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Research Article

Apexification, Apexogenesis: New Treatment Modalities

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1. Introduction

Root development and closure of the apex occurs up to 3 years after the eruption of the tooth. Any periapical injury during this period provides a significant challenge on the part of the dentist. Depending on the vitality of the tooth 2 types of treatment can be performed.

1.1. Apexogenesis: It is a vital pulp therapy procedure preformed to encourage continued physiological development and formation of the root end.

1.2. Apexification: The American association of endodontist defined apexification as a method to induce a calcified barrier in a root with an open apex or the continued apical development of an incomplete root in teeth with necrotic pulp.

2. Root Development

Root development begins when enamel and dentin formation has reached the future cement-enamel junction. At this stage the inner and outer enamel layer are not separated by the stratum intermedium and stellate reticulum but develops as a two layered epithelial wall to form Hertwig's epithelial root sheath. The Hertwig's epithelial sheath tends to disintegrate after the radicular cells differentiate into odontoblasts and the first layer of dentin has been laid down. Its remnants however persists as epithelial network of strands near the external surface of the root. Hertwig's epithelial root sheath is responsible for the shape of the root or roots. The epithelial diaphragm surrounds the apical opening to the pulp and eventually becomes the apical foramen.

An open apex is formed in the developing tooth until apical closure approximately 3 years after eruption. Majority of traumatic injuries to the pulp occurs before root formation is complete in children. Complete destruction of Hertwig's epithelial sheath results in incomplete formation of root. However this does not mean this is an end to deposition of hard tissue in the region of tooth apex. Hard tissue can be formed by cementoblast that are normally present in the apical region and the fibroblasts of the dental follicle and the periodontal ligaments that undergoes differentiation after the injury to become hard tissue producing cells.

There are two types of biological repairs that have been described in literature following apexification.

1. Continued root growth.
2. Occlusion of apex with calcified materials.

2.1. Indication of Apexification

- In a non- vital immature permanent immature tooth with an open apex.

2.2. Objective of Apexification

- To induce closure of open apical third of root canal or the formation of an apical calcific barrier against which obturation can be achieved.

2.3. Diagnosis and Case Selection for Apexification

Careful case selection and accurate pulpal diagnosis is very important.

1. Visual examination –the presence of swelling or sinus tract indicates pulpal necrosis and acute or chronic abscess respectively.

2. Percussion – tenderness on percussion indicates inflammation in the periapical tissues.

3. Vitality testing – vitality testing in the immature teeth is unreliable as these teeth provides unpredictable responses to pulp testing. Prior to root completion, the sensory plexus of nerves in the sub od-

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ontoblastic region is well developed. And as the injury itself can lead to erratic responses, over reliance on the results of clinical tests of pulp vitality, particularly electric pulp testing is not recommended.

4. Radiographic interpretation- this can be difficult as a radiolucent area normally surrounds the developing open apex of an immature tooth with a healthy pulp. It may be difficult to differentiate between the finding and a pathologic radiolucency resulting from pulp necrosis. In these cases comparison with the periapex of the contralateral tooth might be helpful.

It is not possible to establish a close correlation between the results of these individual tests and a histologic diagnosis but by combining the results of the history, examination and clinical test and accurate clinical diagnosis of pulp vitality can be made. A necrotic pulp in an immature tooth will lead to apexification.

2.4. Treatment Options

1. Surgical method

2. Non – surgical method

2.5. Surgical Methods: The disadvantages of surgical interventions include the difficulty of obtaining the necessary apical seal in the young pulpless tooth with its thin, fragile, irregular walls at the apex. These walls may shutter during preparation of the retro cavity or condensation of the filling material. Apicoectomy further reduces the root length resulting in unfavourable crown root ratio.

2.6. Non-Surgical Methods

- Custom cone (blunt-end, rolled cone)- it is not advisable as the apical portion of the root is frequently wider than the coronal portion, making proper condensation of gutta percha impossible.
- Short fill technique-
- Apexification with various materials
- One visit apexification.

2.7. Materials used for Apexification

A variety of materials have been proposed for apexification

- Calcium hydroxide
- Mineral trioxide aggregate (MTA)
- Tricalcium phosphate
- Dentin chips
- Calcium hydroxide ceramics and hydroxyapatite
- Bone Morphogenic Protein (BMP)

2.8. Calcium Hydroxide Apexification

Although a number of materials have been proposed for the induction of apical barrier formation, calcium hydroxide has gained the widest acceptance. It was introduced by Kaiser in 1964 for apexification. He proposed that calcium hydroxide mixed with camphorated paracholorophenol would induced the formation of a calcified barrier across the apex. This procedure was popularized by Frank, who emphasized the importance of reducing contamination within the canals by instrumentation and medication. Klein and Levy (1974) described the successful induction of an apical barrier with the use of calcium hydroxide and cresetin [1-7].

2.9. Mechanism of Action of Calcium Hydroxide

As the calcium ions do not come from the calcium hydroxide dressing but from the blood stream, the mechanism of action of calcium hydroxide in the induction of an apical barrier remains controversial. Mitchell and Shanwalker concluded that calcium hydroxide had an unique potential to induce heterotopic bone formation.

Holland et al demonstrated that the reaction of the periapical tissues to calcium hydroxide is the same as that of pulp. Calcium hydroxide produces a multilayered necrosis with subjacent mineralization.

Schroeder and Granath have postulated that the layer of firm, necrosis generates a low grade irritation of the underlying tissue sufficiently produce a matrix that mineralizes.

Many researchers also believes that the pH of calcium hydroxide is an important factor in its ability to induce hard tissue formation. It has also been demonstrated that the antimicrobial activity of calcium hydroxides may have a role in the induction of hard tissue formation. It has been seen that the apical barrier formation is more successful in the absence of microorganisms. The antimicrobial activity is related to the release of hydroxyl ions, which are highly oxidant and cause damage to the bacterial cytoplasmic membrane, protein denaturation and damage to bacterial DNA.

Heithersay postulated that calcium hydroxide may act by increasing the calcium concentration at the precapillarly sphincter, reducing the plasma fluid. in addition , the calcium ion can affect the enzyme pyrophosphatase, which is involved in collagen synthesis. stimulation of these enzyme can facilitate repair mechanisms.

2.10. Controversy Regarding Whether or How Often Calcium Hydroxide Dressing Should Be Changed

Chawla suggested that it is sufficient to place the paste only once and wait for radiographic changes. Chaosack et al found that after the initial root filling with calcium hydroxide there was nothing to be gained by repeated root filling either monthly or three monthly.

Proponens of a single application claimed that calcium hydroxide is only required to initiate the healing reaction and therefore repeated applications are not warrented. A number of authors proposed that calcium hydroxide should be replaced only when symptoms developed or the material appears to be wash out of the canal when viewed radiographically.

Abbot however points out the regular replacement of the dressing as a number of advantages. It allows clinical assessment of barrier formation and may increase the speed of bridge formation. He also suggested that the ideal time to replace a dressing depends on the stage of treatment and the size of the foramen opening. This must be assessed for each individual tooth at each stage of development.

3. Time Required for Apical Barrier Formation in Apexification Using Calcium Hydroxide

Sheehy and Roberts reported that average length of time for apical barrier formation range from 5 to 20 months. **Finucane and Kinirons** found that the mean time for formation of apical barrier using calcium hydroxide is 34.2 weeks (range13-67weeks).

3.1. Factors influencing time required for barrier formation

- Rate of change calcium hydroxide dressing.
- Barrier forms rapidly in cases with narrower initial apical width.
- Age- Age was found to be inversely proportional to the time required for apical barrier formation.
- Presence of periapical radiolucency-

Presence of periapical radiolucency at the start of treatment increases the time required for barrier formation. Time required for barrier formation extended by 5 months to an average of 15.9 months.

It has been reported in literature that calcium hydroxide when used for apexification had a success rate of 74% to 100%.

3.2. Histology of Apexification with Calcium Hydroxide

Calcified materials that forms over the apical foramen has been histologically identified as an osteoid or cementoid. Histologically there appears differentiation of adjacent connective tissue cells in to specialized cells. There is also deposition of calcified tissue adjacent to filling materials. The closure of apex may be partial or complete but consistently has minute communications with the peri-apical tissues.The root development after apexification procedures generally results in a somewhat different shape than the configuration of the root after normal differentiation.

3.3. Drawbacks of using Calcium Hydroxide for Apexification

One major drawback of apexification of using calcium hydroxide is the effect that a long term application of calcium hydroxide has on the structurally integrity of the root dentin. Studies had demonstrated that with longer exposures of dentin to calcium hydroxide, its ability to resist fracture is significantly decreased.

4. Technique of Apexification using Calcium Hydroxide

4.1. First visit

The first phase of treatment is to disinfect the root canal system to ensure periapical healing.

- The canal length is estimated with a parallel preoperative radiograph and confirmed radiographically with the first endodontic instrument.
- The tooth is anesthetise and isolated with rubber dam.
- Access is gain to the pulp chamber.
- Preparation of the canal due to the thin dentinal walls is performed very lightly and copious irrigation using 0.5% sodium hypochlorite is done. Lower strength of hypochlorite is used because of the danger of extruding through open apex.
- The canal is dried with paper points and a creamy mix of calcium hydroxide is put into the canal with lentulospiral. The calcium hydroxide is left in the canal for at least one week to be effective in accomplishing disinfection.

4.2. Second Appointment

- A thick paste of calcium hydroxide is packed into the root canal. Calcium hydroxide placement methods vary from injection of paste, using lentulospiral and condensation or even using packed dry powder.
- A temporary restoration is placed.

The patient is recalled after 6 months. The tooth is reentered an apexification is verified with radiograph. If apical barrier has formed root canal treatment should be done.

However, apexification with calcium hydroxide produces inconsistent results.

- The periapex closes with a definite recession of the root canal.
- The obliterated apex develops without any change in root canal space.
- A thin calcific bridge that is not radiographically discernible develops.
- A calcific bridge forms just coronal to the apex and can be determined radiographically.

5. Mineral Trioxide Aggregate Apexification

Although calcium hydroxide has been the material of choice for apexification a number of authors have worked with other materials. MTA has been found to be one of the materials that can be used for apexification. This material was introduced by Torabinezad in 1993. MTA is a powedered consisting of fine hydrophilic particles of Tricalcium silicate, tricalcium oxide and silicate oxide. It has low solubility and a radio-opacity that is slightly greater than that of dentin. The material has good sealability and biocompatibility and its pH of 12.5 is similar to that of calcium hydroxide and it has been suggested that it might have some antibacterial property. In studies done by Shababhang et al, they concluded that MTA produced apical hard tissue with greater consistency.

5.1. One Visit Apexification (MTA Apexification)

Morse et al, defined one visit apexification as the non surgical condensation of a bio-compatible material in to the apical end of the root canal. The rational is to establish of an apical stop that would enable the root canal to be filled immediately. There is no attempt at root end closure rather an artificial stop is created.

A number of materials has been proposed for this

- MTA
- Tricalcium phosphate
- Freeze dried dentin

5.2. Techniques of single visit Apexification or MTA Apexification

The inherent difficulties of inducing barrier formation over a period of months are avoided when the treatment is completed in one appointment. Such treatment is described as a single visit apical closure with MTA. When MTA is used in this manner it becomes the final obturating material in the apical to middle third of the canal system (Witherspoon).

• The tooth is anesthetize and isolated with rubber dam.

• An access opening and working length is determined.

• The canal is cleaned and shaped using Nickel titanium endodontic instrument with copious irrigation with sodium hypochlorite (2.5%).

• The smear layer is removed with the use of EDTA.

• Once cleaning and shaping is completed, a sequence of pluggers are loosely fitted in the root canal system.

• The smallest plugger should fit loosely 1.5mm from the working length.

• MTA is then placed in the middle to apical third of the root canal system and then compacted with a syringe of plugers.

• Once the MTA layer is adequately compacted to the working length and confirmed with radiograph the excess material is removed.

• The remainder of the root canal system can be filled with a core material that stops against the MTA. This layer can be extended up to the coronal third of the canal.

• Finally, composite resin is layered against core material extending to fill the opening.

5.3. Disadvantages of The Single Visit Apexification with MTA

• Contraindicated in extremely immature with wide open apices because compaction of MTA in such cases may result in fracture of dentinal walls.

• Causes staining of the gingival and tooth discoloration.

5.4. Advantages of Single Visit Apexification

When obturation finally occurs following hard tissue deposition calcium hydroxide, the dentist can never know about the integrity of apical barrier. Single visit apical closure with MTA avoids many of the pitfalls of traditional treatment methods.

Calcium hydroxide apexification remains the most widely used technique for treatment of necrotic teeth with immature apices. However newer techniques like one visit apexification and pulp revascularization provide alternative treatment option in these kind of cases.

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