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Diagnosis and Treatment Modalities of Open Apex – A Review

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Abstract

Immature tooth with an open apex is encountered by a clinician from time to time. Proper diagnosis and treatment planning is necessary to save the tooth and for continued root development. This review is about diagnosis and treatment options available for cases of open apex.

Key words*: immature, open, apex, diagnosis, management*

Introduction

Open apex refers to the absence of sufficient root development to provide a conical taper to the canal and is referred to as blunderbuss canal (means that the canal is wider towards the apex than the cervical area). The completion of root development and closure of the apex occurs up to three years after eruption. Hertwig's epithelial root sheath forms the apical foramen.

Stages of root development given by Cvek[(1)]:

Stage 1 : wide divergent opening with <50% of root length formed

Stage 2 : wide divergent opening with 50% of root length formed

Stage 3 : wide divergent opening with 66% of root length formed

Stage 4 : Wide apical opening with nearly complete root

Stage 5 : closed apical foramen with complete root length

Open apices can be blunderbuss (funnel shaped) which is divergent and flaring or non-blunderbuss (cylindrical shaped) which is parallel and broad.[(2)] The causes of open apex are pulpal necrosis arising as a result of caries or trauma, extensive apical resorption as a result of orthodontics, periapical pathosis or trauma, over instrumentation (iatrogenic) and others like dens in dente and dentin dysplasia. The problems faced clinically in a tooth with open apex are thin dentinal walls that are susceptible to fracture, frequently associated with periapical lesions with/without apical resorption, short roots compromising the crown-root ratio further affecting long-term prognosis. Large open apices pose a challenge in determining the working length, decision on the necessity of root canal preparation, and achieving control during obturation.

Diagnosis

Clinical tests include careful medical examination, thorough dental history of all the symptoms and characteristics of associated pain, visual examination of presence/absence of swelling, crown discolouration, caries, mobility and periodontal probing to check the status of pulp. Electric and thermal tests are of limited value due to their varied responses in permanent teeth with immature apex.[(3)] After traumatic injuries electric and thermal pulp tests may be unreliable, only

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generalized impressions may be gained from these tests.[4] Doppler flowmetry (LDF) can be used for measurement of blood flow in traumatized teeth.[5] Pulse oximeter also offers accurate means of monitoring pulp vitality by recording the oxygenation of pulpal flow.[6] Radiographic examination and CBCT are important tools. However it is still difficult to determine if the pulp is reversibly or irreversibly affected. Moreover children may have unreliable clinical symptoms and exaggerated responses to percussion, palpation and pulp tests that do not correlate well with histopathological condition of pulp in immature teeth.[7] However with early diagnosis and intervention, pulp preservation strategies promote an environment for continued dentine apposition and root formation.

TREATMENT

The treatment modalities for an open apex are as follows; if it is reversible pulpitis (vital pulp), then the treatment has to be apexogenesis which includes indirect pulp capping, direct pulp capping or pulpotomy. If it is irreversible pulpitis (necrosed pulp) , then the treatment includes apexification or regeneration of pulp. Apexification is either by Calcium hydroxide, Mineral Trioxide Aggregate (MTA) or biodentine.

APEXOGENESIS

It can be defined as a vital pulp therapy procedure to encourage continued physiological development and formation of the root end.[8] The goals are to allow continued development of root length, maintain pulp vitality thus allowing continued deposition of dentin, promoting root end closure thus creating natural apical constriction and generating dentine bridge at the site of pulpotomy.

Indirect Pulp Capping

It is a procedure in which a material is placed on thin partition of remaining carious dentine that if removed might expose the pulp in immature permanent teeth. It is also called stepwise technique.The indications are permanent teeth, normal response to pulp tests, no symptoms of pulpitis or with diagnosis of reversible pulpitis and deep caries lesion, radio graphically with no apical pathosis.[9]

The proceedure is to first remove the caries. The remaining infected dentin is covered with Calcium Hydroxide(CAOH) and an overlying base of Intermediate Restorative Material(IRM).If the patient is asymptomatic after 3-8 weeks, then temporary filling is removed carefully and checked to confirm change in colour and hardness of affected dentin. Hard set CAOH is placed followed by an resin modified glass ionomer(RMGIC) base and a bonded composite/amalgam.The mode of action is when the infected dentine is removed, the affected dentine can rematerialize and promote odontoblasts to form reactionary dentine formation at the pulp-dentine junction.[10] Reactionary dentin is secreted by functional up regulation of surviving primary odontoblasts, stimulated by signaling molecules such as growth factor proteins and bioactive molecules released from dentine matrix during injury to the dentin-pulp complex.[11] CAOH has a long track record as an indirect pulp capping agent due to its high alkalinity and its ability to produce a dentinal barrier.

Direct Pulp Capping

It is the treatment for exposed vital pulp by sealing the pulpal wound with material such as mineral trioxide aggregate or calcium hydroxide to facilitate the formation of reparative dentine and maintain pulp vitality. The indications are restorable permanent teeth, carious or traumatic exposure with vital pulp or symptoms of pulpitis or with diagnosis of reversible pulpits.[9] The proceedure includes hemostasis with 6% Naocl following pulpal exposure.Then capping can be done using CAOH or MTA.In MTA technique, it can be done in single visit by RMGIC base followed immediately with final restoration or it can be done in two steps.First an interim restoration with moist cotton pallet is placed along with unbonded composite followed by final restoration with bonded composite/amalgam after 5-10 days.

Pulp capping materials such as MTA and calcium hydroxide induce the release of growth factor proteins and bio active molecules from dentin matrix. Postnatal stem cells in human dental pulp are capable of differentiating into odontoblast-like cells upon receiving inductive signals from bioactive molecules and growth factor proteins. Reparative dentin is formed from odontoblast-like cells and not from primary odontoblasts as in case of indirect pulp capping.[12]

Partial pulpotomy or Cvek's pulpotomy is the surgical removal of coronal portion of vital pulp as a means of preserving the vitality of the remaining coronal and radicular pulp tissues. The indications are restorable permanent teeth, deep carious lesions or traumatic fractures longer than 24 hours with vital pulp exposure, when pulpal inflammation is expected to be greater than normal and pulpal bleeding cannot be controlled within several minutes or with symptoms of pulpitis or with diagnosis of reversible pulpitis.[9] Similar to direct pulp capping, calcium hydroxide and mineral trioxide aggregate induce dentine bridge formation most likely by indirect mechanism through the release of growth factors from dentine matrix. Growth factors proteins stimulate the differentiation of post-natal stem cells in human dental pulp into odontoblasts-like cells that forms dentine bridge.[12,13] Partial pulpotomy and direct pulp capping are considered to be similar proceedures and differ only in amount of undestroyed tissue remaining after procedure.

Complete pulpotomy (cervical pulpotomy) is the removal of entire coronal pulp to the level of the root canal orifice or as much as 2-3mm apical to the orifices. The indications are restorable permanent teeth, deep carious lesions or traumatic fractures longer than 72 hours with vital pulp exposure or when pulpal bleeding cannot be controlled within 10 minutes.[14] In response to pulpal dressing with calcium hydroxide or mineral trioxide aggregate, apposition of hard tissue is achieved similarly as direct pulp capping and partial pulpotomy.

Dentine bridge formation following apexogenesis is a reparative process of dentine-pulp complex. However, the continued root formation is a normal physiological process.[15]

APEXIFICATION

It is a method to induce a calcific barrier across an open apex of an immature pulpless tooth. The indications are permanent teeth with non vital pulp with open apex and thin dentin walls or where standard instrumentation technique cannot create apical stop.[9] Materials used for apexification for formation of hard tissue barrier are Calcium hydroxide, MTA, Biodentine and Bioaggregate.

The high PH value of CAOH results in zone of liquefaction necrosis subjacent to CAOH and a deeper zone of coagulation necrosis next to periradical tissues.[16] This coagulation necrosis zone stimulates release of growth factors (wound healing signals) and bioactive molecules from cemented matrix and alveolar bone marrow matrix.[17] During this process numerous vascular inclusions may occur.[18] Drawbacks of CAOH are longer duration time of hard tissue induction i.e. 6 to 18 months , incomplete apical hard tissue barrier occurs due to vascular inclusions and may allow bacterial invasion through these defects and long term calcium hydroxide dressing may weaken the dentine and lead to root fractures.

MTA is another material used for apexification. It was introduced by Torabinejad in 1993.The setting time is 3-4 hours (2hrs 45min). The composition is powder containing tricalcium silicate, dicalcium silicate, calcium sulfate, tricalcium aluminate, tetracalcium aluminoferrite, bismuth oxide and liquid containing distilled water. When MTA is placed against periodontal tissues, the high PH value of MTA results in a very narrow zone of coagulation necrosis next to periodontal tissues. MTA modulates production of cytokines and stimulates differentiation and migration of hard tissue forming cells. Therefore, hydroxyapatite is formed on MTA surface and a biological seal is created.[19] Hydroxyapatite is formed in between the root canal and MTA.

Biodentine is commercially available from 2009. The final setting time is 45minutes. The powder contains tricalcium silicate, dicalcium silicate, calcium carbonate, zirconium oxide, iron oxide and opacifiers. Liquid is Calcium chloride in aqueous solution with admixture of polycarboxylate.Bioaggregate has setting time of 4-72hrs. The powder contains tricalcium silicate, dicalcium silicate and tantalium pentoxide.Liquid is deionised water.

Working Length For Apexification

The definition of open apex varies according to authors and is reflected by the minimum ISO size used to describe it.Some of them are ISO 60 by ElAyouti et al and ISO 80 by Moore et al.[20,21] Different techniques for WL determination are electronic apex locator (EAL) followed by radiographs, paper point technique(tactile), tactile method with a file and paper point technique to supplement initial EAL readings.[20,22,23]

REVITALIZATION/REGENERATION TREATMENT

This procedure is to revive tissues in the pulp space and continue root formation in immature teeth with non-vital pulp. The goal is to provide appropriate environment for regeneration of pulp i.e. absence of bacteria and necrotic pulp tissue, presence of a scaffold and a tight coronal seal.The indications are that tooth must be non-vital and not be suitable for apex genesis, apexification, partial pulpotomy, or root canal obscuration treatments. It should be permanent and immature tooth with open apex that is wide to a diameter of 1.1mm or larger. The patient must be aged 7-16 years and in good health.

The recommendations are to use antibiotic paste as a disinfectant (to be warned about potential discolouration), an anesthetic without a vasoconstrictor should be used when attempting to induce bleeding into the root canal, a thin layer of white MTA or calcium hydroxide should be placed over the blood clot. An endodontic sealer is not compatible. The tooth should be restored with resin modified glass monomer to help prevent micro leakage.

Tooth is anesthetised and isolated. It is irrigated with 2.5% Sodium hypochlorite (without mechanical instrumentation).The canal is dried and triple antibiotic paste(TAP) also called Hoshino's paste is placed and closed dressing is given.After one month the TAP is removed with 2.5% sodium hypochlorite and 17% EDTA. Conditioning the dentin surface with EDTA enhances the adherence and differentiation of dental pulp stem cells during pulp regeneration.[24] A file is passed beyond the working length and bleeding is induced (protein scaffold). It is left for 15minutes for the blood to clot.MTA is placed over the clot and then moist cotton placed. Temporary restoration is given. The patient is recalled after 24 hours.Then the cotton is removed and bonded restoration is given. Calcium hydroxide paste is another intracanal medicament that has been used to disinfect the canal before inducing bleeding. It may not be suitable if there is remaining vital pulp tissue in the canal. On direct contact of CAOH paste with tissue, their is formation of calcified tissue which may occlude the pulp space. CAOH may damage hertwig's epithelial root sheath and thereby destroy its ability to induce the nearby undifferentiated cells into odontoblasts.[25] Drawbacks of regeneration are discolouration, long treatment period, poor root developement, insufficient bleeding and root canal calcification.

Conclusion

All the treatment options should be properly weighed when a clinician encounters an open apex case. The patient should be recalled for followups. Formation of the complete root should be observed and monitered.

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