THE USE OF MINERAL TRIOXIDE AGGREGATE VERSUS CALCIUM HYDROXIDE IN THE TREATMENT OF NECROTIC IMMATURE TEETH

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Abstract: *Due to their morphologic and structure features, immature permanent teeth represents a special entity with apical zone development in full swing. That is why the treatment of immature teeth with necrosis is a real challenge to induce root-end barrier formation using endodontic materials and providing good apical seal. Till now, the most appropriate material used has been calcium hydroxide but the recent putting in practice of mineral trioxide aggregate (MTA) with excellent biological and physical qualities seems to reduce the domination of calcium hydroxide in endodontics field. The aim of this study is to analyse and to compare the biological and microbial properties of both materials based on scientific evidence from previous literature.*

Cuvinte cheie: *hidroxid de calciu, mineral trioxid agregat, apexificare, barieră apicală*

Rezumat: *Dinţii permanenţi tineri (DPT) reprezintă prin caracteristicile morfologice şi de structură o entitate aparte aflată în plin proces de dezvoltare radiculară.Gangrena complicată la DPT cu pierderea totală a vitalităţii pulpare constituie o provocare în ceea ce priveşte inducerea apexificării utilizând diverse materiale endodontice specifice cu scopul de a forma o barieră apicală care să sigileze definitiv canalele radiculare. Materialul de elecţie utilizat în acest scop este hidroxidul de calciu dar apariţia relativ recentă a mineralului trioxid agregat (MTA) graţie calităţilor sale fizice, chimice şi biologice pare să reducă încet dar sigur supremaţia îndelungată a hidroxidului de calciu. Scopul acestei lucrări este de a analiza şi compara pe baza datelor culese din literatura de specialitate, avantajele şi dezavantajele celor două materiale utilizate în tratamentul gangrenei DPT în ceea ce priveşte proprietăţile antimicrobiene şi biologice.*

INTRODUCTION

In apical and periapical zone there are unlimited repair potentials able to induce root-end finalization *(apexification*) or just hard tissue barrier formation *(apexogenesis)*.In most clinical cases we confront with total lost of pulp vitality which requires standard endodontics procedures to neutralize bacterial toxins and to achieve appropriate conditions to induce barrier formation. Finally, the apical sealing consists in a tridimensional fibrous or hard plug which will delimitate root-canal from periapical zone.

PERSONAL CONTRIBUTIONS

This comparative study is based on scientific research selected from articles and studies most of them from the last ten years.

The dates were divided into groups which describe the physical, chemical and biological properties and also the specific techniques of apexification for both materials.

1. General characterictics

Calcium hydroxide, used in practice for the first time by *Herman* in 1920 for treatment of dental pulp, is a strong base that results from calcium oxide hydration. Well-conducted researches about the properties of calcium hydroxide, like histocompatibility, antimicrobial potential and ability of sealing give credibility to choise this medication in immature teeth necrosis

.It is necessary to take into account the influence of vehicles on properties of calcium hydroxide and the time of action for express microbial control.(5)

The combination with saline solution or distilled water gives better results (approximately 60 % total reparation) than association with camphorated paramonoclorophenol (CMPC) with only 20% total reparation.(11)

Mineral trioxide aggregate was developed by Dr.Torabinejad at Loma Linda University in 1990 and since then is used like an endodontic material. There have been many articles published in dental journals which confirm the excellent biological and physical properties.(26)

It is available as ProRootMTA but recently a new cement was laundred commercially labeled as MTA-Angelus.MTA is a white or grey powder of fine hydrophilic particles consisting of compounds of tricalcium silicate, tricalcium oxide, tricalcium aluminate and silicate oxide.(14)

Several studies have reported that MTA is similar to commercial Portland cement (PC) which represents 80 % and the rest of 20 % is bismuth oxide added for radio-opacity.(2). On hydration both materials (PC and MTA) are forming a calcium silicate gel and calcium hydroxid in ratio 4:1, which can explain the similar mechanism of MTA and calcium hydroxide.

2. Physical, chemical and antimicrobial properties

Calcium hydroxide is considered in present the main endodontic material in treatment of necrotic immature teeth because of its properties:

- *high alkaline pH* (12,6) which explains antimicrobial properties able to destroy in just 1-6 minutes 99,9% of bacteries in contact with calcium hydroxid
- *persistent* root-canal *secretions* are stopped; Sjögren demonstrated that after 7days root canals are completed sterilize
- *low solvability* in water determine a gradual release of hydroxyl ions and also a low

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- most studies referring to microbial effect are using a minimum inhibitory concentration below 5% of calcium hydroxide. In practice this concentration is higher than 5% thus the microbial effect is certain (8).

Disadvantages:

- the major disadvantage of calcium hydroxid is *higher resorbability* which require periodic replacement till the complet root formation
- if the root-canal is not *straight* and *large* enough the application of material till apical zone can be difficult
- to destroy *Enterococus Faecalis*, bacteria responsible for treatment failure, calcium hydroxide needs more time than for others bacteries
- it has a poor sealing ability.(23)

Mineral trioxide aggregate:

- the main component of MTA is *calcium* conclusion based on chemical analysis of the salts dissolved from MTA in water. Calcium ions may cross the cell membrane therefore this ion would play a greater role in the reparative process than hydroxyl ion.(13)
- concentration of hydroxyl ions (pH) is 10 after mixing with distil water increasing after 3 hours at 12 which guarantee the long lasting microbial effect and unfavourable environment for microorganisms growth
- calcium ions release from MTA stimulated hard tissue deposition.(25)
- because of its hydrophilic properties and setting in a moisture environment, perfect isolation is counterindicated. Sometimes, it is necessary to let a moisture cotton ball in the pulp chamber so that MTA setting in ideal conditions (4 hours are necessary).(9)
- a comparative *in vitro* study demonstrated that MTA and Portland cement have similar action on *P.aeruginosa.*More, it showed that calcium hydroxyde paste has a superior antimicrobial effect comparing with MTA and PC.(18)

3. Histocompatibility and biological effect

Calcium hydroxide

- has the ability to activate tissue enzymes like alkaline phosphatase which release organic phosphate that reacts with calcium and results a sediment of calcium phosphate laid on organic matrix.(5)
- the release of calcium ions and alkaline pH are very important for biological and antimicrobial properties of an endodontic material which contains calcium hydroxid or oxide
- several studies showed that calcium ions from hard tissue barrier are coming from *blood circulation* and the role of ions is to create a necrosis layer which stimulates formation of collagen matrix

Mineral trioxide aggregate

- besides its nontoxicity, MTA is not resorbable , has good biological action and stimulates repair.(3) because allows cellular adhesion, growth and proliferation on its surface
- excellent sealing ability against facultative microorganisms and a good apical root-end filling material.(14)
- more studies demonstrated that MTA determine complete periapical healing when is used properly on disinfected root-canals.(16)
- MTA stimulated hard tissue deposition and mineralized barrier formation with a high consistency as regards quality but not quantity.(21)
- histologycal exams evidenced stimulation of cementum overgrowth with minimum or absent inflammatory response.(3)
- neither white nor grey form of MTA has genotoxicity and citotoxicity properties (19) ▫although MTA has no specific indication in chronic periapical lesions is proved to be very efficient in certain clinical cases, complete healing occurring after an important period of time.(9)
- the most frequent reaction after one week treatment with MTA is proliferation of granulation tissue with a few inflammatory signs.(3)
- a recent study showed that MTA does not affect phagocytosis and ability of two macrophage subtypes, to eliminate microbes.(17)
- MTA is considered now the ideal material used for nonsurgical treatment of radicular furcation and perforation.(9)

4. The use of MTA and calcium hydroxid in apexification

Apexification is defined 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.(1) To induce apexification **calcium hydroxide** is considered the most indicated endodontic material but it has several disadvantages:

- variability of treatment time, number of appointments and radiographs difficulty in patient follow-up, delayed treatment.(21)
- possibility of increasing tooth fractured after calcium hydroxide was used for extended periods

Mineral trioxide aggregate represents an alternative because of his multiple advantages:

- reduction in treatment time and possibility to restore tooth with a minimal delay and thus to prevent the fracture of root and also avoiding changes in the mechanical properties of dentine because of prolonged use of calcium hydroxide. (22)

If the root canals are not appropriate prepared and dezinfected the secondary effects which appear are the absence of apical hard tissue barrier, inflammatory reactions and finally root-canal and bone resorbtion

5. The technique of apexification

Calcium hydroxide is associated with the most common technique which consists in mechanical and chemical root-canal preparation and filling with an endodontic material. After clinical steps the patient needs to be follow-up from 3 to 3 months (the complete apexification is done in at least 6-24 months). Periapical pathology, secondary pain or destroyed filling are factors that increase the period of treatment. Failures of this technique may be caused by a repeated overfilling with a high pH which induces a necrotic zone in periapical tissues (15).

That is why several authors are recommending the new technique *one visit apexification,* which consist in an apical plug of MTA placed in the last 5 mm of incompleted root canal. Obturation of root-canal and immediately placement of a coronal restoration are possible and are regarded as key elements for the long term conservation of treated tooth.(24)

The protocol followed for apexification with MTA

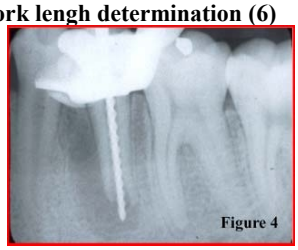
To use MTA the powder is mixed for 30 seconds with a drop of distilled water. The mixture should be homogeneous and with a consistency similar to wet sand.If the MTA is not use immediately after mixing its deshydration can be prevented by covering the mix on the glass slab with a wet gauze. It is optional if MTA is placed into canals after the use of calcium hydroxide for one week.After preoperative radiograph (Picture no.1) and isolation with of tooth with rubber dam , should be followed the next steps:

1. Chemical and mechanical debridation with sodium hypochlorite (5,25%), EDTA 17% and clorhexydine 2% and irrigation sodium hypochlorite 5,25%.
2. Drying of the canal with a sterile paper point on the work

length determined previous (Picture no. 2)

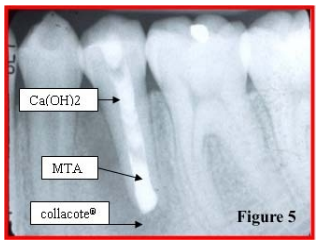
Picture no. 1 Aspect of immature tooth (6) with pulp necrosis

Picture no.2 Work lengh determination (6)

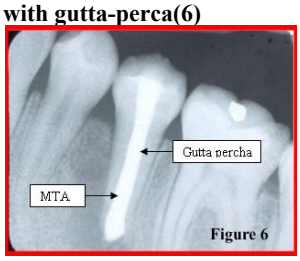


3. The proper size plugger choice so that can be neither too large to stuck in the root walls or to small to penetrate the plug of MTA
4. Placement of collagen matrix to the apical zone (CollaCote) as an organic foundation for MTA (Picture no .3)
5. Apical zone sealing with MTA plug in the last 3-4 mm and after radiological examination the adjustment if needed with an endodontic plugger (Picture no. 4)

Picture no. 3 Radiotransparent periapical CollaCote matrix (6)

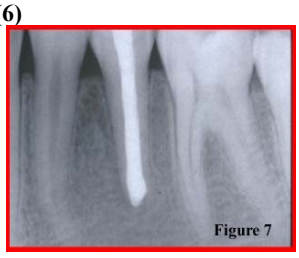


Picture no. 4 Apical sealing with MTA plug followed by complete filling with gutta-perca(6)



6. Complete filling of root canal with gutta-percha and corono-radicular restoration with a bonded resin composite. (6)

Picture no. 5. The aspect of apical and periapical zone after 2 years. It showed complete root maturation and periapical lesions healing (6)



The MTA is use in apexification after the complete remission of acute symptoms because the low pH of inflammatory lesions from apical zone compromise the healing and the barrier hard tissue formation.

CONCLUSIONS

The importance of calcium hydroxide in endodontic developed occurred due to specially its biological properties that should not be neglected. Scientific investigations should be carried out frequently to evaluate materials recommended for use in endodontic. It is necessary whenever to give time for calcium hydroxide paste to manifests its potential action on microorganisms present in endodontic infection.Despite efficacity of this dressing some authors criticize the quality of the hard tissue bridge formed with calcium hydroxide, claiming tunnels defects, which can compromise the protecting efficiency of bridge.(5)

Based on the results of previous studies mineral trioxide aggregate is an advantages alternatives of calcium hydroxide being more biocompatible and with a greater sealing capacity. Althought MTA is the most investigated material in dentistry, producing remarkable results, the majority of studies were made in labs or using animals. The research must be continued for clinical evaluation in human subjects.(12) MTA reacts with fluids from tissues to induce apical hard tissue barrier(27).The cellular response and the mechanism of hard tissue barrier induction are still little known and necessitate more investigations. At 6 months, 1 year and 2 years follow-up periods the clinical and radiographic appearance of teeth showed the resolutions of periapical lesions and continued root end formation in all except the cases in which the MTA was extruded out the apex (4).

As regard association of MTA with calcium hydroxide in treatment of immature permanent teeth several studies showed that the regeneration of periapical tissues appears in a shorter period and the healing is complete.(10)

In conclusion, most of scientific researches done by now demonstrated the efficacy of both endodontics materials, with advantages and disadvantages, the choice of one depending on clinical situations, apexification technique and social-echonomics conditions.

REFERENCES

1. American Association of Endodontics-Glossary of endodontic terms.Chicago, 2003.
2. Duarte Ma. , Demarchi AC, Kuga MC Fraga Sde C – pH and calcium ion release of 2 root-end filling materials. Oral Surgery , Oral Medicine , Oral Pathology , Radiology and Endodontics 95 , 345-7 , 2003
3. Economides N., Pantelidou O., Kokkas A., Tziafas D.- Short-term periradicular tissue response to mineral trioxideaggregate(MTA) as root- end filling material.International Endodontic Journal 36 , 44-48 , 2003
4. Erdem Pinar, Arzu, Sepet, Elif- Mineral trioxide aggregate for obturation of maxillary central incisors with necrotic pulp and open apices. Dental Traumatology,Vol. 24 Nr.5,pp 38-41,2008
5. Estrela Carlos, Holland Roberto. Calcium hydroxide: study based on scientific evidences. J. Appl. Oral Sci. (serial on the Internet). 2003 Dec (cited 2009Mar 01); 11(4): 269-282.
6. Fayad M., Montero JM.- Multiple versus one -step apexification. Discuss a new approach for management of a necrotic immature teeth, nov. 2004, Smile-on
7. Gafar M., Iliescu A. –Odontologie – Endodonție clinică şi practică.Editura Medicală , Bucureşti , 1998

8. Gergely JM., Di Fiore PM.- Intracanalar medication in endodontic treatment.A survey of endodontic programs.General Dentistry 41, p328-331, 1993
9. Girdea Maria, Ciobanu Gabriela, Amariei C.- Advantages of ProRoot MTA in treating periapical lesions. Clinical cases .OHDMBSC – vol.V , No.4 , December , 2006
10. Ham KA., Whiterspoon DE., Gutmann JL.et al – Preliminary evaluation of BMP-2 expression and histological characteristics during apexification with calcium hydroxide and mineral trioxide aggregate .Journal of Endodontics 31 , p 275-9 , 2005
11. Holland R, Cruz AG, Nery MJ, Souza V, Otoboni-Filho JA, Bernabé PFE. Efecto de los medicamentos colocados en el interior del conducto,hidrosolubles y no hidrosolubles en el proceso de reparación de dientes de perro con lesión periapical. Endodoncia 17:90-100. 1999
12. Holland R, Otoboni-Filho JA, Souza V, Nery MJ, Bernabé PFE, Dezan-Jr E. A comparison of one versus two appointment endodontic therapy in dogs teeth with apical periodontitis J Endod 29,121,2003
13. Hunter AR., Kirk EE., Robinson DH., Kardos TB.- A slow release calcium delivery system for the study of reparative dentine formation. Endodontics and Dental Traumatology 14 , p112-118, 1998
14. Lee SJ., Monsef M., Torabinejad M. – Sealing ability of a mineral trioxide aggregate for repair of lateral root perforations Journal of Endodontics 19 , p541-544 , 1993
15. Rafter M. - Apexification:a review .Dental Traumatology 21 ,1-8,2005
16. Regan JD., Gutmann JL., Witherspoon DE.- Comparison of Diaket and MTA when used as root-end filling materials to support regeneration of the periradicular tissue International Endodontics Journal 35,p 840-7, 2002
17. RezendeTM., Vieira LQ., Cardoso FP., Oliveira RR.et al – The effect of mineral trioxide aggregate on phagocytic activity and production of reactive oxygen, nitrogen species and arginase activity by M1 and M2 macrophages. International Endodontic Journal 40 p603-611, 2007
18. Ribeiro, Caroline Sousa et al. Comparative evaluation of antimicrobial action of MTA, calcium hydroxide and Portland cement. J. Appl. Oral Sci., Oct, vol.14, no.5, p.330-333,2006
19. Ribeiro DA., Matsumoto MA., Duarte MAH., Marques MEA.-Ex vivo biocompatibility tests of regular and white forms of mineral trioxide aggregate. International Endodontic Journal 39 , p26-30 , 2006
20. .Schwartz R.S. et al – Mineral trioxide aggregate : a new material for endodontics. Journal of American Dental Association,.130(7):pp 967-75,1999
21. Shabahang S., Torabinejad M., Boyne PP., Abedi H., McMillan P-A comparative study of root-end induction using osteogenic protein-1, calcium hydroxide and mineral trioxide aggregate in dogs. Journal of Endodontics 24 ,1999
22. Simon S., Rilliard F., Berdal A., Machtou P.- The use of mineral trioxide aggregate in one visit apexification treatment: a prospective study. Interntional Endodontic Journal 40., 186-197, 2007
23. Shuurs AH., Gruythuysen RJ., Wesselink PR.- Pulp capping with adhesive resin-based composites vs calcium hydroxide: a review .Endodontics and Dental Traumatology 16,240-50,2000
24. Steinig TH., Regan JD., Gutmann JL-The use and predictable placement of Mineral Trioxide Aggregate in one visit apexification cases. Australian Endodontic Journal 29,p 34-42, 2003
25. Tamburic SD., Vuleta GM., Ognjanovic JM.- In vitro release of calcium and hydroxyl ions from two tipes of calcium hydroxide preparation. International Endodontic Journal 26 , p125-30 ,1993
26. Torabinejad M., Watson TF., Ford TRP.- Sealing ability of a mineral trioxide aggregate when used as a root end filling material Journal of Endodontics 19 p591-595, 1993
27. Whitherspoon DE., Ham K. – One visit apexification: technique for inducing root-end barrier formation in apical closures. Practical Periodontics &Aesthetic Dentistry 13 , p455-60 , 2001