Case Report

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Dentistry Section

Three Dimensional Analysis of Root Development and Bone Formation in an Immature Non Vital Permanent Molar using Regenerative Endodontic Procedure: A Case Report

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ABSTRACT

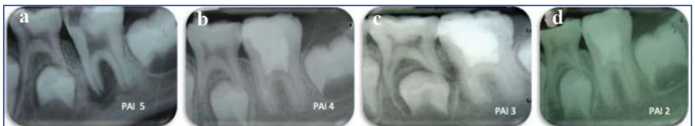
The Regenerative Endodontic Procedure (REP) is one of the latest biological procedures for successfully treating immature non vital teeth. Treating non vital immature teeth in children with associated bone resorption poses a challenge. In the present case, a 10-year-old male patient presented with an immature pulpally involved right permanent first molar, exhibiting a periapical radiolucency measuring 2×3.2×10.5 mm (distal root) and 4.4×5.2×10.5 mm (mesial root). The molar was non-surgically treated using a minimally invasive REP approach, aiming for anatomical healing and root completion. Mineral Trioxide Aggregate (MTA) was applied over a blood clot used as a scaffold. The radiolucency decreased significantly to a size of 0.9×1.3×0.2 mm (distal root) and 1×0.4×0.2 mm (mesial root). Continuous root formation was also observed, resulting in complete resolution of the Apical Bone Defect (ABD). The mesial and distal roots progressed from Nolla stage 8 (2/3rd of root formation) to Nolla stage 9 (root formation complete) over a twelve-month period. Three-dimensional (3D) analysis was employed to explain pathosis and the healing of lesions from every aspect. The present case demonstrates that REP may be the treatment of choice for managing non vital immature permanent posterior teeth with severe ABD in a paediatric patients, particularly when the surgical approach is contraindicated due to the presence of other developing structures. Furthermore, long-term follow-up is required, and the type of healing and root completion may vary depending on the stage of root formation, disinfection, and coronal seal achieved.

Keywords: Computed tomography, Immature tooth, Regeneration

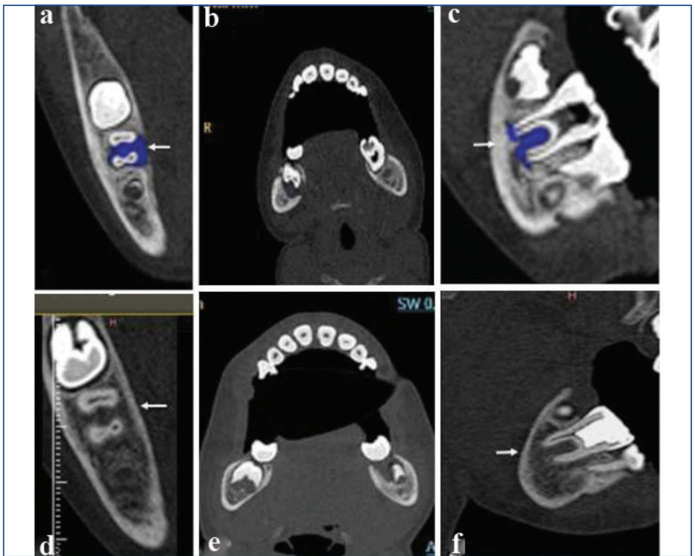
CASE REPORT

A 10-year-old male presented with a deep carious lesion in the right permanent mandibular first molar, involving the pulp. Over the course of nearly a year, he experienced occasional mild soft tissue swelling and dull pain, which resolved on its own. At the time of reporting, he had no swelling or pain. A periapical radiograph was taken using a Kodak RadioVisioGraph 5200 sensor (Carestream Dental), revealing a carious lesion radiolucency infiltrating the pulp space. The roots exhibited open apices, with Nolla stage 8 root development in the mesial root and Nolla stage 7 in the distal root [Table/Fig-1a]. All roots displayed bone rarefaction and periapical radiolucency with an irregular border, encompassing half of the mesial root and extending to the furcation area. A 3D analysis of the first molar was performed, generating transverse, axial, and sagittal sections [Table/Fig-2a-c]. Volumetric analysis of the lesion was also conducted [Table/Fig-3]. The images depicted a Cone-beam Computed Tomography-Periapical Index (CBCT-PAI) 5+ D (4.4×5.2×10.5 mm) lesion size, along with apical destruction of cortical bone. Root canal length, dentine thickness, root canal lumen, bone margin, and periapical ABD were assessed and summarised in [Table/Fig-4]. The final diagnosis was pulpally involved immature non-vital molar with apical periodontitis and bone resorption.

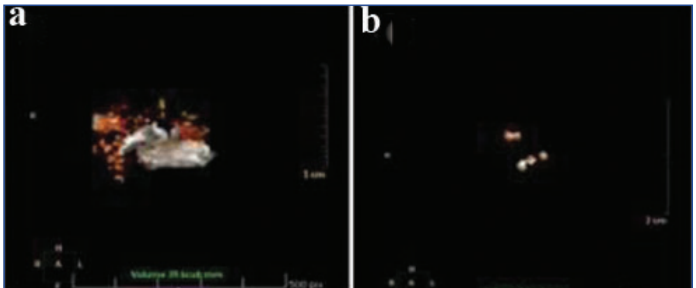
The REP was planned using a cell-free approach, employing a blood clot as a scaffold. The treatment adhered to the guidelines set by the American Association of Endodontics (AAE) [1]. The procedure,



[Table/Fig-1]: A 2D Periapical Index Score (PAI) on consecutive visits over one year period of REP. (a) Preoperative radiograph; (b) At three-month follow-up; (c) At six-month follow-up; (d) Recall radiograph one year postoperative.



[Table/Fig-2]: A 3D image obtained pre and postoperative (1 year) after REP in permanent first molar (marked in blue; white arrows) respectively in transverse (a,d); axial (b,e); and sagittal; (c,f) sections (0.5 mm thickness).



[Table/Fig-3]: A 3D image showing marked volumetric reduction in size of lesion: (a) Preoperatively; (b) Postoperatively after one year.

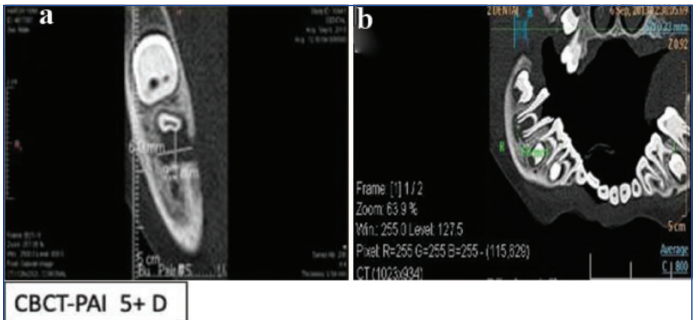
Root	Preoperative			Postoperative		
M1	7.8 mm			8 mm		
M2	8.6 mm			9.1 mm		
Distal	7.6 mm			8.6 mm		
Dentin						
M1	1.3 mm	0.7 mm	0.7 mm	1.2 mm	1.1 mm	1.5 mm
M2	1.7 mm	1.3 mm	0.8 mm	1.4 mm	1.1 mm	0.9 mm
Distal	1.7 mm	1.3 mm	0.8 mm	1.3 mm	0.9 mm	0.9 mm
Lumen of root canal						
M1	0.8 mm	0.7 mm	0.8 mm	0.9 mm	filling	0.9 mm
M2	0.4 mm	0.7 mm	0.8 mm	0.6 mm	0.4 mm	0.5 mm
Distal	0.4 mm	0.5 mm	0.6 mm	0.6 mm	0.6 mm	0.6 mm
Defect size						
Distal	2×3.2×10.5 mm			0.9×1.3×0.2 mm		
M1	2.6×3.2×10.5 mm			0.9×1.8×0.2 mm		
M2	4.4×5.2×10.5 mm			1×0.4×0.2 mm		
CT.No	30-74			150-250		
Bone margin	2-5 mm			5-6 mm		

[Table/Fig-4]: Measurements: the root canal length, dentine thickness, lumen of root canal, bone margin and peri-Apical Bone Defect (ABD) measured using the computed tomography both preoperative and postoperative after one year follow-up. M: Mesial

along with its risks and benefits, was explained to the parents, and written informed consent was obtained.

Following one month of disinfection therapy using calcium hydroxide paste, the molar was treated again under a rubber dam. Apical bleeding was induced by gently irritating the tissue with a size 15K file in all canals. Once a blood clot formed, MTA was carefully placed over the clot in the coronal canal space. White MTA (ProRoot® et al., Tulsa Dental, Tulsa, OK) was applied over the blood clot, followed by glass ionomer (GC Fuji IX, Tokyo, Japan), and composite (3M, St. Paul, Minnesota, USA) to seal the access cavity.

During a three-month follow-up visit, the patient was asymptomatic [Table/Fig-1b]. The radiograph displayed evidence of healing and regression in radiolucency, as well as progress in tooth maturation [Table/Fig-1c]. After one year, both the mesial and distal root canals demonstrated maturation to Nolla stage 9 and bony healing [Table/Fig-1d]. Follow-up radiographs were taken [Table/Fig-2d-f,3b], revealing healing from CBCT-PAI 5+D (4.4×5.2×10.5 mm) [Table/Fig-5a, b] to CBCT-PAI 1 (1×0.4×0.2 mm). This indicated repair and anatomical healing with organised hard tissue (radiopaque) formation [2]. The presence of periodontal ligament space in the healed area indicated anatomical healing. Three-dimensional measurements of root canal length, dentine thickness, root canal lumen, bone margin, and periapical ABD were taken, compared, and summarised in [Table/Fig-4]. The follow-up demonstrated complete healing with root and bone formation.



[Table/Fig-5]: Defect size maximum score measured on CBCT: (a) mesiodistal diameter; (b) diagonal diameter.

DISCUSSION

The treatment of an immature, non-vital, carious infected molar with apical pathosis presents several challenges for a clinician [3]. Conventional apexification treatment of an immature molar tooth poses challenges to the tooth's longevity [4]. The use of blood clot in REP is now an established treatment for non-vital immature teeth [5,6]. However, REP may be challenging and unpredictable in severe cases of periapical pathology with significant bone resorption. It requires long-term follow-up, and the type of healing and root completion varies depending on the stage of root formation, disinfection, and achievement of a coronal seal.

In the present case, clinical signs and symptoms of radiolucent root size lesions in a permanent immature molar were reversed after cell-free REP. Three-dimensional analysis revealed standard resolution and complete healing of resorptive lesions, along with continued root formation until root completion. This demonstrates the promising success of REP in healing non-vital molars with severe bone defects. Disinfection, stem cells of the apical papilla, and blood clots as scaffolds have been reported to be responsible for pulp regeneration, dentin production, and root development. Recent literature reports cases treated with REP showing long-term success and healing with hard tissue.

For instance, Yang J et al., chose REP as a conservative treatment for immature dens invaginatus with a large periapical lesion, leading to the elimination of periapical pathology and closure of the open apex [7]. Kim HC et al., demonstrated the success of REP through a single-visit pulp revascularisation procedure in teeth with dental anomalies, without the use of specific intracanal medicaments [8]. Lui JN et al., showed the clinical effectiveness of REP in a tooth with resistant infection, leading to the formation of a reparative phenotype confirmed by histologic examination [9]. Additionally, Petel R and Noy AF demonstrated the long-term survival of a hypoplastic immature permanent canine treated with successful REP, with a follow-up of 13 years [10].

The use of three-dimensional radiographic evaluation in the present case allowed for a close inspection of the buccal and lingual cortical plates, revealing complete healing of the resorptive lesions. This three-dimensional healing analysis enables clinicians to confidently select minimally invasive, biologically based endodontic treatment options like REP for severe cases of immature molar endodontics. Three-dimensional radiographic evaluation proves to be quantitatively valuable in measuring coronal-apical, mesiodistal, and buccolingual bone loss/fill [11,12]. It also aids in a better understanding the root canal morphology, showing regular anatomical root formation post-treatment [13,14]. Researchers have proposed a Computed Tomography (CT) protocol with a reduced radiation dose using various modifications [15]. However, considering the additional cost associated, its usage should be limited based on necessity.

CONCLUSION(S)

Cell-free REP using blood clot can be the treatment of choice to promote anatomical bone healing, continued root formation, and resolution of signs and symptoms for the treatment of non-vital, immature molars with severe apical periodontitis. Clinicians can consider REP as the treatment of choice for the management of non-vital, immature posterior teeth with large periapical lesions and apical bone pathology.

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