Review article

BIOCERAMICS IN ENDODONTICS – A REVIEW

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Abstract

Bioceramics are materials which include Alumina, Zirconia, Bioactive glass, Glass ceramics, Hydroxyapatite, resorbable Calcium phosphates, among others. They have been used in dentistry for filling up bony defects, root repair materials, apical fill materials, perforation sealing, as endodontic sealers and as aids in regeneration. They have certain advantages like biocompatibility, non toxicity and dimensional stability and most importantly in endodontic applications, being bio-inert .An extensive search of the endodontic literature was made to identify publications related to bioceramics used in endodontics. The outcome of laboratory and clinical studies on the biological and physical properties of bioceramic-based sealers along with comparative studies with other sealers was assessed. This review focuses on an overview of Bioceramics, classification, uses, advantages and retreatment of bioceramics. It also gives a detailed insight into individual bioceramic materials currently used in the fields of Endodontics along with their properties and applications.

Key Words: .

INTRODUCTION

Bioceramics allude to biomaterials that are utilized in direct contact with living tissues in the medical field. Different kinds of bioceramics that are accessible to medicine and dentistry incorporate bioinert bioceramics like Zirconia and Alumina that don't respond to the climate they are in contact with. Bioactivity of the materials alludes to its capacity to make a hydroxyapatite layer when in contact with tissue liquid wealthy in calcium and phosphate. This property permits the material to be exceptionally biocompatible, osteoinductive, osteoconductive, and enhances its property of sealability (1). Bioceramic-based sealers have just been accessible for use in endodontics for as far back as thirty years, their ascent to unmistakable quality compare to the expanded utilization of bioceramic innovation in the fields of medicine and dentistry. Bioceramics are earthenware materials planned explicitly for clinical and dental use. They incorporate alumina, zirconia, bioactive glass, glass earthenware production, hydroxyapatite, and calcium phosphates. The classification of bioceramic materials into bioactive or bioinert materials is an element of their association with the encompassing living tissue. Bioactive materials, for example, glass and calcium phosphate communicate with the encompassing tissue to energize the development of more tough tissues. Bioinert materials, for example, zirconia and alumina produce an insignificant reaction from the encompassing tissue, viably having no organic or physiological impact.(1)

According to the NIH Consensus Conference on Biomaterials (1987) a biomaterials is **"Any substance (other than a drug) or combination of substances, synthetic or natural in origin, which can be used at any period of time as a whole or in part of a system which treats, augments or replaces any tissue, organ or function of the body."** Williams described

CLASSIFICATION

Bioceramics can be categorized as:

1. Bioinert: Non interactive with biological structures.
2. Bioactive: Durable tissues that can go through interfacial communications with encompassing tissue.
3. Biodegradable, soluble or resorbable: Eventually replaces or joined into tissue. This is specially significant with lattice frameworks. (1)(3)

Advantages of Bioceramics

They have great biocompatibility because of their resemblance with organic hydroxyapatite. Inherent osteoinductive capacity in view of their ability to assimilate osteoinductive substances if there is a bone recuperating process nearby. Acts as a regenerative scaffold of resorbable lattices which prepares a framework that is finally dissolved as the body rebuilds tissue. Probability to accomplish incredible liquid tight seal, form a chemical bond with the tooth structure and have a great radiopacity. They have antibacterial properties because of precipitation in situ after setting, a phenomenon that causes bacterial sequestration. Bioceramics form porous powders which consist of nanocrystals of diameters of 1-3 nm, which forestall attachment of microorganisms. Sometimes, fluoride ions are constituents of apatite crystals, and the came about nanomaterial has antibacterial properties.(4)

USES

Endodontic uses- pulpotomy, resorption, apexification perforation repair, retrograde filling, sealers, obturation and regenerative endodontics.

Restorative uses- pulp capping, Dentin substitute, dentin remineralization and dentin hypersensitivity (4)

BIOCERAMICS IN CONSERVATIVE DENTISTRY & ENDODONTICS

Significant advances have been made in the field of bioceramics utilized for endodontic treatment. Bioceramics are biocompatible in nature and have amazing physico-chemical properties. They can work as cements, filling materials, root canal sealers and root repair materials, which have the benefits of antibacterial properties and better sealing capacity.(4,5)

Bioceramics used in endodontics are:

Calcium silicate based Cements-

- Portland cement
- Mineral trioxide aggregate (MTA)
- Biodentine (Septodont, France)

Sealers

- MTA Fillapex (Angelus, Brazil)
- BioRoot RCS (Septodont, France)
- Endo CPM Sealer (EGO SRL, Buenos Aires, Argentina)
- TechBiosealer (Profident, Kielce, Poland).
- EndoSequence BC Sealer (Brasseler, Savannah,GA, USA)
- iRoot BP
- iRoot BP Plus
- iRoot FS (Innovative Bioceramix Inc., Vancouver, Canada),
- Bioaggregate (Innovative Bioceramix Inc., Vancouver, Canada)
- Tech Biosealer
- Ceramicrete (developed at Argonne National Lab, Illinois, USA)
- Total Fill

Mineral Trioxide Aggregate

Mineral Trioxide Aggregate(MTA), a noteworthy biocompatible material utilized for different clinical applications, introduced by Dr. Mahmoud Torabinejad and co workers in Loma Linda University. Commercially available MTA are ProRootMTA (Dentsply), White ProRoot MTA (Dentsply), MTA- Angelus (Solucoes Odontologicas), MTA- Angelus Blanco (Solucoes Odontologicas), MTA Bio (Solucoes Odontologicas).(6)

Composition: MTA is basically a mixture of three powder ingredients: Portland cement (75%), bismuth oxide (20%) and gypsum (5%). It consists of calcium oxide (50-75 wt %) and silicon oxide (15-20 wt %), which together constitute 70-95% of the cement. Blending of these raw materials produces tricalcium silicate, dicalcium silicate, tricalcium aluminate, tetracalcium alumino ferrite. There are two commercial types of MTA: grey and white and the difference lies due to the presence of iron in the white MTA which further forms the tetra calcium alumino-ferrite phase. (7)

Setting time: According to Torabinejad et al. setting time is 2 hours and 45mins for grey MTA. (6)

Mechanism of action: At the point when put in direct contact with human tissue it structures CH that discharges calcium particles for cell attachment and multiplication, establishes an antibacterial climate by its basic pH, tweaks cytokine creation, energizes the separation and relocation of hard tissue–delivering cells and structures HA (or carbonated apatite) on the MTA surface and gives a biologic seal.(6)

Compressive Strength: According to Torabinejad M et al., the compressive strength of MTA at 24 hours is 40.0 MPa and at 21 days is 67.3 MPa. (8)

Flexural Strength: A study done by Walker MP et al., showed that the flexural strength of MTA was 14.27 MPa when specimens were exposed to two-sided moisture after 24th hour of setting time.(7)

Radiopacity: Torabinejad et al. reported the mean radiopacity for MTA at 7.17 mm of an equivalent thickness of aluminum.(9)

Marginal adaptation and sealing ability: Torabinejad et al. (1995) explained that MTA has excellent sealing ability which may occur because MTA expands during setting reaction. Sealing ability of MTA is enhanced in presence of moist environment due to the setting expansion (6)

Biocompatibility and Cytotoxicity: A study done by Torabinejad indicated that MTA it isn't mutagenic and is significantly less cytotoxic contrasted with Super EBA and IRM. No DNA harm was seen with genotoxicity trial of cells after treatment of fringe lymphocytes with MTA. On direct contact they produce insignificant or no incendiary response in delicate tissues and are fit for initiating tissue regeneration. MTA developed cementum which was novel compared with other root-end filling materials in animal studies. MTA is additionally said to invigorate cytokine creation in human osteoblasts**.**(10)

Bioactivity and Regenerative Potential: The capacity of MTA and Biodentine to actuate reparative dentin synthesis and changing growth factor beta 1 (TGF-β1) secretions was assessed by Laurent P et al. They indicated that early odontoblastic differentiation and commencement of mineralization was seen with both MTA and Biodentine and thus forms reparative dentin synthesis. Subsequently MTA is considered as a bioactive material with osteoinductive properties.(7)

Biodentine

Biodentine was made commercially available in 2009 as a dentin replacement material by Septodont (France) in the form of a capsule containing the desirable ratio of its powder and liquid.(6)

Composition: Biodentine is available in the form of a capsule containing the ideal ratio of its powder and liquid (7). The powder contains calcium carbonate, dicalcium silicate, tricalcium silicate and oxide filler, iron oxide shade, and zirconium oxide. Zirconium oxide acts as a radiopacifier. The liquid comprises of calcium chloride which functions as an accelerator and a hydrosoluble polymer that acts as a water reducing agent.(11)

Setting Time: The setting time of Biodentine as per manufacturer's instructions is 9-12 minutes. (11)

Compressive Strength: During the setting of Biodentine, compressive strength of Biodentine increments upto 100 MPa in the first hour and 200 MPa at 24th hour. It keeps on improving with time more than a few days reaching upto 300 MPa following one month which is comparable to the compressive strength of normal dentine i.e. 297 MPa. (7)

Flexural Strength: Flexural quality of Biodentine recorded following two hours, has been discovered to be 34 MPa. (7)

Microhardness: Goldberg et al., found the microhardness of Biodentine to be 51 Vickers Hardness Number (VHN) at 2 hour and 69 VHN after one month.(7)

Radiopacity: ISO 6876:2001 has set up that 3mm Al is the base radiopacity value for endodontic cements. (11)

Microleakage: Biodentine is discovered to be related with high pH (12) and deliver calcium and silicon ions which activates mineralization. This makes a mineral penetration zone along dentin-cement interface which bestows a superior seal.(7)

Marginal Adaptation and Sealing Ability: Micromechanical bonding of Biodentine permitted incredible versatility of Biodentine crystals to the base dentin. (7)

Bond Strength: Hashem DF et al., inferred that Biodentine has low strength during starting phases of setting.(7)

Biocompatibility and Cytotoxicity: In an investigation done by Zhou et al., Biodentine was discovered to be less toxic contrasted with glass ionomer during the 1-and 7-day perception period. Another examination done by P'erard et al. determined the gene expression ability and biocompatibility of Biodentine and found that it alter the multiplication of pulp cell lines.(11)

EndoSequence Root Repair Material/IrootSP/ IrootBP

As of late, another root repair material has been acquainted with the market i.e., EndoSequence Root Repair Material (ERRM; Brasseler, Savannah, GA). It is also commercially available as iRoot SP injectable root canal sealer and iRoot BP Plus putty root canal filling and repair material. It is made out of zirconium oxide, monobasic calcium phosphate, calcium silicate, tantalum oxide and fillers and is available as paste in preloaded syringes and furthermore in a putty form. Its working time is 30 minutes and a final set is accomplished in around 4 hrs. (4)

MTA Fillapex

MTA Fillapex (Angelus Solucoes Odontologicas, Londrina, PR, Brazil) is a recent calcium silicate-based bioceramic sealer. MTA Fillapex was made trying to join the physico-chemical properties of resin based sealer with the biologic properties of MTA. The composition of MTA Fillapex after Mixture is mineral trioxide total, natural resin, salicylate resin, silica and bismuth. As indicated by the producer, MTA Fillapex has a sufficient working time, high radiopacity, and easy handling. Its pH and dissolvability may profit the antibacterial efficacy of MTA Fillapex. (12)

MTA Plus

MTA Plus (Avalon Biomed Inc., Bradenton, FL, USA) is more fine powder, cheaper item that is similar to tooth-shaded ProRoot MTA, and can be blended in with a liquid or a gel. This tricalcium silicate and dicalcium silicate based material can be utilized as a root canal sealer when blended in with gel, which additionally improves handling and washout resistance. By utilizing a gel and fluctuating the powder to gel proportion, diverse setting times and physical properties can be achieved. MTA Plus indicated improved reactivity and delayed capacity to deliver calcium and increment the neighborhood pH to alkaline values contrasted with ProRoot MTA. The ion releasing property is interlinked with its porosity, fine powder, solvency, water sorption and the development of calcium phosphate minerals. (13)

Bioceramic gutta-percha

Dissimilar to customary gutta-percha, EndoSequence BC gutta-percha (Brasseler USA, Savannah, GA) is exposed to a restrictive cycle of impregnating and covering each cone with bioceramic nanoparticles. Each EndoSequence BC gutta-percha cone has gone through a novel hardening measure making them simple to work with inside the canal. At the point when utilized with BC Sealer, the maker guarantees that a monobloc can be accomplished by the chemical and mechanical bonding to both dentin and the EndoSequence BC Points. BC Sealer and BC Points permit a "three-dimensional" bonded obturation with no shrinkage.(13)

Bioactive glass

Bioactive glass (BAG), calcium sodium phosphosilicate, is a broadly contemplated bioceramic material utilized in the field of conservative dentistry, cariology, and periodontology because of its high biocompatibility and noteworthy bioactive ability in forming apatite-like structure. recent researches have demonstrated some potential for its utilization in endodontic procedures. Mohn et al. mixed BAG particles with 50 wt% bismuth oxide as a potential root canal filling material, and discovered radiopacity with a likeness 4.94 mm aluminum and high pH value. Another investigation joined BAG with composite materials and found sealing capacity was improved. BAG has a directly and an indirectly pH-related antibacterial effect. Nanometric bioactive glass delivers more alkaline species, and therefore showed a more grounded antimicrobial impact against clinical confines of enterococci than the micron-sized BAG.(13)

Generex A

Generex A (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) is a calcium-silicate-based material that has a few similitudes to ProRoot MTA however is mixed in with remarkable gels rather than water utilized for MTA. Generex A material has totally different handling properties in contrast with MTA. Generex A mixes to dough like consistency, making it simple to fold into a rope-like mass like IRM. (4)

Capasio

Capasio (Primus Consulting, Bradenton, FL, USA) is composed primarily of dental glass, bismuth oxide, and calcium alumino-silicate with a silica and polyvinyl acetate-based gel. A recent study found that Capasio and MTA enhance apatite deposition when exposed to synthetic tissue fluid thus had the mineralization capacity. When used as a root-end filling material, Capasio is more likely to penetrate dentinal tubules. (4)

Bioaggregate

BioAggregate (Verio Dental Co. Ltd., Vancouver, Canada) is made out of nanoparticles sized tricalcium silicate, calcium phosphate, silicon dioxide, tantalum oxide and presents improved execution compared with MTA. Tricalcium silicate is the primary component phase, tantalum oxide is added as a radiopacifier and it is aluminum free. On hydration, the tricalcium silicate produces calcium silicate hydrate and calcium hydroxide. Tricalcium silicate is stored around the cement grains, while calcium hydroxide responds with the silicon dioxide to produce extra calcium silicate hydrate. This outcomes in decrease of calcium hydroxide in the aged cement. (4)

Ceramicrete

It is a flexible phosphate ceramic, altered for use in dentistry and medicine. This self-setting phosphate ceramic sets by an acid base reaction, to form a potassium magnesium phosphate hexahydrate ceramic lattice phase. Its mechanical properties are improved by adding calcium silicate whiskers to create a phosphosilicate ceramic material. Hydroxyapatite is produced on surface, when set ceramicrete material is inundated in a phosphate containing liquid. The material is nonporous and produces calcium and phosphate particles during the setting it is utilized as a rootend filling material. Due to possessing radio opacity like root dentin, ceramicrete is a superior apical fixing material.(14)

Doxadent

It is a calcium aluminate item commercially available in powder liquid form that can be utilized as a restorative material for permanent restorations. The fundamental parts in Doxadent are zirconium dioxide, alumina, water, calcium oxide and other antacid oxides. As the powder and liquid are blended, water disintegrates the calcium aluminate powder that prompts the development of calcium, aluminum and hydroxyl particles which forms katoite and gibbsite.(14)

RETREATMENT OF BIOCERAMICS

Bioceramic sealer cases are certainly treatable. The key in retreatment of bioceramic cases is to utilize a ultrasonic with a plentiful amount of water. This is especially significant toward the beginning of the strategy in the coronal third of the tooth. Work the ultrasonic with copious water down the channel to roughly a large portion of its length. Now, add a solvent to the canal (chloroform or xylol) and switch over to an EndoSequence file (#30 or 35/0.04% taper) run at a speed of 1,000 RPM. Continue with this file, right to the working length, utilizing solvent. An option is to utilize hand files for the last 2-3 mm and afterward follow the gutta-percha evacuation with a rotary file to ensure synchronicity. (3,15)

CONCLUSION

The advent of bioceramic technology has changed the outcome of both surgical and non-surgical endodontic treatment. These materials provide a number of advantages and have a promising future in dentistry. However limitations still exist when compared to the ideal material. While MTA was the benchmark in bioceramic materials, material advances have constantly tried to overcome disadvantages and improve its properties. Bioceramics now have a wide array of applications both in endodontics and restorative dentistry. An up-to-date knowledge of these new bioactive materials is essential to ensure the selection of the most suitable material in different clinical situations. With further research and modifications, bioceramics have the potential to become the preferred materials for the various endodontic procedures.

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