(International Print/Online Journal)

SJIF IMPACT FACTOR: 6.829
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 9, Issue 4, Page No: 451-461
July-August 2026

IJMSCR

Endodontic Microsurgical Management of a Radiographically Diagnosed Periapical Cyst Following Root Canal Treatment of a Calcified Maxillary Central Incisor and Peg-Shaped Maxillary Lateral Incisor: A Case Report

Anju Balachandran,Shabna Moyin,Namitha Divakar,Drishya Kishore,Minusha Mohanan
[1,5]Post Graduate,[2]Head of the Department,[3]Reader,[4]Senior Lecturer
Department of Conservative Dentistry and Endodontics, Sree Anjaneya Institute of Dental Sciences

***Corresponding Author:**
Anju Balachandran
Post Graduate, Department of Conservative Dentistry and Endodontics, Sree Anjaneya Institute of Dental Sciences

Type of Publication: Case Report
Conflicts of Interest: Nil

Abstract

Background:

Complex periapical lesions associated with calcified root canal anatomy and developmental dental anomalies may present considerable diagnostic and therapeutic challenges. Cone-beam computed tomography (CBCT) provides three-dimensional information regarding lesion extent, cortical bone involvement, root morphology, root resorption, and root canal anatomy, thereby facilitating accurate treatment planning. Endodontic microsurgery provides a conservative approach for management of persistent periapical pathology when nonsurgical treatment alone may be inadequate.

Case Report:

A 36-year-old male patient reported with pain in the maxillary anterior region. Clinical examination revealed nonvital maxillary left central and lateral incisors (21 and 22). The lateral incisor exhibited a malformed peg-shaped crown. Preoperative radiographic examination demonstrated a large periapical radiolucency involving 21 and 22. CBCT revealed an extensive periapical lesion measuring approximately 14.1 mm mesiodistally, 10.7 mm buccolingually, and 10.8 mm superioinferiorly, with loss of the buccal and palatal cortical plates at the apical region of 21 and 22. Tooth 21 demonstrated complete calcification of the pulp chamber and coronal root canal, with a patent canal confined to the apical one-third and evidence of external root resorption at the palatal aspect of the root apex. Tooth 22 demonstrated a peg-shaped malformed crown, a lingual enamel defect, a V-shaped cervical defect, and a patent root canal without gross calcific foci. Following nonsurgical root canal treatment of 21 and 22, endodontic microsurgery was performed. A full-thickness mucoperiosteal flap was elevated, the periapical pathological tissue was enucleated, and apical management was performed under magnification. Root-end preparation was followed by retrograde filling with mineral trioxide aggregate (MTA). The flap was repositioned and sutured to achieve primary closure.

Conclusion:

This case demonstrates the value of CBCT-guided treatment planning and magnification-assisted endodontic microsurgery in the management of extensive periapical pathology associated with calcified canal anatomy, developmental tooth anomaly, cortical plate loss, and external root resorption. Careful lesion removal, apical management, and MTA root-end filling provided a conservative approach aimed at preservation of the involved teeth and restoration of the periapical tissues.

Keywords: CBCT; Endodontic microsurgery; Periapical cyst; Calcified root canal; Peg-shaped lateral incisor; External root resorption; MTA; Root-end filling

Introduction

Periapical lesions of endodontic origin are frequently encountered pathological conditions resulting from microbial infection of the root canal system and subsequent inflammatory responses in the periapical tissues. Although nonsurgical root canal treatment remains the primary treatment modality for apical periodontitis, persistent or extensive periapical lesions may require surgical intervention when resolution does not occur following orthograde treatment or when anatomical limitations compromise predictable nonsurgical management [1,2].

Periapical cysts represent an important category of inflammatory odontogenic lesions and are commonly associated with long-standing pulpal infection and apical periodontitis. However, definitive differentiation between a periapical granuloma and a radicular cyst cannot reliably be made solely on the basis of conventional radiographic findings. Histopathological examination remains necessary when a definitive cyst diagnosis is required [3,4].

The presence of extensive calcification within the root canal system can significantly complicate endodontic treatment. Calcification may result in narrowing or complete obliteration of the pulp chamber and coronal root canal, making canal location and negotiation difficult. Such anatomical conditions increase the risk of procedural errors and may compromise adequate chemomechanical preparation [5].

Developmental anomalies can provide an additional treatment challenge. Peg-shaped maxillary lateral incisors demonstrate altered crown morphology and may be associated with enamel defects and variations in root morphology. Appropriate assessment of the tooth and surrounding structures is therefore essential before treatment [6].

Cone-beam computed tomography has become an important adjunct in the diagnosis and management of complex endodontic cases. Its three-dimensional capability allows detailed evaluation of lesion dimensions, cortical plate involvement, root morphology, root resorption, and canal anatomy. In the present case, CBCT demonstrated an extensive periapical lesion involving 21 and 22, associated loss of the buccal and palatal cortical plates, severe calcification of the coronal canal anatomy of 21, and external root resorption at the apical region of 21 [7-9].

Endodontic microsurgery permits direct visualization and management of the root apex and periapical tissues. Modern microsurgical principles, including magnification, conservative flap design, precise osteotomy, lesion enucleation, root-end preparation, and placement of a biocompatible root-end filling material, have improved the predictability of surgical endodontic treatment [10-12].

The present case report describes the endodontic microsurgical management of a large periapical lesion radiographically diagnosed as an infected periapical cyst involving the maxillary left central incisor (21) and peg-shaped maxillary left lateral incisor (22), with extensive calcification of 21 and external root resorption at its apical region**.**

2. Case Presentation

A **36-year-old male patient** reported to the Department of Conservative Dentistry and Endodontics with a chief complaint of pain in the maxillary anterior region. The patient's medical history was non-contributory.

Clinical examination revealed nonvital maxillary left central incisor (21) and lateral incisor (22). The maxillary lateral incisor demonstrated a distinctly **peg-shaped and malformed crown**. The clinical findings were correlated with periapical radiography and subsequently with CBCT imaging.

The initial periapical radiograph demonstrated a large, well-defined periapical radiolucency involving the apical regions of 21 and 22. The radiographic appearance suggested an extensive chronic periapical pathological process.

A panoramic radiograph was also available as an overview of the maxillary and mandibular dentition. It demonstrated the endodontically treated maxillary anterior teeth and the associated periapical pathology in the region of 21 and 22.

3. Preoperative Radiographic Examination

The preoperative intraoral periapical radiograph demonstrated a large radiolucent lesion associated with the apical regions of 21 and 22, extending across the periapical region of the adjacent teeth.

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

The radiographic appearance was characterized by a relatively well-defined radiolucent lesion involving the apical region of both teeth. The lesion was considerably larger than would be expected from a localized apical lesion, warranting further three-dimensional assessment.

The peg-shaped morphology of 22 was also clinically evident and represented an important developmental anatomical feature.

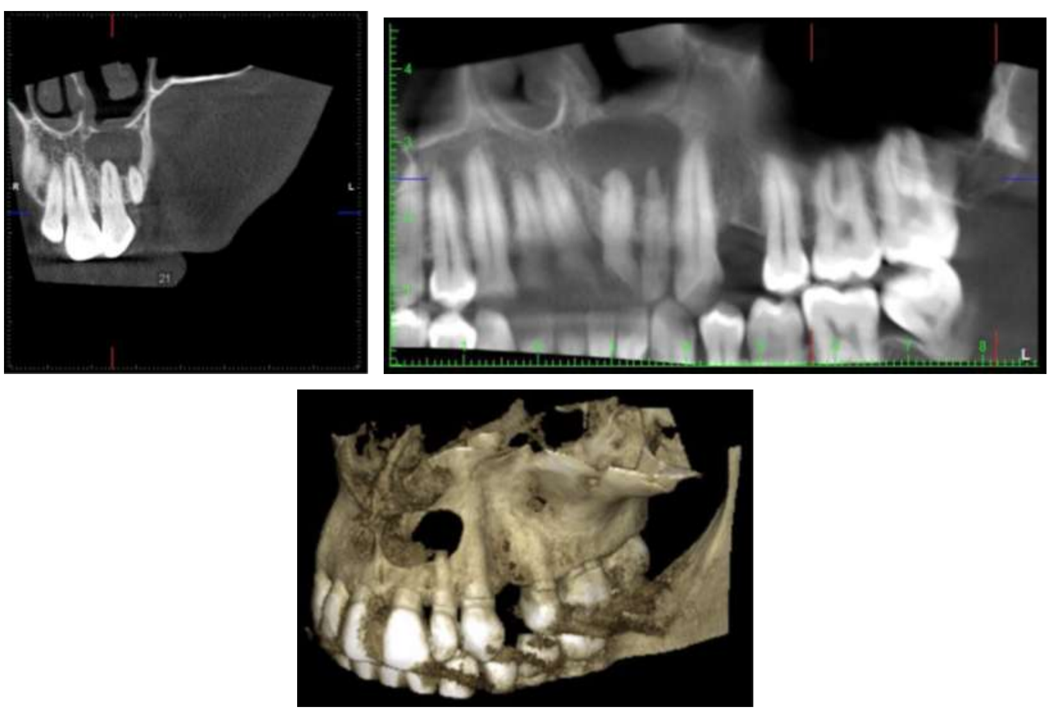
Because of the extensive lesion and the suspected calcification of the root canal system of 21, CBCT was subsequently performed for detailed assessment.

Figure 1. Preoperative intraoral periapical radiograph demonstrating a large, well-defined periapical radiolucency involving the apical regions of maxillary left central incisor (21) and lateral incisor (22).

4. CBCT Examination

CBCT IMAGING

Figure2. CBCT imaging demonstrating the maxillary and mandibular dentition and the endodontically treated maxillary anterior teeth with associated periapical pathology.



© 2026 IJMSCR. All Rights Reserved

CBCT imaging was performed for evaluation of teeth 21, 22, and 23. The scan was obtained for assessment of pathology in the maxillary anterior region.

Serial axial, coronal, and sagittal sections demonstrated a large periapical lesion associated with 21 and 22. The lesion extended through the periapical region and was associated with loss of the surrounding cortical bone.

The lesion measurements were:

- **Mesiodistal diameter:** 14.1 mm
- **Buccolingual width:** 10.7 mm
- **Superioinferior depth:** 10.8 mm

The buccolingual measurement was approximate because both buccal and palatal cortical plates were lost at the root-apex region. The lesion exhibited a partially well-defined regular border with hazy internal content. Loss of the **buccal and palatal cortical plates** was evident in relation to the apical region of 21 and 22.

4.1 CBCT findings in relation to 21

The CBCT examination demonstrated that tooth 21 measured approximately **20.7 mm in length**.

The pulp chamber and coronal portion of the root canal were completely calcified. A patent root canal could be identified only in the apical one-third. This finding explained the significant difficulty anticipated during nonsurgical endodontic treatment.

A large periapical radiolucent lesion was associated with the apex of 21. In addition, evidence of **external root resorption was present at the palatal aspect of the root apex**.

4.2 CBCT findings in relation to 22

Tooth 22 measured approximately **17.7 mm in length**.

The tooth exhibited a malformed peg-shaped crown. A radiolucent defect was evident on the lingual aspect of the enamel. A V-shaped defect was also noted at the labial cervical region, and the tooth was positioned close to the labial cortical plate.

The root canal was clearly identifiable and did not demonstrate gross calcific foci.

4.3 Evaluation of 23

Tooth 23 measured approximately 24.8 mm. A V-shaped defect was noted at the labial cervical region of the crown; however, no gross bony changes were observed at the periapical region.

The CBCT radiographic diagnosis was reported as an **infected periapical cyst involving 21 and 22, calcified pulp chamber and coronal root canal of 21, malformed crown of 22, and cervical abrasion involving 22 and 23**. Clinical correlation was recommended for establishment of the final diagnosis.

5. Diagnosis

Based on the clinical findings, pulp sensibility testing, conventional radiography, and CBCT findings, a diagnosis of **pulpal necrosis with an extensive periapical lesion involving 21 and 22** was established.

Radiographically, the lesion was suggestive of an **infected periapical cyst**. However, because no histopathological findings are provided, the cystic nature of the lesion should be regarded as a **radiographic diagnosis** rather than a histopathologically confirmed diagnosis.

The additional anatomical diagnoses included:

1. Extensive calcification of the pulp chamber and coronal root canal of 21.
2. Patent canal limited to the apical one-third of 21.
3. External root resorption at the palatal aspect of the root apex of 21.
4. Peg-shaped malformed crown of 22.
5. Lingual enamel defect of 22.
6. Cervical V-shaped defect involving 22 and 23.

6. Treatment Planning

Considering the clinical and radiographic findings, treatment was planned with the objectives of eliminating the intracanal infection, preserving the involved teeth, and managing the extensive periapical pathology.

Because tooth 21 exhibited extensive calcification of the pulp chamber and coronal root canal, particular attention was directed toward canal location and negotiation. The CBCT findings demonstrated that only the apical one-third of the canal remained patent.

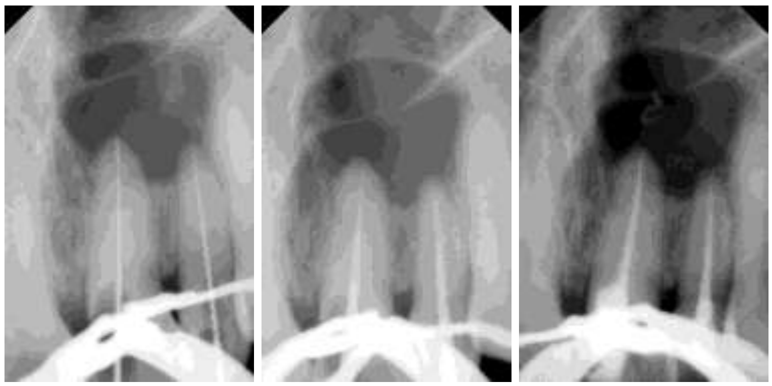
Tooth 22 exhibited a patent root canal without gross calcific foci and was therefore amenable to conventional nonsurgical root canal treatment.

© 2026 IJMSCR. All Rights Reserved

Nonsurgical root canal treatment was performed for 21 and 22. Following completion of orthograde treatment, the extensive periapical lesion and associated cortical plate destruction were considered indications for surgical intervention. Endodontic microsurgery was therefore planned to directly access and remove the pathological tissue and to manage the apical portions of the involved roots.

7. Nonsurgical Root Canal Treatment

Figure 3. Post-endodontic intraoral periapical radiograph demonstrating completed root canal treatment of 21 and 22 with persistent extensive periapical radiolucency.



Endodontic Treatment

Following administration of adequate local anesthesia, rubber dam isolation was established, and endodontic treatment was initiated under strict aseptic conditions.

Tooth21:

The calcified pulp chamber and coronal portion of the root canal presented considerable difficulty during canal negotiation. The access cavity was prepared, and careful exploration of the calcified canal was performed using a DG-16 endodontic explorer. Initial negotiation was attempted with a #10 K-file, supplemented by a D-Finder file to negotiate the calcified portion of the canal. The canal was carefully explored until apical patency was established with a #10 K-file, as far as anatomically feasible.

Cleaning and shaping were performed following standardized endodontic principles with copious irrigation throughout the procedure. 3% sodium hypochlorite (NaOCl) was used as the primary irrigating solution. Following completion of biomechanical preparation, 17% ethylenediaminetetraacetic acid (EDTA) was used for smear-layer removal. A final rinse with normal saline (0.9% sodium chloride) was performed, and the canal was dried with sterile paper points.

The prepared canal was obturated using gutta-percha cones in combination with Endoseal zinc oxide–eugenol-based root canal sealer (Prevest DenPro, India), according to the manufacturer's instructions. (Prevest Denpro)

Tooth 22:

The root canal of tooth 22 was identified and negotiated under rubber dam isolation. Canal patency was established with a #10 K-file, followed by cleaning and shaping according to standardized endodontic principles. Copious irrigation was performed throughout the procedure using 3% sodium hypochlorite (NaOCl). After completion of instrumentation, 17% EDTA was used for smear-layer removal, followed by a final rinse with 0.9% normal saline. The canal was dried with sterile paper points and obturated with gutta-percha and Endoseal zinc oxide–eugenol-based sealer.

All endodontic procedures were performed under rubber dam isolation to maintain aseptic conditions. A postoperative intraoral periapical radiograph was obtained to confirm the quality and extent of root canal obturation in teeth 21 and 22. The radiograph demonstrated adequately obturated root canals with a

© 2026 IJMSCR. All Rights Reserved

persistent, extensive periapical radiolucency involving the apical regions of both teeth.

8.Endodontic Microsurgical Procedure

FIGURE 4:Clinical photograph demonstrating surgical access and flap elevation during endodontic microsurgery.

FIGURE 5:Flap elevation

FIGURE6: Cyst enucleation

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

FIGURE 7 : Placement of MTA as the retrograde root-end filling material

Figure 8. Intraoperative clinical photograph showing elevation of the full-thickness mucoperiosteal flap and surgical exposure of the maxillary anterior periapical region.

FIGURE 9:Repositioned mucoperiosteal flap and sutured surgical site following completion of endodontic microsurgery

Following administration of local anesthesia, endodontic microsurgery was performed under operative magnification. A full-thickness mucoperiosteal flap was reflected to expose the periapical region. The periapical lesion was identified and carefully enucleated and curetted. The apical portions of teeth 21 and 22 were exposed and resected under magnification, with particular attention to the external root resorption noted at the palatal aspect of the apex of 21 on CBCT. The resected root ends were inspected and prepared for retrograde filling. Following thorough irrigation and hemostasis, MTA putty was placed in the prepared root-end cavities of 21 and 22 to achieve an effective apical seal. The surgical site was inspected, irrigated, and the mucoperiosteal flap was repositioned and sutured to obtain primary closure. A postoperative intraoral periapical radiograph was obtained to assess the apical resection and root-end filling. The sutures were removed after 1 week.

9. Postoperative Care

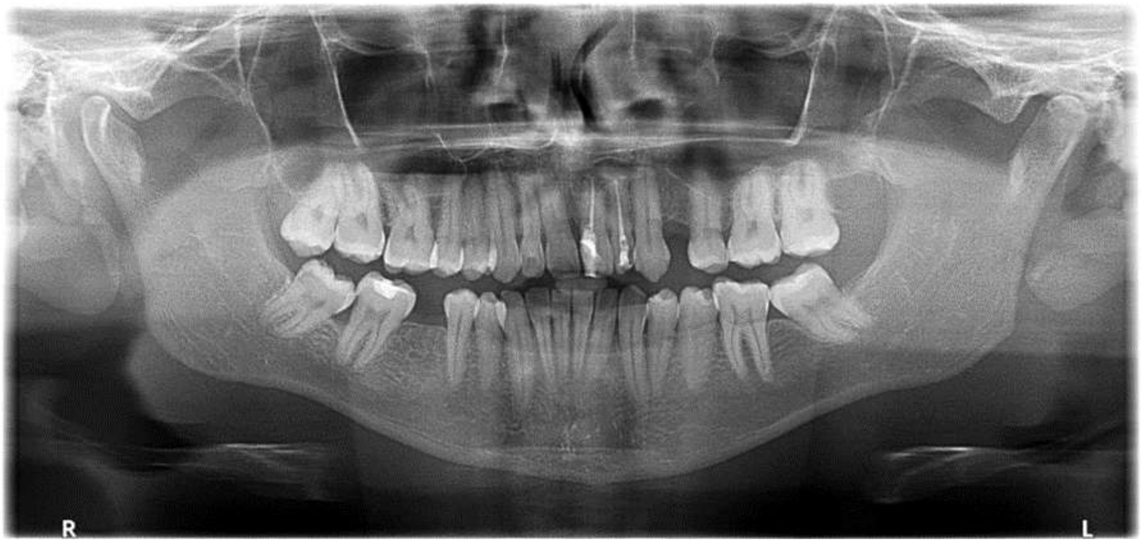
Postoperative instructions were provided to the patient regarding oral hygiene and care of the surgical site. The patient was advised to avoid trauma to the surgical area and to follow the prescribed postoperative instructions.

The patient was recalled for assessment of postoperative healing, including evaluation of pain, swelling, soft-tissue healing, and tooth function.

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

10. Follow-up

FIGURE 10:Postoperative follow-up OPG demonstrating the treated teeth and evaluation of periapical healing.



Clinical and radiographic follow-up was performed at 1 year. The patient was clinically asymptomatic, with satisfactory soft-tissue healing and no evidence of swelling or sinus tract. An orthopantomogram (OPG) obtained at the 1-year follow-up demonstrated satisfactory periapical healing, with marked reduction of the preoperative periapical radiolucency and evidence of new bone formation in the periapical region of teeth 21 and 22.

Discussion

The present case demonstrates the complexity of managing a large periapical lesion involving two adjacent maxillary anterior teeth with distinct anatomical challenges. Tooth 21 exhibited extensive calcification of the pulp chamber and coronal root canal, with a patent canal restricted to the apical third, whereas tooth 22 presented with a developmental peg-shaped crown. The combination of altered dental anatomy, extensive periapical pathology, cortical plate destruction, and external root resorption necessitated detailed diagnostic evaluation and individualized treatment planning.

Cone-beam computed tomography (CBCT) played an important role in the diagnosis and treatment planning of the present case. The lesion measured approximately **14.1 mm mesiodistally, 10.7 mm buccolingually, and 10.8 mm superoinferiorly**, with loss of both buccal and palatal cortical plates at the apical region of 21 and 22. Petersson et al. (2012), in a systematic review of radiological methods for detecting periapical lesions, reported that CBCT has the potential to demonstrate periapical bone destruction that may not be readily visualized on conventional radiographs [13].

Similarly, **Kruse et al. (2015)** systematically evaluated the diagnostic efficacy of CBCT for periapical lesions and reported that CBCT showed higher diagnostic accuracy than two-dimensional imaging in studies using direct observation as the reference standard. However, the authors also emphasized that CBCT was not sufficiently reliable for differentiating periapical granulomas from cysts. (**Aminoshariae, Kulild and Syed (2018)** further demonstrated in a systematic review that the odds of detecting a periapical lesion were approximately twice as high with CBCT compared with traditional intraoral radiography (OR 2.04). These findings support the use of CBCT in the present case for assessing lesion dimensions, cortical plate involvement, canal calcification, and external root resorption [14,15].

The extensive calcification of tooth 21 represented a major endodontic challenge. CBCT demonstrated marked calcification of the pulp chamber and coronal root canal, with a patent canal restricted to the apical third. This information enabled anticipation of the difficulty of canal negotiation and facilitated conservative treatment planning. **Giri et al. (2025)**, in a systematic review of case reports concerning

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

calcified canals, highlighted that canal obliteration significantly compromises access and instrumentation and emphasized the importance of advanced imaging, magnification, small instruments, and carefully planned canal negotiation. In the present case, the use of a **#10 K-file and D-Finder** facilitated negotiation of the calcified canal while maintaining a conservative approach [16].

The presence of **external root resorption at the palatal aspect of the apical region of 21** further complicated the case. External root resorption may result in irregularities of the external root surface and apical anatomy, making accurate assessment difficult with conventional radiography. CBCT facilitated identification of the resorptive defect before surgery, while direct visualization under magnification during microsurgery allowed assessment and management of the apical region following resection [14].

The morphology of tooth 22 represented an additional anatomical consideration. The tooth exhibited a **peg-shaped malformed crown associated with a lingual enamel defect and cervical V-shaped defect**. Despite these morphological alterations, CBCT demonstrated a clearly identifiable root canal without significant calcific obstruction, allowing conventional nonsurgical root canal treatment to be completed [13].

The decision to perform **endodontic microsurgery (EMS)** was based on the extensive periapical pathology, cortical plate destruction, external root resorption, and preoperative CBCT findings. **Setzer et al. (2010)** performed a systematic review and meta-analysis comparing traditional root-end surgery with endodontic microsurgery. Their analysis demonstrated pooled success rates of **59% for traditional root-end surgery and 94% for endodontic microsurgery**, with the probability of success being 1.58 times greater for microsurgery. These findings support the use of a microsurgical approach in complex cases such as the present one [17].

In an updated meta-analysis, **Tsesis et al. (2013)** evaluated outcomes of surgical endodontic treatment performed using modern microsurgical techniques and provided further evidence supporting the predictable outcome of contemporary endodontic surgery. The use of magnification in the present case facilitated direct visualization of the surgical field, precise apical resection, removal of pathological tissue, and controlled root-end preparation [18].

The **large size of the periapical lesion and associated cortical plate destruction** represented unfavorable prognostic factors. A recent systematic review and meta-analysis by **Zhang et al. (2023)** evaluating hard-tissue factors affecting endodontic microsurgery reported an overall pooled success rate of 84.5%. Importantly, lesions measuring **≤5 mm demonstrated better healing outcomes than lesions >5 mm**, with reported success rates of 78.4% and 63.3%, respectively. The authors concluded that lesion size is an important prognostic factor influencing the outcome of endodontic microsurgery. The lesion in the present case was substantially larger than 5 mm, making the satisfactory healing observed at the 1-year follow-up clinically noteworthy [19].

Following apical resection, **MTA putty** was selected as the root-end filling material. **Tang, Li and Yin (2010)** conducted a systematic review comparing MTA with other root-end filling materials and concluded that MTA demonstrated better clinical outcomes than amalgam and gutta-percha, while its effectiveness was comparable with intermediate restorative material [20].

The favorable biological properties of MTA have also been extensively described by **Torabinejad and Parirokh (2010)**, who reviewed its sealing ability and biocompatibility and concluded that MTA demonstrates favorable sealing characteristics and biocompatibility. These properties supported the selection of MTA putty for root-end filling in the present case [20].

The diagnosis of a **periapical cyst** should nevertheless be interpreted cautiously. Although the lesion was described radiographically as an infected periapical cyst, imaging characteristics alone cannot reliably establish the histopathological diagnosis. **Kruse et al. (2015)** specifically reported that although CBCT may improve detection of periapical lesions, it was not reliable for differentiating periapical cysts from granulomas when histology was used as the reference standard [14].

Similarly, **Peters and Lau (2003)** emphasized the importance of histopathological examination in confirming the diagnosis of periapical lesions because lesions of endodontic and non-endodontic origin may present with similar clinical and radiographic appearances. More recently, **Alotaibi et al. (2020)** demonstrated that clinical and radiographic diagnoses

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

of periapical lesions may not always correspond with the histopathological diagnosis and reiterated that biopsy and histopathological examination remain the reference standard. .Therefore, if the enucleated tissue in the present case was not subjected to histopathological examination, it would be preferable to describe the lesion as a **periapical lesion radiographically suggestive of a cyst**, rather than a histopathologically confirmed periapical cyst [20].

This diagnostic limitation is further supported by **Natanasabapathy et al. (2021)**, who, in a systematic review and meta-analysis evaluating non-invasive differentiation of periapical cysts and granulomas, emphasized that histopathology remains the reference standard and that imaging-based differentiation should be interpreted cautiously [20].

At the **1-year follow-up**, the patient demonstrated satisfactory clinical healing, and an **OPG showed marked reduction of the preoperative periapical radiolucency with evidence of satisfactory periapical bone healing**. Since postoperative CBCT was not obtained, the assessment of healing in the present case was based solely on conventional panoramic radiography and should therefore be interpreted as satisfactory radiographic healing rather than complete three-dimensional resolution [18,19].

Overall, the present case highlights the importance of **CBCT-assisted diagnosis, careful management of calcified canals, operative magnification, microsurgical enucleation and apical resection, and MTA root-end filling** in the management of complex periapical pathology associated with altered dental anatomy. The satisfactory clinical and radiographic outcome at 1 year demonstrates that a carefully planned combination of nonsurgical endodontic treatment and endodontic microsurgery can provide favorable healing even in the presence of a large periapical lesion, cortical plate destruction, canal calcification, and external root resorption [17-20].

Conclusion

The present case illustrates the successful multidisciplinary management of a complex periapical lesion associated with a calcified maxillary central incisor and a peg-shaped maxillary lateral incisor.

CBCT provided critical three-dimensional information regarding the size and extent of the periapical lesion, loss of the buccal and palatal cortical plates, severe calcification of the coronal canal of 21, and external root resorption at the palatal aspect of its root apex.

Following nonsurgical root canal treatment, endodontic microsurgery permitted direct access to the pathological lesion, complete enucleation, apical management, and placement of MTA as a root-end filling material.

The case emphasizes the importance of **three-dimensional imaging, individualized treatment planning, magnification-assisted microsurgery, meticulous lesion removal, and appropriate apical sealing** in the management of complex endodontic pathology.

Long-term clinical and radiographic follow-up is essential to document the final outcome and periapical healing.

References

1. Kruse C, Spin-Neto R, Wenzel A, Kirkevang LL. Cone beam computed tomography and periapical lesions: a systematic review analysing studies on diagnostic efficacy by a hierarchical model. **Int Endod J.** 2015;48(9):815-828. doi:10.1111/iej.12388.
2. Aminoshariae A, Kulild JC, Syed A. Cone-beam computed tomography compared with intraoral radiographic lesions in endodontic outcome studies: a systematic review. **J Endod.** 2018;44(11):1626-1631. doi:10.1016/j.joen.2018.08.006.
3. European Society of Endodontology. European Society of Endodontology position statement: use of cone beam computed tomography in Endodontics. **Int Endod J.** 2019;52(12):1675-1678. doi:10.1111/iej.13167.
4. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. **Int Endod J.** 2009;42(6):507-515.
5. Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature—part 1: comparison of traditional root-end surgery and endodontic microsurgery. **J Endod.** 2010;36(11):1757-1765. doi:10.1016/j.joen.2010.08.007.

Volume 9, Issue 4; July-August 2026; Page No 451-461
© 2026 IJMSCR. All Rights Reserved

6. Setzer FC, Kohli MR, Shah SB, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature—part 2: comparison of endodontic microsurgical techniques with and without the use of higher magnification. **J Endod.** 2012;38(1):1-10. doi:10.1016/j.joen.2011.09.021.
7. Tsesis I, Rosen E, Taschieri S, Telishevsky Strauss Y, Ceresoli V, Del Fabbro M. Outcomes of surgical endodontic treatment performed by a modern technique: an updated meta-analysis of the literature. **J Endod.** 2013;39(3):332-339. doi:10.1016/j.joen.2012.11.044.
8. Pinto D, Marques A, Pereira JF, Palma PJ, Santos JM. Long-term prognosis of endodontic microsurgery—a systematic review and meta-analysis. **Medicina (Kaunas).** 2020;56(9):447. doi:10.3390/medicina56090447.
9. Sabeti M, Ihsan MS, Kharat P, Azarpazhooh A. The effect of hard tissue defects on the clinical outcome of endodontic microsurgery: a systematic review and meta-analysis. **Clin Oral Investig.** 2023;27:7079-7089. doi:10.1007/s00784-023-05341-3.
10. Liao WC, Lee YL, Tsai YL, Lin HJ, Chang MC, Chang SF, Chang SH, Jeng JH. Outcome assessment of apical surgery: a study of 234 teeth. **J Formos Med Assoc.** 2019;118(6):1055-1061.
11. Song M, Kim SG, Lee SJ, Kim B, Kim E. Prognostic factors of clinical outcomes in endodontic microsurgery: a prospective study. **J Endod.** 2013;39(12):1491-1497.
12. Yoo YJ, Baek SH, Kum KY, Shon WJ, et al. Prognostic factors of long-term outcomes in endodontic microsurgery: a retrospective cohort study over five years. **J Clin Med.** 2020;9(8):2458.
13. Tang Y, Li X, Yin S. Outcomes of MTA as root-end filling in endodontic surgery: a systematic review. **Quintessence Int.** 2010;41(7):557-566.
14. Parirokh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review—part I: chemical, physical, and antibacterial properties. **J Endod.** 2010;36(1):16-27. doi:10.1016/j.joen.2009.09.006.
15. Torabinejad M, Parirokh M. Mineral trioxide aggregate: a comprehensive literature review—part II: leakage and biocompatibility investigations. **J Endod.** 2010;36(2):190-202. doi:10.1016/j.joen.2009.09.010.
16. Parirokh M, Torabinejad M. Mineral trioxide aggregate: a comprehensive literature review—part III: clinical applications, drawbacks, and mechanism of action. **J Endod.** 2010;36(3):400-413. doi:10.1016/j.joen.2009.09.009.
17. Giri K, Banga K, Arora S, Elmsmari F, et al. Management of calcified root canals during root canal treatment: a systematic review of case reports. **PeerJ.** 2025;13:e19900. doi:10.7717/peerj.19900.
18. Natanasabapathy V, et al. Ultrasound imaging for the differential diagnosis of periapical lesions of endodontic origin in comparison with histopathology—a systematic review and meta-analysis. **Int Endod J.** 2021. doi:10.1111/iej.13465.
19. Peters E, Lau M. Histopathologic examination to confirm diagnosis of periapical lesions: a review. **J Can Dent Assoc.** 2003;69(9):598-602.
20. Chen C, Zhang R, Zhang W, Li F, Wang Z, Qin L, et al. Clinical and radiological outcomes of dynamic navigation in endodontic microsurgery: a prospective study. **Clin Oral Investig.** 2023;27(9):5317-5329. doi:10.1007/s00784-023-05152-6.

© 2026 IJMSCR. All Rights Reserved