

## Effect of a newly developed dental device for root canal treatment using PEEK material for smear layer removal

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**Reaming and filing are used for pulp extraction and cleaning infected root canals. The smear layer is a residue of softened dentin in the dentin tubules. In endodontic treatment, the removal of the smear layer is very important in terms of infection control. Poly Ether Ether Ketone (PEEK) material has excellent resistance to heat, hydrolysis, chemical breakdown, radiation, and flames. It is widely used in industry for cleaning automobile parts such as gears. This study used PEEK material, which was developed as a root canal expander. A scanning electron microscope was used to evaluate its effect on the removal of the smear layer in the root canal. (J Osaka Dent Univ 2023; 57: 203-208)**

**Key words: PEEK; Root canal; Smear layer**

### INTRODUCTION

Endodontic treatment is one of the most common procedures in clinical dentistry for pulpal and periodontal tissue disease. When the pulp (including the nerves, arteries, veins, lymphatic tissue, and fibrous connective tissue) becomes infected or damaged, endodontic treatment is necessary to preserve the tooth.<sup>1-3</sup> Root canal enlargement during endodontic treatment is commonly performed to remove softened dentin.<sup>4-6</sup> Root canal enlargement is performed with a manual dental reamer, file, or mechanical root canal enlargement device with an endomotor.<sup>7-9</sup> The smear layer is formed as a result of the removal of softened dentin, and is composed of dentin debris that has ended up in the dentin tubules.<sup>10, 11</sup>

Since the smear layer is a byproduct of infected dentin, the canal is at risk of infection and contamination. Therefore, removal of the smear layer is important in endodontics from the perspective of infection control. 3% ethylenediaminetetraacetic acid (EDTA) is used in endodontics to chemically remove the smear layer through a demineralization reaction.<sup>12-14</sup> On the other hand, the physical removal of the smear layer can be achieved by using

an ultrasonic generator. Physical smear layer removal is considered an effective method for this.<sup>15-17</sup>

PEEK material is known for its excellent resistance to heat, hydrolysis, chemical substances, radiation, and flames. It is widely applied.<sup>18-20</sup> In this study, we used scanning electron microscopy (SEM) to examine the effect of PEEK material, which was developed as a root canal expander, on the removal of the smear layer in the root dentin of bovine anterior teeth.

### MATERIALS AND METHODS

#### Bovine premolar root

We used 24 roots of anterior teeth of Japanese cattle (Osaka Zoki, Osaka, Japan) slaughtered for meat. This study was approved by the Animal Experiment Committee of Osaka Dental University (Approval No. 22-03001).

#### Treatment of the root canal

The control group consisted of: bovine premolar root canals that had not been filed; bovine premolar root canals that had not been filed but had been treated with 3% EDTA (Smearclin; Nishika, Yamaguchi, Japan) for 2 minutes; the root canal walls of bovine premolars that had been filed but not

**Table 1** Treatment group

Treatment group
Control groups
No pulpectomy
No pulpectomy + 3% EDTA
Filing 40 times (pulpectomy)
Filing 40 times (pulpectomy) + 3% EDTA
Experimental groups
Filing 40 times (pulpectomy) + PEEK
Filing 40 times (pulpectomy) + 3% EDTA + PEEK

treated; and bovine premolar root canals that had been filed and treated with 3% EDTA for 2 minutes. The experimental group consisted of: bovine premolar root canals that had been filed and treated using a PEEK device (Micron, Tokyo, Japan) fitted with a SonicEndo device (Yoshida, Tokyo, Japan) for 30 seconds; and bovine anterior root canals that had been filed and treated with 3% EDTA for 2 minutes and then treated using the PEEK device for 30 seconds (Table 1). Filing was performed 40 times using a #40 hand H file (Manny, Shiga, Japan).

### Scanning electron microscopy (SEM)

The osmium was deposited in a vacuum using an osmium coater (HPC-20; Mito, Ibaraki, Japan), and the surface microstructure of the root canal wall of the first half of the root was observed using a scanning electron microscope (S-4800; Hitachi, Tokyo, Japan).

## RESULTS

### Canals that had not been filed (unfiled canals)

Pulp tissue remained on the canal wall (Fig. 1).

### Canals treated with 3% EDTA without filing (unfiled canals treated with 3% EDTA)

A concavity was observed in part of the dentin tubule that revealed a fossa opening, and pulp tissue remained on the root canal wall (Fig. 2).

### Canals where dental files had been used on the root canal wall

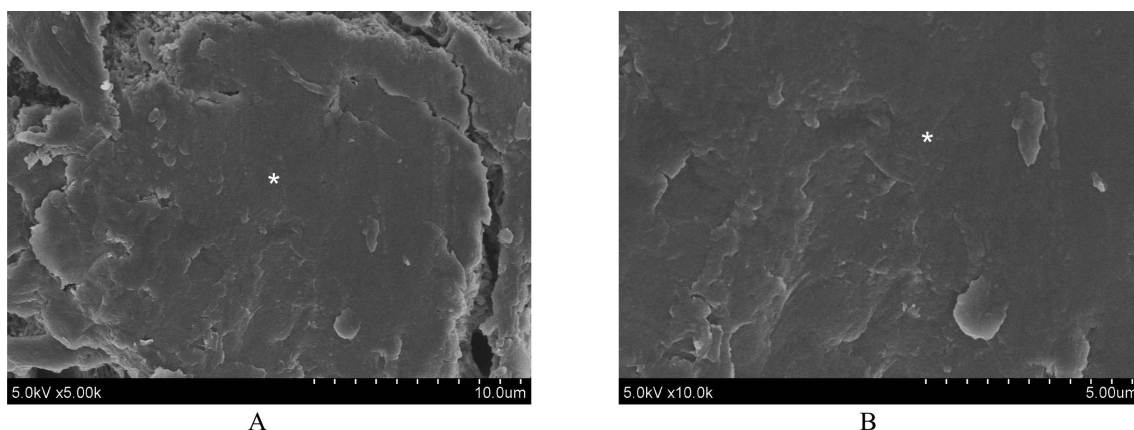
A smear layer was formed on the root canal wall by the dental files with striations in the same direction, partially sealing the dentin tubules (Fig. 3).

### Canals where dental files had been used on the root canal wall and the canal had been treated with 3% EDTA (3% EDTA treatment after filing)

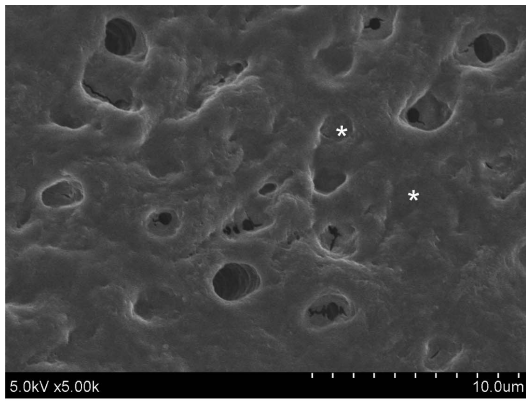
The smear layer was partially removed, but there was a residual smear layer on the root canal wall and some dentin tubules were sealed (Fig. 4).

### Canals that had been filed and treated with the PEEK material device

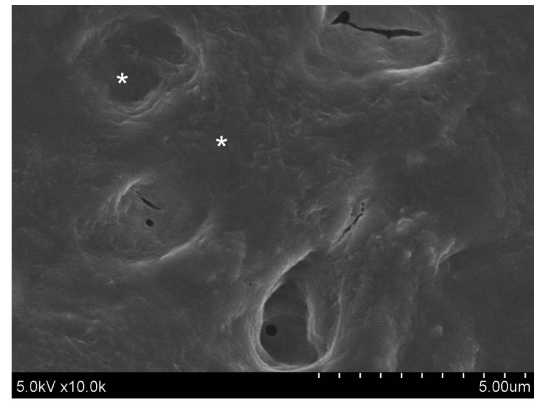
No pulp tissue was observed on the root canal wall, but a smear layer remained in some areas. Opening of the dentin tubules was observed in some areas (Fig. 5).



**Fig. 1** Residual pulp tissue observed on the root canal walls in both (A) and (B) (\*Dental pulp tissue).

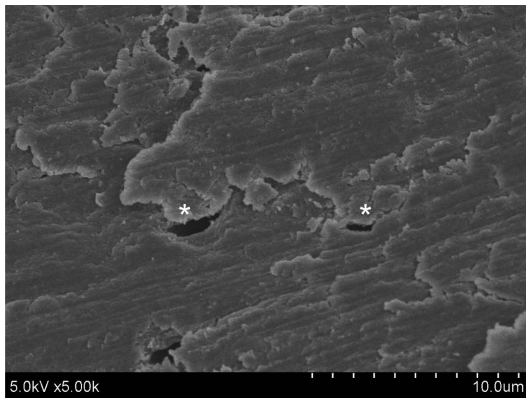


A

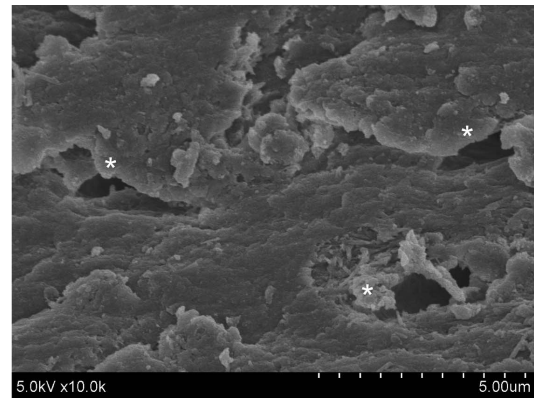


B

**Fig. 2** Residual pulp tissue observed on the root canal walls in both (A) and (B) (\*Dental pulp tissue).

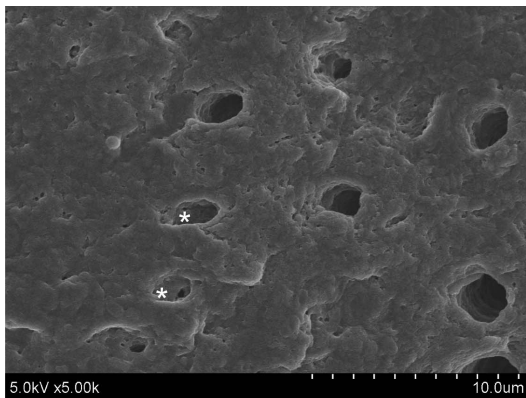


A

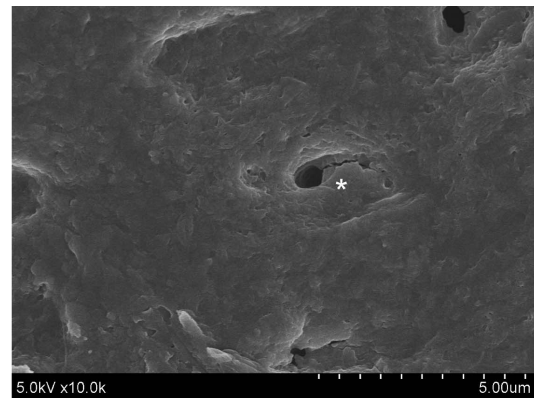


B

**Fig. 3** Residual smear layer without opening of the dentin tubules observed in both (A) and (B) (\*Smear layer).

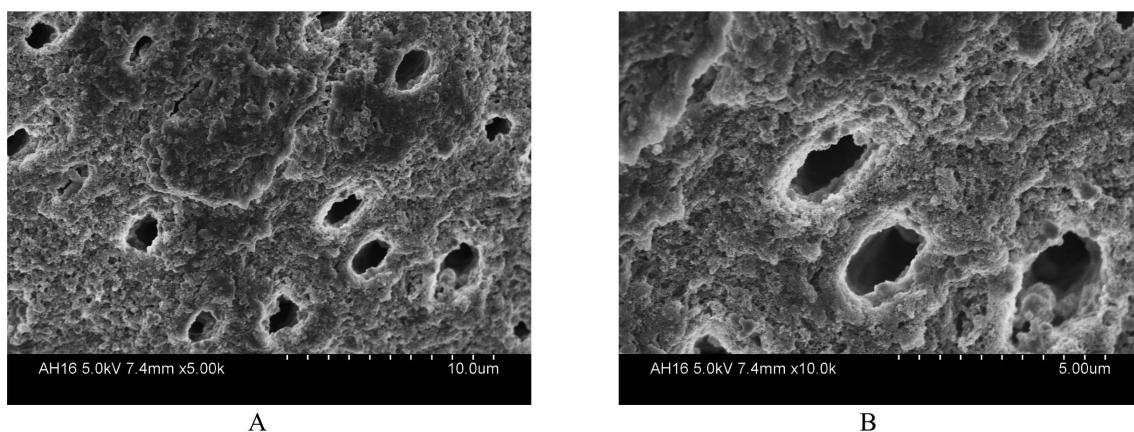


A

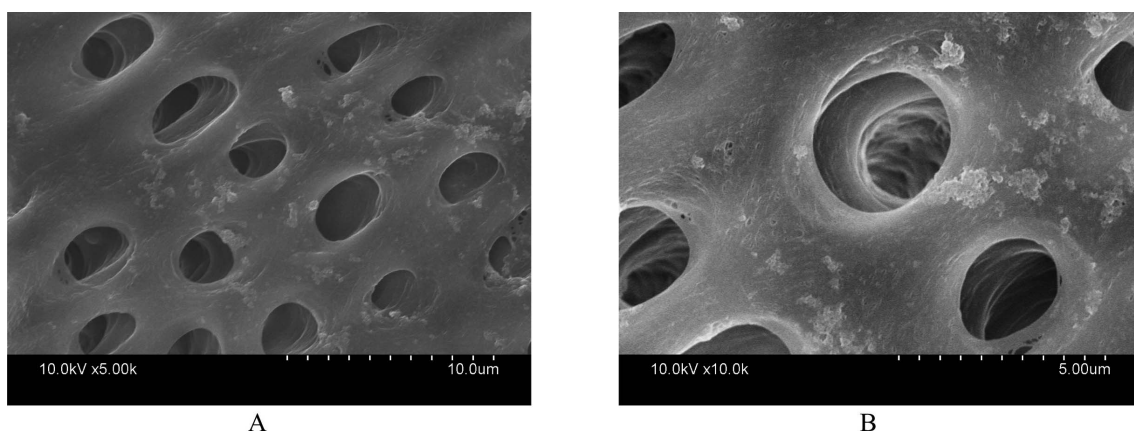


B

**Fig. 4** Partial opening of dentin tubules and residual smear layer observed in both (A) and (B) (\*Smear layer).



**Fig. 5** Residual smear layer observed in some areas in both(A) and (B) along with some open dentin tubules.



**Fig. 6** No residual smear layer, and open dentin tubules observed in either (A) or (B).

**Canals where dental files had been used and the root canal wall had been treated with 3% EDTA followed by treatment with the PEEK material device**

No residual pulp tissue or residual smear layer was observed on the root canal wall, and the dentin tubules were open (Fig. 6).

**DISCUSSION**

It is known that the formation of a smear layer and its persistence near the dentin tubule orifice in the root canal wall can adversely affect the prognosis of endodontic treatment. Residual pulp tissue also adversely affects endodontic treatment. Therefore, complete removal of the smear layer and pulp tissue is considered to have a favorable endodontic prognosis.<sup>21-23</sup>

Table 2 summarizes the results for the six categories of root canal treatment in terms of the remaining pulp tissue, presence of a smear layer, and dentin tubule visibility. When 3% EDTA was applied without filing, no pulp tissue was removed from the root canal wall. When filed, a smear layer was formed, and when 3% EDTA treatment was applied after filing, no pulp tissue remained, although the smear layer remained in places. These conditions may have a negative impact on the endodontic prognosis.<sup>24-26</sup> On the other hand, when the PEEK material device was used after filing, although the pulp tissue was removed, some of the smear layer remained, and partial opening of the dentin tubules was observed. After filing, treatment with 3% EDTA and the subsequent use of the PEEK device, both the pulp tissue and the smear

**Table 2** Treatment results

Treatment	Dental pulp residue	Smear layer	Dentin tubule visibility
No pulpectomy	+		–
No pulpectomy + 3% EDTA	+	++	±
Filing 40 times (pulpectomy)	–	±	–
Filing 40 times (pulpectomy) + 3% EDTA	–	±	±
Filing 40 times (pulpectomy) + PEEK	–	--	+
Filing 40 times (pulpectomy) + 3% EDTA + PEEK	–		++

layer were removed, and almost all of the dentin tubules were observed to be completely open.

Based on these results, we think that although the smear layer can be partially removed by using the PEEK material device alone, the smear layer can be more effectively removed when the device is used in combination with 3% EDTA as a chemical smear layer removal system. We found that the PEEK material device developed as a root canal expander is useful for removing the smear layer of the bovine root canal wall, and that it is even more effective when used in combination with 3% EDTA.

The authors declare that they have no conflicts of interest related to this study.

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