Morphological assessment of dentine and cementum following apicectomy with Zekrya burs and Er:YAG laser associated with direct and indirect Nd:YAG laser irradiation

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Objectives. This study aimed to assess the apical surface morphology of maxillary central incisors resected 3.0 mm from the tooth apex using Zekrya burs or Er:YAG laser, with or without subsequent direct Nd:YAG laser irradiation (apical and buccal surfaces) and indirect irradiation (palatal surface).
Study design. Forty maxillary central incisors were instrumented and obturated. The roots were divided into 4 groups according to the root resection method (Zekrya bur or Er:YAG laser – 1.8 W, 450 mJ, 4 Hz, 113 J/cm^2) and further surface treatment (none or Nd:YAG laser – 2.0 W, 100 mJ, 20 Hz, 124 J/cm^2). The teeth were prepared for SEM analysis. Scores ranging from 1 to 4 were attributed to cut quality and morphological changes. The data were analyzed by the Kruskal-Wallis test and by Dunn's test.
Results. SEM images showed irregular surfaces on the apical portions resected with Zekrya burs, with smear layer and grooves in the resected dentine and slight gutta-percha displacement and plasticization. On the other hand, apicectomies carried out with Er:YAG laser showed morphological changes compatible with ablated dentine, with rough surfaces and craters. In spite of the presence of plasticized gutta-percha, with the presence of bubbles, an irregular adaptation of the filling material to the root walls was also observed. Direct Nd:YAG laser irradiation of the apical and buccal surfaces of the resected roots resulted in areas of resolidification and fusion in the dentine and cementum, with a vitrified aspect; indirect Nd:YAG laser irradiation of the palatal surfaces yielded a lower number of changes in the cementum, with irregular resolidification areas.
Conclusions. There were no differences in terms of cut quality between the use of burs and Er:YAG laser or between the 2 surfaces (apical and buccal) treated with Nd:YAG laser with direct irradiation. However, morphological changes were significantly less frequent on surfaces submitted to indirect irradiation (palatal) when compared with those directly irradiated. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:e77-e82)**

Periradicular surgery is indicated in cases of persistent periradicular pathologies following endodontic treatment and/or retreatment, such as the presence of root canal areas that could not be cleaned and obturated[1-3] or obstructions that impede endodontic access (i.e., posts, fractured instruments, or even when pain and exudates persist).[4,5] Other indications include new surgery when the first procedure was unsuccessful because of failure on sealing the root-end cavity, anatomic abnormalities, and periapical infections associated with periodontal disease.[6-9] The presence of apical biofilm is considered to be one of the causes of unsuccessful endodontic treatment, because standard disinfection procedures and root canal preparation usually fail in eliminating it.[10] In addition, factors associated with inflammatory periapical tissue may interfere with reparation.[11]

With the advent of more refined techniques and more biologically acceptable retrofilling materials,[12-16] more favorable postoperative prognoses have been observed, as well as improved regeneration of periradicular tissues. In addition, the use of high-speed burs has been

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associated with laser irradiation for apical root resection,[12,17] as well as for the treatment of the remaining structure.[18-21]

The use of lasers in periapical surgeries started in the 1980s, with the CO_2 laser.[19,22] Later, Stabholz et al.[23] found a decrease of dentine surface permeability of resected roots after Nd:YAG laser irradiation. Apical cuts using an Er:YAG laser followed by application of the Nd:YAG laser on the resected surface have also been observed to promote morphological changes on the dentine surface, smear layer removal, and sealing of dentinal tubules.[24-28]

The purpose of this study was to assess the use of Zekrya burs and Er:YAG laser in apical resection through scanning electron microscopy (SEM). The study focuses on adaptation of the filling material to the dentine wall and on the presence of morphological changes on the resected root surface.

MATERIALS AND METHODS

The present study was approved by the Research Ethics Committee of the School of Dentistry at Universidade de São Paulo. Forty extracted human permanent maxillary central incisors were randomly selected from the tooth bank of the School of Dentistry of Universidade de São Paulo. Specimens were immersed in 10% formalin for 48 hours, and then carefully washed with 1% sodium hypochlorite and brushed under running water. Teeth were placed in labeled vials containing saline solution, numbered 1 to 40, and stored at 37°C, for 72 hours.

Crowns were sectioned using diamond burs under water cooling. Root canal preparation was carried out with 1% sodium hypochlorite and the apex of the root was established as the working length, using a 0.04 taper, #40 K3 file (SybronEndo, Orange, CA). Following preparation, teeth were irrigated with 15 mL 1% NaOCl followed by 15 mL of 17% EDTA-T and then dried with aspiration and sterile paper points. All specimens were obturated using AH Plus sealer (Dentsply, DeTrey, Konstanz, Germany) and calibrated 0.04-taper gutta-percha cones, using the lateral condensation technique. Following obturation, teeth were randomly divided into the following 4 groups (n = 10):

- G1: roots were resected 3.0 mm from the apex using Zekrya burs, perpendicularly to the root.
- G2: resection as in G1. The resected surface was directly irradiated with Nd:YAG laser (2.0 W, 100 mJ, 20 Hz, 124 J/cm^2) on the apical, buccal, and proximal surfaces; the palatal surface was indirectly irradiated using a sapphire surgical mirror.
- G3: roots were resected 3.0 mm from the apex using Er:YAG laser (1.8 W, 450 mJ, 4 Hz, 113 J/cm^2), under constant cooling, perpendicularly to the root.
- G4: resection as in G3. The resected surface was irradiated with Nd:YAG laser as in G2.

Following apicectomies, the resected surfaces and apical 3.0 mm of all specimens were carefully treated with 17% EDTA solution.

Direct Nd:YAG irradiation was carried out maintaining a 0.5-cm distance between the irradiation source and the apical cut and buccal/proximal surfaces, in horizontal, vertical, and cross-sectional directions for 10 seconds on each surface; the palatal surface was indirectly irradiated by reflection of the beam from a surgical mirror.

After treatment completion, specimens were analyzed using SEM to assess the quality of the cut provided by the burs and the laser, as well as the presence of morphological changes on the resected surface resulting from direct and indirect irradiation. Two calibrated blinded examiners analyzed the SEM images and assigned scores from 1 to 4 for cut quality and morphological changes (Tables I and II, respectively). Data were statistically analyzed using the Kruskal-Wallis nonparametric test.

Table I. Quality criteria for the assessment of resected surfaces

Score	*Criteria*
1	Almost complete gutta-percha adaptation, smooth surface
2	Moderate gutta-percha adaptation, smooth surface
3	Poor gutta-percha adaptation, smooth surface
4	No gutta-percha adaptation, smooth surface

Table II. Quality criteria for the assessment of morphological changes

Score	*Criteria*
1	Almost complete laser melting; many areas of resolidification
2	Moderate laser melting; some areas of resolidification
3	Poor laser melting; few areas of resolidification
4	No laser melting; no areas of resolidification

Table III. Scores obtained in cut quality assessment

	Score				*Kruskal-Wallis*
Group	*1*	*2*	*3*	*4*	*($P < .05$)*
Zekrya burs	22	10	7	1	NS
Er:YAG laser	17	14	5	4	

NS, nonsignificant.

RESULTS

Table III shows the scores obtained for cut quality while using Zekrya burs (G1 and G2) and Er:YAG laser (G3 and G4). There was no statistical difference in the cut quality provided by the bur and the laser.

Table IV. Scores obtained in the assessment of morphological changes

Group	Score				Kruskal-Wallis ($P < .05$)*
	1	*2*	*3*	*4*	
Zekrya burs + direct Nd:YAG on apical surface	19	1	0	0	a
Zekrya burs + direct Nd:YAG on buccal surface	15	4	1	0	a
Zekrya burs + indirect Nd:YAG on palatal surface	3	10	5	2	b
Er:YAG laser + direct Nd:YAG on apical surface	19	1	0	0	a
Er:YAG laser + direct Nd:YAG on buccal surface	16	4	0	0	a
Er:YAG laser + indirect Nd:YAG on palatal surface	2	10	6	2	b

*Different letters indicate significant statistical differences between groups.

Scores obtained in the assessment of morphological changes associated with direct Nd:YAG laser irradiation on apical and buccal surfaces, and indirect irradiation on palatal surfaces (G2 and G4), are presented in Table IV. The Kruskal-Wallis test did not show statistical differences between the 2 surfaces treated with direct irradiation, apical and buccal. However, morphological changes were significantly less frequent on the surfaces treated with indirect irradiation, palatal, when compared with directly irradiated surfaces.

DISCUSSION

Clinical evidence has shown that even when endodontic procedures are well carried out, unsuccessful outcomes may occur, probably as a result of both intra- or extraradicular microbial factors and nonmicrobial factors.[29] Whenever clinical treatment or retreatment is not enough to ensure a successful outcome, and refractory periapical lesions persist, periapical surgical interventions become necessary.[30,31]

In our study, the apical 3 mm of the roots were resected because we believed that this measure would allow for a better-quality cut, in addition to reducing apical ramifications by 98% and lateral canals by 93%.[12] Finally, the use of Nd:YAG laser irradiation on these regions caused a significant reduction in marginal permeability between the filling material and the dentine wall, and changed the morphology of the root apex via fusion and resolidification[18,19] (Fig. 1, *B* and *D*).

Resection angle is a very influential factor in what concerns apical infiltration: more inclined cuts result in more exposed dentinal tubules, mainly at the buccal surface, which could be minimized with an increased depth of retrograde obturation. Lower resection angles, on the other hand, are associated with better results in terms of surface infiltration, limiting communication between the canal system and the periapical region.[12,32,33] Resected dentine should present a smooth and regular surface, so as to favor reparation.[34]

In our study, the use of burs was associated on SEM with a slight displacement of gutta-percha, following the same direction of bur rotation. Such displacement caused the gutta-percha to be compressed against the canal walls, as a result of the mechanical action of the bur, not to mention the presence of grooves on the resected dentine surface (Fig. 1, *A*).

On the other hand, apical resections with Er:YAG laser resulted in morphological changes suggestive of a rough dentine surface, with craters, compatible with ablated dentine. In addition, in laser resections, gutta-percha presented bubbles, with an irregular adaptation of the filling material to the root walls. This approach allowed a continuation between the filling material and the canal walls, probably as a result of the thermal effect of irradiation (Fig. 1, *C*). However, no statistically significant differences were found between the 2 methods.

Fig. 1, *E* to *H*, shows the effect of Nd:YAG laser irradiation on buccal surfaces, and Fig. 1, *I* to *L*, shows the same effect on palatal surfaces. It is possible to observe that the effect of indirect Nd:YAG laser irradiation on the palatal surface of the root, with the aid of a sapphire mirror, was less efficient if compared with direct application of the laser on the buccal root surfaces. Direct laser irradiation was associated with areas of fusion and resolidification on the cementum, with a vitrified aspect. Nevertheless, such findings do not discard the use of indirect irradiation in clinical practice, as direct irradiation on the palatal surface of the tooth is practically impossible.

Laser irradiation has a dual character and wave characteristics that allow the phenomena of reflection, refraction, interference, diffraction, and polarization to be explained by wave theory, whereas the emission and absorption phenomena can be explained by corpuscular theory. Any wave, including laser, is reflected whenever it faces an obstacle, and the angle of incidence is always preserved. When nonmetallic surfaces are used, such as glass, water, and sapphire, about 5% of the beam is reflected; the silver layer that is present on a mirror, in its turn, allows a reflection of over 90%.

This study corroborates the notion that, after the performance of apicectomies with either burs or Er:YAG laser, the apical remnant should be submitted to retropreparation and obturation using a material that can adapt to the dentine walls and favor reparation of periradicular tissues. Although Nd:YAG laser irradiation on the apical surface has been shown to cause morphological changes to the dentine and a reduction

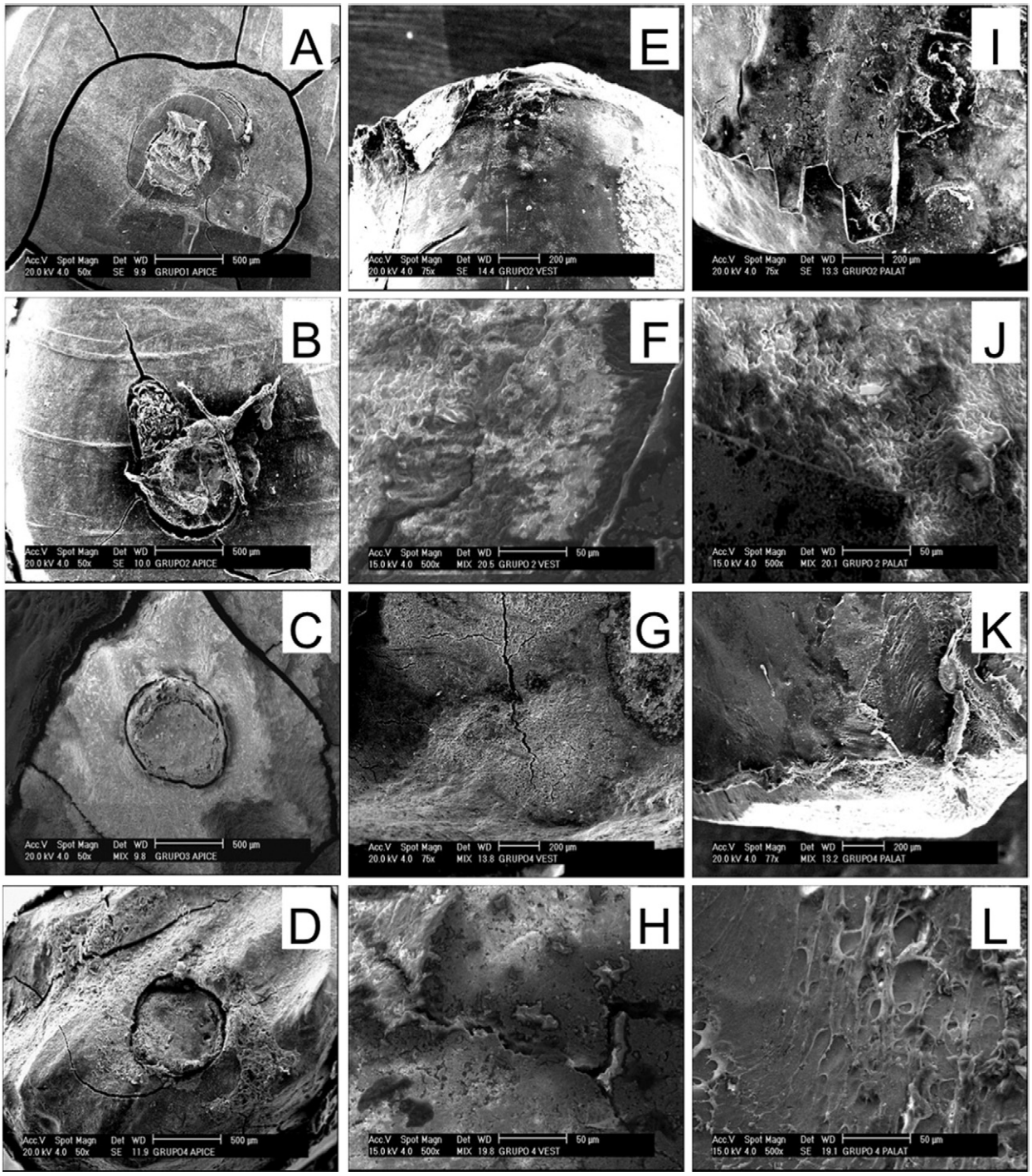

Fig. 1. Scanning electron micrographs. **A,** Zekrya bur, apical surface, ×50; **B,** Zekrya bur + direct Nd:YAG, apical surface, ×50; **C,** Er:YAG laser, apical surface, ×50; **D,** Er:YAG laser + direct Nd:YAG, apical surface, ×50; **E,** Zekrya bur + direct Nd:YAG, buccal surface, ×75; **F,** Zekrya bur + direct Nd:YAG, buccal surface, ×500; **G,** Er:YAG laser + direct Nd:YAG, buccal surface, ×75; **H,** Er:YAG laser + direct Nd:YAG, buccal surface, ×500; **I,** Zekrya bur + indirect Nd:YAG, palatal surface, ×75; **J,** Zekrya bur + indirect Nd:YAG, palatal surface, ×500; **K,** Er:YAG laser + indirect Nd:YAG, palatal surface, ×77; **L,** Er:YAG laser + indirect Nd:YAG, palatal surface, ×500.

in infiltration indices,[23] it was not able to promote adaptation of the filling material to the root canal walls.

Further studies should be carried out to investigate the effects of indirect Nd:YAG laser irradiation on the palatal surface of apicectomized roots, with the aim of

obtaining results similar to those associated with direct irradiation.

CONCLUSION

Apical cuts using Zekrya burs were associated with an irregular surface, with the presence of grooves on the resected dentine, and slight displacement and plasticization of gutta-percha, compressing it against the canal walls. Apicectomies carried out with the Er:YAG laser, on the other hand, provoked morphological changes on the dentine surface that were compatible with the ablated dentine. Also in this case, the gutta-percha presented a plasticized aspect, with the presence of bubbles; however, an irregular adaptation of the filling material to the root canal walls was observed. The use of Nd:YAG laser irradiation on apical surfaces caused a slight adaptation between the filling material and the dentine wall and changed the morphology of the root apex via fusion and resolidification. Direct Nd:YAG laser irradiation on the surfaces of the resected roots yielded areas of fusion and resolidification on the dentine and cementum, with a vitrified aspect. Indirect irradiation of the Nd:YAG laser with the aid of a sapphire mirror on the palatal surfaces of the resected roots, on the other hand, provoked fewer changes to the cementum, with irregular areas of fusion and resolidification.

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