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Single-Step Apexification with Mineral Trioxide Aggregate (MTA) –Case Reports

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Abstract: *The completion of root development and closure of the apex occurs up to 3 years after the eruption of the tooth. The treatment of pulpal injury during this period provides a significant challenge for the clinician. The most commonly advocated medicament is calcium hydroxide, although recently considerable interest has been expressed in the use of mineral trioxide aggregate (MTA). We report a case with MTA were used successfully for one step apexification in teeth with open apex.*
Key words: *Immature teeth, one visit apexification, Mineral Trioxide Aggregate, monoblock, artificial barrier.*

I. Introduction

Dental trauma to the anterior dentition is common in the young adolescent patient . Prevalence estimates suggest that up to one-half of children, ages 5-18, will incur some type of dental injury during their school years. Also showed that the majority of dental trauma occurred before the age of 12 (86%)[1]. Trauma leading to complicated crown fractures and/or pulp necrosis can be a significant problem in this population due to incomplete root development commonly found in these teeth. An incompletely formed tooth is left with thin dentin walls highly susceptible to fracture .These thin-walled teeth also have a higher incidence of cervical root fracture which reduces the long-term restorative and overall prognosis of the tooth .[1,2]

Historically, treatment of these teeth has been limited to extraction or heroic endodontics. In the past, an effective treatment has been apexification with long-term calcium hydroxide treatment followed by obturation with gutta percha.[3] This treatment has been demonstrated repeatedly in the literature to be successful at resolving periapical lesions. However, this therapy requires many appointments and can take over 1 year to treat. In spite of the documented success of this treatment, calcium hydroxide apexification can still leave the tooth weakened with thin dentinal walls. Furthermore, there is evidence that this treatment allows the remaining tooth structure to be prone to fracture. With the advent of mineral trioxide aggregate (MTA), apexification could be completed predictably in one appointment. MTA has been advocated as a replacement for calcium hydroxide in apexification treatment [4, 5]. There has been concern that MTA may replicate the root weakening seen with calcium hydroxide due to a similarly alkaline pH. In a 2008 study looking at fracture resistance and histological finding in immature teeth treated with MTA, the roots of immature ovine incisors were not weakened . The teeth were filled with either calcium hydroxide or MTA from the apical end, so there was no access preparation. Teeth from each group, including an unrestored control, were fractured at 2 weeks, months and 1 year. MTA demonstrated the highest fracture resistance at 1 year. Histological analysis revealed a protein expression pattern unique to the MTA group that the authors hypothesized prevented destruction of the collagen matrix in the root dentin, thereby preventing loss of physical properties. [6, 7]

Following an apical MTA plug, these teeth are typically obturated with gutta percha. The gutta percha does not reinforce the tooth, still resulting in a weak root prone to fracture [7]. Recent developments in the management of traumatized, immature teeth, specifically a revascularization protocol, may soon become the standard of care for these cases, providing a possibility of physiologically mediated continued root formation [7]. However, with this therapy still in its nascent stage of development, the treating dentist is still left with a dilemma of managing these challenging cases. [7]

Surgical removal of tooth structure weakens the remaining tooth. Restorative dentistry removes coronal tooth structure, and weakens cusps and marginal ridges, increasing the likelihood of fracture as compared to a sound tooth .[7]

Arunpraditkul, et al (2009) compared the fracture resistance of coronal tooth structure with 4 walls versus 3 walls. a mean of 578 kg, 786 kg, and 785 kg for three walls (buccal, lingual and mesial wall missing, respectively). There was no significant difference between the 3-walled groups, but the 4-walled group was significantly different than the 3-wall groups ($p < 0.05$)[8]. Bader et al (2004) in their case control study on risk indicators for posterior tooth fracture demonstrated that a 10 percent increase in the relative volume of the restoration yielded a six-fold increase in likelihood of cusp fracture [9]. Their conclusion was dentinal support is the most important factor in reducing incidence of cusp fracture. Root canal therapy removes radicular tooth structure leaving the root more susceptible to fracture. Root fracture is the same concern that clinicians have with the immature tooth, but the clinical problem is amplified by the fact that many immature teeth have considerably less radicular tooth structure than a sound tooth that has undergone root canal therapy[9]. In 1992, Sornkul and Stannard, in their study evaluating the strength of roots before and after endodontic treatment demonstrated that preparation of the canal significantly weakened the root. Their experiment tested composite resin cores and two types of posts with respect to root strengthening ability. They concluded that three factors were important for preventing future root fracture: a) the amount of remaining tooth structure, b) the strength of the post/core material, and c) the bonding between the core material and dentin. The amount of remaining tooth structure was singled out as the most important factor of the three.[10]

Three techniques have been suggested to obturate an immature tooth, which involved the use of a root filling material without the induction of apical closure.[11,12]

_ Placement of a large gutta-percha filling or customized gutta-percha cone with sealer at the apex.

_ Placement of gutta-percha with sealer short of the apex.

_ Periapical surgery.

These techniques did not gain popularity since there was no physical apical barrier to facilitate obturation. However, two other techniques were reported which aimed to provide an apical barrier .[11.12]

_ Placement of calcium hydroxide to induce a mineralized apical barrier.

_ Placement of a biocompatible material such as dentinal chips against which a root filling could be placed.

Apexification can be defined as a 'method to induce a calcific barrier in a root with an open apex or continued apical development of teeth with incomplete roots and a necrotic pulp'.[7] Calcium hydroxide has been the first choice of material for apexification4 with repeated changes over the course of 5-20 months to induce the formation of calcific barrier Its efficiency has been demonstrated by many authors even in the presence of an apical lesion.[13] The unpredictable and often lengthy course of this treatment modality presents challenges, including the vulnerability of the temporary coronal restoration to re-infection and has several disadvantages such as variability of treatment time (average 12.9 months)[14,15] , difficulty of the patients recall management, delay in the treatment and increase in the risk of tooth fracture after dressing with calcium hydroxide for extended periods. For these reasons, single visit apexification has been suggested.[15] Mineral trioxide aggregate (MTA) has been proposed as a material suitable for one visit apexification because of its biocompatibility, bacteriostatic activity, favourable sealing ability and as root end filling material.[7] MTA offers the barrier at the end of the root canal in teeth with necrotic pulps and open apices that permits vertical condensation of warm gutta-percha in the remainder of the canal.[7,16,17,18] The practical technique and two case reports are presented in which MTA was used for apexification in open apex cases to develop an apical stop to facilitate obturation. This article presents a case report where tooth with open apex were managed using single step apexification with MTA.

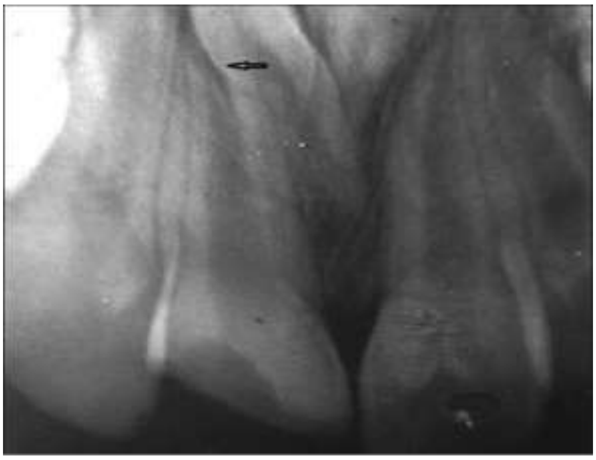

Figure 1; Periapical radiograph showing wide open apex in relation to 11

II. Case Reports

An 11-year-old male patient reported with a chief complaint of discolored right maxillary central incisor with a history of trauma 1 year back. The concerned tooth did not respond to both electric and heat test. The periapical radiograph revealed a large blunderbuss canal of the same tooth . On clinical examination, Ellis Class IV fracture in permanent right maxillary central incisor was evident. Apexification with MTA was planned. Access opening was prepared under rubber dam isolation and working length was determined. Pus was extruded from the root canal immediately after the access preparation; irrigation was done with saline.

Biomechanical preparation was carried out using 80 size k file with circumferential filing motion. Root canal debridement was done using alternative irrigation with 2.5% NaoCl and saline. Calcium hydroxide was placed in the root canal and patient recalled after 5 days. At subsequent appointment, canal was irrigated with 2.5% NaoCl and 2% chlorhexidine. The canal was dried with paper points and MTA-Plus placed with pluggers until thickness of 6 mm . A wet cotton pellet was placed in the canal and access cavity was sealed with temporary cement. In next appointment, root canal was obturated with GP using lateral condensation technique. Access cavity sealed with glass ionomer cement .

Figure 2; Radiograph showing placement of mineral trioxide aggregate

III. Discussion

When treating nonvital teeth, the main issue is eliminating bacteria from the root canal system. As instruments cannot be used properly in teeth with open apices because of often divergent apices & thin dentinal walls, cleaning and disinfection of the root canal system rely on the chemical action of NaOCl as an irrigant and calcium hydroxide as an intracanal dressing.[7] MTA is a powder consisting of fine hydrophilic particles of tricalcium silicate, tricalcium oxide and silicate oxide. It has low solubility and a radiopacity that is slightly greater than that of dentin. This material has demonstrated good sealability and biocompatibility. MTA has a pH of 12.5 after setting which is similar to the pH of calcium hydroxide and it has been suggested that this may impart some antimicrobial properties. [19] Because of MTA's excellent biological properties and ability to create a good seal, it has been recommended for creating an artificial barrier in the apical area of teeth with open apices, thus compressing treatment time to 1 or 2 visits. The cell's response to MTA and the mechanism of deposition in barrier formation are unknown and require further investigation. [20] Mineral trioxide aggregate as an apexification material represents a primary monoblock. Apatite-like interfacial deposits form during the maturation of MTA resulting filling the gap induced during material shrinkage phase and improves the frictional resistance of MTA to root canal walls. The formation of nonbonding and gap filling apatite crystals also accounts for seal of MTA. MTA has superior biocomaptibilty and it is less cytotoxic due to its alkaline pH and presence of calcium and phosphate ions in its formulation resulting in capacity to attract blastic cells and promote favorable environment for cementum deposition. [21]

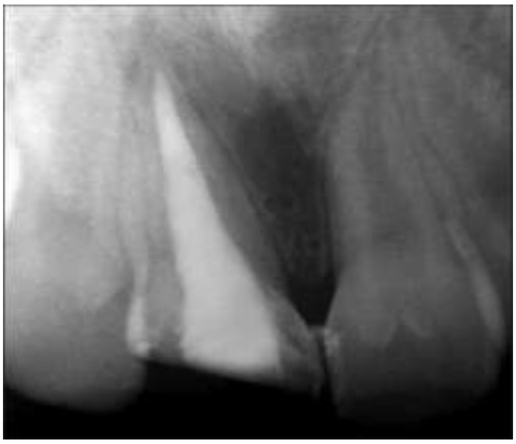

Figure 3: Radiograph showing complete obturation of 11

The apical plug created with MTA can be interpreted as an artificial barrier to condense the subsequent root canal filling material, in order to prevent reinfection of the canal system.5 Some authors have postulated that possible leakage of MTA could be influenced by the thickness of the apical plug. A recent study reported that the orthograde use of MTA provided an adequate seal against bacterial infiltration regardless of the thickness of the apical plug[22]. Hachmeister,et al underlined that the thickness of the apical plug may have a significant impactonly on displacement resistance.[23] There are new strides in the apexification procedure with MTA. MTA as an apexification material represents a primary monoblock. Appetite like interfacial deposits form during the maturation of MTA result in filling the gap induced during material shrinkage phase and improves the frictional resistance of MTA to root canal walls. MTA has superior biocompatibility and it is less cytotoxic due to its alkaline pH and presence of calcium and phosphate ions in its formulation results in capacity to attract blastic cells and promote favorable environment for cementum deposition. A total of 5 mm barrier is significantly stronger and shows less leakage than 2 mm barrier. In the present case, MTA was placed for around 6 mm in the apical region.[24] In the present case reports, the thickness of the MTA apical plug varied from 3 mm to 5 mm. In teeth with a short root canal the thickness of the apical plug was reduced to 3 mm to allow for the subsequent filling of the more superficial portion of the canal with resin materials. 5mm barrier is significantly stronger and shows less leakage than 2 mm barrier. MTA has demonstrated the ability to stimulate cells to differentiate into hard tissue – forming cells and to produce a hard tissue matrix. A number of animal studies have demonstrated a more predictable healing outcome when MTA is used when compared with teeth treated with calcium hydroxide14. In a prospective human outcome study, 57 teeth with open apices were obturated with MTA in one appointment. Forty – three of these cases were available for recall at 12 months, of which 81% of cases were classified as healed . Despite its good physical and biologic properties, extended setting time has been a main disadvantage. Calcium chloride was used with intention to stimulate hardening process of MTA. Studies have shown that not only the sealing ability but its physicochemical property was improved by addition of $CaCl_2$.[25]

IV. Conclusion

Single visit apexification with a novel biocompatible material like MTA is a new boon in effective management of teeth with open apex .This innovative procedure is predictable and less time consuming one. Mineral trioxide aggregate showed clinical and radio-graphic success as a material used to induce root-end closure in necrotic immature permanent teeth. MTA is a suitable replacement for calcium hydroxide for the apexification procedure.

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