International Journal of Science Academic Research
Vol. 07, Issue 03, pp.564-566, March 2026
Available online at http://www.scienceijsar.com
ISSN: 2582-6425

Research Article

RESEARCH ADVANCES IN CLASSIFICATION AND TREATMENT OF TOOTH INCLUSION

[1, 2, 3, *]Zi-Hao Li, [3]You-Yue Wang, [2, 3]Zhi-Qiang Feng and [2, 3]Xiao-Zhen Zhan

[1]Science and Education Office, The First Affiliated Hospital of Jinan University, Guangzhou 510630, People's Republic of China
[2]Hospital of Stomatology, The First Affiliated Hospital of Jinan University, Guangzhou 510630, People's Republic of China
[3]School of Stomatology, Jinan University, Guangzhou 510632, People's Republic of China

Received 17th January 2026; **Accepted** 25th February 2026; **Published online** 27th March 2026

Abstract

Tooth invagination is a dental developmental anomaly caused by excessive folding or localized hyperplasia of the enamel organ, resulting in its penetration into the dental papilla. Due to the complex anatomical structure and root canal morphology typically associated with tooth invagination, its treatment presents significant challenges. The application of new technologies such as cone-beam computed tomography (CBCT), root canal microscopic techniques, and 3D printing has played a crucial role in the diagnosis and treatment of tooth invagination. This review examines the etiology, prevalence, classification, treatment approaches, and application of novel technologies in diagnosing and managing tooth enamel hypoplasia, aiming to provide clinical guidance for its management.

Keywords: Tooth intrusion, Oehlers classification, Root canal microscope, 3D printing.

INTRODUCTION

Dens invaginatus (DI) is a morphological abnormality among congenital dental developmental anomalies. It likely arises during the early stages of tooth development, specifically during proliferation and morphogenesis[1,] due to excessive folding or localized overproliferation of the ameloblasts, which invade the dental papilla. Clinically, it is generally classified into several manifestations: abnormal root surface grooves, abnormal lingual cusps, and teeth-within-teeth. In DI, enamel folds into the dentin, creating a "funnel-shaped" invagination that traps food debris and bacteria [2.] This predisposes the tooth to caries, potentially leading to root canal infection, pulp necrosis, impaired root development, or apical periodontitis with destruction of periapical tissues. This condition has a low incidence rate, and the complex anatomical structure and root canal morphology of affected teeth present significant treatment challenges. However, the emergence of new equipment and technologies such as cone-beam computed tomography (CBCT), root canal microscopes, and 3D printing has provided substantial assistance in treating dental folds. This review examines the etiology, incidence, classification, treatment approaches, and application of new technologies in diagnosing and managing impacted teeth, aiming to provide clinical guidance for deep impaction (DI) management.

Etiology and Incidence

The exact causes and pathogenesis of dental inclusions remain controversial and incompletely understood. They may be associated with multiple factors including trauma, bacterial infection, psychological factors, and external stimuli. Additionally, genetic factors play a significant role; studies have identified mutations in the PAX9, KIF4A, and RUNX2 genes as contributors to dental inclusion anomalies[3].

Corresponding Author:** ***Zi-Hao Li,
Science and Education Office, The First Affiliated Hospital of Jinan University, Guangzhou 510630, People's Republic of China.

The incidence of tooth retraction is relatively low, with significant variation in reported rates among different studies[4.] Literature reports indicate a prevalence ranging from 0.04% to 10.00%[5], making it clinically uncommon. Tooth retraction can occur in both deciduous and permanent dentition, with a higher prevalence in permanent teeth[6]. Among permanent teeth, maxillary lateral incisors exhibit the highest incidence at approximately 90%[7], followed by maxillary central incisors, while other tooth positions rarely show this condition. In deciduous teeth, it primarily affects deciduous molars[1]. No association has been found between tooth retraction occurrence and age or gender [7]. It typically presents symmetrically, with a bilateral incidence rate of approximately 43% **Error! Reference source not found.**. Therefore, when a dens invaginatus is clinically observed on one side, clinicians should examine the corresponding tooth on the opposite side.

CLASSIFICATION OF DENS INVAGINATUS

Clinically, multiple classification systems exist for DI. However, the most widely adopted classification internationally is that proposed by Oehlers in 1957. This classification divides DI into two major categories based on anatomical features, histopathology, and radiographic findings: coronal dens invaginatus (CDI) and radicular dens invaginatus (RDI). CDI results from invagination of the ameloblasts, with the invagination originating from the coronal side at the cemento-enamel junction (CEJ). while the radicular variant results from invagination of the Hertwig's epithelial root sheath, originating from the root side of the cemento-enamel junction [7-10]. Crown-type RDI can be further classified into three subtypes based on invagination depth and relationship with periapical tissues: Type III involves penetration through the root into the periodontal tissues. Type III can be further subdivided into Type IIIa, where the defect forms a lateral opening in the root and communicates with the periodontal tissues, and Type IIIb, where the defect traverses the entire root, forming a pseudorapid at the apical region and connecting with the periodontal tissues. Currently, the concept of RDI has

been superseded by the definition of malformed root surface fissures[11]. Research indicates that according to Oehlers' classification, Type I is the most common, accounting for approximately 69.8% to 93.8% of cases, Type II accounts for about 3.1% to 26.6%, and Type III is relatively rare, representing approximately 3.0% to 12.5% [1112].

DIAGNOSIS AND TREATMENT METHODS FOR TOOTH RECESSION

Diagnostic Methods for Tooth Recession

In less severe cases, patients with tooth recession typically exhibit no obvious subjective symptoms, often presenting only as morphological changes. Most cases are incidentally discovered during routine dental examinations. As these teeth are more susceptible to trauma or external stimuli, clinical symptoms such as pain or discomfort in the affected area may develop as the condition progresses[14]. Clinically, dentists can visually inspect the tooth for abnormal contours and use a probe to assess for penetration or an embedded sensation. If no obvious surface depression is visible, methylene blue staining may aid in early detection of lesions [15]. However, due to the complex morphology of tooth retraction and the variability among individual cases, clinical examination alone cannot definitively determine the classification or specific circumstances of tooth retraction. Therefore, imaging studies such as radiographs or CBCT are necessary to better and more comprehensively understand the actual condition of tooth retraction.

Treatment Methods for Tooth Retraction

The treatment goal for DI is to preserve the vital pulp and retain the affected tooth [16]. In the early stages of Type III intrusion, extraction was the primary treatment approach [17]. By the 1970s, Grossman [18] proposed replacing extraction with root canal therapy (RCT). Based on his reported case series, RCT demonstrated excellent outcomes for treating intrusion. Today, RCT is the recommended primary treatment for dental intrusion. Treatment plans for DI typically require individualized approaches based on classification type, severity of intrusion, pulp and periapical tissue infection status, and root apex development [19]. For Type I intrusion, the primary goal is eliminating the surface depression, with preventive filling being the preferred method. This can be achieved using fissure sealants or flowable composite resin. For Type II enamel hypoplasia, if the depressed area shows caries without pulp involvement, the defect should be removed followed by direct or indirect pulp capping. If caries has infected the pulp, root canal therapy is indicated[20]. Type III tooth retraction, being connected to periodontal tissues, is prone to combined periodontal-pulp pathology. Treatment should integrate ultrasonic technology, microscopic root canal therapy, and materials like trioxide mineral aggregates or novel bioceramics[16]to thoroughly remove infected material while appropriately preserving tooth structure. The complex anatomy of impacted teeth often leads to unpredictable treatment outcomes and significantly increases therapeutic difficulty, posing a major challenge for clinicians. The emergence of new equipment and technologies such as cone-beam computed tomography (CBCT), root canal microscopes, and 3D printing will help improve the diagnostic rate and treatment success rate of DI [21].

APPLICATION OF NEW TECHNOLOGIES IN THE DIAGNOSIS AND TREATMENT OF INTRA-DENTALINCISIONS

A thorough preoperative understanding of the affected tooth's anatomy and root canal morphology, combined with precise pulp exposure during surgery, standardized procedural protocols, and exceptional clinical technique, are critical to the success of root canal therapy. However, unlike conventional root canal therapy, tooth intrusion often presents with abnormal anatomical structures and atypical root canal morphology. Relying solely on clinical examination by the dentist and freehand manipulation based on experience frequently fails to achieve optimal therapeutic outcomes. Therefore, the assistance of new technologies and materials is essential to enhance treatment success rates and improve prognosis.

Application of Cone-Beam Computed Tomography (CBCT) in Diagnosis and Treatment of Tooth Intrusion

Cone-beam computed tomography (CBCT) in oral and maxillofacial dentistry differs from previously prevalent panoramic or periapical radiographs. These traditional two-dimensional images suffer from low resolution and susceptibility to overlapping tooth root or alveolar bone artifacts [22]. CBCT overcomes these limitations, particularly for specific tooth anomalies. CBCT serves as a valuable diagnostic tool, providing coronal, sagittal, axial, and 3D images that display tooth and root canal morphology from multiple angles. This enables clinicians to gain clearer and more comprehensive insights into root canal number and configuration [23], holding significant importance for diagnosing tooth intrusion. Early diagnosis and treatment of impacted teeth are essential for achieving optimal outcomes. Therefore, as CBCT becomes increasingly widespread, it should be adopted as a necessary adjunctive examination for diagnosing and treating impacted teeth in clinical practice [24].

Application of the Root Canal Microscope in Diagnosing and Treating Intra-dental Fractures

Microscopic root canal therapy is a treatment approach utilizing high-magnification microscope technology [25]. Thorough removal of infected material is critical for successful root canal treatment. However, teeth with intra-dental fractures differ from normal teeth, featuring complex anatomical structures and variable root canal morphology. This makes conventional root canal treatment relying solely on experience and tactile sensation challenging to achieve optimal outcomes. The root canal microscope provides ample illumination for the procedure, magnifying the root canal area [26] and enhancing the clarity of the surgical field. This allows the dentist to operate under direct visualization, thoroughly removing diseased tissue within the root canal while also reducing the incidence of complications such as root canal omissions or lateral perforations.

Application of 3D Printing Technology in the Diagnosis and Treatment of Dental Enclaves

3D printing technology can replicate affected teeth, allowing clinicians to observe tooth structure more intuitively and comprehensively. Additionally, it enables the design of 3D guides that aid in accurately locating and preparing complex root canal pathways [27], effectively removing infected material

from root canals, preventing treatment complications, and maximizing preservation of healthy tooth structure while maintaining the tooth's resistance [28]. Although challenges such as higher costs and complex fabrication processes remain, its distinct advantages are expected to open broad application prospects in the future.

CONCLUSION

The complex anatomy and diverse root canal morphology of impacted teeth necessitate personalized treatment plans tailored to individual cases. While CBCT, microscopic endodontic techniques, and 3D printing have enhanced treatment success rates, a preventive approach remains paramount. Early detection and preventive therapy can halt the progression of pulp pathology in impacted teeth and avoid complex endodontic procedures.

Competing interests: The authors declare that there are nocompeting interests regarding the publication of this paper.

REFERENCES

1. Barbosa Brandão EC, Aguiar Ribeiro A, Alto Seabra LM. Rare Condition of Dens Invaginatus in a Maxillary Primary Molar and a Birooted Maxillary Primary Canine diagnosed during Routine Examination. Int J Clin Pediatr Dent. 2017 Apr-Jun;10(2):193-195.
2. Hülsmann M, Hengen G. Severe dens invaginatus malformation: report of two cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1996 Oct;82(4):456-8.
3. Yan Nana, Du Qin. Recent Advances in Research on Genetic Factors Associated with Dental Developmental Structural and Morphological Abnormalities[J]. Journal of Practical Hospital Clinical Medicine, 2023, 20(2): 127–131.
4. Wang Ying, Zhang Hong, Du Aobo, Zhang Zhimin. Recent Advances in Classification Criteria and Treatment Concepts for Dental Retraction [G]. Journal of Stomatology, 2021, 41(10): 942-946.
5. Zhang P, Wei X. Combined therapy for a rare case of type III dens invaginatus in a mandibular central incisor with a periapical lesion: a case report [J]. J Endod, 2017, 43(8): 1378-1382.
6. Bansal AV, Bansal A, Kulkarni VK, et al. Dens invaginatus in primary maxillary molar: a rare case report and review of literature[J]. Int J Clin Pediatr Dent, 2012, 5(2): 139-141.
7. Hao Yifan, Feng Jing, Yan Hongjing, Si Chao, Gong Bojuan, Li Zhimin. Advances in the Diagnosis and Treatment of Tooth Retraction [J]. Shandong Medicine, 2021, 61(33): 103–107.
8. Gallacher A, Ali R, Bhakta S. Dens invaginatus: diagnosis and management strategies, Br Dent J, 2016, 221 (7), 383-387.
9. Oehlers FAC. Dens invaginatus (Dilated composite odontome) I Variations of the invagination process and associated anterior crown forms[J].Oral Surg Oral Med Oral Pathol, 1957,10(11)：1204 -1218.
10. Oehlers FAC. The radicular variety of dens invaginatus [J]. Oral Surg Oral Med Oral Pathol, 1958,11 (11):1251-1260.
11. Goon W W, Carpenter W M, Brace N M,et al. Complex facial radicular groove in a maxillary lateral incisor[J].J Endod,1991,17(5):244-248.
12. Ricucci D, Milovidova I, Siqueira J F. Unusual location of dens invaginatus causing a difficult-to-diagnose pulpal involvement. J Endod, 2020, 46（10）：1522-1529.
13. Zhu J, Wang X, Fang Y, et al. An update on the diagnosis and treatment of dens invaginatus. Aust Dent J, 2017, 62 (3), 261-275
14. McKinney R, Olmo H. Developmental Disturbances of the Teeth, Anomalies of Structure. In: StatPearls. Treasure Island (FL): StatPearls Publishing; July 17, 2023.
15. Wu Lei, Xie Siming, Wang Dongjun, Duan Jianmin. A Case of Type II Tooth Retraction Complicated by Apical Periodontitis [J]. Journal of Operative Dentistry, Endodontology, and Periodontology, 2015, 25(12):762.
16. Zhang Chen, Hou Benxiang. A Re-examination of the Diagnosis and Treatment of Tooth Retraction [J]. Chinese Journal of Stomatology, 2020, 55(5):302-308.
17. Xu Lijie. Two Cases of Non-surgical Treatment for Tooth Retraction [J]. Journal of Practical Stomatology, 2020, 36(1):129-131.
18. Grossman LI. Endodontic case reports [J]. Dent Clin North Am, 1974, 18(2):509-527.
19. Siqueira JF Jr, Rôças IN, Hernández SR, et al. Dens invaginatus: Clinical implications and antimicrobial endodontic treatment considerations. J Endod. 2022; 48(2):161-170.
20. Wang Yanhua. Two cases of dens invaginatus treatment assisted by a root canal microscope [J]. Journal of Practical Stomatology, 2016, 32(4):589-592
21. Gu Xueying, Quan Jiamiao, Li Song. Anatomical Morphology and Treatment Options for Tooth Retraction [J]. Prevention and Treatment of Oral Diseases, 2019, 27(10): 662-666.
22. Jiang Yiyun, Wu Daming, Mei Yufeng. Advances in the Application of Oral and Maxillofacial Cone-Beam CT in Dental Anatomy [J]. Stomatology, 2017, 37(6): 558-561.
23. Shi Xiong, Li Shengjiao, Zhou Jianping, Zhang Li, Li Bailong. Application of Cone-Beam CT in the Diagnosis of Tooth Retraction [J]. Journal of Oral and Maxillofacial Surgery, 2019, 29(3):164-168.
24. Tian Jia, Chen Gang, Wang Shengguo. Advances in the Clinical Treatment of Dental Inclusion [J]. Modern Medicine and Health, 2023, 39(9): 1551-1554.
25. Li Juan, Yuan Yifang, Jia Jie, Ren Chenfu. Comparison of the Efficacy of Microscopic Root Canal Therapy and Conventional Root Canal Therapy for Pulpitis [J]. Henan Medical Research, 2023, 32(20): 3739-3741.
26. Liu Jing, Yuan Yuan. Observation on the Efficacy of Microscopic Endodontic Treatment in Complex Root Canals [J]. Electronic Journal of General Dentistry, 2015, 2(12): 36-37.
27. Wu Tong, Bai Yuhong, Li Ren, Liang Yaping, Ma Yue. Advances in the Application of 3D Printing Technology in Endodontic Research [J]. Chinese Science and Technology Journal Database (Full-text Edition): Medicine and Health, 2022(1):0191-0194.
28. Wang Hong, Zhang Qianqian, Li Xuguang, Deng Yongqiang, Wang Rongrong. A Case of Oehlers Type II Intraoral Depression Treated with a 3D-Printed Digital Guide for Root Canal Localization [J]. Journal of Practical Stomatology, 2021, 37(3): 428-431.

****