Original Research Paper

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Efficacy of Mineral trioxide aggregate in apexification in maxillary anterior teeth"

Radiology

KEYWORDS: Apexification, Calcium hydroxide, Coronal seal, Mineral trioxide aggregate

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ABSTRACT

Introduction: Endodontic treatment of the pulpally involved permanent tooth with an immature root apex poses a special challenge for the clinician. The main difficulty encountered is lack of an apical stop against which an obturating material can be compacted. Apexification procedure was widely used for such teeth and many materials including calcium hydroxide has been tried but none had been completely successful, thus a new material with successful results was introduced as Mineral trioxide aggregate (MTA).

Aim: Thus, the present study aimed at studying the efficacy of Mineral Trioxide aggregate in promoting root end closure of the pulpally involved permanent tooth with an immature root apex in maxillary anteriors.

Materials and Methods: A cross-sectional study was conducted on 48 children aged between 8-10 years with traumatic injuries of maxillary permanent anteriors with immature open apex / root formation that were affected by irreversible pulpitis with or without periradicular pathosis. After performing conventional RCT, teeth were restored with metapex and after 1 week were sealed with MTA.

Results: Preoperative symptoms and periapical lesions, overfilling of root canals did not hinder the process of apexification. The mean time taken for apical biological barrier formation was 3 +/- 2.9 months. The periapical radiolucencies were resolved in 4.6 +/- 1.5 months. Intactness of coronal seal was of almost importance during the treatment period and loss of coronal seal negatively influenced apexification.

Conclusion: The present study substantiated that Mineral trioxide aggregate is a potential apical barrier material with good sealing ability and a high degree of biocompatibility.

Introduction

Endodontic treatment of the pulpally involved permanent tooth with an immature root apex poses a special challenge for the clinician. The usual cause of endodontic involvement in a tooth with an incompletely developed root is trauma. The main difficulty encountered is lack of an apical stop against which an obturating material can be compacted. Before the introduction of apical closure techniques, Demreitt advocated extraction for non-vital permanent teeth, if the root was not completely formed.[1]

Ingle advocated routine endodontic therapy with an overfilling of the canal. Apical surgery was then performed to properly seal the apex. Although the surgical approach was successful, the mechanical and physiological aspects offered may contraindications. In the pulpless tooth with an incompletely formed apex, the thin, fragile dentinal walls made it difficult to achieve an apical seal. When a portion of root was removed to obtain a seal, the crown-to-root ratio was poor. Because this situation was usually present in the child patient, a less traumatic approach was desirable.[2]

Apexification is the most widely accepted procedure for treatment, in those partially developed permanent tooth that clinically and radiographically display evidence of pulp necrosis. In partially developed permanent teeth, an observation of clinical response to electrical and thermal testing, radiographic presence of periapical inflammation and symptoms of pain and swelling not necessarily mean a total loss of pulp vitality. Due an excellent vascular supply in the pulp of partially developed permanent teeth, viable tissue can still be present despite extensive and painful inflammation. This residual undamaged pulp tissue if there is any and the odontoblastic layer associated with the pulp tissue resume their matrix formation and subsequent calcification, guided by the reactivated sheath of hertwig.

A number of materials like antiseptic pastes,[3] antibiotic pastes,[4] (Ball 1964), root canal sealers,[5] apical impression techniques,[6] gutta-percha cones with Grossman's cement,[7] zinc oxide paste (Cooke and Rawbotham 1960), Diaket (Friend 1966), Walkoff's paste (Bouchan 1966), osteogenic protein-I, II, Bone morphogenic protein, collagen have been advocated for sealing or inducing closure of the wide open apex with varying degree of success but none has been found to be a successful as calcium hydroxide.

Time taken for apexification is variable. Chawla et al observed that teeth with narrow open apex of older children had a shorter treatment time than younger children. Furthermore teeth without periapical infection showed root growth that was faster than those with periapical infection ($p<0.001$).[8] On the contrary Dominquez[9] in his study concluded that pathology of the tooth before treatment did not influence the time needed to obtain apical closure. Roberts GJ observed in his study that average length of time for apical barrier formation is approximately 5 to 20 months.[10] Marques MM et al studied the effect of renewal of calcium hydroxide paste on apexification and observed that formation of apical calcified tissue was more noticeable in teeth where the material was not changed however bone resorption was evident concluding that renewal of calcium hydroxide was not necessary for apexification to occur however it did reduce significantly the intensity of inflammation process.[11]

Inspite of the high success rate of calcium oxide in apexification appreciable degree of failure is also reported due to frequently encountered fracture of immature teeth filled with calcium hydroxide for extended periods thus reducing the fracture strength, unpredictable results, difficulty in creating a leak-proof temporary restoration for the duration of the treatment leading to complications and the main disadvantage of calcium hydroxide apexification is lengthy treatment protocols[12]

So, the alternative treatment is the use of an artificial apical barrier that allows immediate obturation of the canal. Mineral Trioxide Aggregate (MTA) has recently been advocated as a material to serve as an apical barrier for root end induction. At present, MTA is widely used in endodontic therapy. MTA was introduced to dentistry as root-end filling material. It was developed at Loma Linda University, C.A., U.S.A in 1993's by Mahamoud Torabinejad. It has recently been

advocated as material to serve as an apical barrier for root end induction. MTA was reported to produce equivalent amounts of apical hard tissue with no more inflammation than calcium hydroxide or osteogenic Protein-I. Bone, cementum and uninflammed periodontal tissue was demonstrated in direct opposition to MTA. Because, of its good sealing ability and high degree of biocompatibility, good marginal adaptation, and a longer setting time, MTA would seems to be the material of choice for an apical barrier.[12]

Mineral trioxide aggregate or MTA (Pro Root MTA, Densply Tulsa Dental) is composed primarily of Tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. The material is 75% Portland cement. It sets in the presence of moisture, and has a hardening time of 2 hours 45 minutes to 4 hours. Numerous tests were done to evaluate the physical properties of MTA and its biocompatibility. In leakage tests, MTA showed significantly less leakage than amalgam, super EBA, or IRM. Another study measured the amount of time needed for staphylococeus aureus to penetrate around 3 mm thickness of root-end filling of amalgam, IRM, Super EBA or MTA. MTA gave significantly less leakage than the other material and the sealing ability of MTA is attributed to its hydrophilic nature and expansion when cured in a moist environment.

MTA appeared to be a valid option for apexification with the added advantage of speed of completion of therapy. MTA is claimed or superior to other root-end closure materials with respect to dye and bacterial leakage and cytotoxicity. It is proved that MTA stimulates osteoblasts producing interleukin (IL-1, IL-1, IL-6) and macrophage colony stimulating factor. MTA induces cementogenesis by offering a biologically active substance for osteoblasts, allowing good adherence of the bone cells to the materials and it also stimulates cytokine production. MTA is the only material that consistently allows for the regeneration of the periodontal ligament, the opposition of a cementum like material and formation of bone.

In cases such as these, where the material must have a tissue interface, it has performed well, this could be in part because of the high pH of MTA 10.2 initially and rising to 12.5 in 3 hours. Additionally, Sarkar and Coworkers found that MTA exposed to synthetic tissue fluid at 37C released its metallic constituents, primarily calcium and produced precipitates with composition and structure similar to hydroxyapetite. It is also non-toxic, well tolerated by the periapical tissues, non-corrosive, dimensionally stable, radiopaque and non-absorbable and not effected by presence of moisture. In response to the material, cell growth is favored and the expression of the IL-1, IL-6 suggests that it may promote healing through the stimulation of bone metabolism. The presence of IL-I has been shown to stimulate angiogenesis which is necessary for connective tissue healing. Transforming growth factor - (TGF-) influences the development, remodeling and regeneration of cells. Phosphorylated glycoprotein, osteoprotein are expressed and localized to the root surface during cementogenesis.

Thus, the present study aimed at studying the efficacy of Mineral Trioxide aggregate in promoting root end closure of the pulpally involved permanent tooth with an immature root apex in maxillary anteriors and the time period required to complete apical barrier in pulpally involved permanent maxillary anterior teeth with a wide open blunderbuss apex (Immature root) with evaluation of the efficacy of MTA in resolving periradicular pathosis and inducing apexification in young immature pulpless tooth with evaluation of endodontic and periapical tissue compatibility, physical stability and evaluation of the radiographic and symptomatic finding with MTA.

Materials and Methods

A cross-sectional study was conducted at Dr. R. Ahmed Dental College & Hospital, Dept. of Pedodontics and Preventive Dentistry, Kolkata. 48 Samples (Patients) were selected from the children attending the outpatients department of same, who reported for (treatment for anterior teeth injury.

Criteria for selection of the patients

1. Children with traumatic injuries of maxillary permanent anteriors leading to Ellis Class III and Class IV fracture i.e. Crown fracture with pulp exposure between 8 to 10 years were selected for the study. Evaluation of the pulp status was performed by evaluating the subjective symptoms like pain, swelling, discharging sinus, objective symptoms like thermal testing, percussion, palpation. Intraoral periapical radiographic examination was conducted to assess depth of fracture with respect to the pulp and sub-gingival extensions of any fracture line, number, curvature, size and shape of all the root canals and chambers, periradicular lesions if, present, presence of root fracture, external resorption, internal resorption, pulp stones, linear calcifications, status of root end development and degree of optical closure. From the above diagnostic methods permanent anterior teeth with immature open apex / root formation that were affected by irreversible pulpitis with or without periradicular pathosis were selected for the study.

2) Permanent maxillary anterior teeth with adequate alveolar bone support.

3) Restorable teeth

Children who undergoing orthodontic therapy, crowding and cross bite, having severe proximal caries having any kind of pernicious oral habit, teeth with root fracture, crown root fractures, luxation, intrusion, extrusion and avulsion and anterior tooth/teeth fracture with accompanying maxillofacial injuries or other physical injuries were not considered in the study.

Method

First the patient was asked to rinse his/her mouth with 0.2% Chlorhexidine gluconate solution for approximately 30 seconds, followed by administration of 1.8 ml of local anesthesia. Conventional root canal treatment was performed with copious irrigation of canal with sterile isotonic saline. The root canal was dried with absorbent points. Then non-setting calcium hydroxide (RC Cal, Metapex, Vitapex) was placed in the root canal for the purpose of disinfection. Then a suitable coronal seal was placed with cavit. After 1 week the calcium hydroxide was removed by repeated rinsing with Sodium hypochlorite 2.5% followed by rinsing with sterile water. The canal was dried with absorbent points. The MTA powder was mixed with distilled water following the manufacturer's instructions and taken to the canal orifice using amalgam carrier and then packed in the apical third of the canal using Hu Friedy pluggers or gutta-percha point or MTA applicator. At least 4mm is taken. A radiograph was taken to verify the placement of MTA. The walls of the canal coronal to MTA apical barrier were cleaned using H-fills and paper points. A wet cotton pellet was then placed in the canal to produce a humid ambient for the MTA with the aim of achieving it's solidification and a suitable coronal seal was placed with cavit. Two days later, the temporary filling was removed and the hardness of the MTA was checked. Finally, it was possible to perform the root canal obturation with gutta-percha with zinc-oxide euginol sealer using lateral condensation technique and access cavity was closed with intermediate restorative materials. The patient was instructed to report after 3 months, After 3 months, the tooth was radiographically and clinically evaluated for –

a) Presence or absence of any subjective or objective symptoms.
b) Radiographic evidence of regression or progression of any preexisting pathology.
c) Radiographic evidence of calcific bridge formation.
d) Types of root end closure.
e) To achieve valuable root length, if any.

Statistical analysis

Entire data obtained from this study was entered in a master chart and then tabulated. Frequency, percentage, means, Standard Deviation (SD), median, minimum and maximum values of variables was calculated. Chi- Square test and SND test were used for comparison between proptions and success rate respectively. The p-value<0.05 was considered statistically significant. Data analysis was

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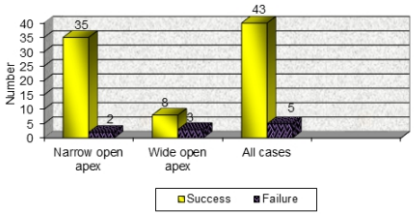
done using Statistical Package for Social Sciences (SPSS) version 1 for windows.

Results

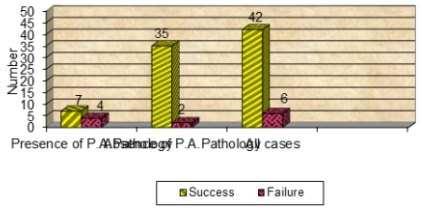
There were a total of 48 patients subjects with a median age of 8 to 9 years in 60.41% of total sample and within 9 to 10 years in 39.59% of total sample population. The present study stated that there was about 66.67% and 56.25% of male and female patients respectively of the total sample population with no significant difference observed in success of apexification with respect to age and gender ($p > 0.05$). Among 75% of the total preoperatively asymptomatic patients only 5.55% had failure of apexification in contrast to preoperatively symptomatic patients with 33.34% failure rate demonstrating statistically significant difference ($p<0.05$). This study demonstrated that inspite of overfilling the material in to the apical areas in 14.58% cases, successful apexification occurred in 100% of cases. The comparison of successful and failure cases in narrow and wide open apex showed that among 72.9% of narrow open apex patients, only 5.4% had apexification failure and In subjects with wide open apex, apexification was successful in 72.72%. Thus indicating that subjects with narrow open apex had better prognosis as regards to inducement of root end closure. (Graph 1) 22.91% of the total sample had periapical pathology as was visible in the preoperative radiographs with failure in only 5.4% of the cases with success in 65.5% of cases without periapical pathology. Thus patients without periapical pathology preoperatively had a higher rate of success in achieving apexification.(Graph 2)

This study stated that among 83.33% of total sample with intact coronal seal, had only 4.76% of cases as failure and among 12.5% with lost coronal seal had 33.34% had successful apexification rate with no statistically significant difference.(Graph 3)

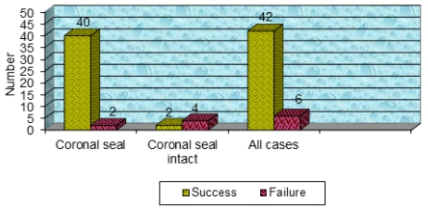
Graph 1 - Pretreatment status of root end development and success of apexification



Graph 2 - Presence of periapical pathology radiographically and success of apexification



Graph 3 - Intactness of coronal seal and success of apexification



Discussion

A tooth erupts into oral cavity with two-third root completion. Development of the root begins after enamel and dentin formation has reached the future cemento-enamel junction. The epithelial dental organ forms Hertwig's epithelial root sheath, which initials formation and moulds the shape of the roots. During the formation of apical foramen of each root has a wide opening limited by the epithelial diaphragm. The dentinal wall taper apically, and the shape of the pulp canal is like a wide-open tube. When root length is established, the sheath disappears but dentin deposition continues internally within the roots. As growth deposition of dentin and cementum closes the apex of the tooth and creates the apical convergence of the root canals common to the completely formed tooth. Root length is not complete until 1-4 years after a tooth erupts into the oral cavity.

In case of trauma leading to pulpal involvement of these immature tooth / teeth, indirect pulp capping, direct pulp capping and pulpotomy techniques have been proved to be successful, aided by the tremendous blood supply present with the open teeth / tooth so that as much root length and dentin formation as possible can occur in the root so as to provide a favorable crown root ratio. When the tooth with an incompletely formed apex suffers irreversible pulpal damage or periapical disease has developed subsequent to such damage, conventional root canal treatment procedures are impossible. Achieving orthograde hermetic sealing of the root canal of these immature teeth with a wide open blunderbuss apex is difficult to achieve. Previously endodontic surgical approach was used to obtain apical seal. Although the surgical approach was successful, the procedure is grossly invasive. The mechanical and psychological aspects of the child patient also offered many contraindications. Hence, there was a need of minimally invasive procedure viz-apexification.[13] Granath[14] first reported the use of calcium hydroxide for apical closure in 1959. The technique was given impetus by the description of three cases of apexification by Frank[15] in 1996 using calcium hydroxide and camphorated chlorophenol. Frank's capacity to function after pulpal injury. Materials like zinc oxide pastes (Cooke and Rowbotham 1960), Diaket (Friend 1966), have been advocated for sealing or inducing closure of the wide open apex.[16] All have met with varying degrees of success and failure. Although several materials have been used none are as effective in promoting a calcific barrier as calcium hydroxide.[17] Although even calcium hydroxide has its own disadvantages. So, the alternative treatment is the use of an artificial apical barrier that allows immediate obturation of the canal. Mineral trioxide aggregate (MTA) has recently advocated as a material to serve as an apical barrier for root end induction.[18,19]

Holdent et al[20] in his study of apexification with MTA in 20 teeth with incompletely formed apices reported an overall success rate of 85% based on clinical and radiological evaluation. D'Arcangelo C and D'Amario M[21] considered the technique of apexification to be successful in many cases with placement of MTA as root-end filling material. Stefopoulos S et al[22] reported a success rate of 94.1% in inducing apexification in 17 non-vital immature central incisor teeth using MTA. Our study demonstrated that successful apexification occurred significantly more in teeth with narrow opex apex ($Z=4.13$; $p<0.001$) than in teeth wide open opex. Chi-square test was also statistically significant ($\chi^2=4.34$; d.f.=1, $p<0.050$).Of the total successful cases, 35 were of narrow open apex and 8 were of wide open apex. The difference in the two proportions is highly significant ($Z=4.13$, $p<0.001$).Similar results were obtained by D.Finucane and M.J. Kiniron[23] and suggested that a calcific barrier formed more rapidly in cases with narrower initial apical width. Another study conducted by Kleier D.J. and Bar E.S.[24] concluded that development of interappointment symptoms was significantly related to the size of apical opening.

Our study evaluated that subjects periapical pathology was absent as evidenced from the radiographs and the success rate of apexification is high (72.92%) and is statistically significant ($Z=5.42$; $p<0.001$). In subject where periapical pathology was present as visible in the radiographs, the proportion of successful cases is 22.92% and is statistically insignificant ($Z=0.90\%$; $p>0.05$). Thus presence of periapical pathology did not significantly influence the successful outcome of apexification. Kouqoz A et al[25] in their two year follow-up

study concluded that large periapical lesions can respond favorably to non-surgical endodontic treatment with calcium hydroxide and complex and difficult treatments in children might not be required.

Chawla HS et al[26] presented a comparative study between calcium hydroxide and MTA for their efficacies and time taken for formation of apical biologic calcific barriers and resolution of periapical radiolucencies, if present at base line, in teeth with unformed apices. They concluded that the 2 materials were found to be equally efficacious in the management of non-vital teeth with unformed apices. Time taken to complete the treatment and the biological barrier formation in MTA was significantly less than that for calcium hydroxide. The healing time for periapical radiolucencies was almost identical. The periapical radiolucency were resolved in 4.6 +/- 1.5 months for MTA and 4.4 +/- 1.3 months for calcium hydroxide group of apexification. The present study showed that successful apexification occurred in subjects with intact coronal seal. Lim KC[27] compared the micro-leakage of glass ionomer cement (Ketac Fil) with reinforced zinc oxide eugenol cement, kalzinol. There was no significant difference in the microleakage observed in Ketac Fil restorations and Kalzinol (p=0.45) at the end of 30 days. Thus the present study cavit was used as intermediate restorative material and were intact in most of the cases during the treatment period.

Conclusion

The present study substantiated that Mineral trioxide aggregate is a potential apical barrier material with good sealing ability and a high degree of biocompatibility. The treated teeth were asymptomatic and radiographic examination demonstrated apparent regeneration of periradicular tissue and new hard tissue formation in the apical area of the affected teeth. Preoperative symptoms and periapical lesions, overfilling of root canals did not hinder the process of apexification. The mean time taken for apical biological barrier formation was 3 +/- 2.9 months. The periapical radiolucencies were resolved in 4.6 +/- 1.5 months. Intactness of coronal seal was of almost importance during the treatment period and loss of coronal seal negatively influenced apexification.

The advantage of using a material to form an immediate apical barrier over the conventional apexification treatments is that endodontic treatment can be achieved in fewer appointments thereby minimizing failure rates. The findings of this study need further extensive research with the noble hope of improving the health status of the community as a whole.

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