Apical Seal with Different Obturating Materials Following Apical-third Root Resection Using Er:YAG Laser and Conventional Carbide Bur: A Comparative Study

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Purpose: The objective of the present study was to compare the effect of the conventional carbide bur and Er:YAG laser (contact mode) used for apical resection on the roots of teeth obturated using the lateral compaction technique with various sealers and gutta percha points.

Materials and Methods: A total of 120 noncarious extracted human teeth was collected for the study. Access cavities were prepared and the teeth were cleaned and shaped. Following obturation, the apical 3 mm of the teeth were resected using either the bur or Er:YAG (2940 nm wavelength) laser in contact mode. ESEM was used to evaluate micromorphological changes in the structure of dentin and effects on the obturation material.

Results: ESEM examination revealed a smooth sectioning of the apical third in all samples at low magnification. Higher magnification showed that the bur and the laser were equally effective in sectioning the tooth and obturation material. The laser sections showed melting of dentin and sealing of dentinal tubules. However, microgaps were seen in all specimens at the root canal dentin wall/obturation-material interface.

Conclusion: Although the carbide bur and Er:YAG laser are equally effective in sectioning the apical third, the presence of microgaps indicates the necessity of providing a good apical seal with retrograde filling material for preventing microleakage following resection.

Keywords: dental lasers, carbide bur, Er:YAG laser, endodontics, apical resection, ESEM analysis.

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Endodontics has progressed in leaps and bounds from the traditional use of silver points to newer obturation materials and techniques. The predictability of endodontic treatment has also increased manifold. Nonsurgical retreatment of "failed" endodontic cases is preferred over surgery, by both the operator and the patient. However, some persistent failure cases do require a surgical intervention.

The concept of surgical endodontic treatment has remained more or less the same over the years, which involves root resection of the apical third followed by retropreparation and retrofilling. A number of modifications to these steps has been suggested and tested, including

- Variation in the angle of resection, eg, 0, 10, 45 degrees to long axis of the tooth.[1]

- Retropreparation or no preparation followed by cold burnishing of the obturation material.
- Variations in the materials used for retrofilling, such as ZnOE Cement IRM, Super EBA, dental amalgam, zinc polycarboxylate cement, glass-ionomer cements, mineral trioxide aggregate (MTA), calcium phosphate cement, bone cement, composite resin (with and without bonding agent), and many others.[2-4]

Traditionally, carbide burs or diamond abrasives attached to air-turbine handpieces have been used for apical resection. Soft tissue lasers have been used extensively in endodontics for disinfection of root canals.[5,6] Hard-tissue lasers were introduced in dentistry about 10 years ago, and since then, a great deal of research on their application in the various fields of dentistry has been carried out. Hard-tissue lasers from the Erbium family (eg, Er:YAG and Er,Cr:YSGG) have been tested in the apical sectioning of teeth.[7,8] The Er:YAG laser has also been shown to have anti-bacterial properties.[9] In vitro studies using the Er:YAG laser for root resection of extracted teeth achieved excellent results, producing smooth, clean resected root surfaces, devoid of charring.[10] Clinically, the use of this laser resulted in improved healing and diminished postoperative discomfort.

The purpose of the present study was to compare the effect of the conventional carbide bur and Er:YAG laser (contact mode) used for apical-third resection of the roots of teeth obturated using the lateral compaction technique (the technique most commonly performed by clinicians) with various sealers and gutta percha points.

MATERIALS AND METHODS

Selection of Samples

One hundred twenty human extracted maxillary incisors were randomly chosen. The teeth were cleaned and washed with a physiological saline solution and stored at room temperature.

Preparation of Samples

Endodontic access cavity preparations were made in all the teeth and apical patency was checked using ISO 8 no. K-File (Dentsply Maillefer; Ballaigues, Switzerland). Cleaning and shaping was done using the ProTaper Rotary system (Dentsply Maillefer) using the X-Smart Endodontic motor (Dentsply Maillefer) in the sequence of shaping files S1-Sx-S2 and finishing files F1-F2-F3-F4. Each instrument was coated with aqueous EDTA prior to insertion in the canal. The canals were irrigated with 5.25% sodium hypochlorite for removal of any organic contents in the root canal system. Two types of gutta-percha points were selected: 60 teeth received soft points (Autofit Gutta Percha 6%, Analytic Endodontics; Orange, CA, USA) and 60 received hard points (6% Protaper points, Dentsply Maillefer). The teeth were dried using paper points. The nonstandardized points were checked by apical gauging using the Endo-gauge (Dentsply Maillefer). Then, the three types of sealers were applied: 1. Roeko Seal (Coltene Whaledent; Mahwah, NJ, USA); 2. AH-Plus Dentsply DeTrey; York, PA, USA); 3. PulpCanal Sealer (SybronEndo; Orange, CA, USA). Each type was applied to 40 specimens (Table 1).

Following obturation, the teeth were checked radiographically for uniformity and overall fill of the obturation. The teeth were stored under humid conditions for 24 h to allow the zinc oxide/eugenol-based sealer to set. Then the teeth were divided into 2 main groups (bur or laser) of 6 subgroups (n = 10) each according to type of gutta-percha point (soft or hard) and filling material as shown in Table 1.

In the bur group (n = 60), samples were apically resected using the SSWFG 1171 L carbide bur (SS White; Lakewood, NJ, USA). In the laser group (n = 60), the apical 3 mm were resected using the Er:YAG Laser (Fotona Fidelis III Plus; Ljubljana, Slovenia) in contact mode using the flat-ended sapphire tip set at parameters of 200 mJ and 20 Hz in VSP mode. The sections were made 90 degrees to the long axis of the tooth at a distance of 3 mm from the anatomic apex.

ESEM Analysis

The sectioned surfaces were examined using ESEM analysis (ARAI; Pune, India) at low magnification of 50X and higher magnifications of 1200X and 2400X. Built-in software was also used to record the microgaps present between the root canal wall dentin and obturation interface.

RESULTS

ESEM analysis of the resected surfaces at 50X magnification showed that both the carbide bur and Er:YAG laser were able to section the tooth in the apical third with a smooth clean surface (Fig 1). At higher magnification, however, all the groups showed some micro-

Table 1 Description of groups and microgaps recorded in the samples following apical sectioning

Group	Range of microgaps (in µm)*	No. of samples (n)
Hard Point + Roeko Seal + Bur Section	19.98 - 62.87	10
Hard Point + AH-Plus + Bur Section	7.13 - 23.94	10
Hard Point + Pulp Canal Sealer + Bur Section	11.07 - 224.84	10
Soft Point + Roeko Seal + Bur Section	22.06 - 41.94	10
Soft Point + AH-Plus + Bur Section	5.46 - 40.51	10
Soft Point + Pulp Canal Sealer + Bur Section	2.61 - 72.27	10
Hard Point + Roeko Seal + Er:YAG Laser Section	7.78 - 50.07	10
Hard Point + AH-Plus + Er:YAG Laser Section	6.92 - 12.64	10
Hard Point + Pulp Canal Sealer + Er:YAG Laser Section	17.59 - 54.34	10
Soft Point + Roeko Seal + Er:YAG Laser Section	7.36 - 17.28	10
Soft Point + AH-Plus + Er:YAG Laser Section	19.00 - 35.29	10
Soft Point + Pulp Canal Sealer + Er:YAG Laser Section	12.99 - 27.27	10

* Numbers indicate minimum and maximum gaps recorded in the particular group

gaps between the intra-radicular dentin and the obturation material. The microgaps recorded in each group were recorded, and the maximum and minimum values are presented in Table 1.

DISCUSSION

ESEM analysis showed that the results obtained with the carbide bur and the laser were comparable. Both methods yielded a clean, horizontal section, but with the parameters used here (4W of power), cutting with the Er:YAG laser took longer. Increasing the power could reduce the time required for resection, but relatively low power settings are used to prevent overheating and other unwanted effects on the dental tissues in a clinical situation. It was also observed that although the laser could cut hard tissue easily, there was some softening of the gutta-percha, resulting in a drag of the material over the sectioned root surface. A number of areas showed a good adaptation of the material over the sectioned surface. However, it is essential to note the areas which show microgaps, as they are potential areas of apical microleakage following the resection procedure (Fig 2). Hence, the study focused on these regions of the root canal wall which showed gaps between the root dentin and obturation material at higher magnification.

The following observations were made:

- Sectioning with the laser resulted in sealing of the dentinal tubules and less smear layer as compared to the bur sectioning.
- The sites irradiated did not show any significant alterations. Areas of melting and cracking were only partially and rarely visible, and phenomena of carboniza- tion were not evident, confirming recent studies[6,8-11] that validate the necessity of water to increase the efficacy of the ablative power and to reduce the structural changes caused by thermal effects (Fig 3).
- The laser-resected surface showed the presence of micro-irregularities and microroughness at a higher magnification.

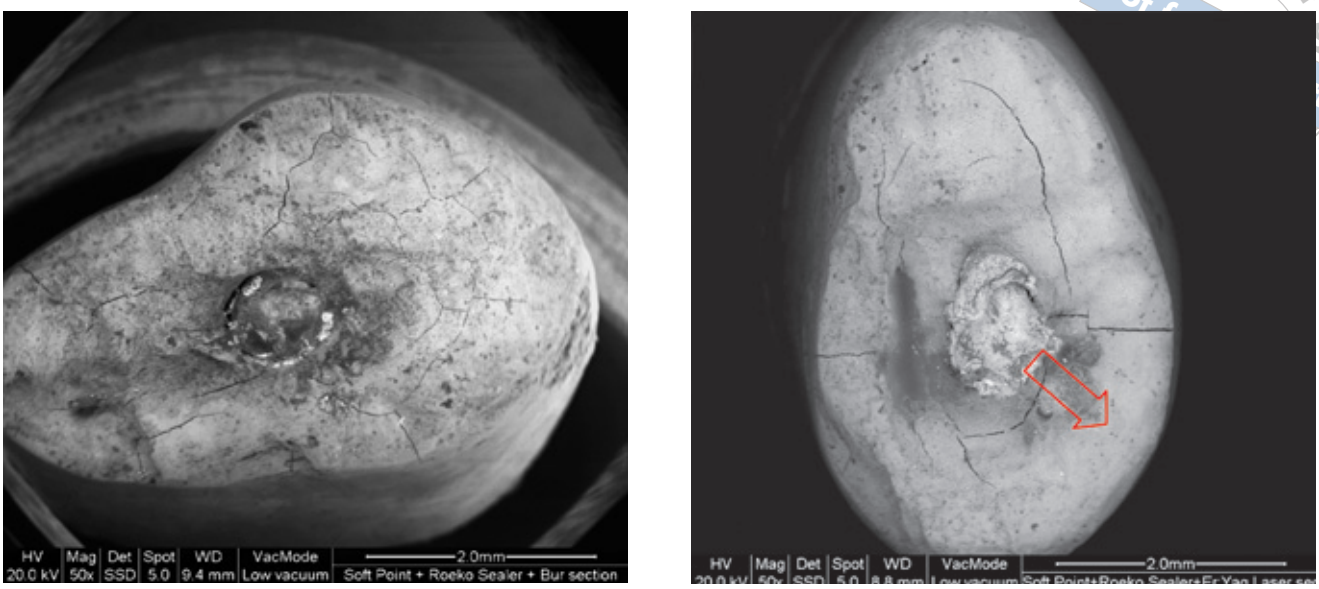


Fig 1 Comparison of the carbide bur section and the Er:YAG laser section. Both show a clean sectioning of the root. The gutta-percha appears to have been dragged in the laser-sectioned specimen (right) (50X magnification).

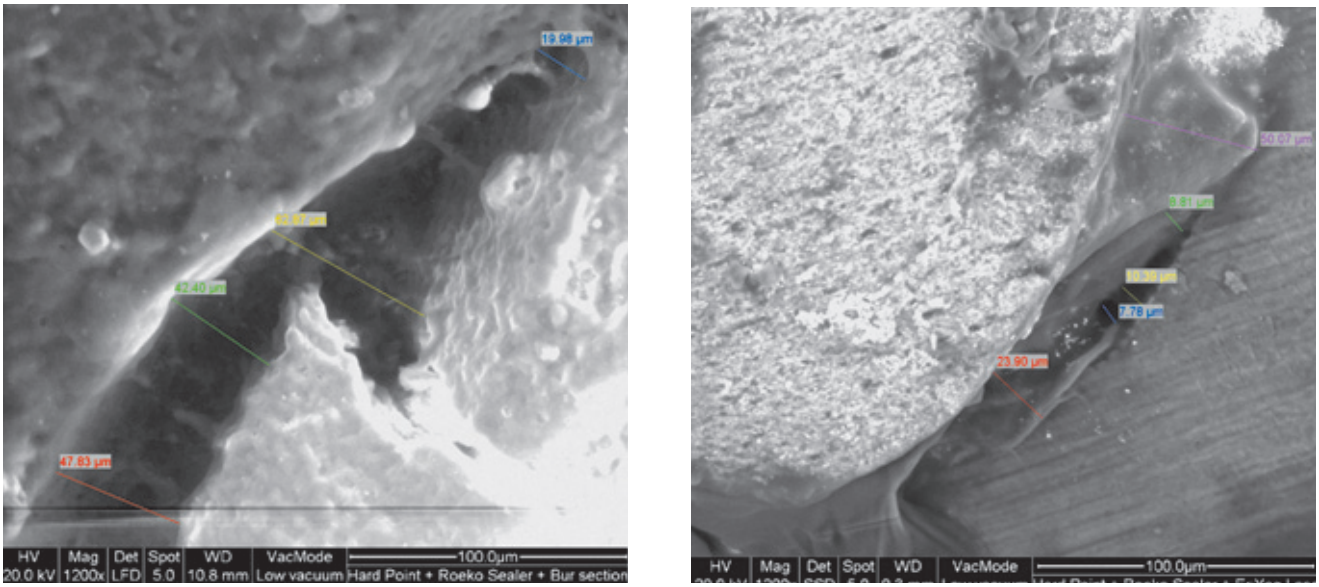


Fig 2 ESEM images showing linear measurements done for recording the microgaps present between the root canal dentin wall and obturation interface over the resected surfaces (1200X magnification).

CONCLUSION

The results of the present study indicate that the carbide bur and the Er:YAG laser are equally efficient in sectioning the tooth at the apical third. The Er:YAG laser, however, has the additional advantage of providing a sterile environment due to its antimicrobial effect and sealing the open dentinal tubules over the resected surface. The specimens with soft points took more time to cut and showed a higher drag than did the specimens bearing hard points, which took less time to cut and showed less drag on the resected surface. In a clinical situation, old root canal fillings may be brittle, and hence the importance of this factor may be slight. This issue is also not significant if the obturation is done with a thermoplasticized solid-core carrier-based gutta-percha technique (Figs 4 to 9). Overall, the seal provided by zinc oxide-based sealers was inferior to that

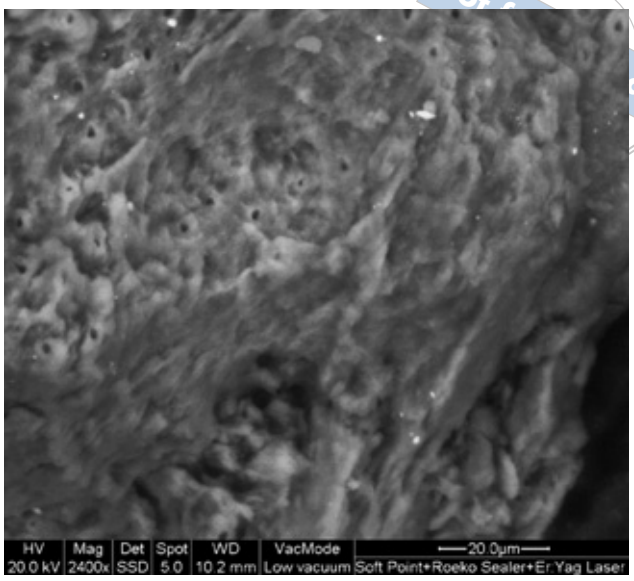
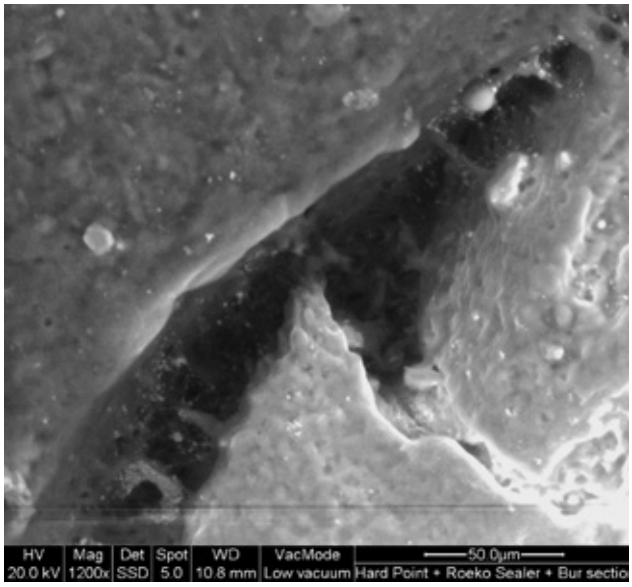


Fig 3 Melting and partial closure of the dentinal tubules in the intraradicular region and on the sectioned surface (2400X magnification).



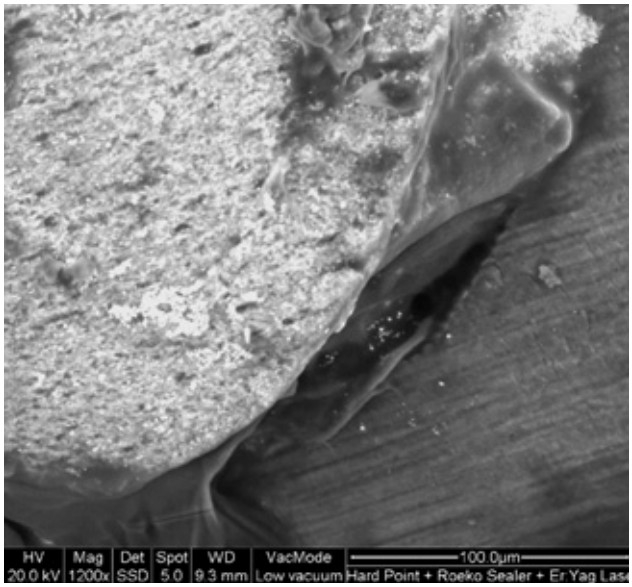


Fig 4 ESEM images comparing bur vs laser resection using a combination of hard points + Roeko Sealer (1200X magnification).

of the resin-based sealers. The soft points were superior to the hard points with respect to the apical seal as seen on the resected surface.

The ESEM images indicated that all samples showed some amount of microgaps that ranged from 39 µm to as high as 200 µm. These findings were consistent with the study conducted by Guilherne et al,[11] who concluded that the enlargement of the gap was due to the fusion of the dentin on the border, close to the gutta-percha. The findings by Leskiet et al[12] also indicate the need for an apical seal, following resection by either the carbide bur or the laser, necessitating a retropreparation followed by a root-end filling material. The surface roughness seen on the laser resected surface could very well call for a bonded restoration in the form of a composite resin as a retroseal material.

Another factor that needs to be taken into consideration is the practicality of sectioning the apical third in

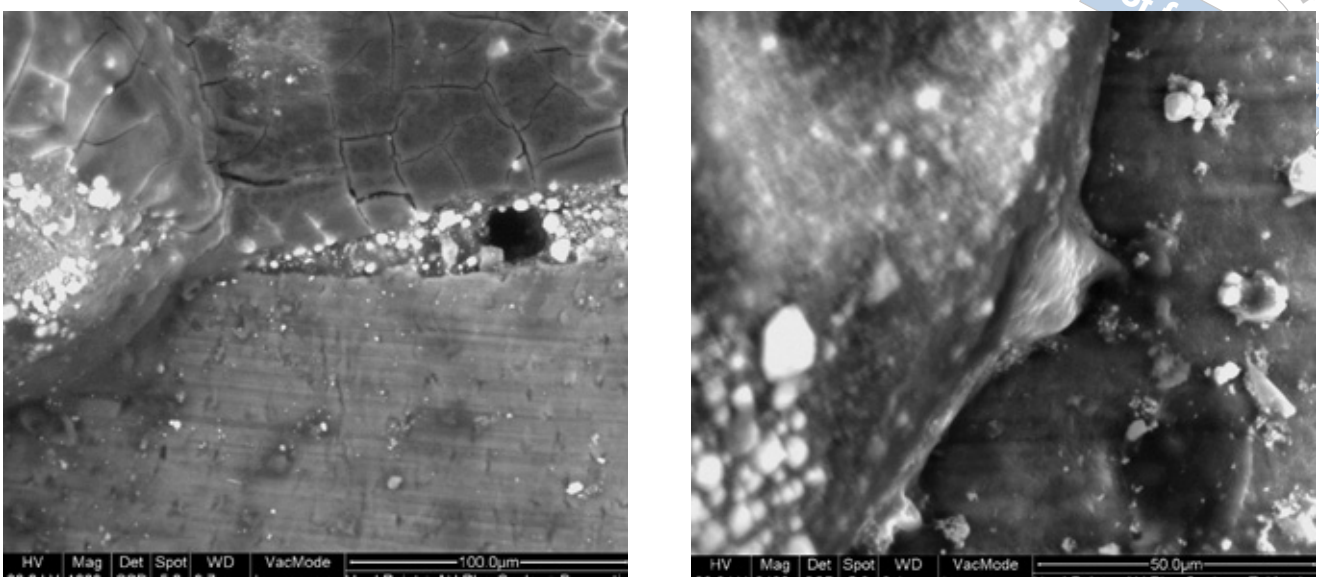


Fig 5 ESEM images comparing bur vs laser resection using a combination of hard points + AH-Plus Sealer (1200X magnification).

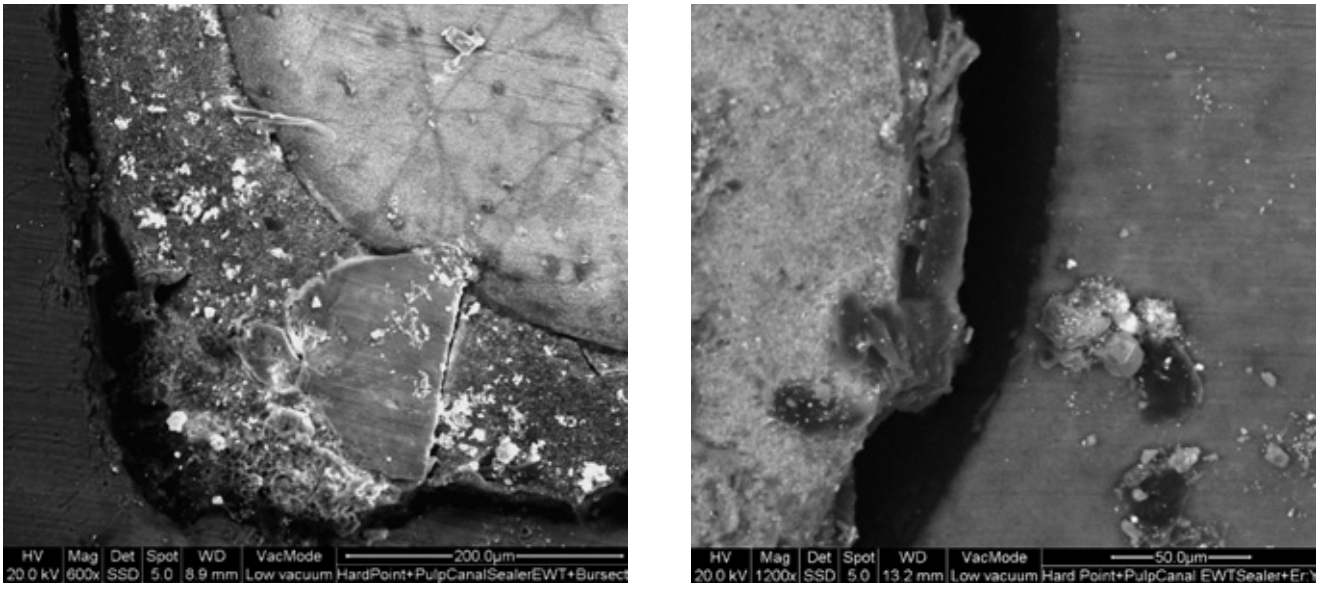


Fig 6 ESEM images comparing bur vs laser resection using a combination of hard points + PulpCanal EWT Sealer (1200X magnification).

all areas of the oral cavity. The visibility and straight line access of the laser beam in areas in the posterior region or areas situated close to anatomic landmarks (such as the neural and sinus lining) are questionable.

Based on the results of this apical resection study, the Er:YAG laser shows promise for its application in surgical endodontics. At the same time, the need for apical retropreparation followed by retrofilling must be emphasized due to the presence of microgaps on the sectioned surface at the intraradicular dentin/obturation material interface.

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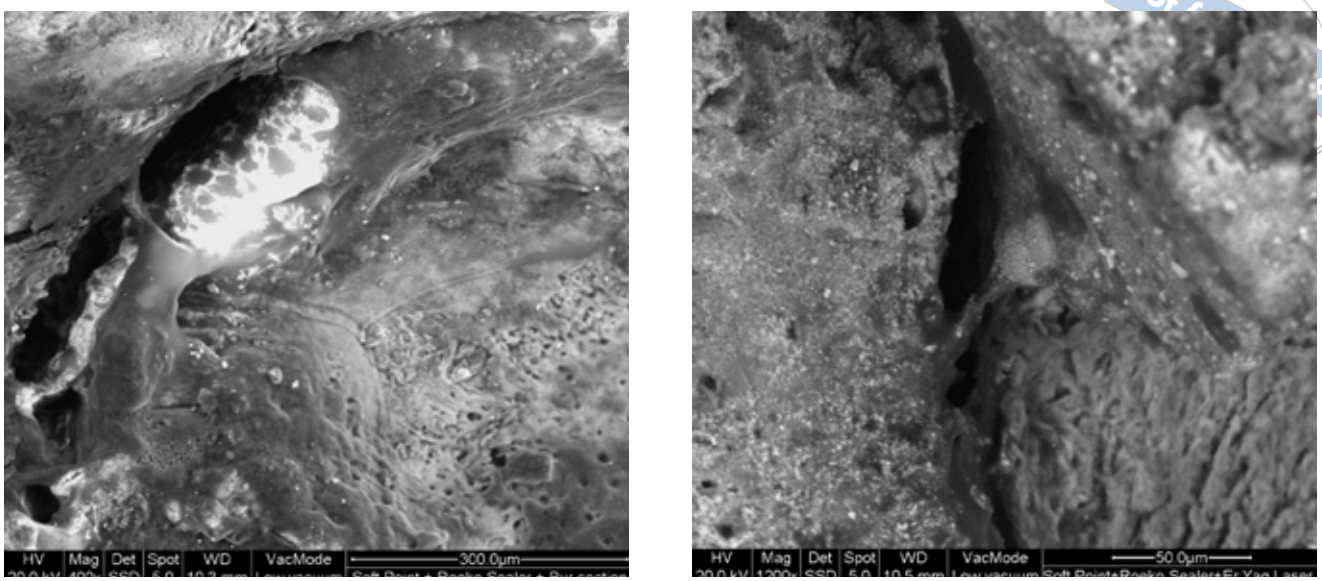

Fig 7 ESEM images comparing bur vs laser resection using a combination of soft points + Roeko Sealer (1200X magnification).

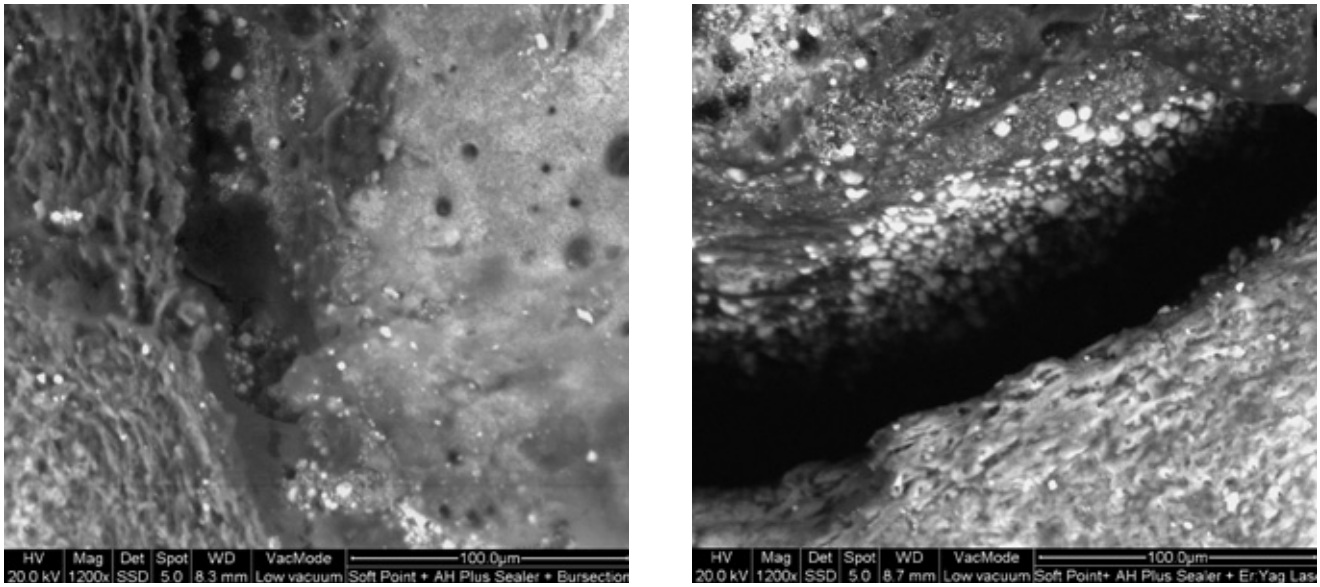

Fig 8 ESEM images comparing bur vs laser resection using a combination of Soft points + AH-Plus Sealer (1200X magnification).

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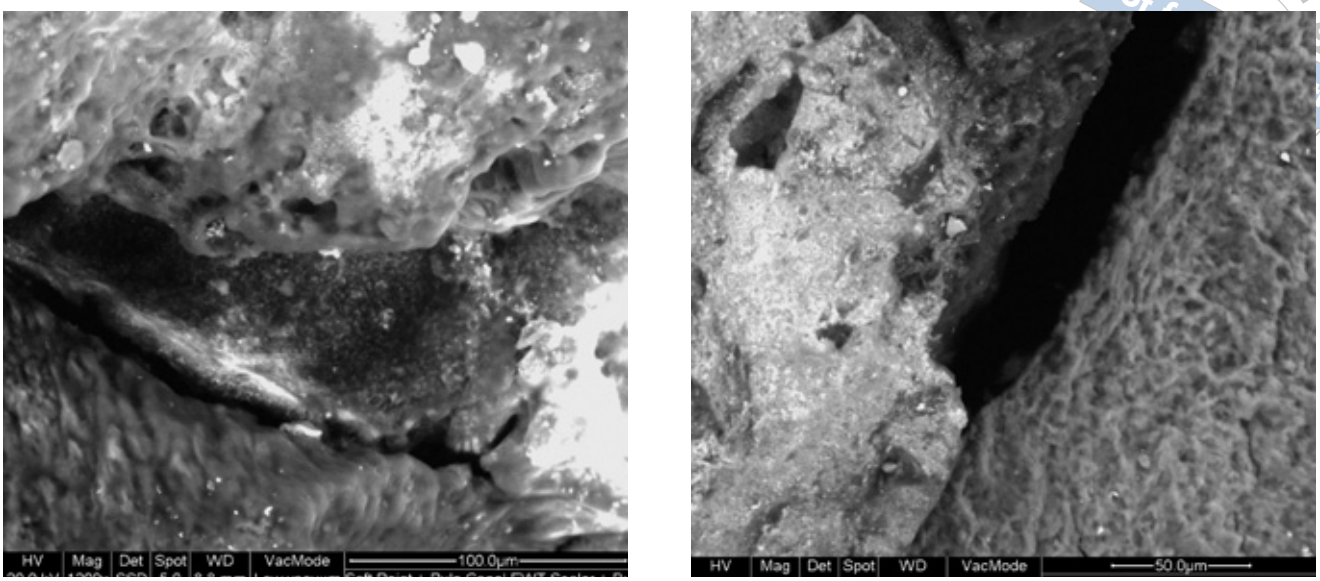

Fig 9 ESEM images comparing bur vs laser resection using a combination of soft points + PulpCanal EWT Sealer (1200X magnification).

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