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Effective Removal of the Smear Layer

The smear layer, a mixture of organic and inorganic materials that includes dentin particles, remnants of pulp tissue and microbial elements, results from the debris created by instrumentation of the root canal system. It can obstruct the penetration of irrigants and sealers into dental tubules; thus, removing the smear layer is a critical step for the success of endodontic treatment.

For many years, irrigation with sodium hypochlorite (NaOCl) followed by ethylenediaminetetraacetic acid (EDTA) has been the gold standard for removing the smear layer. Several irrigation activation techniques have been proposed to improve root canal cleaning, including passive ultrasonic irrigation (PUI), which employs an ultrasonic device that vibrates at high frequencies to enhance the penetration and agitation of the irrigants within the root canal, and laser-activated irrigation (LAI), which uses a laser to create shock waves that facilitate the removal of debris and disrupt biofilms.

Recently, 3 devices have been introduced that claim to enhance the chemical disinfection of the root canal system. According to its manufacturer, the EdgePRO laser employs laser, light and sound technologies. The PulpSucker uses continuous, automated, multicannular irrigation of the root canal to create negative irrigation pressures in the pulp chamber, which passively draws copious volumes of fresh irrigating solution out of the ends of the cannulae in a controlled manner. The iVac incorporates a high-performance medical-grade polymer tip with a piezoelectric ultrasonic handpiece that uses irrigant agitation and aspiration with apical negative pressure to improve debris removal from the root canal. Atav et al from Atlas University, Türkiye, used scanning electron microscopic (SEM) analysis to evaluate how well each procedure removed the smear layer from an instrumented root canal.

The researchers prepared and shaped the root canals of 90 freshly extracted mature premolars. They then randomly divided the teeth into 6 groups:

- control group
- conventional irrigation group
- LAI EdgePRO group
- PUI group

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- PulpSucker group
- iVac group

After final irrigation, the canals were dried with sterile paper points. Teeth were split to expose the root canals and observed using SEM to evaluate the level of smear layer in the coronal, middle and apical thirds. Each third was assigned a score ranging from 1 (no smear layer and dentinal tubules almost completely open) to 5 (total covering with a thick smear layer).

The iVac group scored the best in each third, with statistically significant superior performance in the apical third compared to each of the other irrigation groups. In the middle third, the iVac, LAI and PUI groups performed best, without a statistically significant difference among them, while there were no significant differences among iVac, LAI, PUI and PulpSucker in the coronal third. Conventional irrigation with NaOCl and EDTA performed significantly worse than all other methods in the coronal and middle thirds (Table 1). The conventional irrigation, PUI and PulpSucker groups performed worst in the apical third. The LAI group produced the same smear level removal in the apical and middle thirds, while the iVac group showed the same effectiveness in all thirds.

Conclusion

The results of an ex vivo study using SEM analysis in a laboratory setting cannot necessarily be replicated in a clinical setting. However, this type of study can be used to lay the groundwork for future in vivo clinical studies. It would not be unreasonable to conclude that the activation of irrigants during disinfection procedures creates an environment superior to that obtained by conventional irrigation.

Atav A, Zanza A, Gunes A, et al. Recent innovations in endodontic irrigation and effects on smear layer removal: an ex-vivo study. Clin Oral Investig *2025;29:309.*

Table 1. *Removal of the smear layer in each third of the root canal by group.*

Group	Apical third Mean score	Middle third Mean score	Coronal third Mean score
Control	5.00	4.40	4.40
Conventional irrigation	4.87	4.20	3.07
LAI EdgePRO	2.33	2.13	1.20
PUI	2.23	1.20	1.13
PulpSucker	3.27	2.33	1.27
iVac	1.13	1.13	1.07

Treatment of Maxillary Sinusitis of Endodontic Origin

Dental infections and sinonasal diseases are highly correlated, with as many as 40% of all maxillary sinusitis cases being classified as odontogenic sinusitis, also known as maxillary sinusitis of dental origin (MSDO). One of the most common etiologies of MSDO involves endodontic disease, classified as maxillary sinusitis of endodontic origin (MSEO). Unfortunately, since most patients with maxillary sinusitis are evaluated by otolaryngologists, endodontic sources are frequently overlooked. But preventing recurring MSEO requires the use of an effective treatment plan focused on eliminating necrotic pulp tissue, pathogenic microorganisms and their by-products, typically through endodontic treatment. The characteristics of the periapical lesion and the integrity of the root canal treatment are the most important factors affecting the recovery rate for MSEO.

Gürhan et al from Muğla Sıtkı Koçman University, Türkiye, used cone beam computed tomography (CBCT) images and the periapical and endodontic status scale (PESS) to evaluate the effect that the quality of root canal treatment and the characteristics of periapical lesions associated with maxillary molars have on maxillary sinus mucosal thickening. Patients included in the study had

- ≥1 maxillary molar with a periapical lesion
- local mucosal thickening >2 mm adjacent to the affected tooth
- sinonasal complaints for ≥4 weeks preceding referral

Assessment of periapical lesions and the quality of root canal treatment, along with the amount of sinus mucosal thickening, was performed using CBCT images, while evaluation of the coronal restoration was performed using CBCT images and a clinical examination. The PESS index, a combination of the complex periapical index (COPI) and the endodontically treated tooth index (ETTI), was used to evaluate periapical lesion characteristics and the integrity of root canal treatment.

Fourteen patients completed root canal treatment and attended the 12-month follow-up. Complete resolution of sinus mucosal thickening after 1 year was seen in only 3 patients; however, reduction in mucosal thickening was significant in all patients and for all measurements, including the mesial, distal and center regions. Lesion size was significantly reduced in all patients; mean size decreased from 4.6 mm to 2.2 mm. All COPI parameters showed a significant reduction after root canal treatment. Only 2 patients showed a CF0 score (no complication failures) on the ETTI; the remaining 12 patients received a CF5 score (root with radiolucency). Every patient had demonstrated ≥1 sinonasal symptoms before root canal treatment, most commonly facial pain or pressure accompanied by dental pain; all sinonasal complaints resolved after root canal treatment.

The fact that periapical radiolucency persisted in a majority of patients after 1 year should not necessarily be interpreted as a failure of treatment. A European Society of Endodontology consensus report stated that a 1-year follow-up using intraoral periapical radiographs was acceptable for evaluating the outcome of root canal treatment, but it recommended extending the follow-up period to 4 years if the lesion size continued to decrease in asymptomatic patients. Because CBCT is much more sensitive, its use may detect incomplete or uncertain healing that 2-dimensional radiographs might miss. Thus, a longer follow-up period should be employed to determine true treatment success or failure.

Conclusion

Treatment of patients with MSEO requires a multidisciplinary strategy involving shared decision making between the otolaryngologist and the endodontist. Primary dental treatment in patients with manageable sinonasal symptoms and treatable endodontic pathology is recommended.

Gürhan C, Şener E, Miçooğullan S, et al. The evaluation of resolution of maxillary sinus mucosal thickening of endodontic origin using periapical and endodontic status scale: a clinical CBCT study. J Endod *2025;51:1557-1565.*

The Role of Innervation in Apical Periodontitis

Nonsurgical endodontic therapy resolves apical periodontitis (AP) in approximately 70% to 90% of cases. Failure, however, typically results in cases of persistent AP that require further treatment.

Slightly less than half of persistent cases of AP are symptomatic. While no association appears to exist between symptomatic AP and the histopathological diagnosis of the lesion, there may be a relationship between AP and changes in innervation in the periapical tissues. Given the lack of studies that might shed light on this potential relationship, Obadah et al from the University of Texas Health Science Center at San Antonio attempted to quantify the innervation of periapical tissues obtained from surgical biopsies in cases of symptomatic and asymptomatic AP.

A total of 20 surgical biopsies from endodontic microsurgery procedures performed at a graduate endodontic clinic (10 cases of symptomatic AP, 10 cases of asymptomatic AP) were analyzed; the lesions came from 6 anterior teeth, 7 molars and 7 premolars. Protein samples from the biopsies underwent enzyme-linked immunosorbent assay to evaluate innervation based on the concentrations of β-tubulin 3 (βTUB3), a specific neuronal axon marker; Nav1.8, a specific nociceptor marker; and Nav1.9, a sodium channel that has been associated with pain-related conditions.

Based on the relative levels of βTUB3, the symptomatic lesions had an approximately 6-fold increase in innervation density, along with a significantly greater concentration of Nav1.8 and Nav1.9, when compared with asymptomatic lesions.

Conclusion

Innervation density may be influenced by many factors, including anatomical position, microbial load, tooth function and parafunction, infection duration, and host immune competency. This study looked at lesions obtained as a result of endodontic surgery, which cannot reflect the progression of AP. Nevertheless, the results of this analysis suggested that the progression of AP is accompanied by morphological and functional changes in the innervation of the apical area. The increase in innervation density could result in an enlarged receptor field. Moreover, the changes in protein expression may make the area more resistant to local anesthesia, which could make achieving sufficient analgesia challenging. Further well-designed studies to understand the role of innervation in AP, including its initiation, maintenance and resolution, are needed.

Obadah A, Fu J, Wong D, Diogenes A. Innervation changes in apical periodontitis and its correlation with preoperative symptoms. J Endod *2025;doi:10.1016/j.joen.2025.07.018.*

Successful Treatment of Cracked Teeth

Cracked teeth may lead to an incomplete fracture that disrupts the enamel and dentin. Over time, cracks may allow bacteria to enter the tooth, leading to irreversible pulpal changes, pulpal necrosis and periapical pathology requiring endodontic treatment. Based on 3 critical prognostic indicators—probing depth ≥5 mm, distal marginal ridge involvement and periapical diagnosis—the Iowa Staging Index classifies cracks from stage I (least severe) to stage IV (most severe). Wongkornchaowalit et al from Chulalongkorn University, Thailand, designed a retrospective study to evaluate success and survival rates of endodontically treated cracked posterior teeth and identify the factors associated with endodontic outcomes.

The study reviewed the records of 263 teeth in 253 adult patients who received root canal treatment on posterior teeth due to cracks. Teeth were excluded if the cracks extended >5 mm below the orifice, crossed more than one-third of the pulpal width or exhibited clear evidence of root fracture or a nonrestorable condition. In addition to evaluating the stage of the crack using the Modified Iowa Staging Index, the cracks were further characterized as either

- **coronal cracks** (C): cracks confined within the pulp chamber
- **radicular cracks** (R): cracks extending beyond the orifices into the root canal

After completion of root canal instrumentation, calcium hydroxide was used as intracanal medication, with final obturation performed from 1 to 3 weeks later. Patients were recalled annually. Success was defined strictly as the absence of clinical signs and symptoms, a probing depth increase of ≤1 mm from baseline and complete radiographic resolution of periapical lesions without crestal bone loss; failure was defined as the persistence of symptoms, a probing depth of >1 mm, an unresolved or worsening periapical lesion or increased crestal bone loss.

Mean follow-up was 40.3 months. Based on the strict outcome criteria, 218 teeth (82.9%) were classified as successes, with success rates varying by Iowa stage from 98.3% to 33.3%. Univariable Cox regression analysis showed that 16 prognostic factors were significantly associated with treatment outcomes; highly significant predictors included parafunctional habits, pulpal and periapical diagnoses, probing depth ≥5 mm along the crack line, preoperative periapical lesion, radicular extension ≥3 mm and Modified Iowa Staging Index classifications III and IV. The multivariable analysis found 7 factors—age, probing depths ≥5 mm along the crack line, radicular extension ≥3 mm, periapical lesion, multiple crack lines, absence of occlusal splint in patients with parafunctional habits and restoration with onlay or resin composite—independently associated with endodontic failure. A combination of probing depth ≥5 mm and R line produced the highest endodontic failure rate (Table 2).

Table 2. *Success and failure rates in endodontically treated cracked teeth based on periodontal pocket ≥5 mm (PD) and radicular crack line (R).*

	n	Success	Failure
No PD & no R	118	93.2%	6.8%
PD & no R	4	75.0%	25.0%
No PD & R	114	84.2%	15.8%
PD & R	27	33.3%	66.7%

Conclusion

The results of this study suggested that treating a tooth with a C or an R extension <3 mm without a periodontal pocket is likely to result in a successful outcome, especially when an intraorifice barrier with a flowable hybrid composite is used to enhance the fracture resistance of an endodontically treated tooth.

Wongkornchaowalit N, Soontornkiat T, Krongbaramee T, et al. Treatment outcomes and prognostic analysis of root canal-treated posterior cracked teeth: the modified Iowa index. J Endod *2025;doi:10.1016/j.joen.2025.08.012.*

In the next issue:

- Macrophage-pulp fibroblast interactions
- Cone-beam computed tomography study of periapical pathology
- Optimizing outcomes in endodontic microsurgery

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