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Regenerative Endodontic Procedures in Traumatized Necrotic Teeth

Traumatic injury to a tooth can lead not only to pulp necrosis but to external root resorption, which occurs due to damage of the precementum. External infective root resorption results from damage to the cementum and external root surface in conjunction with infected necrotic pulp; pulp necrosis in mature teeth results if the pulp is not extirpated within 1 to 2 weeks of the injury. While external infective root resorption can be reversed by endodontic intervention, treating external replacement root resorption is more problematic.

Lu et al from Fujian Medical University, China, reported the clinical response to treatment with regenerative endodontic procedures of 20 traumatized incisors diagnosed with external root resorption, in conjunction with pulp necrosis, apical periodontitis and/or abscess, in patients aged 6 to 16 years. Following American Association of Endodontics (AAE) guidelines, necrotic pulp tissue was extirpated from the affected teeth; the root canal was irrigated, dried and medicated with calcium hydroxide; and a temporary restoration was placed. Two weeks later, the temporary restoration was removed, the canal thoroughly flushed and apical bleeding induced, filling the canal up to the cementoenamel junction. Following the formation of a blood clot, the tooth was restored with glass ionomer cement and composite resin. Clinical and radiographic follow-up took place at 1, 6, 12, 24, 36, 48 and 60 months, at which time teeth were evaluated for signs of infection and assessed for external replacement root resorption. Failure was defined as

- the presence of clinical signs and symptoms after regenerative endodontic procedures
- persisting periapical lesions
- progressing resorption
- root fracture

Success was defined as

- cases without any of the indicia of failure and replacement resorption
- evidence of continued root development
- regaining of pulp vitality

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Survival was defined as the tooth's remaining present in the arch throughout the 5-year life of the study.

All 20 treated teeth, including 17 immature teeth and 3 mature teeth, were anterior teeth with necrotic dental pulp and a periapical lesion. Most teeth suffered from avulsion, with the extraoral period ranging from 0.5 to 5 hours. All teeth survived after an average follow-up period of 3 years. Fourteen teeth were classified as successes; only 1 was classified as a failure (due to a recurrence of inflammatory root resorption). Thirteen teeth showed calcified tissue forming in the root canal space; 7 immature teeth showed continued root development (Table 1). Radiographic root area was significantly better in both the nonavulsion group and the avulsion group with extraoral time <60 minutes.

Conclusion

This study found that restorative endodontic procedures provide for reliable treatment outcomes in traumatized permanent necrotic teeth with apical periodontitis. These results agree with a growing number of studies that show restorative endodontic procedures lead to favorable outcomes for these teeth.

Lu J, Lu Y, Lu Z, Kahler B. Clinical and radiographic outcomes of regenerative endodontic procedures for traumatized permanent necrotic teeth with apical periodontitis and external root resorption. Int Endod J *2023;56:802-818.*

Autoimmune Diseases and Apical Periodontitis

Although they share various clinical manifestations, autoimmune disorders all originate from a self-reactive immune response. Allihaibi et al from King's College London, United Kingdom, undertook a study to compare the prevalence of apical periodontitis in patients with autoimmune disorders.

The researchers analyzed 9 years of anonymized medical and dental records from a large dental clinic to find patients aged between 18 and 80 years with a confirmed diagnosis of rheumatoid arthritis, inflammatory bowel disease or psoriasis, regardless of whether their autoimmune disorder was being treated. The identified patients were divided into 3 groups:

- patients treated with conventional disease-modifying anti-rheumatic drugs
- patients treated with biologic disease-modifying anti-rheumatic drugs
- patients not treated with disease-modifying anti-rheumatic drugs

A similar number of age-matched healthy individuals served as the control group.

Medical histories, including underlying autoimmune disorders and medications, along with sociodemographic variables, were recorded for patients in both the treatment and control groups. Also recorded were the patients' dental status, including number of teeth, past endodontic treatment, and the presence of caries, restorations and apical periodontitis. Based on this information, each patient's diseased, missing and filled teeth (DMFT) index score was calculated. Two examiners determined the periapical status of the teeth based on full dental panoramic tomograms.

The mean DMFT score was significantly higher in patients with autoimmune diseases than in the control group, with, on average, >3 additional affected teeth. Patients with autoimmune diseases were nearly 4× as likely to have ≥1 tooth with a diagnosis of apical periodontitis. Additionally, the individual teeth of those patients were

Table 1. *Clinical and radiographic outcomes after 3-year follow-up of teeth treated with regenerative endodontic procedures* (n = 20).

Variable	Teeth
Treatment outcome	
Survival	20 (100%)
Success	14 (70%)
Failure	1 (5%)
Pulp sensibility test	
Cold test	9 (45%)
Electric test	10 (50%)
Postoperative radiographic outcome	
Absence of periapical lesion	20 (100%)
Intact periodontal ligament surrounding the root	14 (70%)
Replacement resorption	5 (25%)
Calcification formed in the root canal	13 (65%)
Continued root development in immature teeth[a]	7 (41%)

[a]*Immature teeth (n = 17).*

1.47× more likely to have developed apical periodontitis than were the teeth in the control group. No significant differences were found among the groups for sociodemographic variables (e.g., age, ethnic origin) or number of endodontically treated teeth. Patients with rheumatoid arthritis had the highest risk of apical periodontitis, while those with inflammatory bowel disease had the lowest. Untreated autoimmune disease patients and those taking biologic disease-modifying anti-rheumatic drugs had a higher probability of developing apical periodontitis than did those in the control group (Table 2).

Conclusion

The results of this study indicated that the presence of an altered immune system plays a role in the pathogenesis of apical periodontitis. Patients with autoimmune disorders should be monitored for the development of apical periodontitis, with a particular emphasis on DMFT scores.

Allihaibi M, Niazi SA, Farzadi S, et al. Prevalence of apical periodontitis in patients with autoimmune diseases: a case-control study. Int Endod J *2023;56:573-583.*

Table 2. *Prevalence of apical periodontitis by patient group, type of autoimmune disease and drug regimen.*

	Apical periodontitis	No apical periodontitis	*p* value
At patient level			
Control	66 (74.2%)	23 (25.8%)	
Autoimmune disease	89 (89.1%)	9 (10.3%)	.015
At tooth level			
Control	244 (10.5%)	2085 (89.5%)	
Autoimmune disease	369 (17.2%)	1776 (82.8%)	.005
By autoimmune disease			
Irritable bowel disease	12 (75.0%)	4 (25.0%)	
Rheumatoid arthritis	24 (100%)	0	
Psoriasis	35 (87.5%)	5 (12.5%)	
≥1 autoimmune disease	9 (100%)	0	.047
By drug regimen			
None	61 (89.7%)	7 (10.3%)	
Biologic disease-modifying anti-rheumatic drugs	10 (100%)	0	
Conventional disease-modifying anti-rheumatic drugs	7 (77.8%)	2 (22.2%)	.034

All p values significant at p < .05.

Persistent Apical Periodontitis and Other Inflammatory Disorders

Although endodontic treatment of teeth with preoperative apical periodontitis (AP) performed in academic settings and at specialist practices has a success rate of 75% to 85%, a failure to adequately eliminate the infection may lead to persistent AP, a chronic inflammatory disease. Agger et al from the University of Oslo, Norway, conducted a study to identify disease-related markers in persistent AP and to learn whether these markers were associated with rheumatoid arthritis and cardiovascular disease.

The authors looked at 20 patients, each being treated for 1 tooth with persistent AP, who had not previously responded to conventional endodontic treatment. All patients had a root-filled tooth with periapical radiolucencies ≥5 mm in diameter. Half the patients had no underlying comorbidities; of the remainder, 3 suffered from cardiovascular disease, 3 from rheumatoid arthritis, 2 from diabetes, 1 from psychological disorders and 1 from both cardiovascular disease and psychological disorders. In each patient, a full-thickness flap was reflected and the lesion enucleated before apicectomy. Crestal and trabecular bone tissue collected from healthy patients during surgical removal of healthy third molars served as a control. Proteins were extracted from all samples and analyzed for 25 different cytokines.

Total protein concentration was significantly elevated in persistent AP samples compared to healthy bone, with total protein content significantly different as well, although there was no difference in total protein concentration based on lesion size or in patients without underlying disease compared with patients with rheumatoid arthritis or cardiovascular disease. Levels of 6 cytokines were significantly higher in persistent AP lesions than in healthy bone, while levels of 7 cytokines were significantly lower. Levels in patients with rheumatoid arthritis were significantly different for 5 cytokines from levels in persistent AP

patients with no underlying comorbidities, but only 1 was significantly different for these patients when compared to the controls.

Persistent AP lesions in patients with cardiovascular disease showed no difference in cytokine expression compared with patients without comorbidities. Neither symptoms, lesion size, tooth type, age nor gender were associated with any difference in cytokine expression.

Conclusion

The results of this study were based on a small sample. Patients with persistent AP and rheumatoid arthritis were found to have elevated levels of cytokine markers compared to persistent AP patients without comorbidities, suggesting a possible relationship between persistent AP and rheumatoid arthritis.

Agger AE, Reseland JE, Hjelkrem E, et al. Are comorbidities associated with the cytokine/chemokine profile of persistent apical periodontitis? Clin Oral Investig *2023;doi:10.1007/s00784-023-05139-3.*

Citric Acid Use In Endodontic Treatment

To further our knowledge of the effectiveness of chelating agents, Gómez-Delgado et al from Universitat de Barcelona, Spain, undertook a systematic review of the published literature on the use of citric acid in endodontic treatment.

The authors conducted an electronic search for all articles published between 2010 and 2022 involving randomized controlled trials, in vitro studies of extracted teeth and in vitro studies of human dentin disks that reported on the use of citric acid as an irrigant in endodontic therapy. Their primary outcome measure was smear layer removal.

Forty-four published studies met the inclusion criteria. In the studies that evaluated smear layer removal, citric acid showed results similar or better compared with ethylenediaminetetraacetic acid (EDTA). Studies that compared citric acid with 5.25% sodium hypochlorite (NaOCl) and saline found that citric acid improved smear layer removal. Three of the 4 studies that focused on growth factor release reported higher levels after the use of 10% citric acid than after EDTA; the other study showed no difference except for significantly higher insulin-like growth factor (IGF) levels with EDTA. Sealer push-out bond strength varied among different brands of sealers, with much higher penetration into dentinal tubules in the coronal and middle thirds of the tooth than in the apical third. Few significant differences were seen between citric acid and EDTA regardless of the sealer used, but the type of sealer did have a significant effect on the push-out bond strength. Compared with irradiation with laser pretreatment, citric acid irrigation achieved superior averages for bond strength.

Results for the removal of calcium hydroxide ($Ca[OH]_2$) varied. One study found that all tested irrigants removed $Ca(OH)_2$ mixed with propylene glycol, but citric acid was superior to EDTA for removing $Ca(OH)_2$ mixed with iodoform and silicone oil, while another study found citric acid superior in removing $Ca(OH)_2$ mixed with chlorhexidine gel. However, a different study found no difference in $Ca(OH)_2$ removal between citric acid and EDTA. Citric acid decreased dentin microhardness and demonstrated higher peritubular and intertubular dentin erosion scores, but also had lower postobturation apical leakage values. All chelating agents reduced the numbers of viable microorganisms (in particular, *Enterococcus faecalis*) compared with irrigation employing NaOCl alone.

Conclusion

Although EDTA is often considered the gold standard in endodontics, citric acid shows comparable antibacterial activity and lower toxicity. It also is more beneficial than EDTA in regenerative endodontic procedures. Because citric acid can also decrease dentin microhardness and cause decalcification and erosion, especially when used before NaOCl, the decision to use citric acid or EDTA needs to be evaluated on a patient-by-patient basis.

Gómez-Delgado M, Camps-Font O, Luz L, et al. Update on citric acid use in endodontic treatment: a systematic review. Odontology *2023;111:1-19.*

In the next issue:

- Laser-activated irrigation and its effect on microbial biofilms
- Use of proteins in chronic apical periodontitis

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