Mineral Trioxide Aggregate v/s Calcium Hydroxide: A Review Article

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Abstract

The main purpose of this article is to compare the mineral trioxide aggregate and calcium hydroxide in pediatric dentistry. Both of the endodontic cement are frequently used in different cases of pedodontics. This article aims to present the various characteristics of mineral trioxide aggregate and calcium hydroxide in a review article.

Keywords: *Mineral Trioxide Aggregate Calcium Hydroxide, Dental cement.*

Introduction

Over several years, different kinds of dental types of cement have been developed to avail of various purposes and to be applied to numerous events in dentistry. MTA is a distinctive endodontic cement & was developed by Torabinejad & members at the Loma Linda University, California, USA. Firstly, it was used as a root-end filling material in endodontic treatment. Over the years, MTA has been expanding its applications which includes root-end filings, direct pulp capping, perforation repairs in roots or furcation. U.S Food & Drug Administration has approved for the endodontic use of MTA in 1998. However, calcium hydroxide is also one of the most important medicaments used in the treatment of pulp disorders and apical periodontitis. Calcium hydroxide is a dental cement has been used in dentistry over the decades.[1]

Mineral Trioxide Aggregate (MTA): MTA is considered as one of the most multifunctional material in dentistry. MTA was identified as root-end filling material as it is a hydraulic cement that settles down in the existence of moisture. Through the internal bleaching of endodontically treated tooth, MTA act as a barrier. It can be utilized as capping material within mechanically exposed pulp & root-end induction. MTA favours the regeneration of tissue along with easy manipulation, possess good sealing stability & acquire long term prognosis.[2]

Composition: MTA gets settled easily in moisture as it is made up of hydrophilic particles. It is mainly constituted of fine hydrophilic particles of tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide & bismuth oxide. MTA resembles Portland cement in composition expect bismuth oxide which is added to MTA for radiopacity. On comparison to Portland cement, particles of MTA are little and identical in size.[3]

MTA is available in 2 types: White MTA (WMTA); Grey MTA (GMTA). These two types mainly differ in lesser amounts of Iron, Aluminium & Magnesium oxides on WMTA than GMTA. GMTA has longer setting time, less radiopacity, solubility & pH value than WMTA whereas WMTA has more compressive strength than GMTA.

Mechanism of action: As soon as MTA is placed in direct influence with human tissues, the dental cement. The dental cement undergoes cell attachment & proliferation when comes in contact with human tissues. It resembles calcium ions which form calcium hydroxide. Due to alkaline pH, it gives antibacterial environment. Modulates the production of cytokine. Undergo hard tissue differentiation which stimulates the migration of cells. Biological seal by the formation of hydroxyapatite (carbonated apatite) on the MTA surface.[4]

Method of preparation: MTA powder should be stored in tight containers and dry condition. Before its use, MTA mixture should be prepared instantly. The

mix should prepare on a glass slab or paper slab with the use of plastic/metal spatulas. The powder water ratio should be 3:1 to obtain putty-like consistency. The mix should be carried with the help of plastic/metal carrier to the place of application. If the location is very wet, dry piece of gauze/foam is used to remove extra moisture whereas water can add up to mixture, if it is very dry. After mixing, MTA has a pH of 10.2 and it increases to 12.5% after a set time of 3 hours. Mixing time is of great importance, dry mix is seen if the mixing time is being lengthened. Mixing time should be below 4 minutes. Islam et al claimed it 2 hours 55 minutes for GMTA & 2 hours 20 minutes for WMTA.[5]

Calcium chloride and sodium hypochlorite lessen the setting time while saline and 2% lidocaine raises the setting time.

Properties: As the MTA material sets, its compressive strength shows identical to IRM and Super EBA. GMTA has more compressive strength than WMTA. MTA radiodensity is same as Zinc Oxide Eugenol. It can be seen radiographically.[6]

The set MTA is insoluble whereas solubility may increase if more water is added while mixing. When the set MTA exposes to water, it releases $Ca(OH)_2$ which may be responsible for cementogenesis induced property. The setting of MTA doesn't hamper in an acidic environment.

MTA has excellent sealing ability perhaps as expansion during setting. Residual calcium hydroxide may inhibit the adaptation of MTA to dentin which reduces the sealing ability. This is of great importance as when $Ca(OH)_2$ is placed in between the appointments before the positioning of MTA. As it provides good seal & prevents microleakage, it indicated as an antibacterial agent. MTA doesn't respond or inhibit with any restorative material. They are biocompatible. MTA can activate cementoblasts and produces cementum. It allows bone healing & regeneration of periodontal ligament. MTA induces thicker Dentinal bridge formation with less inflammation, necrosis and frequent odontoblastic layer formation as compared to $Ca(OH)_2$.[7]

Advantages: Antimicrobial, Microleakage, Cement conductive, Nontoxic, Cell Adherence & Growth. Periodontal Attachment To Cementum Growth, Dentinal Bridge Formation

Disadvantages: High cost, Difficult to manipulate, Longer setting time, Prolonged maturation phase

Uses: Direct pulp capping, Apical plug, root-end filling, Perforation repair, Furcation involvement, Resorptive defects, Apexogenesis/Apexification.

Commercially Available: Pro Root MTA, White ProRoot MTA, Ortho MTA, MTA Fillapex.

Calcium Hydroxide: Calcium hydroxide was introduced to the field of dentistry in 1921. Herman demonstrated the formation of the dentinal bridge in an exposed pulp & now it is considered as the 'gold standard for pulp capping agents.'

Composition: It is composed of calcium hydroxide powder, a vehicle & a radiopacifier.

Vehicle: Mainly there are 3 types of vehicles:

First is water-soluble substances. Some examples are water, saline, methylcellulose, anaesthetic solutions, carboxymethylcellulose & Ringers solution. Second is viscous vehicles. Some examples are glycerine, polyethyleneglycol (PEG), propylene glycol. The third is oil-based vehicles. Some examples are olive oil, silicone oil, camphor, eugenol, some fatty acids.[8]

Radiopacifier: Vehicle is not radiographically seen easily as it does not possess radiopacity. An ideal radiopacifier such as Barium sulfate & bismuth, a compound containing Iodine & Bromine have an atomic weight higher than calcium for radiopacity.[8]

Mechanism of Action: Vehicles in periapical tissues & in the root canal, calcium hydroxide will be solubilized & resorbed/absorbed at different rates as it decides the ionic dissociation kinetics. Calcium hydroxide activates in the presence of moisture and pH increases to 12 and above with minutes when $Ca(OH)_2$ is used as Intracanal medicament. Average time for the treatment is 1-4 weeks.

$$Ca(OH)_2 + H_2O \text{ -----> } Ca^{2+} + OH^-$$

Due to the huge concentration of hydroxyl ions from calcium hydroxide, cytoplasmic membrane damages its protein acts on the organic component & transport the nutrient (OR)

By saponification reaction, during the peroxidation process, the phospholipids/unsaturated fatty acids of the cytoplasmic membrane are being demolished.[9]

Calcium hydroxide has been provided in different modes. As varnish, it is supplied as a liquid which composed $Ca(OH)_2$ suspend in a solvent or even provided as a paste in that calcium hydroxide is suspended in methylcellulose. As a catalyst, $Ca(OH)_2$ present in the oral environment, it responds quicker & structures a tough amorphous compound in a minute. Calcium hydroxide as paste, when it exposes to brightening from a handheld blue light, calcium hydroxide hardens, as it contains polymer resin.[7]

Method of preparation: Up to the desired consistency is attained, mix both calcium hydroxide powder and water. It is the easiest method to prepare $Ca(OH)_2$ paste. Leonardo *et al* expressed in 1982 that a paste doesn't possess good physicochemical properties since it isn't radiopaque and penetrable to tissue fluids when the paste is made with water or more hydrosoluble non-viscous vehicle. It is dissolvable & resorbed in the periapical region and inside the root canal. Insertion of different substances to the calcium hydroxide paste is purposed by him.[6,7]

Uses: Intracanal medicament, Endodontic sealer, Pulp capping agent, Apexification, Pulpotomy, Weeping canals

Advantages: They are bactericidal and act as a mild irritant which stimulates hard tissue formation. They are inexpensive and easy to use and they stop internal resorption

Disadvantages: Formation of tunnel defects, bacterial reinfection, long term usage of $ca(oh)_2$ in apexogenesis may weaken the root, susceptible to fracture, less effective against *Enterococcus faecalis* & *Candida albicans*, chronic pulpal inflammation & internal resorption in a primary tooth, poor coronal seal & strength

However, calcium hydroxide is not generally used in pulp therapy for primary teeth. A mixture of calcium hydroxide & iodoform is found to be easy to apply & resorbs at a slightly faster rate. It has no toxic effect on succedaneous teeth & is radiopaque. Reasons outlined mixture of calcium hydroxide & iodoform can be considered to be a nearly ideal primary tooth root canal filling material.[7,8]

Recent advances: Recent advances of medicaments in Paediatric Endodontics includes dentine, BioRootTm RCS, Smartseal

Biodentine: It is a calcium silicate-based product specifically design as "dentine replacement" material. It has become commercially available in 2009. It was introduced to overpower all the drawbacks of $Ca(OH)_2$ and MTA. It has greater potential to favour the repair of perforations of the pulpal floor, open immature tooth, retrograde filling, apexification, pulp therapy.

Bio Root Tm RCS: It is a mineral-based root canal filling material with Active Biosilicate Technology for permanent obturation. This material helps to stop bacterial growth & alleviates the risk of intracanal reinfection due to high pH. It is biocompatible, resin-free, has good flow and hydrophilic due to which it set even in the presence of moisture.

Smartseal: It is recently introduced material based on polymer technology. Its principle is based on the hydrophilic nature of the obturating points.[10]

Conclusion

In comparison, the characteristics of both the dental materials it is clear that MTA is more effective than calcium hydroxide in various cases. However, calcium hydroxide cannot be used on the primary tooth as it will lead to internal resorption while MTA has major drawbacks which include high cost, discolouration potential. Nowadays, the emergence of calcium silicate-based material such as Biodentine has overcome MTA's limitations.

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References

1. El-Meligy OA, Avery DR. Comparison of mineral trioxide aggregate and calcium hydroxide as pulpotomy agents in young permanent teeth (apexogenesis). Pediatr Dent. 2006;28(5):399-404.
2. Liu H, Zhou Q, Qin M. Mineral trioxide aggregate versus calcium hydroxide for pulpotomy in primary molars. Chin J Dent Res. 2011;14(2):121-125.
3. Shirvani A, Hassanizadeh R, Asgary S. Mineral Trioxide Aggregate vs. Calcium Hydroxide in Primary Molar Pulpotomy: A Systematic Review. Iran Endod J. 2014;9(2):83-88.
4. Sawicki L, Pameijer CH, Emerich K, Adamowicz-

Klepalska B. Histological evaluation of mineral trioxide aggregate and calcium hydroxide indirect pulp capping of human immature permanent teeth. Am J Dent. 2008;21(4):262-266.

5. Moretti AB, Sakai VT, Oliveira TM, et al. The effectiveness of mineral trioxide aggregate, calcium hydroxide and formocresol for pulpotomies in primary teeth. Int Endod J. 2008;41(7):547-555.
6. Maturo P, Costacurta M, Bartolino M, Docimo R. MTA applications in pediatric dentistry. Oral Implantol (Rome). 2009;2(3):37-44.
7. Percinoto C, de Castro AM, Pinto LM. Clinical and radiographic evaluation of pulpotomies employing calcium hydroxide and trioxide mineral aggregate. Gen Dent. 2006;54(4):258-261
8. Kierat A, Laszczyńska M, Kowalska E, Weyna E. Comparison of the influence of mineral trioxide aggregate and calcium hydroxide on the dental pulp of permanent teeth in biological treatment and cell cultures. Ann Acad Med Stetin. 2010;56(2):89-96.
9. Beslot-Neveu A, Bonte E, Baune B, et al. Mineral trioxide aggregate versus calcium hydroxide in apexification of non-vital immature teeth: study protocol for a randomized controlled trial. Trials. 2011;12:174.
10. Pradhan DP, Chawla HS, Gauba K, Goyal A. Comparative evaluation of endodontic management of teeth with unformed apices with mineral trioxide aggregate and calcium hydroxide. J Dent Child (Chic). 2006;73(2):79-85.