**pulp therapy for young permanent teeth**

If we have a diagnosis of vital tooth we try our best not to invade the pulp but it can happen sometime, in that case we do **direct pulp capping**.

Indications: for permanent tooth that have a small carious lesion or mechanical exposure to the normal pulp encountered during cavity preparation.

What we do first is a good isolation, then we inspect the pulp if it’s healthy or not from the bleeding, so after hemorrhage is controlled the pulp is capped with CaOH or MTA prior replacing a restoration that seals the tooth form breaking.

Aim of the treatment: is to maintain pulp vitality by forming calcific barrier in the exposure area keeping in mind that in a teeth affected by caries there is an inflammatory response that protect the pulp from bacteria or bacterial products.

So if we have inflammatory exposure most of the time if we do good isolation the pulp capping will be successful. But if we have carious pulp exposure we have to check if the bleeding stopped or not because if it didn’t stop that means that this pulp is not healthy and we should remove it by partial pulpotomy then we apply the CaOH or MTA.

if the pulp capping is indicated it should be performed immediately after the exposure of the pulp, the tooth should be well isolated and disinfected with sodium hypochlorite if the bleeding cannot be stopped in a few minutes that suggest that the pulp inflammation has progressed deeper in the tissue and the treatment procedure should be modified by shifting to a partial pulpotomy .

MTA should be placed directly over the exposed pulp tissue 1.5-2mm thickness the material should be covered with glass ionomer liner followed by a permanent restoration.

We can use either MTA or CaOH put MTA is better because CaOH results in initial low grade irritation of the injured pulp allowing favorable tissue response followed by dentine bridge formation. The low grade irritation happen because it has a high ph and this high ph prologs the bacterial effect of CaOH , but the problem is that it’s water soluble and under leaky restoration it might resolve and washed out leaving an empty space under the filling material.

That’s why we prefer MTA for direct pulp capping.

Objectives :- to maintain the vitality of the tooth, no post treatment clinical signs & symptoms of sensitivity, pain or swelling should not be evident, pulp healing & reparative dentine formation should occur.

We do it mostly when we have traumatic exposure.

So what we do most of the time is pulpotomy but here we are talking about permanent teeth not primary it’s called partial pulpotmy .

**Partial pulpotomy**: when the pulptomy procedure includes removal of pulp tissue that has inflammatory or regenerative changes leaving intact the reaming vital non inflamed tissue which is covered with a pulp capping agent to promote healing at the amputation site. We do it when the pulp has an inflammatory response so here we don’t do direct pulp capping we should remove it instead.

We use MTA or CaOH in this case but not farmacresol because this teeth is permanent, farmacresol will do fixation and the pulp tissue will not be vital and it will need pulpectomy.

The only difference between pulptomy and direct pulp capping that in pulputomy additional tissue is removed from the exposed pulp.

In the past we removed all the inflamed pulp up to cervical and cleaned the pulp chamber but today we depend on clinical judgment and remove only the apparent inflamed part with professed bleeding.

**Partial pulpotomy for carious exposure :**

Either anterior teeth or molar teeth.

Indication::- In young permanent tooth for carious pulp exposure in which the pulp bleeding is controlled with several minutes, the tooth must be vital with the diagnosis of normal pulp or reversible pulpitis.

The technique :- the tissue beneath the exposure is removed for a depth of 1 mm to 3 mm so you have to remove until you feel that you have a healthy pulp. The best way to remove the coronal pulp tissue is by using a high speed diamond bur.

So you have to try to remove all the caries before proceeding into the pulpotomy, pulpal bleeding must be controlled by irrigation by sodium hypochlorite or chlorohexidine then it is covered with CaOH or MTA.

the CaOH has been demonstrated to have a long term success. We use the non-setting CaOH first then another layer of the sitting CaOH liner then the filling or MTA which is better for the patient.

MTA results in more predictable dentine bridging & pulp health, it has a long term sealing ability & stimulates a high quality & greater amount of reparative dentine, so MTA must be 1.5 mm thick should cover the exposure & surrounding dentine followed by a layer of light cure resin modified GI.

The restoration that seals the tooth from micro leakage is essential for the success of the treatment & establishes environment that will prevent any further future bacterial contamination.

We put at least 1.5mm thickness of MTA that should cover the exposure and the surrounding dentine followed by a layer of resin modified glass ionomer cement, MTA needs time to set so we either use moistened cotton with TF but here we prefer to put a material that sets quickly like CaOH or resin modified GI because we are working directly at the pulp.

If the pulpotomy is successful a tertiary dentine bridge will be formed.

🡪 🡪 For traumatic exposure 🡨 🡨

The upper anteriors are the most affected, they may have complicated fractures involving the pulp, so it is indicated in immature incisors with vital pulp that includes complicated crown fracture.

the smaller the size of the pulp exposure, the better the prognosis “ 1-2 mm” better prognosis also there is a very important factor which is the time when the patient presented the shorter the better, these two factors are very important for the prognosis of the tooth.

The inflamed pulp tissue beneath the exposure is removed to a depth 1 to 3 mm to reach the deeper healthy pulpal tissue.

Removal is carried out by high speed diamond bur with copious irrigation( water cooling )has showed to be the least damaging to the underlying tissue.

Pulpal bleeding is controlled using sodium hypochlorite or chlorohexidine &the site is then covered with CaOH or MTA again then we seal by a layer of resin modified GI & then restore the tooth.

We have to re-evaluate in one month & then once every 3 months for the first year to monitor the vitality & root development.

Sometimes the patient will be back with a green teeth , so we prefer to use white MTA but also the white may discolor the tooth sometime.

So we use white rather than gray MTA esp. in the anterior teeth to decrease the chance of discoloration.

Objectives of partial pulptomy: The remaining pulp should be vital after partial pulpotomy with no adverse clinical signs & symptoms like sensitivity, pain or swelling.

There should be no radiographic signs of internal or external resorption, abnormal canal calcification or periapical radiolucency post operatively, continued root development for teeth with immature roots & apexogenesis (it is a root formation and it is a histological term used to describe the continued physiological formation of the roots apex, formation of the apex in vital young permanent teeth can be accomplished by implementing the appropriate pulp vitality.

The objective of apexogenesis is sustaining a viable hertwig's root sheath to allow a continuing development of the root length for a more favorable root crown ratio(especially in teeth with short roots), and maintaining pulpal vitality to all the remaining odontoblasts to produce thicker roots to decrease the fracture possibility, promoting normal root closure to have a natural apical constriction for root canal fillings if needed, generating dentinal bridges inside the pulp.

The best thing for the tooth is to remain vital and have the natural apical closure over specification.

We finished the vital pulp treatment for young permanent teeth.

Now we will talk about pulp treatment for an already nonvital teeth our options in this case is**: apexfication** mostly for anterior tooth because posterior tooth is multi rooted and hard to work on.

The second option is **revascularization**.

Apexification: is a method of inducing root end closure of an incompletely formed nonvital permanent tooth in which root growth and development have stopped due to pulp necrosis.

- Is a method of treatment for immature permanent teeth in which root growth and development ceased due to pulp necrosis.

- Its purpose is to induce root end closure.

**indications**:

- performed in incisors that have lost vitality after a traumatic injury.

- also indicated in nonvital immature teeth after carious exposures.

Its use in permanent molars, theoretically is possible but practically we don’t use it that much in first molars since they have more than one root canal and sometimes it’s difficult to achieve good apexification in all root canals, so it’s more used in centrals after traumatic injury.

An example: incompletely formed root of a tooth that had trauma, if we want to do a root canal treatment it would be impossible to achieve an apical seal to prevent the extrusion of the filling material. So we want something to make an apical seal. The problem in apexification that even if we achieve an apical seal there will be stress on the walls and might end with fracture through the cervical area

A correct diagnosis should be based on:

* History taking
* Clinical assessment with special investigations.
* Radiographic assessment

When the diagnosis of irreversible pulpitis, pulp necrosis, or acute o chronic apical periodontitis has been established, treatment should be planned and apexification is an option.

**Treatment planning**

- the most important consideration is whether the tooth can be restored to function and aesthetics ( crown to root ratio and the thickness of the walls)

- if it is decided that the tooth is restorable, then apexification can be carried out.

**Apexification technique:**

- proper isolation ideally with rubber dam.

- coronal access should be wide enough to include the pulp horns to prevent future contamination and discoloration. All necrotic pulp tissue should be removed from pulp chamber.

- gentle debridement of the root canal. We are dealing with very thin wall so we must be very gentle.

- irrigation with disinfecting solutions like 0.5% to 2.5% NaOCl or 0.2% chlorhexidine solution should be done without pressure because there is a wide open apex.

- the needle should be loose inside the root canal.

- length of the root canal should be determined radiographically as electronic apex locators are not reliable in teeth with open apices.

- ‘check’ radiographs can be used to confirm the actual working length.

- minimal instrumentation is advised to prevent damage to the thin dentinal tubules.

- you can use either Calcium Hydroxide or MTA. Traditional way is to use calcium hydroxide.

**Ca(OH)2  apexification :**

- after instrumentation we want to fill the canals with non setting Ca(OH)2 that we can inject inside the canal.

- Ca(OH)2 disinfects the root canal and can induce apical closure.

- the high pH and low solubility of Ca(OH)2 keeps its antimicrobial effect for a long period.

- Ca(OH)2 is antimicrobial because of its release of hydroxyl ions which can cause damage to the bacterial cellular components.

- A Ca(OH)2 dressing in a paste consistency can then be injected to the working length.

- A lentulo spiral can be used to spread the material inside the canal.

- put a cotton pellet on the opening of the canal then temporary filling. The cotton pellet should be of appropriate size; because if it was small it will sink in the canal since the Ca(OH)2 is resorbable.

- The second appointment should be from 2 weeks to a month later.

- The Ca(OH)2 is removed with gentle debridement and irrigation. It Should be removed to the working length and then irrigation.

- The aim of the visit is to complete the debridement and remove the tissue remnants denatured by the Ca(OH)2 dressing that could not be removed mechanically in the first appointment.

- At the second visit, a thick paste of Ca(OH)2will be injected again in the root canal. The patient is recalled after longer period of time usually after 3 months.

- the tooth is monitored clinically and radiographically at 3-month intervals.

- When a calcific barrier can be seen in the radiograph, the tooth is reopened and biomechanically cleaned by NaOCl irrigation.

- The apical area should be examined using a file or a paper point to the working length in order to determine the completeness of the apical barrier. If paper point catch blood,the patient feels pain or we didn’t feel the barrier then there is no complete closure of the apex.

- If the barrier is incomplete and the patient feels the touch of the file, the apexification procedure is reestablished until a complete barrier is formed.

- there is a recommendation to remove and reapply the Ca(OH)2 in every visit. And some say that you look on the radiograph and see if there is resorption if so there is a need to remove and reapply the Ca(OH)2. But it’s better to change it every visit.

* The frequency with which to change the Ca(OH)2 dressing is controversial.
* In general, every 3 months.
* The root canal is filled with Gutta Percha.
* The tooth is restored. But the walls will remain week.
* Apexification with Ca(OH)2 is highly successful.
* Apexification with calcium hydroxide is a predictable procedure and an apical barrier will be formed in 74%-100% of cases.
* Apexification with calcium hydroxide requires multiple visits and could take a year or more to achieve a complete barrier that would allow root canal filling using Gutta Percha and sealer.
* Patient compliance is needed. The patient has to report every 3 months.
* Clinically, it is successful but the problem is in patients,. It is always recommended to build up the tooth (to prevent loss of space and overeruption of the opposing) before starting apexification so after trauma for example if the patient comes to the clinic and build up and apexification were made then the patient won’t have pain and the tooth looks nice so usually the patient won’t come back. To have a patient that will come every 3 months is difficult, however, If the patient did it will be highly successful. But MTA we can do it in a couple of visits so it’s faster and better for the patient

**Complications:**

- the most common complication is cervical crown or root fracture because the cervical portion of the tooth is very thin and may fracture easily. Because Ca(OH)2 denatures dentine so it makes it more prone to fracture.

- It has been reported that Ca(OH)2 may significantly increase the risk of root fracture after long-term application.

**MTA Apexification:**

* After removal of the coronal and nonvital radicular tissue just short of the root end a biocompatible agent such as calcium hydroxide is placed in the canals for 2-4 weeks to disinfect the canal space.
* At the following visit, MTA can be placed at the apical portion of the immature root and will act as an apical plug after setting. So an immediate apical plug will be formed and root canal filling can be used.
* The MTA product powder is mixed with supplied sterile water.
* A moist cotton pellet is placed in direct contact with the material and left until a follow-up appointment. We can put a moist paper point on it and close above it for a week to allow for a complete setting before we can put the root canal filling material.
* Hydration of the powder results in a colloidal gel which solidifies into a hard structure in 3-4 hours.
* In instances when complete closure cannot be accomplished by MTA, an absorbable collagen wound dressing ( e.g. Colla-Cote) can be placed at the root end to allow MTA to be packed within the confines of the canal space. The collagen wound dressing is absorbable but it makes a stop that allows us to put MTA above it.
* Small pieces of a synthetic collagen material, can be gently compacted using hand pluggers to produce a barrier at the level of the apex.
* MTA is placed at the apical area, as determined by the radiograph using special carriers or endodontic pluggers.
* A radiograph is taken to confirm adequate placement of MTA to form an apical stop approximately 3-4 mm thick.
* The blunt end of a large paper point is moistened with water and left in the canal to promote setting.
* A cotton pellet is placed in the chamber and the tooth is restored with a temporary filling.
* Gutta Percha is used to fill the remaining canal space.
* If the canal walls are thin, the canal space can be filled with composite resin instead of GP to strengthen the tooth against fracture.
* It was demonstrated that the resistance to fracture of immature teeth could be increased by using resin modified glass ionomer inside the root canal.
* MTA reduces time needed for completion of the treatment and for restoration of the tooth.
* MTA reduces has osteoinductive properties and sets in the presence of moisture.

The MTA apical seal has a number of **advantages:**

* Less patient compliance is required.
* The dentin will not lose its physical properties.
* The material allows for earlier restoration of the tooth, thus minimizing the likelihood of root fracture.

While advances with MTA and bonded restorations go some way towards a better outcome, ultimately no apexification method can produce the outcome that apexogenesis can achieve, i.e. apical maturation with increased thickness of the root.

**Revascularization:**

Tooth in this method will continue to grow in thickness to achieve apical closure and will have better prognosis.

* With immature permanent teeth requiring pulp therapy, the pulpal status traditionally determines the treatment modality.

 Vital pulp: Apexogenesis, Nonvital pulp: Apexification

And now there is a revascularization option for the nonvital pulp

* Certain clinical observations reported recently have broken this clear-cut guideline by showing that apexogenesis may occur in teeth which have nonvital pulps.
* A new protocol has been suggested in which hemorrhage is induced to fill the canal with a blood clot as a scaffold to allow generation of live tissues in the canal space and continued root formation (length and wall thickness).
* Retrospective studies, prospective clinical studies and case reports utilizing a blood clot revascularization technique have promising outcomes characterized by:
* The absence of clinical disease,
* Regression of an apical lesion and
* Continued root development
* This new protocol of treatment coincides with the recent concept of regenerative medicine which promotes the research and practice of tissue regeneration.
* The dental papilla at the wide open apex contains stem cells that are robust.
* These stem cells survive the infection and retain the capacity to give rise to new odontoblasts influenced by Hertwig Epithelial Root Sheath, allowing new root dentine to form and root maturation to proceed to completion.
* Instead of using Ca(OH)2 as the intracanal medicament (because it denatures the tooth) between visits to disinfect and to induce apical barrier formation, an antibiotic paste is used for the purpose of disinfection only.

**Triple antibiotic paste / Ca(OH)2:**

* Ca(OH)2 may not be suitable if there is remaining vital pulp tissue in the canal.
* The direct contact of Ca(OH)2 paste with the tissue will induce the formation of a layer of calcific tissue which may occlude the pulp space , therefore preventing pulp tissue from regeneration.
* Another concern is that Ca(OH)2 may damage the Hertwig’s epithelial root sheath and thereby destroy its ability to induce the nearby undifferentiated cells to become odontoblasts.
* Triple antibiotic paste is a mixture of ciprofloxacin, metronidazole and minocycline.
* A disadvantage of this therapy is tooth discoloration to a bluish-grey hue caused by the antibiotic mix.
* Minocycline in the antibiotic mixture may be responsible for the discoloration, but the outcome is not consistent.
* Patients and parents/guardians should be advised of potential staining and a subsequent need for bleaching.
* After 3 months, if there are no radiographic signs of regeneration, apexificaion or nonsurgical root canal treatment can be initiated.
* **Treatment protocol:**
* Access preparation.
* Irrigate canal ( 20ml 6% NaOCl and 10 ml 0.12% chlorhexidine)
* Paper point dry canal
* Place antibiotic paste in canal for 2-3 weeks.
* Confirm absence of exudates, irrigate canal ( 10 ml 6% NaOCl)
* Gently probe canal to induce bleeding.
* Allow clot to form below the CEJ.
* Place MTA, wet cotton pellet and a temporary filling over clot for 2 weeks.
* Replace temporary filling with a definitive restoration.
* Revascularization will happen and the root length will increase
* Assessment of revascularization can be done by taking a radiograph of the tooth.
* **Modifications to technique:**
* Some recommended using an anesthetic without a vasoconstrictor to help induce bleeding into the canal space.
* Another modification is using a collagen product such as Colla Plug as a barrier over the clot to contain the MTA.
* Omitting minocycline from the paste is suggested to reduce staining, but the paste’s antimicrobial effect without minocycline is unknown.
* Revascularization therapy offers advantages including shorter overall treatment time, infection control, cost effectiveness, root lengthening and hard tissue deposition.