Journal of
Medical Case Reports

CASE REPORT

Open Access

Endodontic management of internal replacement resorption of two maxillary central incisors with the aid of cone-beam computed tomography as the diagnostic tool: a case report and review of literature

Fatemeh Eskandari[1], Safoora Sahebi[2*], Negar Ghorbani Jahandizi[3] and Hossein Mofidi[4]

Abstract

Background Internal root resorption is an infrequent resorption of dentin and stands among one of the endodontic challenges which comprises two types: internal replacement and inflammatory resorption. Regardless of the location, root resorption does not regress and continues to cause discomfort or sometimes tooth loss if left untreated. Internal replacement resorption is rarer compared with the other type of internal resorption. Regarding the scarcity of internal replacement resorption, the present article reports a case of endodontic management of internal replacement resorption by using NeoPutty mineral trioxide aggregate and cone-beam computed tomography to illustrate and clarify characteristics, diagnosis, possible etiologies, and treatment modalities for internal replacement resorption.

Case presentation A 55-year-old Iranian man was referred for a sinus tract. Periapical radiographs revealed a periradicular lesion and cone-beam computed tomography showed the internal replacement resorption of teeth nos. 8 and 9. The root canal was explored using ultrasonic tips under magnification. Irrigation was done using 2.5% sodium hypochlorite with ultrasonic irrigation. Calcium hydroxide was placed in the root canal for 2 weeks as an intracanal medicament. At the next appointment, after calcium hydroxide removal, the root canal was dried and obturated using NeoPutty mineral trioxide aggregate. At the 2 year follow-up, the teeth were unresponsive to percussion test.

Conclusion Traumatic injuries may lead to internal replacement resorption, which has a progressive nature and urges instant endodontic management. Mineral trioxide aggregate seems to be a promising material for internal replacement resorption. Besides, cone-beam computed tomography and dental operative microscopes can improve the outcome of endodontic therapy in certain challenging cases.

Keywords CBCT, Endodontics, Internal root resorption, MTA, Root canal treatment, Root resorption

*Correspondence:
Safoora Sahebi
sahebis@sums.ac.ir
Full list of author information is available at the end of the article

Background

Pulpal inflammation is likely to cause internal root resorption [1]. Internal root resorption is typically asymptomatic and is often discovered incidentally during regular radiographic evaluations [2]. However, if ankylosis occurs, the teeth will gradually develop infraocclusion in young patients [3]. Histologically, internal resorptions occur in replacement and inflammatory types. The replacement type entails subsequent deposition of hard tissue that resembles cementum or bone but not dentin [4]. The hallmark of internal replacement resorption is the presence of islands of mineralized tissue within the root canal space [5]. Radiographically, the internal replacement resorption appears with partial or full obliteration of the pulp chamber and irregularly enlarged root canals with radiopaque, calcified tissue [6, 7]. The progressive nature of root resorptions requires instant endodontic management [8].

Radiographic evaluation is imperative in endodontic treatment planning [9]. Intraoral periapical radiographs are the method of choice for diagnosis, management, and assessment of endodontic pathosis such as periapical lesions [10]. The conversion of three-dimensional objects into two-dimensional graphs exposes the periapical radiography to several drawbacks such as geometrical distortions and camouflage of important areas by anatomical noise [11, 12].

On the contrary, cone-beam computed tomography (CBCT) originally generates three-dimensional images and thereby eliminates the limitations of two-dimensional radiographs and better depicts the root canal system [13–15]. CBCT has several endodontic applications, including diagnosing periapical lesions caused by pulpal inflammation, identifying and localizing internal or external resorption, detecting vertical root fractures, visualizing accessory canals, and evaluating the reasons for non-healing root canal-treated teeth. The identification and management of external and internal root resorption can be particularly challenging, making CBCT an excellent tool for these tasks [16]. CBCT has been utilized for detecting small lesions, classifying them, localizing and distinguishing resorptive defects from other types of lesions, and guiding treatment decisions [17]. CBCT offers a 3D perspective of resorption, providing greater accuracy than periapical radiographs in diagnosing the presence, size, and characteristics of root resorption [18].

Internal root resorption is a condition that occurs rarely [6]. Diagnosing and managing this condition has posed significant challenges for dental professionals. Because of its subtle nature, internal resorption can advance considerably before being noticed [19]. Owing to a lack of a similar report in literature, the present article reports the case of a successful endodontic surgery of internal replacement resorption in two maxillary central incisors detected through CBCT. This case underscores the importance of advanced imaging techniques in diagnosing and managing complex endodontic conditions, contributing valuable insights to the field.

Case presentation

A 55-year-old Iranian man was referred from a general practitioner to the Department of Endodontics, Shiraz School of Dentistry, Iran. Prior to this referral, the patient had visited the general dentist with the chief complaint of a fistula at the apex of tooth number 8. However, after access cavity preparation, the patient was referred owing to the calcified canal and inability to locate the canal. In clinical examinations, a sinus tract was observed at the midbuccal attached gingiva of tooth no. 8. The patient reported a dental trauma dating back to 40 years ago. The medical history showed controlled hypertension. Family and psychosocial history was noncontributory.

Investigations

Tooth no. 8 was unresponsive to pulp sensibility tests and palpation, but a different sensation to percussion was recorded. There was no intraoral or extraoral swelling and the pocket depth and mobility were normal. Periapical radiographs revealed the calcification of teeth nos. 8 and 9, as well as a periradicular lesion in tooth no. 8 (Fig. 1). To assess the presence or absence of perforation and evaluation of tooth no. 9, CBCT images (5 cm × 5 cm field of view) were taken and horizontal, sagittal, and axial sections were attained (Fig. 2). The images showed internal replacement resorption in teeth no. 8 and 9, and a radiolucent periapical lesion. Pulpal and periradicular diagnoses were the pulpless and infected root canal system of tooth no. 8, and a chronic apical abscess of tooth no. 8, respectively.

Fig. 1 Preoperative periapical radiograph

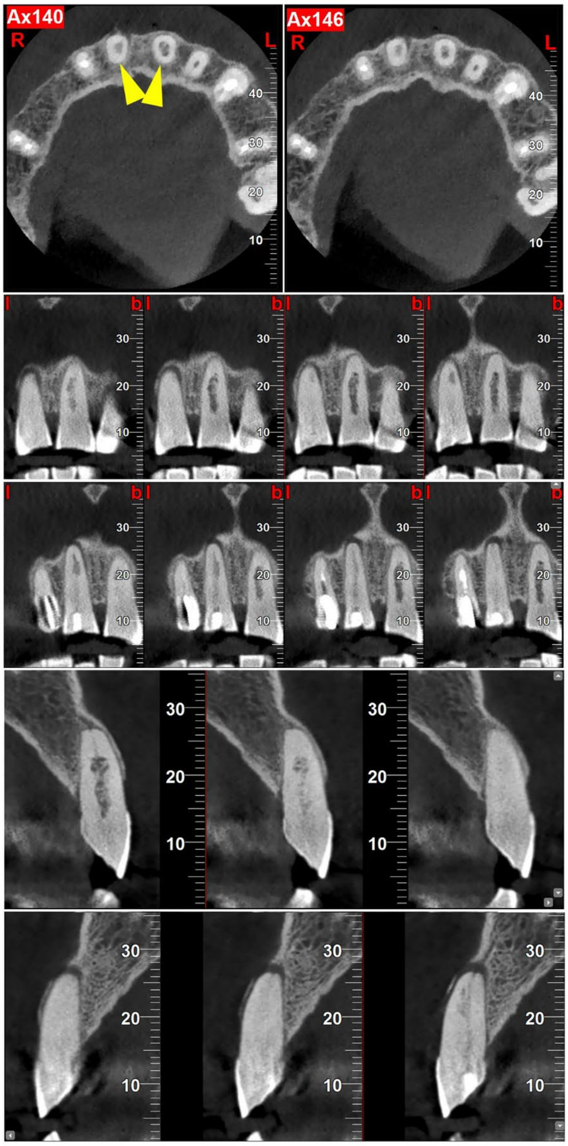

Fig. 2 Preoperative cone-beam computed tomography scans. (The yellow arrows point to the central incisors that were diagnosed with internal replacement resorption)

Differential diagnosis

External inflammatory root resorption

Pulp necrosis following avulsion and luxation makes the necrotic tissue vulnerable to bacterial contamination. The interaction between bacteria within the root canal and damage to the cementum on the outer surface of the root triggers external inflammatory root resorption [20].

Radiographic features

Radiographic imaging shows that external inflammatory root resorption (EIR) is identified by the presence of bowl-shaped cavities along the root surface, which are radiolucent, concave, and sometimes have irregular edges. The adjacent alveolar bone also displays radiolucencies that correspond to these cavities. In the affected area, the lamina dura is completely lost [5].

Treatment

Informed consent was obtained for the procedure, and explicit consent to publish this case report was also secured from the patient. At the first treatment session, following administration of local anesthesia (3% citanest; DarouPakhsh, Tehran, Iran), exploration of the root canal was attempted using ultrasonic tips under magnification and illumination (dental operative microscope; Zeiss, Oberkochen, Germany). Intraoral periapical radiographs were taken after every 3 mm of tooth preparation to verify the direction of the procedure. Once the root canal was located, the tooth was isolated, and root canal treatment was carried out. Working length determination was established using periapical radiograph. Chemomechanical preparation was completed using the hand K-files and rotary Protaper File System (Dentsply Tulsa; Switzerland). Irrigation was carried out using 2.5% sodium hypochlorite (Chloraxid, Cerkamed, Poland) with ultrasonic irrigation. Then, calcium hydroxide (CH) powder (Prime Dental Product, Mumbai, India) was combined with saline to achieve a creamy consistency. It was applied in the root canal using a lentulospiral (Dentsply, Maillefer) and sealed with Cavit (3M, ESPE).

The next treatment session was set for 2 weeks later. The patient denied any postoperative discomfort or pain and the sinus tract was healed. Therefore, tooth no. 8 was obturated. Initially, the #30 K-file was used in a circumferential filing action, along with irrigation with 2.5% sodium hypochlorite, to remove the intracanal dressing. Irrigation was ultrasonically activated to maximize the CH removal. Afterwards, the root canal was dried by using paper points (Dentsply Maillefer; Ballaigues, Switzerland). Then, the Neoputty mineral trioxide aggregate (MTA) (Maillefer, Dentsply, Ballaigues, Switzerland) powder was placed from the apical portion of the root canal to the coronal portion of the resorption using a plastic instrument and was densely packed. Afterwards, the rest of the root canal system was obturated using Gutta Percha cones (Dentsply Maillefer, Ballaigues, Switzerland) by warm vertical technique [5]. Postoperative radiographs were taken (Fig. 3).

Tooth no. 9 was unresponsive to thermal tests; however, it responded to the electric pulp test (EPT).

Fig. 3 Postoperative radiograph of the root canal therapy of tooth number 8

Fig. 4 Intraoperative radiographs

Fig. 5 Postoperative radiograph of the root canal therapy of tooth number 9

Fig. 6 Root canal therapy of teeth numbers 8 and 9 at the 2-year follow-up

Moreover, it was observed through CBCT graphs that tooth no. 9 had internal replacement resorption as well. Hence, intentional root canal therapy was performed, as previously described for tooth no. 8, during two sessions (Figs. 4 and 5). Then, the patient was referred for restoration of teeth nos. 8 and 9.

Outcome and follow up

At the 6-month, 1-year, and 2-year follow-ups (Fig. 6), the patient denied any postoperative discomfort or pain, all signs and symptoms of disease had resolved and the teeth were functional. In addition, the teeth were unresponsive to the percussion test. Also, the connective tissue condition was normal.

Discussion and review of literature

Internal root resorption, particularly the rarer form known as internal replacement resorption, presents significant challenges in endodontics. This case report exemplifies the successful management of internal replacement resorption using advanced techniques, including cone beam computed tomography (CBCT) and NeoPutty mineral trioxide aggregate (MTA). Traditional radiographic methods often fall short in accurately diagnosing such conditions, which can lead to delayed treatment and potential tooth loss. By utilizing CBCT, we were able to achieve a precise diagnosis and effectively manage the case, providing a valuable reference for clinicians facing similar challenges.

The presented case of a 55-year-old man with internal replacement resorption illustrates the critical importance of immediate endodontic intervention following traumatic injuries, which can lead to progressive resorption. Our approach highlights effective treatment modalities that can be employed in such cases. The successful outcome, evidenced by the teeth being unresponsive to percussion testing at the 2-year follow-up, reinforces the efficacy of MTA as a promising material for addressing internal replacement resorption.

Furthermore, this report contributes to the limited literature on internal replacement resorption by documenting the clinical course, diagnostic challenges, and treatment strategies employed. We aim to enhance understanding of the characteristics, possible etiologies, and management options for this condition, thereby encouraging further exploration and discussion within the dental community.

Intraradicular internal root resorption is a relatively uncommon clinical condition, even following traumatic injury [21]. Remaining asymptomatic until certain stages, clinical diagnosis of root resorption is generally an incidental radiographic finding [22]. Clastic activities cause loss of dental hard tissues, which can be either a physiologic or pathologic process and either internal and external based on the location [23]. The rare type of internal root resorption occurs when the pulp tissue is chronically inflamed and invaded by bacteria, which results in necrotic odontoblasts [24, 25]. Clinically, this condition is often asymptomatic; however, it may occasionally present with a red or pink spot, which indicates the presence of granulation tissue in the resorbed area [26].

Diagnosis can be made through a wide range of techniques, including visual examination (based on tooth crown discoloration), radiographic diagnosis, conventional and cone-beam computed tomography, light microscopy, and electron microscopy [26] Radiographically, internal resorption appears as a well-demarcated, radiolucent ballooning or widening of the pulpal root canal that extends into the canal itself [27]. Although its exact etiology and pathogenesis are still unknown, chronic infections or trauma are usually the culprits [16]. Figure 7 schematically demonstrates the pathogenesis of internal resorption [28].

Histologically, the two forms of internal root resorption include internal inflammatory resorption, which is purely

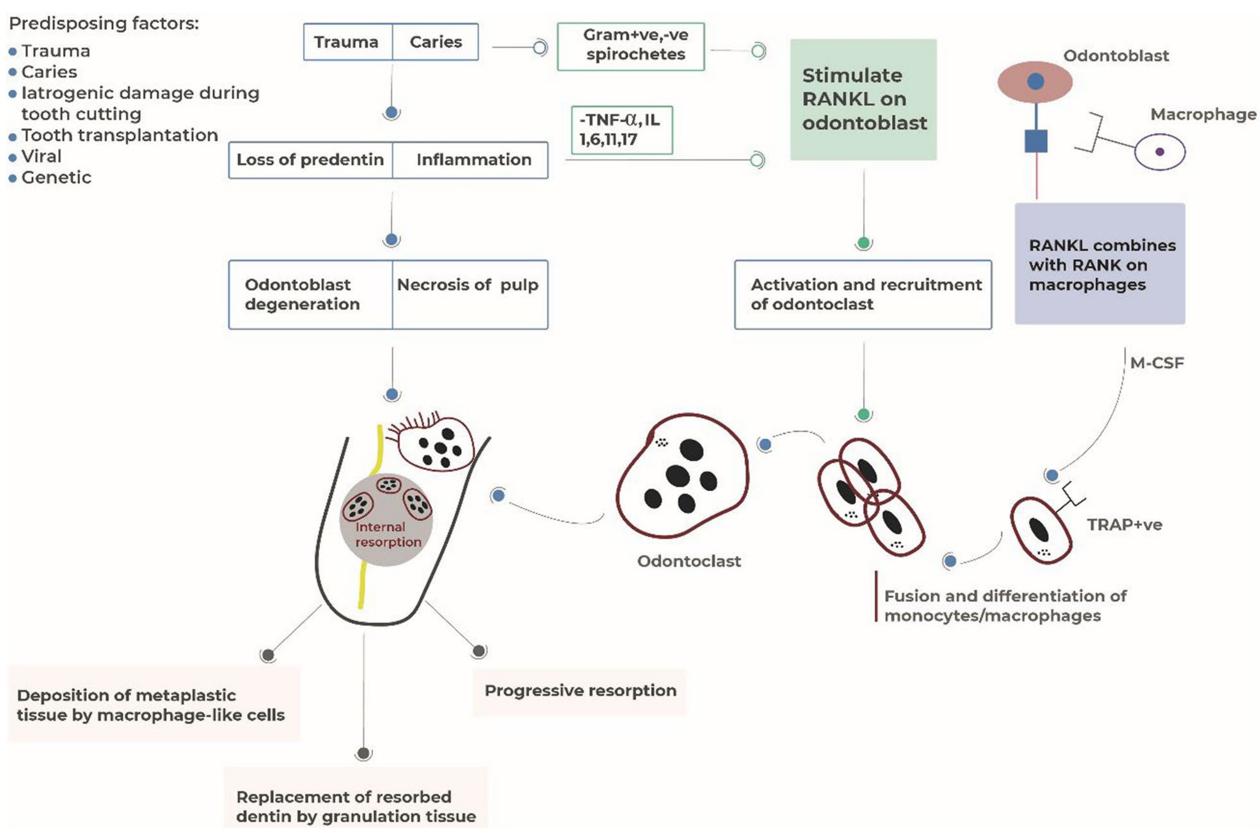

Fig. 7 Schematic representation of pathogenesis of internal resorption

destructive, and internal replacement resorption, which is accompanied by repair and is characterized by the metaplastic bone/cementum-like tissues adjacent to the resorption sites [16, 21]. Regardless of the location, root resorption does not regress and causes discomfort or sometimes tooth loss if untreated [29]. Internal replacement resorption is defined by the islands of mineralized tissue (metaplastic bone/cementum-like tissues) that occupy the root canal space [21, 30]. It is distinguished by the radiopaque material that partially replaces the enlarged root canal space and makes it appear as partial canal obliteration. This radiodense material is different in density from the surrounding dentin, and the internal resorption is not as defined as the radial pulp enlargement resorption. Histologic assessment of internal resorption showed that the normal pulp tissue was replaced with tissues resembling periodontal connective tissue, with osteogenic and resorptive potential [31]. The probable etiology of internal replacement resorption is damage to the pulp tissue, which is usually related to trauma [32]. Hence, the history of trauma in the current case might be the etiologic factor for internal replacement resorption.

Even if the resorption is autonomously restricted and remains asymptomatic, infection and/or pressure may continue to destroy the hard dental tissues and cause irreversible damage [33]. Prognosis depends on the lesion age and location (supraosseous or infraosseous), contamination of the area, bone loss in the area, and the sealing of the employed canal filler [34]. The prognosis in the present case was good; however, follow-ups were required to prevent recurrence.

CBCT has conquered the boundaries of conventional radiographs [35]. This imaging modality reliably shows the anatomic variations within the main pulp canal, besides visualizing an individual tooth or teeth in any view rather than predetermined views, thus making the treatment outcome more predictable [36–38]. Although CBCT indications are restricted with respect to the as low as reasonably achievable (ALARA) principle owing to its higher radiation dose than conventional radiography [39], an accurate radiographic interpretation of the resorption process is essential for the diagnosis, treatment, and prognosis. CBCT visualizes the defects three-dimensionally; therefore, the entrance/exit portal and the extent of resorption can be determined [40].

Concerning the external and internal resorptions, CBCT illustrates the target area in the desired plane without the drawbacks of conventional radiography such as distortion and artifacts [41]. High-resolution Iluma CBCT images were reported to excel at detecting and locating both internal and external cervical root resorption ex vivo compared with an intraoral film by using three different angulations [27]. The superiority of CBCT in the diagnosis and management of resorptive lesions has been confirmed in several case reports and case series [16, 22, 42]. Patel *et al.* [43] used CBCT in patients with external and internal resorptions and concluded that this imaging modality was more precise than the periapical radiography in diagnosis and correct treatment of internal resorptions. Khojastepour *et al.* [44] reported that CBCT efficiently detected perforation in internal root resorption with an 81.3% sensitivity and 84.4% specificity. CBCT was not the first imaging option in the current case; however, images were taken with a restricted field-of-view and focused radiation beam to achieve the most precise diagnosis and to form the most suitable treatment plan. Furthermore, thyroid exposure was prevented by a lead thyroid collar and apron, without interfering with the scan.

In the present case report, CBCT revealed the presence and exact location and depth of internal replacement resorption of the maxillary central incisor and the periapical conditions. Accordingly, CBCT defined the treatment complexity and the expected outcomes on the basis of the location and extent of the root defect.

The operating microscope's exceptional magnification and illumination significantly enhance the effectiveness of traditional endodontic therapy and are vital for accurately diagnosing and managing complex endodontic cases [45]. The use of the operating microscope in endodontics provides superior visibility, magnification, and lighting compared with loupes, allowing for more conservative access and greater accuracy in treatment [46, 47]. Thanks to their benefits, the identification of root canals on the pulp chamber floor can be improved by 18–52.4% compared with traditional methods using magnifying glasses or the unaided eye [47]. Moreover, work-related repetitive stress injuries can be reduced by using magnifying loupes and operating microscopes to correct bad posture and improve the working posture [48]. In the current case report, the magnification using a dental microscope facilitated locating root canals during access cavity preparation and improved the visualization of the root canal space.

The type of root-end filling material employed is another influencing factor on the outcome of endodontic microsurgery. Among the favorable options are calcium silicate cements such as MTA owing to several promising properties such as bactericidal effects, satisfactory sealing capability, potency to induct hard tissue formation, biocompatibility, great success rate, and potential to induce tissue repair and to stimulate mineralization [49, 50]. MTA is not only a surgical root-end filling material but also used in many other clinical applications such as pulp capping, pulpotomy, perforation repair, and treatment of root resorption and traumatized teeth with immature apices [51]. Seemingly, it is an appropriate option to be used for perforating internal replacement resorption. Furthermore, cell culture and animal research have shown the proliferation of periodontal cells and cementoblasts over MTA [6, 52]. Long-term positive outcomes provide evidence for the effectiveness of MTA in treating root perforations caused by external or internal resorption [53]. Nunes *et al.*[53] stated that MTA might increase resistance in cases of extensive dental destruction. In the present case, NeoPutty MTA was used for the obturation of root canals. NeoPutty MTA is an innovative bioceramic material specifically formulated for endodontic procedures. This premixed, ready-to-use product addresses some of the common challenges associated with traditional MTA materials, such as the complexities of mixing powder and liquid components and the lengthy setting times [54].

To the best of the authors' knowledge, there is no report of an exactly similar case and treatment approach in literature. However, Subay *et al.*[6] reported a case of perforating internal replacement resorption of a maxillary central incisor of a 20-year-old female. Calcium hydroxide medication was performed for 3 months, and subsequently, the perforation and root canal was obturated by using MTA. A 6-year follow-up revealed clinically asymptomatic condition and radiographic evidence of hard tissue repair, resembling a barrier and periodontal membrane healing surrounding the perforation site.

Conclusion

Traumatic injuries may lead to internal replacement resorption, which has a progressive nature and urges instant endodontic management. MTA seems to be a promising material for internal replacement resorption. Besides, CBCT and dental operative microscopes can improve outcomes of endodontic therapy in certain challenging cases.

Abbreviations

MTA Mineral trioxide aggregate
CBCT Cone-beam computed tomography

Acknowledgements

Appreciations are expressed to Ms. Farzaneh Rasooli for copyediting, proofreading, and improving the use of English in this manuscript.

Author contributions

SS supervised the study and edited the manuscript. NG and HM performed the clinical work. FE was involved in data curation and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

Funding

Not applicable.

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Ethics approval and consent to participate

Ethics approval was not required for this study because dental image data used in this study is obtained fully anonymized and no identifiable private information is included. The study was performed in full accordance with ethical principles, including the World Medical Association Declaration of Helsinki (version 2008). In addition, informed written consent was obtained after reviewing the risks and benefits of endodontic microsurgery with the patient.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests

The authors explicitly declare that there are no competing interests in relation to this article.

Author details

[1]School of Dentistry, Shiraz University of Medical Sciences, Ghasrdasht Street, 71956-15878 Shiraz, Iran. [2]Department of Endodontics, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Fars, Iran. [3]Department of Endodontics, School of Dentistry, Hormozgan University of Medical Sciences, Bandar Abbas, Iran. [4]Department of Endodontics, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran.

Received: 29 October 2024 Accepted: 31 January 2025
Published online: 01 May 2025

References

1. Bhuva B, Barnes J, Patel S. The use of limited cone beam computed tomography in the diagnosis and management of a case of perforating internal root resorption. Int Endod J. 2011;44(8):777–86.
2. Asgary S, Eghbal MJ, Mehrdad L, Kheirieh S, Nosrat A. Surgical management of a failed internal root resorption treatment: a histological and clinical report. Restor Dent Endod. 2014;39(2):137–42.
3. Rotstein I, Ingle JI. Ingle's endodontics. New Haven: PMPH USA; 2019.
4. Fernandes M, De Ataide I, Wagle R. Tooth resorption part I-Pathogenesis and case series of internal resorption. J conserv dent. 2013;16(1):4.
5. Berman LH, Hargreaves KM. Cohen's pathways of the pulp-e-book. London: Elsevier Health Sciences; 2020.
6. Subay RK, Subay MO, Tuzcu SB. Endodontic management of root perforating internal replacement resorption. Eur J Dent. 2018;12(03):450–3.
7. Venkatesh A, Sangavi T, Karthick A, Malarvizhi D. Management of internal root resorption: a review. Eur J Mol Clin Med. 2020;7(10):658–62.
8. Mincik J, Urban D, Timkova S. Clinical management of two root resorption cases in endodontic practice. Case Rep Dent. 2016;2016:1–6.
9. Patel S, Dawood A, Ford TP, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. Int Endod J. 2007;40(10):818–30.
10. Shekhar V, Shashikala K. Cone beam computed tomography evaluation of the diagnosis, treatment planning, and long-term followup of large periapical lesions treated by endodontic surgery: two case reports. Case Rep Dent. 2013;2013:564392–404.
11. Patel S, Brown J, Pimentel T, Kelly R, Abella F, Durack C. Cone beam computed tomography in endodontics–A review of the literature. Int Endod J. 2019;52(8):1138–52.
12. Uraba S, Ebihara A, Komatsu K, Ohbayashi N, Okiji T. Ability of cone-beam computed tomography to detect periapical lesions that were not detected by periapical radiography: a retrospective assessment according to tooth group. J Endod. 2016;42(8):1186–90.
13. Ghahramani Y, Moazami F, Samadi Y, Eskandari F. Maintaining a hopeless traumatized maxillary central incisor as a transient treatment option: a case report with a 3-years follow-up. Iran Endod J. 2022;17(3):160–3.
14. Krug R, Connert T, Beinicke A, Soliman S, Schubert A, Kiefner P, *et al.* When and how do endodontic specialists use cone-beam computed tomography? Aust Endod J. 2019;45(3):365–72.

15. Iqbal MK, Gartenberg J, Kratchman SI, Karabucak B, Bui B. The clinical significance and management of apical accessory canals in maxillary central incisors. J Am Dent Assoc. 2005;136(3):331–5.
16. Celikten B, Uzuntas CF, Kurt H. Multiple idiopathic external and internal resorption: case report with cone-beam computed tomography findings. Imaging sci dent. 2014;44(4):315–20.
17. Levin MD, Jong G. The use of CBCT in the diagnosis and management of root resorption. In: 3D imaging in endodontics: a new era in diagnosis and treatment. Cham: Springer International Publishing; 2016. p. 131–43.
18. Fatemi A, Yosef N. CBCT in treatment planning of external cervical resorption: A case series. 2017.
19. Thomas P, Krishna Pillai R, Pushparajan Ramakrishnan B, Palani J. An insight into internal resorption. Int Sch Res Not. 2014;2014:1–7.
20. Finucane D, Kinirons MJ. External inflammatory and replacement resorption of luxated, and avulsed replanted permanent incisors: a review and case presentation. Dent Traum. 2003;19(3):170–4.
21. Patel S, Ricucci D, Durak C, Tay F. Internal root resorption: a review. J Endod. 2010;36(7):1107–21.
22. Kalender A, Öztan MD, Basmaci F, Aksoy U, Orhan K. CBCT evaluation of multiple idiopathic internal resorptions in permanent molars: case report. BMC Oral Health. 2014;14(1):1–6.
23. Sarris K, Stergiou Y, Mikrogeorgis G, Mouza A, Paras S, Lyroudia K. Examination of irrigant flow on a tooth with internal root resorption by using a computational fluid dynamics model. Eur Endod J. 2021;6(2):177–82.
24. Altundasar E, Demir B. Management of a perforating internal resorptive defect with mineral trioxide aggregate: a case report. J Endod. 2009;35(10):1441–4.
25. Pérez-Alfayate R, Mercadé M, Vera J. Relationship between internal root resorption and dens in dente. J Clin Exp Dent. 2020;12(8):e800–4.
26. Mittal S, Kumar T, Mittal S, Sharma J. "Internal root resorption: an endodontic challenge": a case series. J Conserv Dent. 2014;17(6):590–3.
27. Parmar A, Vadher R, Parmar G, Dhanak N. Management of Internal resorption: case report. Ind J Basic Appl Med Res. 2014;3:38694.
28. Thomas P, Krishna Pillai R, Pushparajan Ramakrishnan B, Palani J. An insight into internal resorption. ISRN Dent. 2014;12:759326.
29. Patel S, Saberi N, Pimental T, Teng PH. Present status and future directions: root resorption. Int Endod J. 2022;00:1–30.
30. Berman LH, Hargreaves KM. Cohen's pathways of the pulp. London: Elsevier Health Sciences; 2020.
31. Kanas RJ, Kanas SJ. Dental root resorption: a review of the literature and a proposed new classification. Compendium. 2011;32(3):e38–52.
32. Rotstein I, Ingle JI. Ingle's endodontics. 7th ed. New Haven: PMPH USA; 2019. p. 1500.
33. Marinescu I, Bănică A, Mercut V, Gheroghe A, Drăghici E, Cojocaru M, *et al.* Root resorption diagnostic: role of digital panoramic radiography. Curr Health Sci J. 2019;45(2):156–66.
34. Tavsan O, Simsek N. Internal root resorption management: case series. Ann Med Res. 2020;27(1):415–9.
35. Sanaei-Rad P, Bolbolian M, Nouri F, Momeni E. Management of internal root resorption in the maxillary central incisor with fractured root using Biodentine. Clin Case Rep. 2021;9(7):e04502-e4507.
36. Sousa TO, Hassan B, Mirmohammadi H, Shemesh H, Haiter-Neto F. Feasibility of cone-beam computed tomography in detecting lateral canals before and after root canal treatment: an ex vivo study. J Endod. 2017;43(6):1014–7.
37. Patel S, Durack C, Abella F, Shemesh H, Roig M, Lemberg K. Cone beam computed tomography in endodontics–A review. Int Endod J. 2015;48(1):3–15.
38. Zhang M-M, Fang G-F, Chen X-T, Liang Y-H. Four-year outcome of nonsurgical root canal retreatment using cone-beam computed tomography: a prospective cohort study. J Endod. 2021;47(3):382–90.
39. Zehnder M, Connert T, Weiger R, Krastl G, Kühl S. Guided endodontics: accuracy of a novel method for guided access cavity preparation and root canal location. Int Endod J. 2016;49(10):966–72.
40. Cohenca N, Simon JH, Mathur A, Malfaz JM. Clinical indications for digital imaging in dento-alveolar trauma. Part 2: root resorption. Dent Traumatol. 2007;23(2):105–13.
41. Levin MD, Jong G. The use of CBCT in the diagnosis and management of root resorption. In: 3D imaging in endodontics. Cham: Springer; 2016. p. 131–43.
42. Kadyan R, Dahiya A, Sharma T. Study of internal root resorption management on permanent teeth. Int Dent Sci. 2019;5:191–4.
43. Patel S, Dawood A, Wilson R, Horner K, Mannocci F. The detection and management of root resorption lesions using intraoral radiography and cone beam computed tomography–An in vivo investigation. Int Endod J. 2009;42(9):831–8.
44. Khojastepour L, Moazami F, Babaei M, Forghani M. Assessment of root perforation within simulated internal resorption cavities using cone-beam computed tomography. J Endod. 2015;41(9):1520–3.
45. Hou B. Role of the operating microscope in diagnosis and treatment of endodontic diseases. Zhonghua kou qiang yi xue za zhi = Zhonghua kouqiang yixue zazhi = Chin J Stomatol. 2018;53(6):386–91.
46. Liu M, Zhang Y, Sun P, Qiao Y, Pan K. Endodontic treatment of the mandibular first molar with six root canals: a case report and literature review. Exp Ther Med. 2022;24(6):1–6.
47. Olbertz J, Braguini AP, Vitali FC, Dos Santos JD, Martins HC, Régis JR, *et al.* Influence of age and experience with magnification on locating the second mesiobuccal canal in maxillary first molars: a preliminary study. Aust Endod J. 2022. https://doi.org/10.1111/aej.12729.
48. Del Fabbro M, Taschieri S. Endodontic therapy using magnification devices: a systematic review. J Dent. 2010;38(4):269–75.
49. Kim H-J, Yu M-K, Lee K-W, Min K-SJ. Surgical management of an accessory canal in a maxillary premolar: a case report. Restor Dent Endod. 2019;44(3):e30–6.
50. Duarte MAH, Marciano MA, Vivan RR, Tanomaru Filho M, Tanomaru JMG, Camilleri J. Tricalcium silicate-based cements: properties and modifications. Braz Oral Res. 2018;32:e70.
51. Eskandari F, Razavian A, Hamidi R, Yousefi K, Borzou S. An updated review on properties and indications of calcium silicate-based cements in endodontic therapy. Int J Dent. 2022;2022:1–19.
52. Bendyk-Szeffer M, Łagocka R, Trusewicz M, Lipski M, Buczkowska-Radlińska J. Perforating internal root resorption repaired with mineral trioxide aggregate caused complete resolution of odontogenic sinus mucositis: a case report. J Endod. 2015;41(2):274–8.
53. Nunes E, Silveira FF, Soares JA, Duarte MA, Soares SM. Treatment of perforating internal root resorption with MTA: a case report. J Oral Sci. 2012;54(1):127–31.
54. Acharya S, Gurunathan D, Sahoo D, Singh B, Sahoo A, Acharya S. Comparative evaluation of the antimicrobial activity of NeoPutty MTA and modified NeoPutty MTA: an in vitro study. J Int Soc Prev Community Dent. 2023;13(6):493–9.

Publisher's Note