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Single-Step Regenerative Endodontic of an Immature Necrotic Maxillary Incisor using Calcium Hydroxide: A 3-Year Follow-Up

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ABSTRACT

Regenerative endodontic is a treatment procedure that promotes the apexogenesis of a necrotic immature permanent tooth. This case report presents the successful management of a 9-year-old anxious Malay male patient with a necrotic, immature maxillary right central incisor via a regenerative endodontic technique. The root canal was not mechanically cleaned during the treatment period but was irrigated with normal saline. The calcium hydroxide compound was used for disinfection without inducing blood clot formation. A clinical and radiographic follow-up was performed for thirty-six months where the tooth was considered asymptomatic, vital, and with a complete root formation.

1. BACKGROUND

Treatment of an immature permanent tooth with necrotic pulp has always been a challenge in endodontics. Treatment options include apexification procedures using calcium hydroxide to induce the formation of a calcific barrier at the apex or placement of mineral trioxide aggregate plug (Wei et al., 2022) These techniques can achieve clinical success, but do not allow further root development and maturation and leave the tooth susceptible to fracture (Raddall et al., 2019). Nowadays, there have been introduced better

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alternatives to conventional treatment of immature permanent teeth exhibiting periapical pathology offered by regenerative endodontic procedures (Sabeti et al., 2023; Wei et al., 2022).

Regenerative endodontic is a treatment attempt at preserving the vitality of remaining dental pulp stem cells and mesenchymal stem cells of the apical papilla resulting in the completion of root maturation such as elongation of root length with an increase in root dentin thickness (Sabeti et al., 2023; Eldessoky et al., 2023). A highly vascularized and a conjunctive rich living tissue is generated by periodontal cells and is able to colonize the available pulp space (Lim et al., 2021). That will lead to the formation of odontoblasts by the differentiation of apical stem cells and induce an apposition of hard tissue (Eldessoky et al., 2023). The treatment resulted in the elimination of clinical symptoms and resolution of apical periodontitis (Diogenes & Ruparel 2017). Regenerative endodontics involves a two- or multi-step procedure. The first visit focuses on disinfection of the pulp canal (AAE 2022; Sabeti et al., 2023; Wei et al., 2022). The second appointment is centered on removing the medicament, the release of growth factors by blood clot induction, sealing the tooth by placing a pulp space barrier such as mineral trioxide aggregate, and a permanent coronal seal (Eldessoky et al., 2023; Wikström et al., 2022).

The primary goal of regenerative endodontics is the elimination of symptoms and the evidence of bony healing (Sabeti et al., 2023; Wei et al., 2022). The secondary goal is to increase root wall thickness and length. The tertiary goal is a positive response to vitality testing (Eldessoky et al., 2023). For disinfection, the use of triple antibiotic and calcium hydroxide was effective to eradicate polymicrobial flora present in the root canal system (Diogenes & Ruparel 2017). It was suggested that the triple antibiotic paste was composed of ciprofloxacin, metronidazole, and minocycline (Wikström et al., 2022; Diogenes & Ruparel 2017). There are concerns about antibiotic resistance, and hypersensitivity and the medication may negatively influence growth factor release from dentine, thus the use of calcium hydroxide had been recommended. Calcium hydroxide has antibacterial properties in view of the high pH of calcium hydroxide inhibits bacterial growth that may prevent the development of vital tissue (Sabeti et al., 2023; Wei et al., 2022).

The aim of this report is to describe a conservative approach to attempt regenerative endodontic in the immature maxillary central incisor with periapical involvement in a 9-year-old boy after a traumatic injury using copious irrigation of normal saline with no instrumentation and dressing of calcium hydroxide compound for disinfection. The case was observed for up to three years and root development, as well as tooth vitality, was confirmed.

2. CASE DESCRIPTION

A 9-year-old anxious boy was referred to the Paediatric Dental Specialist Clinic, UiTM Campus Sungai Buloh for the management of a fractured upper anterior permanent tooth. The patient had two histories of trauma, slipped, and fell at the swimming pool and school in the year 2018. He went to the private clinic the next day after the first episode of trauma and was recommended to seek dental treatment at a specialist centre. No loss of consciousness and no vomiting post-trauma. His medical history was not significant. The clinical manifestation of the patient includes fractured of the mesiopalatolabial crown of the upper right central incisor (#tooth 11) without pulpal exposure, gingival inflammation, tenderness to percussion, and grade I mobility. An electric pulp test and cold stimuli confirmed that tooth 11 was non-responsive. Radiographic examination revealed an immature open apex measuring 1.5 mm in diameter (Fig. 1(A)). Root fracture was not evident. A diagnosis of subluxation with an uncomplicated crown fracture was made and tooth 11 was build-up with composite resin. On the second episode of trauma, chipped-off on tooth 21 was presented and a diagnosis of uncomplicated crown fracture was made, and it was restored with composite resin (3M™ Filtek™ Universal Restorative). Twelve months after the initial visit, gingival swelling and sinus formation occurred on tooth 11, and a diagnosis of apical periodontitis with a sinus tract

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was made. A sinus tract was found apically on the mesiolabial aspect of 11. Thus, root canal treatment was initiated. Proper isolation was maintained, a copious amount of normal saline was used for irrigation and no instrumentation was performed. Calcium hydroxide compound was placed as intracanal disinfection, however, the root canal was not mechanically cleaned during the treatment period. The access cavity was sealed with kalzinol followed by glass ionomer cement as a temporary filling. After 1 month, the non-setting Calcium hydroxide was removed, and the canal was left empty. There was a positive response to electric pulp testing and cold test after 21 months of review. After this period, the sinus tract disappeared. The upper part of the canal was sealed with a triple barrier in the form of Biodentin, GIC (Shofu Dental Supplies (Shanghai Co., Ltd, China), and Composite resin (3M™ Filtek™ Universal Restorative). The tooth was in good condition without root fracture, obvious discoloration, or other problems. Radiographic examination at 30 and 36 months after the initial treatment confirmed the closure of the apex and thickening of the root wall (Fig.1 (G&H)).

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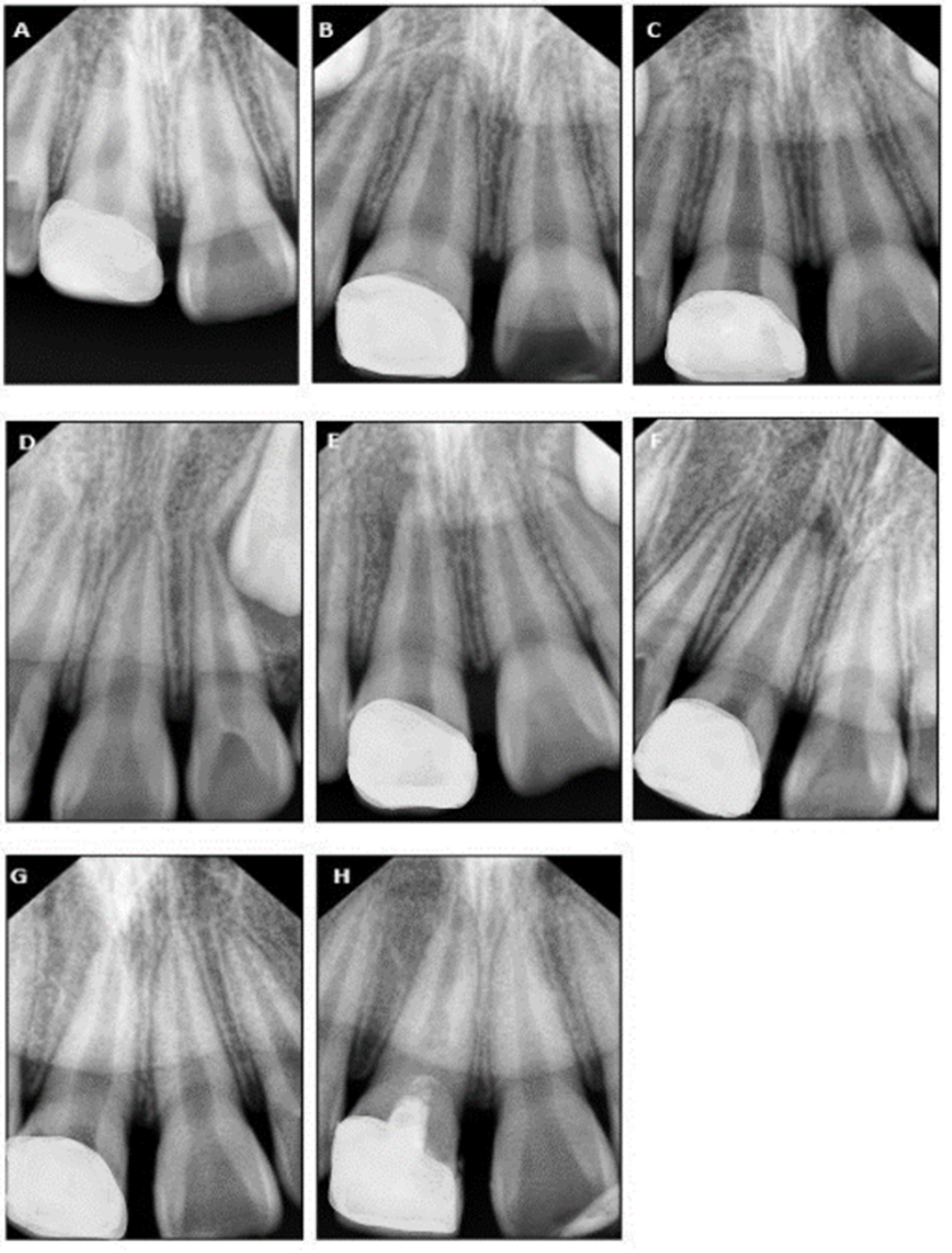

Fig. 1. (A): Pre-operative, (B): 11 months after the injury and single visit regeneration was initiated, (C): Follow-up radiographs 5 months, (D): the periapical radiolucency has resolved 9 months after regenerative endodontic, (E): 13 months (F): 21 months, (G): 30 months, apex closure was observed after regenerative endodontic (H): 36 months

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3. DISCUSSION

This case report illustrates the successful revascularization treatment of a traumatic right maxillary central incisor that had chronic apical periodontitis. The time frame for this report took three years from the date of the initial examination until the final follow-up radiograph was taken. In this case, we decided to use the regenerative endodontic approach instead of the apexification technique because of the potential to gain the benefits of root development and strengthening the root structure even in the presence of periapical pathology initially (Fang et al., 2018). Regenerative endodontic treatment provides a favorable alternative through the development of a longer and thicker root, thereby strengthening the roots against fractures and with the possibility of gaining vitality (Fang et al., 2018). Additionally, in young children with a large apical diameter greater than 1 mm radiographically, revascularization shows better results compared to apexification (Murray 2023; Lim et al., 2021).

In this study, we are using a single-visit regenerative endodontic technique which was originally introduced by Banchs & Trope (2004) (Banchs & Trope, 2004). As our patient was anxious during the dental procedure, single-visit revascularization can reduce the number of visits, promote patient compliance, and reduce the cost of treatment. The single-visit revascularization avoids the possibility of further bacterial contamination of the canal, avoids apical irritation, and focuses on preserving the remaining vital pulp tissue and mesenchymal stem cells of the apical papilla (Sabeti et al., 2023; Eldessoky et al., 2023). It is pivotal for the success of the revascularization procedure to maintain the viability of dental pulp stem cells and stem cells of the apical papilla that has a greater potential to rebuild the lost pulp tissue and continue the root maturation (Fang et al., 2018). Interestingly, stem cells of the apical papilla can survive pulp necrosis and can differentiate into secondary odontoblasts which can deposit dentin (Sabeti et al., 2023; Eldessoky et al., 2023). Thus, a less invasive and non-instrumentation approach aims to minimize irritation of the remaining vital pulp tissues or stem cells of the dental pulp and apical papilla of the canal and needs to be followed to preserve these essential stem cells (Murray, 2023; Marí-Beffa et al., 2017). After revascularization, this study revealed that the revascularized tooth regained vitality after 21 months. Over longer periods of evaluation, the tooth may generate a positive response due to the regeneration of stem cells (Fang et al., 2018).

Apart from that, multi-visit revascularization could be an alternative for teeth that present with total pulpal necrosis (Lim et al., 2021). In such circumstances, case selection is crucial when deciding which regenerative endodontic protocol is ideal based on pulpal condition. It is also important for the clinician to identify patients that report a sense of pain when the instrumentation using a file within the canal. This may indicate the presence of viable tissue within the canal. It is suggested that in these cases, the current technique can be beneficial prior to attempt a more invasive procedure (Murray 2023; Wikström et al., 2022). However, in cases of total pulpal necrosis, a more aggressive technique may be required to eradicate the bacteria in the canal system and periapical tissues (Murray, 2023; Marí-Beffa et al., 2017).

The revascularization protocol pointed out different methods for disinfecting necrotic immature including placing antimicrobial agents (triple antibiotic paste) or calcium hydroxide (Murray, 2023; Raddall et al., 2019). The complications of a mixture of antibiotics have been also reported such as crown discoloration, development of resistant bacterial strains, and allergic reaction (Murray, 2023; Marí-Beffa et al., 2017). Therefore, calcium hydroxide was promoted as this material has bactericidal effects disinfecting the root canal due to the high pH (Murray, 2023). The root canals then were filled with calcium hydroxide to the periapical area to neutralize lipopolysaccharide reduced by anaerobic bacteria and induce continued root formation (Marí-Beffa et al., 2017). Eradication of bacteria and necrotic tissue from the root canal system is the key factor in successful revascularization because the process will halt in the presence of infection (Marí-Beffa et al., 2017).

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As a result, the bacteria in the coronal pulp were presumably removed and allowing the vital, well-nourished apical pulp cells to proliferate (Staffoli et al., 2019). Calcium hydroxide is also capable of solubilizing bioactive molecules, including growth factors of the human dentin matrix, which, in turn, can stimulate pulp stem cells to differentiate into odontoblast-like cells, thus producing a tissue similar to dentin (Murray 2023; Raddall et al., 2019).

Nevertheless, Gúzman et al (2022) (Gúzman et al., 2022) reported that long-term calcium hydroxide as an intracanal dressing might increase the probability of root fracture. In the present study, we considered that the cytotoxic effect of calcium hydroxide was negligible as it was placed only in the coronal part of the canal. Apart from that, literature has reported that chlorhexidine irrigation might have cytotoxic effects on human cells and interfere with the attachment of dental papilla stem cells to the root canal walls (Yan et al., 2023). Thus, in this case, normal saline was used as an irrigant.

These prognostic factors such as good oral hygiene and excellent coronal sealing can optimize the chances of successful regenerative therapy (Yan et al., 2023). Eradication of bacteria and necrotic tissue from the root canal system is the key factor in successful revascularization because the process will halt in the presence of infection (Raddall et al., 2019). As a result, the bacteria in the coronal pulp were presumably removed and allowing the vital, well-nourished apical pulp cells to proliferate. Calcium hydroxide also is capable of solubilizing bioactive molecules, including growth factors of the human dentin matrix, which, in turn, can stimulate pulp stem cells to differentiate into odontoblast-like cells, thus producing a tissue similar to dentin (Raddall et al., 2019).

Maintenance of adequate and effective oral hygiene is crucial for the long-term success of regenerative therapy (Lin et al., 2022). Inadequate oral hygiene may induce the formation of biofilm causing inflammation of the soft and hard tissue (Eldessoky et al., 2023). On the other hand, coronal sealing is a key factor in the durability of the procedure as it helps consolidate the root canal treatment performed (Eldessoky et al., 2023). Hence, it would be necessary to first remove the bacterial challenge from the coronal pulp, leave the pulp space empty and finally provide a sufficient coronal seal to prevent added bacteria from entering the space provided (Lopes et al., 2021; Glynis et al., 2021). A long-term coronal seal in the present case was provided by placing a triple seal of Biodentin, followed by glass ionomer cement and composite resin. Biodentin sustains a high pH for extended periods and has exceptional marginal adaptation. This material significantly increases TGF- β 1 secretion from pulp cells which consequently induces odontoblast differentiation and mineralization (Glynis et al., 2021). Also, Biodentine biocompatibility with adjacent pulp tissue increased pulp cell proliferation and biomineralization was suitable for maintaining the vitality of dental pulp stem cells and creating a suitable environment for regeneration of the dental pulp (Glynis et al., 2021) which requires intervention to neutralize the bacterial invasion and disrupt the bacterial biofilm within the complex anatomy (Murray 2023; Fang et al., 2018).

In this patient, the 36-month recall clinical and radiographic examination was consistent with an immature tooth that had successfully regenerative endodontic after a subluxation injury, and an uncomplicated crown fracture associated with apical periodontitis. Although it is premature to generalize the treatment procedure in this report, regenerative endodontic in an immature tooth with periapical involvement was possible in this case. We suggest that the healing potential of the pulp tissue in young permanent teeth reported here merits further investigation.

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4. CONCLUSION

Key factors for a successful treatment outcome are careful case selection, the choice of medications for disinfection, excellent oral hygiene, and proper coronal sealing. This case shows that regenerative endodontic treatment can be successfully done using calcium hydroxide and this technique create a suitable environment for pulp regeneration and result in root maturation via regaining the vitality of the tooth. Treatment is considered successful if all unfavorable signs and symptoms have been removed and the roots develop satisfactorily.

Fig. 2. The follow-up photographs three years after revascularization

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CONFLICT OF INTEREST STATEMENT

All authors deny any conflict of interest in the management and reporting of this case.

AUTHORS' CONTRIBUTIONS

Dayang Fadzlina Abang Ibrahim, the first author, conceived, wrote, revised the article and provided the data for the case report and submitted the revised manuscript.

Norashikin Abu Bakar, a corresponding author, conceptualized the central research idea, provided the theoretical framework, anchored the review and revisions, and approved the article submission. All authors have critically reviewed the case report and are responsible for the content and the manuscript.

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