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RESEARCH ARTICLE

BIOCERAMICS- BOON IN ENDODONTICS

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ABSTRACT

Bioceramics are materials which include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, resorbable calcium phosphates. They have been used in dentistry as root repair materials, bony defects repair, apical filling material, perforation repair and help in tissue regeneration. They have certain advantages like biocompatibility, non toxicity, dimensional stability and bio-inertness. They have a structural similarity to Hydroxyapatite, an intrinsic osteo conductive activity and have an ability to induce regenerative responses in the human body.This review focuses on an overview of Bioceramics, classification and their advantages and also gave a detailed insight into individual bioceramic materials currently used in the fields of endodontics.

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INTRODUCTION

With the introduction of new techniques and technology the field of endodontics is widely changing. Various advancements in endodontic materials has led to significant growth in endodontics. As with the introduction of Bio-ceramics the prognosis and treatment outcome of certain procedures have totally revolutionised in endodontics. Bioceramics are chemically processed biocompatible ceramic compounds which can be obtained both in situ and in vivo. Bioceramics are quite similar to biological hydroxyapatite thus exhibit excellent biocompatibility properties. Different bioceramic products are obtained during the hydration process e.g. hydroxyapatites, they have the ability to induce a regenerative response in the human body. Mineral hydroxyapatite has an osteoconductive effect, which leads to the bone formation at the interface. Bioceramics have an intrinsic osteoinductive capacity, because of documented ability to absorb osteoinductivesubstance.[1] Bioceramics have antibacterial properties, as a result of precipitation they form porous powders containing nanocrystals with the diameter of 1–3 nm, which prevent bacterial adhesion.[2] In addition, bioceramics can be combined with synthetic hydroxyapatite, and might constitute of fluoride ions incorporated in apatite crystals resulting in antibacterial properties.[3] The aim of this paper is to perform a literature review on bioceramic materials currently used in endodontics and on their various characteristics.

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Classification of Bioceramics:

Bioinert: These are non-interactive with the biological systems (Alumina, zirconia).

Bioactive: These are durable tissues that can undergo interfacial interactions with surrounding tissue (bioactive glasses, bioactive glass ceramics, hydroxyapatite, calcium silicates).

Biodegradable: These are soluble or resorbable materials, those eventually can be replaced or incorporated into the tissue (Tricalcium phosphate, Bioactive glasses).

Advantages of Bioceramics:

- Due to their similarity with biological hydroxyapatite crystals they have excellent biocompatibility.
- Bioceramics have intrinsic osteoinductive capacity because of their ability to absorb osteoinductive substance if there is a bone healing process nearby.
- These provide a framework of resorbable lattices that act as a regenerative scaffold that is eventually dissolved as the body rebuilds tissue.
- They have ability to achieve excellent hermetic seal, form a chemical bond with the tooth structure and have good radiopacity [4,5].
- Bioceramics have antibacterial properties these form porous powders containing nanocrystals with

diameters of 1-3 nm as a result of precipation, which prevents bacterial sequestration and adhesion. Sometimes, fluoride ions are constituents of apatite crystals, which further lead to antibacterial properties[6].

BioceramicsIn Operative Dentistry And Endodontics

Mineral Trioxide Aggregate MTA was introduced by Dr Torabinajed in 1993. This material have osseo conductive, osseo inductive, and biocompatible properties. It has been marketed as Pro Root since its approval by FDA in 1998. It is used primarily to seal lateral root perforations and as a root-end filling material and also used for pulp capping, pulpotomy, apexogenesis, repair of root perforations, and as a root canal filling material[7]. MTA powder contains fine hydrophilic particles that set in the presence of moisture. It is currently available in grey and white forms those differ in their chemical composition. Grey form composed of dicalcium and tricalcium silicate and bismuth oxide whereas white form consists of tricalcium silicate and bismuth oxide[8]. Bismuth oxide provides radioopacity which is present in both hydrated and nonhydrated MTA. When mineral trioxide powder is mixed with water, initially calcium hydroxide and calcium silicate hydrate are formed resulting in high alkalinity of MTA which later precipitate into a poorly crystallized and porous solid gel [9].

Properties of MTA

- Long setting time when compared to other materials, whichis their major drawback.
- Mineral trioxide aggregate has less compressive strength when compared to other materials after 24 hours.[10,] The compressive strength and bond strength reach their maximum after several days mixing because the hydration rate of dicalcium silicate is slower than tricalcium silicate[11].
- The pH value of mineral trioxide aggregate is 10.2 after mixing and it rises to 12.5 at 3 hours.

Certain limitations of MTA

- It does not come in premixed form, so difficult to use asretrofills and they have large particle size that cannot be extruded through a small syringe.

Advantages: MTA has excellent tissue biocompatibility so proposed as a potential medicament for pulp capping with reversible pulpitis[12,13,14]. It has superior tissue reaction, amount and type of dentin bridge formation as compared to calcium hydroxide. With MTA, dentin bridge formation after pulp capping was seen at about 1 week which progressively increased in length and thickness in duration of 3 months whereas following pulp capping with calcium hydroxide, the dentin bridge was less consistent with numerous tunnel defects.[14] In a histological study by Jabbarifar et al[15] MTA was found to be a better choice as apulpotomy material. Several materials have been used as root-end filling agents but the main disadvantage is micro leakage and the lack of biocompatibility. MTA was found to be material of choice for pulpotomy as compared to forma cresol and hydroxyapatite treated teeth as, MTA exhibited significant reduction in inflammation, more cementum formation and regeneration of periradicular tissues [16].

Apexification is a process to obtain an apical barrier in immature non vital permanent tooth so as to prevent the extrusion of the obturatingmaterial [17]. An MTA plug of 4mm thickness is placed at the apical region to form a barrier, sealing the canal from the periapical area [18,19.] Mineral Trioxide Aggregate can be used to obturate the root canal of retained primary tooth where the succedaneous permanent tooth is absent but not recommended for obturation of primary teeth that are expected to exfoliate as it is observed that MTA would be absorbed slowly. Lee and associates [20] found that MTA had significantly less micro leakage and less tendency for overfilling or under filling, when compared with amalgam. Torabinejad and Chivianhave suggested the use of MTA for sealing vertical root fractures. MTA need to be more explored by clinicians so that its complete beneficial properties can be obtained.

Biodentine: Biodentine was developed and introduced by septodont research group as a new class of dental material those havehigh mechanical properties, excellent biocompatibility and bioactive behaviour. Chemical composition of already known endodontic repair cements are based on the Ca3SiO5-water chemistry which made them highly biocompatible, septodont increased the physicochemical properties which makes biodentine [21]. Clinically biodentine is easy to handle and biocompatible for the restorative procedures and for classical endodontic procedures. According to all the ISO standards, as well as different preclinical and clinical collaborations, biodentine turns out to be one of the most biocompatible materials ofall the biomaterials as demonstrated in dentistry.

Setting reaction of Biodentine: The chemical reaction involves hydration of tricalcium silicate which produces hydrated calcium silicate gel and calcium hydroxide. The hydrated calcium silicate gel and calcium hydroxide tends to precipitate at the surface of the particle. The CSH (calcium silicate hydration) gel formation is due to the permanent hydration ofthe tricalcium silicate, which gradually fill in the spaces between the tricalcium grains.

Properties of Biodentine: The working time of biodentine is upto 6 minutes with a final set at around 10-12 minutes.When tested according to ISO standard with Gilmore needles, the working time is over 1 minute and setting time is between 9-12 minutes. Biodentine has a consistency after mixing which can be manipulated with a spatula, with an amalgam carrier which is used for endodontic cements in retrograde fillings. Biodentine has superior mechanical properties as determined by the lower water content in the mixing stage. After the initial setting of biodentine, decrease in porosity has been observed leading to improvement in the internal structure. There is a sharp increase in the compressive strength of the material in the first hour and reach upto 200Mpa at 24 hours which is more than glass ionomers. The bending resistance of biodentine is superior to GIC but much lower than the composite resins [22]. It has the surface hardness in the same range as natural dentine. Biodentine is suitable for endodontic treatment as contains zirconium dioxide for radio opacity indications. Biodentine is used as a dentine substitute under a composite restoration, as a direct pulp capping material and as an endodontic repair material.

Bioaggregate: BioAggregate is composed of nano particle sized tricalcium silicate, tantalum oxide, calcium phosphate

and silicon dioxide presents improved performance as compared with MTA. Tricalcium silicate is the main component phase, tantalum oxide is added as a radio pacifier and it is free of aluminium [23]

Setting reaction: On hydration, the tricalcium silicate produces calcium silicate hydrate and calcium hydroxide. The former is deposited around the cement grains, while the latter reacts with the silicon dioxide to form additional calcium silicate hydrate. This results in reduction of calcium hydroxide in the aged cement. MTA reacts in a similar fashion; however, since it contained no additives, the calcium hydroxide was still present in the aged cement [24].

Biocompatibility-Bioactivity was demonstrated by deposition of hydroxyapatite. The tantalum oxide was inert as compared to bismuth oxide, and tantalum was not leached in solution.[25]

Differences between MTA and Bioaggregate

- Bio Aggregate does not contain aluminium and contains additives such as calcium phosphate and silicon dioxide as opposed to MTA.
- MTA exhibited the presence of aluminium, while Bio Aggregate had phosphorus.
- Bio Aggregate exhibits high calcium ion release early, which is maintained over the 28-day period as compared to MTA.
- Reactivity of Bioaggregate was slower when compared to MTA [26].
- BioAggregate is more biocompatible, has better sealing ability, higher fracture and acidic resistance than MTA [27].
- Bio Aggregate has a greater potential to induce odontoblastic differentiation and mineralization than that of MTA in pulp capping [28].

Calcium Phosphate Cement: In vivo and in vitro studies shown calcium phosphate cement as a promising material for grafting applications. It is an bioactive and biodegradable grafting material in the form of powder and liquid. Calcium phosphate cement can be used as a canal obturation material. Good ell et al: recommend CPC as a substitute for calcium hydroxide in apexification cases.

E. Calcium Hydroxide Based Cement: Rhoner in 1940 first clinically used calcium hydroxide as a root canal filling material [29]. A ''miracle' material'' Biocalexwas developed by French researchers, and it was believed to make radical changes to endodontic instrumentation methods [30]. Biocalex/Endocal is a root canal filler that uses calcium oxide in ethyl glycol, when calcium oxide combines with water in the tooth it becomes calcium hydroxide which has well known long term use as an excellent root canalmaterial. The calcium hydroxide based pulpcapping agent, Dycalbecame popular as a sealer among some clinicians in late 1970s, later on many root canal sealers based on calcium hydroxide became popular [31]. The rationale for the addition of calcium hydroxide to root canal sealers is from its antibacterial and tissue repair abilities as observed in calcium hydroxide based base and lining materials. When compared with zinc oxide eugenol (ZOE), AH 26 and Ketac-Endo sealers in dye leakage studies, Sealapex, CRCS, and Apexit showed no significant difference in leakage at 30 days to 32 weeks [32,33]. Sealapex exhibited slower bacterial penetration than AH 26 and AH Plus. In an animal study, Seal apex in tissue contact will dissolve and was partially replaced by ingrowths of connective tissue [34]. Soares et al reported the presence of disintegrated Seal apex sealer particles in macrophage away from the root-filling material in the periapical regions of dog teeth.

Conclusion

Bioceramics have evolved to become an integral part of our modern dental health care systems specially in field of endodontics. The advantages of bioceramics are its biocompatability and antimicrobial properties. Bioceramics offer treatment options for better prognosis in various operative and endodontic procedures. They have transcend many traditionally used materials such as calcium hydroxide. Still various research is still going on to improve the properties of bioceramics so that they can become more widely used.

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