BIOCERAMICS IN ENDODONTICS
A REVIEW

Authors:

Ajay P Joseph[1]
Dinesh Kamath[2]
Varun Mathew Manakunnathu[3]
Gis George[4]

Senior lecturer[134]
Department of Endodontics and Conservative dentistry
Indira Gandhi Institute of Dental Sciences
Nellikuzhi P. O., Kothamangalam, Kerala 686 691

Professor and Head
Department of Endodontics and Conservative dentistry
Indira Gandhi Institute of Dental Sciences
Nellikuzhi P. O., Kothamangalam, Kerala 686 691.

Correspondence Author
Dr Ajay P Joseph
Senior lecturer
Department of Endodontics and Conservative dentistry
Indira Gandhi Institute of Dental Sciences
Nellikuzhi P. O., Kothamangalam, Kerala 686 691
Email: joseph_ajai@yahoo.co.in
Ph. 9495851566

ABSTRACT

Bioceramic materials, since their introduction in Endodontics have significantly changed the prognosis of many cases which were once considered impossible. These materials find wide applications, as in direct pulp capping, apexification, apexogenesis, root repair, root canal sealants, etc. They are also widely used as retrograde filling materials and as bone grafts to enhance bone healing. Ever since its introduction, continuous researches have been going on in this field to introduce better products, providing better biocompatibility and handling properties. This review gives an overview on some of the major Bioceramic materials used in Endodontics, their advantages, properties and applications.

Key words- Biomaterial, Bioceramics, Endodontics.

J Odontol Res 2018;6(2)11-14.

INTRODUCTION

A Biomaterial is used to make devices to replace a part or a function of the body in a safe, reliable, economic, and physiologically acceptable manner. The Clemson University Advisory Board for Biomaterials has formally defined a biomaterial to be "a systemically and pharmacologically inert substance designed for implantation within or incorporation with living systems" [1].

The ideal requisite of Biomaterials is that it should be Noncarcinogenic, Bacteriostatic, should not discolor tooth, and promote Cementogenesis, Osteogenesis & healing[2].

The field of Biomaterial science has made giant leaps in the last five decades, due to the extensive research that has been going on in the field. The emphasis was always in developing newer and more biocompatible materials that can replace or develop the body tissues.

Bioceramics is a diverse class of biomaterials. The class of ceramics used for repair and replacement of diseased and damaged parts of musculoskeletal systems are termed bioceramics[3]. Bioceramics in Endodontics find wide applications as in direct pulp capping, apexification, apexogenesis, root repair, root canal sealants, etc. In Periapical surgeries, also they are used as retrograde filling materials and as bone grafts to enhance bone healing.

I. PORTLAND CEMENT:

Portland cement is a hydraulic binding material which when mixed with water tends to harden[4]. It is widely used in building industry. However it also finds wide application in dentistry. The main interest of its use in dentistry is as an alternative to MTA, as it is less expensive and widely available. These two materials show high similarity in their composition, except for the bismuth oxide present in MTA which confers Radiopacity.

It was in the year 1824, that Joseph Aspdin patented this product so-called Portland cement (PC) which was actually obtained from the calcination of the mixture of lime stones coming from Portland in England and silicon-argillaceous materials[5]. Portland cement is used in dental procedure such as pulpotomy, pulp capping, repair of root perforations and root end filling. Sakai et al compared the clinical and radiographic effectiveness of MTA and PC as pulp dressing agents in carious primary teeth. No statistically significant difference regarding dentine bridge formation was found between both groups throughout the follow-up period[6].

II. MINERAL TRIOXIDE AGGREGATE

Mineral Trioxide Aggregate (MTA) was introduced in the year 1993 by Mahmoud Torabinejad. It was later patented and marketed in the year 1995 and was given approval for use in endodontics in 1998. MTA is actually believed to have been derived from ordinary Portland cement or in fact a modification of the Portland cement. Modifications have been made in designing this wonderful material, especially with respect to particle size, setting rate, solubility and possibly toxicity (by reducing the heavy metal content).

MTA is called as hydraulic cement, mainly because it primarily depends on hydration reactions for its setting reaction, compared to other cements which depends on acid base reactions[7]. MTA constitutes the following chemical composition or phases, tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetra calcium aluminoferrite, calcium sulfate dehydrate, bismuth oxide, alkali metal oxides and sulfates[8]. MTA is available in two forms as grey and white MTA. Main difference in white MTA was the elimination of alumino ferrite that is responsible for grey color, which in fact affected the esthetic part.

MTA find wide application in dentistry as in, Direct pulp capping, Pulpotomy, Repair of root perforation, Retrograde root canal filling, Apexogenesis, Apexification, Repair of root resorption and Regenerative procedures. The high alkalinity induced by MTA initially causes necrosis of pulp followed by dentin deposition[9]. It was also found that MTA caused reparative dentin formation in a very short period of time compared to calcium hydroxide. A 100% success rate was obtained in the case of teeth with open apices when MTA was used. Bacteriostatic action provided by calcium hydroxide and MTA was also found to be the same in studies. MTA is also used widely as a retrograde filling material due to the high biocompatibility provided by the material. MTA gives better results when tested for leakage and biocompatibility than IRM and Super EBA, and has the ability of induction of hard tissue[10]. MTA has been widely used as the material of choice in regenerative/ revascularization procedures owing to the high pH and biocompatibility provided by the material. MTA modulates cytokine production and encourages differentiation and migration of hard tissue producing cells whereby hydroxyapatite is formed on the MTA surface, and a biologic seal is created[10]. Latest studies have shown that MTA-enriched nanocomposite TiO2-polymeric

powder coatings support human mesenchymal cell attachment and growth[11].

III. CALCIUM ENRICHED MIXTURE OR NEW ENDODONTIC CEMENT

Calcium Enriched Mixture (CEM) is a newly introduced material, which is chemically similar to Portland cement and Mineral Trioxide Aggregate. The material was developed by Saeed Asgary.

In vitro studies conducted to compare the compositions of mineral trioxide aggregates (MTAs), Portland cements (PCs), and a new endodontic cement (NEC) revealed that NEC differs chemically from MTAs and PC. Phosphorous is the major component of NEC, whereas in MTAs and PCs this element is close to the detection limit. It was also seen that in contrast with MTA, NEC showed surface composition similar to surrounding dentin[12]. CEM just like MTA and Portland cement is found to produce an alkaline environment with a pH ranging from 9-11.5. Clinical uses of NEC are similar to MTA. It has good handling characteristics and forms an effective seal when used as root-end–filling material. The studies conducted showed that Mineral trioxide aggregate and CEM cement were associated with a similar favorable biological response to pulpotomy treatment and demonstrated a more effective induction of dentinal bridge formation compared to Calcium Hydroxide[9].

IV. BIODENTINE

Biodentin is a new bioactive calcium silicate-based cement that has been recently launched in the dental market as a 'dentin substitute'. Introduced by Septodont, this material claims to make use of a proprietary 'Active Biosilicate technology'[13]. Biodentin has been formulated using MTA based cement technology and hence; claims improvements of some of the properties such as physical qualities and handling, including its other wide range of applications like endodontic repair and pulp capping in restorative dentistry.

The product file of Biodentine states that the powder component of the material consists of tricalcium silicate, dicalciumsilicate, calciumcarbonate and oxide filler, iron oxide shade, and zirconium oxide. Tricalcium silicate and dicalcium silicate are indicated as main and second core materials, respectively, whereas zirconium oxide serves as a radiopacifier. The liquid contains calcium chloride as an accelerator and a hydrosoluble polymer that serves as a water reducing agent. The hydrosoluble polymer reduces the viscosity of the cement and improves handling[14].

The setting time of the material is around 9-12minutes, which is much faster compared to MTA which takes around 165 minutes for initial setting. During the setting of Biodentine, the compressive strength increases 100 MPa in the first hour and 200 MPa at 24th hour and it continues to improve with time over several days until reaching 300 MPa after one month which is comparable to the compressive strength of natural dentine i.e. 297 MPa. Relatively easier manipulation and faster setting is the major advantages of this material when compared to MTA. Like MTA Biodentine find wide application in dentistry like direct and indirect pulp capping, as a dentine substitute under composite, as an endodontic repair material, retrograde root filling, and apexification.

V. BIO AGGREGATE

BioAggregate (Verio Dental Co. Ltd., Vancouver, Canada) is composed of nano particle sized Tricalcium silicate, tantalum oxide, calcium phosphate, silicon dioxide and presents improved performance compared with MTA. Tricalcium silicate is the main component phase, tantalum oxide is added as a radiopacifier and it is free of aluminum[15].

The manufacturers claim this material to have an Aluminum-Free Composition so that health problems due to aluminium toxicity are avoided. It also claims to have excellent biocompatibility with the vital peri radicular tissue. BioAggregate mixture is easy to manipulate and apply. The material complements the natural color of teeth and all the ingredients are pure white in color. Tantalum Pentoxide has been substituted for Bismuth oxide (used in MTA) that provides better radio opacity.

The cytotoxic evaluation of mineral trioxide aggregate and BioAggregate were compared by placing them in the subcutaneous connective tissue of rats and it was found that BioAggregate had better inflammatory and foreign body reaction than the MTA group[16]. Studies have shown that the material is non toxic to osteoblasts and has the ability to induce mineralization-associated gene expression in osteoblasts. Presently BioAggregate is manufactured by two companies Veriodental and Diadent. The trade names are respectively IBC BioAggregate and Dia Root BioAggregate. BioAggregate is more biocompatible, has better sealing ability, higher fracture and acidic resistance than MTA 50.

VI. BC SEALER

BC sealer is a revolutionary premixed and injectable root canal sealer utilizing new bioceramic

nanotechnology. The material is introduced and marketed by Brassler USA.

This material claims to bond with both dentin and the treated gutta percha (which is provided by the manufacturer). The material claims to provide excellent sealing through the monobloc concept by bonding to both dentin and gutta percha[18]. According to the manufacturer the material contains Zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide, filler and thickening agents.

CONCLUSION

Bioceramics has evolved to become an integral and vital segment of our modern health-care delivery system. The beginning of the era of Bioceramics started off with the discovery of Bioglass In 1969 by Larry Hench. Since then the field of Bioceramics has been undergoing constant research and refinement to provide with newer materials that exhibits better biocompatibility and bone forming properties. The idea was always to improve the composition, microstructure, and molecular surface chemistry of various types of bioceramics to match the specific biological and metabolic requirements of tissues or disease state. The biological activity of Bioceramics has to be understood thoroughly through various in vitro and in vivo studies to improve their biocompatibility, and decrease toxicity and the knowledge on mechanical feature will add up to play a key role for the choice of the bioceramics in their broad implication as implants.

REFERENCES

1. Joon B.Park, Joseph D. Bronzino. Biomaterials: Principles and Applications Aug-2002: CRC Press, 29.
2. Kenneth J. Anusavice, Philips dental materials, 10th edition, 75-109.
3. Hench LL. Bioceramics: From concept to clinic. J. Am. Ceram. Soc. 1991; 74:1487-1510.
4. Naiana Viana Viola, Mário Tanomaru Filho, Paulo Sérgio Cerri. MTA versus Portland cement: review of literature. RSBO. 2011 Oct-Dec;8(4):446-52
5. França TRT, Silva RJ, Queiroz MS, Aguiar CM. Arsenic content in Portland cement: A literature review. Indian J Dent Res 2010; 21: 591-5.
6. Sakai VT, Moretti AB, Oliveira TM, Fornetti AP, Santos CF, Machado MA. Pulpotomy of human primary molars with MTA and Portland cement: a randomized controlled trial. Br Dent J 2009; 207:128-9.
7. B.W.Darwell, R.C.T Wu. "MTA"– A hydraulic silicate cement: review update and setting reaction. J dental mat 2011; 27: 407-422.
8. Torabinejad M, Hong CU, McDonald F, Pitt Ford TR. Physical and chemical properties of a new root-end filling materials. J Endod 1995; 21:349–53
9. Tabarsi B, Parirokh M. Comparative study of dental pulp response to several pulpotomy agents . Int Endod J. 2010 Jul; 43(7):565-71.
10. Parirokh M and Torabinejad. Mineral Trioxide Aggregate: A Comprehensive Literature Review-Part III: Clinical Applications, Drawbacks, and Mechanism of Action JOE 2010; Vol 36
11. Shi W, Mozumder MS, Zhang H, Zhu J, Perinpanayagam H.MTA-enriched nanocomposite TiO(2)-polymeric powder coatings support human mesenchymal cell attachment and growth. Biomed Mater.2012; Oct; 7(5).
12. Saeed Asgary, Mohammad Jafar Eghbal. Comparison of Mineral Trioxide Aggregate's Composition with Portland Cements and a New Endodontic Cement. JOE 2009; Vol 35: Number 2
13. SeptodontBiodentine™ Active Biosilicate Technology™. Scientific file 2010
14. Malkondu O, Karapinar Kazandag M, Kazazoglu E. A review on biodentine, a contemporary dentine replacement and repair material. Biomed Res Int 2014;2014:160951
15. Parirokh M, Torabinejad M. Calcium silicate–based cements in mineral trioxide aggregate: Properties and clinical applications. Hoboken, NJ, USA: John Wiley & Sons, 2014
16. Khalil WA, Eid NF. Biocompatibility of BioAggregate and mineral trioxide aggregate on the liver and kidney. Int Endod J. 2013 Aug; 46(8):730-7
17. Tuloglu N, Bayrak S. Comparative evaluation of mineral trioxide aggregate and bioaggregate as apical barrier material in traumatized nonvital, immature teeth: A clinical pilot study. Niger J Clin Pract 2016;19(1):52-57.
18. Kenneth Koch, Dennis Brave. Bioceramic technology – the game changer in endodontics Endodontic Practice April 2009