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update on endodontics

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Prevalence of Periapical Disease

Untreated caries, trauma and failed endodontic treatment can result in periapical pathology from pulpal necrosis and infection. The replacement of 2-dimensional radiographs with cone beam computed tomography (CBCT) has led to a significant increase in the accurate diagnosis and characterization of periapical pathology, enabling the detection of previously undetected periapical lesions, which may remain asymptomatic and, therefore, undiagnosed. Because most existing data come from small studies restricted to one geographic area with heterogeneous methodologies and inconsistent diagnostic criteria, large-scale CBCT-based epidemiologic analyses are rare.

To address this lack of knowledge, the Global Periapical Health Study (GPHS), covering 54 countries (3 in Africa, 13 in the Americas, 21 in Asia, 15 in Europe and 2 in Oceania), was established to evaluate the periapical status of teeth under different conditions, using a standardized diagnostic protocol, unified training manuals and centralized coordination. One examiner from each country analyzed preexisting CBCT scans until 3500 roots had been assessed. Third molars, primary teeth and teeth

with severe resorption were excluded. Mesiobuccal, distobuccal, palatal and any additional roots in maxillary molars were scored for periapical status using the CBCT periapical index, as were mesial, distal and additional roots in mandibular molars; fused roots and evidence of root canal treatment were recorded, as were demographic variables.

Martins from the Universidade de Lisboa, Portugal, and Versiani from the Dental Specialty Center, Brazil, recently published the first study results using data from the GPHS. Evidence from 189,000 roots in 138,536 teeth (47% anterior, 28% premolars, 25% molars) from 6688 patients showed an overall prevalence of periapical pathology of 58.6% at the patient level and of 7.3% at the tooth level. A higher prevalence was found in maxillary teeth (9.3% vs

5.3% in mandibular teeth). Mandibular canines had the lowest prevalence, followed by mandibular lateral incisors, mandibular central incisors and maxillary canines; maxillary first molars had the highest, followed by mandibular first molars, maxillary second molars and maxillary second premolars (Table 1). Apical periodontitis appeared in 16.3% of the mesiobuccal roots of

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maxillary molars, the highest percentage for any molar root.

Men had 1.22× higher odds of periapical pathology than did women. Prevalence increased progressively with age, topping out at 10.5% in people ≥61 years old. Roots that had undergone previous root canal treatment showed a significantly higher prevalence of periapical radiolucencies than did untreated teeth (44.3% vs 2.6%); logistic regression found 22× higher odds of periapical pathology in endodontically treated teeth. The prevalence of periapical pathology in the United States was above the worldwide average at both the patient level (70.8%) and the tooth level (9.3%).

Conclusion

Periapical pathology is highly prevalent throughout the world, most frequently in maxillary teeth and endodontically treated teeth. This information can set guidelines for future research to further understanding of posttreatment outcomes and ways to reduce periapical disease.

Martins JNR, GPHS Research Group (including all authors participating in the GPHS Research Group), Versiani MA. The Global Periapical Health Study: a big data CBCT analysis of periapical pathology across 54 countries. *J Endod* 2026;52:740-760.

The Role of Macrophages

Fibroblast cells in the pulp control pulp inflammation and regeneration, synthesizing and releasing multiple active molecules that enhance neoangiogenesis and dental pulp stem cell proliferation. Among these cells are macrophages, which have multiple functions:

- phagocytosis of pathogens, cell debris and dead cells
- antigen presentation
- production of proinflammatory cytokines

When stimulated, macrophages differentiate into 2 different types:

- **proinflammatory M1 macrophages**, which specialize in pathogen elimination and immune cell recruitment
- **anti-inflammatory M2 macrophages**, which specialize in debris clearance and decreased immune cell response

When inflammation is severe enough, macrophages differentiate into the M1 phenotype that, when extended, may damage the tissue. M2 macrophages suppress inflammation and contribute to tissue repair, remodeling and vascu-

logenesis. No studies have evaluated the precise roles of M1 and M2 macrophages in the pulp healing process.

To fill this gap, Le Fournis et al from Aix-Marseille Université, France, created an in vitro study to evaluate the effect of fibroblast-induced macrophage differentiation on the initial steps of pulp regeneration. After culturing primary human pulp cells from immature third molars and sorting dental pulp stem cells and pulp fibroblasts, the researchers mimicked the physical injury and presence of bacteria and toxins found in carious lesions by incubating some of the fibroblasts with lipoteichoic acid (LTA) and then physically injuring them (LTA/injury group); another group of fibroblasts were injured but not exposed to LTA (injury group). Undifferentiated macrophages were incubated with one set of fibroblasts, then cultured with dental pulp stem cells and human umbilical vein endothelial cells; macrophages' vascular endothelial growth factor (VEGF) secretion was quantified.

Dental pulp stem cells significantly increased with M2 macrophages and the injury group; viability was not affected by M1 macrophages and the LTA/injury group, similar to that seen in dental pulp stem cell migration toward macrophages, which was reduced in M2 macrophages and the injury group. VEGF secretion increased in all groups and was significantly greater in the M2 macrophages and the injury group compared with the M1 macrophages, with the M2 macrophages secreting >2× the level of VEGF secretion found in the injury group. Neoangiogenic properties significantly increased with the M2, the injury and the LTA/injury macrophages.

Table 1. Presence of periapical pathology.

	Maxillary teeth	Mandibular teeth
Central incisor	7.3%	3.4%
Lateral incisor	6.5%	2.5%
Canine	4.1%	2.0%
First premolar	9.7%	3.3%
Second premolar	10.1%	5.3%
First molar	18.6%	14.6%
Second molar	11.0%	9.4%
Overall	9.3%	5.3%

Conclusion

These results indicate that macrophages play an important role in pulp regeneration—M1 macrophages via their proinflammatory effects, and M2 macrophages by enhancing dental pulp stem cell proliferation and neo-angiogenesis, 2 major steps in pulp regeneration. This information may aid in discovering targeted therapeutic strategies to treat pulp injuries.

Le Fournis C, Girard T, Roumani S, et al. Macrophage-pulp fibroblast interactions modulate initial dental pulp regeneration in vitro. Int Endod J 2026;59:852-862.

Internal Resorption Within Root Canals

Internal resorption, a pathologic process characterized by the progressive destruction of the tooth structure from within the root canal system, can, if left untreated, lead to tooth loss. In addition to being either transient or progressive, internal resorption takes 2 forms:

- **internal replacement resorption**, characterized by the irregular replacement of hard tissue with bone- and cementum-like tissue
- **internal inflammatory resorption**, characterized by a uniform replacement pattern of hard tissue with periodontal-like connective tissue

Internal resorption lesions may remain asymptomatic or progress unnoticed until large enough to be radiographically apparent, often as an incidental finding during an examination. Cone beam computed tomography (CBCT) has significantly greater ability to detect internal resorptive defects at an early stage. Once internal resorp-

Table 2. Survival and success at follow-up.

	Survival	Success
1-year outcome	23/26	20/24
5-year outcome	11/14	8/12
7-year outcome	8/11	7/10

tion has been diagnosed, management involves endodontic treatment.

Because the prevalence of internal resorption is low, few studies with adequate sample sizes or long-term follow-ups exist. DeLuca et al from Tufts University, Massachusetts, conducted an observational study to identify factors associated with outcomes of teeth diagnosed with internal resorption and describe characteristics of these lesions as seen on CBCT scans.

The authors identified 50 teeth from 50 patients diagnosed with internal resorption who were treated at a postgraduate endodontic clinic between 2010 and 2025 and followed for up to 7 years. They recorded lesion location (coronal, middle, apical third), height and width, overall size (small, <2 mm; medium, 2 to 3 mm; large, >3 mm), presence and size of perforation, root location of internal resorption in molars, and presence or absence of periapical radiolucency. Treated teeth were labeled “successes” if they were present and functional, displayed normal responses to percussion and palpation testing, remained asymptomatic, did not require further treatment, lacked any sign of infection and showed clear resolution or absence of radiographic evidence of pathosis. Treated teeth were labeled “failures” if they were extracted, became symptomatic or showed clinical or radiological signs of pathosis. Teeth labeled “survived” were still present and functional in the mouth.

Of the 50 teeth in the study, 49 were diagnosed with inflammatory resorption, with the remaining tooth diagnosed with replacement resorption. First molars and maxillary central incisors were most frequently affected. Of the 26 teeth followed for ≥1 year, 23 survived, 22 received endodontic treatment and 3 failed, extracted due to poor prognosis based on lesion size. At 1 year, 20 of 24 teeth were adjudged successes; 15 of the teeth had undergone nonsurgical root canal treatment, 4 nonsurgical retreatment and 1 nonsurgical root canal treatment with apicoectomy. Similar results were seen at 5- and 7-year follow-ups (Table 2). Teeth with a diagnosis of normal pulp or normal apical tissues, along with teeth of female patients, were significantly more likely to fail. Lesion widths in the apical third were significantly smaller than those in the middle or coronal third.

Conclusion

Although this study analyzed the largest dataset in the literature, the sample size was still small, which may have skewed some of the results. Nevertheless, the study’s information can help guide the practitioner when treating patients with this unusual condition.

DeLuca S, Amato R, Finkelman M, et al. Internal resorption: a retrospective cone-beam computed tomography analysis of 50 cases with outcome assessment. Int Endod J 2026; 59:794-805.

Evidence for Endodontic Microsurgery

While nonsurgical root canal treatment remains the standard of care for apical periodontitis, failures do occur, typically because of missed canals or persistent infection. Nonsurgical retreatment resolves 80% to 90% of cases. When nonsurgical retreatment is not feasible or fails to achieve a resolution, endodontic microsurgery is a predictable and effective surgical technique that preserves the natural dentition, offering unique biological and long-term functional benefits unavailable with dental implants.

Kim and Kim of Yonsei University, Korea, recently reviewed current evidence on endodontic microsurgery, including the effect of lesion type on clinical outcomes, the efficacy of adjunctive regenerative procedures and the latest technological advancements.

The lesions most commonly encountered in endodontic microsurgery can be split into 2 types:

- **isolated endodontic lesions**, characterized by the absence of periodontal involvement
- **combined endodontic-periodontal lesions**, characterized by periodontal pocket formation, endodontic-periodontal communications or loss of the buccal plate

Isolated endodontic lesions on anterior teeth respond positively to endodontic microsurgery, with successful outcomes typically around 90% and stable healing over time. Long-term follow-up studies report 10-year survival rates of >80%. Molar teeth, how-

ever, show a consistently lower rate of success; the presence of an isthmus is a significant negative prognostic factor for long-term success. Given the presence of isthmuses in the mesial roots of mandibular molars, any such isthmuses must be included in the retrograde cavity preparation without excessively thinning the surrounding dentin, which can compromise the structural integrity of the tooth.

Combined endodontic-periodontic lesions are more likely to undergo delayed or incomplete healing and are more susceptible to long-term failure, especially in the absence of a buccal bone plate >3 mm. In addition to resolution of the periapical infection, healing requires the regeneration of supporting periodontal structures. Smokers have a higher failure rate at 10 years; other systemic conditions can negatively affect endodontic and periodontal outcomes. Since most endodontic microsurgery studies exclude systemically unhealthy patients, more work is needed to determine the effect of systemic conditions on endodontic and periodontal healing.

Evidence for the effectiveness of adjunctive regenerative procedures to enhance bone fill and facilitate periapical healing remains inconclusive, as studies have had small sample sizes, nonrandomized study designs, unequal group allocations and a lack of differentiation among lesion types. Given the high baseline success rate of endodontic microsurgery in treating isolated endodontic lesions, few studies of adjunctive regenerative procedures have been undertaken. Results using adjunctive regenerative procedures in the treatment of endodontic-periodontic lesions and through-and-through lesions have been inconsistent; a current study of the

long-term impact of adjunctive regenerative procedures on endodontic-periodontic lesions may provide evidence-based indications for their clinical use in endodontic microsurgery.

Guided surgical systems, ranging from static and dynamic navigation to new robotic platforms, can address anatomical complexity, case difficulty and operator variability, contributing to improved precision and reduced operating time. Excellent results have been reported for these technologies along with endodontic microsurgery for isolated endodontic lesions, but data on long-term treatment outcomes are not yet available.

Conclusion

Endodontic microsurgery requires a clear understanding of lesion-specific prognostic factors and evidence-based strategies. As technology progresses, use of endodontic microsurgery continues to expand, leading to improved outcomes and more widespread preservation of the natural dentition.

Kim U, Kim E. Optimising outcomes in endodontic microsurgery: evidence, uncertainties and future directions. *Int Endod J* 2026;59:746-761.

In the next issue:

- Conservative management of a partially impacted mandibular second molar
- 10-year cohort comparing tooth preservation with implant replacement

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