discussion

The question of whether periapical lesions can relapse after endodontic surgical procedures has long been discussed, and the role of root-end filling is probably one of the most controversial technical aspects in periradicular surgery. However, some concepts are relevant and have been demonstrated. It is a matter of fact that the most favourable chances of success are related to technically correct root-end management in which a 3-mm deep cavity is prepared following the long axis and the filling material is properly adapted to the cavity margin (3).

A comprehensive overview of the causative factors of non-resolving periapical lesions that are seen as asymptomatic radiolucencies after treatment emphasized that the presence of residual microorganisms in the apical portion of the root canal system is the major cause of persistent apical periodontitis in both poorly and properly treated cases (5). An imperfect seal at the interface between the root-end filling and the cavity margin was a common feature in the present series of failed cases. It could be hypothesized that the presence of such a gap would favour a continuous bacterial leakage from the infected root canal system to the periapical tissue. Such stimuli would sustain periapical tissue inflammation, making available a large amount of nutrients that might easily diffuse into the apical canal tubules and support the metabolism of surviving bacteria. This effect can be emphasized when the root-end filling is absent. The latter may be due to a precise choice of the clinician or to the presence of an undetected canal. In our study, all samples had been root-end filled with Super-EBA. The selected patients belonged to a larger cohort of patients (approximately 160) in which Super-EBA was used as

root-end filling material, and in which an overall success rate of over 90% was recorded. Hence, we believe that the gaps observed in the present study were unrelated to the specific adaptation features of the material to the cavity walls, but dependent on inappropriate intrasurgical application of Super-EBA.

The preparation of a sample for SEM analysis is one of the most critical aspects of this method of investigation. In fact, dehydration and drying procedures may create artifacts in hard tissues. Two different approaches for SEM analysis should thus be considered (6). The "direct" approach consists of the dehydration and drying of the original sample. This procedure may create artifacts in sample morphology and differences in observation analysis. The "indirect" approach, which was used in the present study, is carried out by taking impressions of the tooth surface. A positive model is then manufactured and examined. In this case, it is possible to preserve the original sample characteristics, as critical point drying and dehydration can be avoided.

Song et al. (4) specified the possible causes of endodontic surgical failure as the absence of root-end filling and incorrect root-end preparation. The presence of a missing canal, or of an untreated isthmus, together with an unsuitable root-end filling are the other causes identified. In all of these cases, the more probable causative factor in surgical failure was the presence of a pathway between the root-end canal system and the periradicular tissue. Von Arx et al. (7) noted that the major objective of this surgery was to obtain periradicular tissue regeneration, including the formation of a new periodontal attachment apparatus by excluding any potentially noxious agent within the physical confines of the affected root. Our perspective is that root-end cavity preparation, performed in order to treat all of the root-end cavity anatomy and to allow three-dimensional root-end filling, is determinant in the outcome of this surgical procedure.

In support of this theory, several histological studies have underlined the role of intraradicular infection, usually in the form of biofilms, as the primary cause of endodontic treatment failure (8-10). In these studies, biopsies consisted of the root tip and surrounding pathologic tissue removed surgically. The hypothesis suggested by

the present findings, however, must be confirmed in the long term and with a larger sample of patients.

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