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THE RISE OF BIOCRAMICS IN ENDODONTICS : A REVIEW

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ABSTRACT

Bioceramics are biocompatible ceramic materials, which are being used for various procedures in the medical and dental field. They include alumina, zirconia, bioactive glass, glass ceramics, coatings and composites, hydroxyapatite, resorbable calcium phosphates and radiotherapy glasses. They are ceramic or metal oxides with enhanced biocompatibity, sealing ability, antibacterial and antifungal activity. They have the ability to either function as human tissues or to resorb and encourage the regeneration of natural tissues. At present, bioceramics have a wide array of surgical, endodontic and prosthodontic applications in dentisry. In this review, we discuss about its various uses in endodontic procedures which include as sealer, for root repair and pulp caping and in periapical surgeries.Further clinical research is required to make it the material of choice.

KEYWORDS: **Bioceramic, sealer, pulp capping, root repair, periapical surgery**

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INTRODUCTION

L.L.Hench and others, in 1969, had introduced a new material called Bioglass and had observed that several glasses and ceramics could bond to living bone[1]. Since this breakthrough, significant evolution has been seen with bioceramic technology being used in dental as well as medical practice. Bioceramics are specifically designed ceramic materials which include alumina and zirconia, bioactive glass, glass ceramics, coatings and composites, hydroxyapatite and resorbable calcium phosphates and radiotherapy glasses[2, 3].These materials have been used in a variety of medical procedures due to their biocompatibility to either function as human tissues or to resorb and encourage the regeneration of natural tissues. Alumina has been used in orthopedics due to its low coefficient of friction, wear rate and biocompatibility. Bioceramics have also been widely used for joint or tissue replacements, for coatings to improve the biocompatibility of metal implants, and can function as resorbable lattices that get dissolved as the body rebuilds tissue[4]. Alumina and zirconia have been used for prosthetic devices. Porous ceramics such as calcium phosphate based materials have been used for filling bone defects. Some calcium silicates (MTA (Tulsa dentsply) and Bioaggregate (diadent) have also been used in dentistry as root repair materials and for apical retrofills.

CLINICAL PROPERTIES

Bioceramics can be categorized as[2, 3, 4]:

- Bioinert: Non interactive with biological systems
- Bioactive: durable tissues that can undergo interfacial interactions with the surrounding tissue
- Biodegradable,soluble or resorbable: eventually replace or get incorporated into tissues.

Bioceramics have been used in dentistry due to the following reasons:
Firstly, Bioceramics are exceedingly biocompatible, non toxic, do not shrink upon setting and are chemically stable within the biological environment.Secondly, they will not result in an inflammatory response even if an overfill occurs during the process of obturation or root repair.Thirdly, their ability to form hydroxyapatite and a bond between dentin and the filling materials makes them an increasingly preferable material in dentistry[5, 6].The working time of a bioceramic sealer is approximately four hours at room temperature. Its shelf life is two years and does not need to be stored in a refrigerator. Its setting is dependent on the moisture present in the dentinal tubules. It has a high pH during the initial setting process which accounts for its bactericidal activities[7]. A very small tip can be used for its delivery due its small particle size.

BIOCERAMIC AS ROOT CANAL SEALER

Bioceramic sealer is a non-toxic calcium silicate cement. Bioceramics have now become highly successful as endodontic sealers due to their several advantages such as
-improved biocompatibility,
-excellent sealing ability,
- high pH (12.8) which accounts for its anti bacterial activity,
-non shrinkable and non resorbable property
-improved convenience and delivery
- ease of application and
-increase in strength of root following obturation.
Bioceramic sealers have been designed as premixed sealers due to which problems such as insufficient and non homogeneous mix are avoided. These premixed sealers harden only when exposed to a moist environment such as that produced by the dentinal tubules. They are hydrophilic in nature and have a unique ability to form hydroxyapatite. They form a chemical bond between the filling material and the dentin walls[8]. This eliminates the presence of any space between the dentinal walls and the sealer. Bioceramics have shown radiopacity and flow in accordance with the ISO 6876/2001 recommendations[9]. In an invitro study by Ghoneim et al, it was shown that bioceramic sealer (iRoot SP) when compared to Activ gutta percha cones show increased resistance of fracture of endodontically treated roots[10]. Another study showed that bioceramic sealer (iRoot SP) had the greatest bond strength to

root dentin when compared to other commonly used sealers such as AH plus, Epiphany and MTA Fillapex[11].ProRoot Endo Sealer is a tri-calcium silicate based sealer which demonstrates sealing ability comparable to epoxy resin sealers, has bioactive apatite deposition[12], improved setting time over MTA and similar dimensional stability when compared to MTA[13]. iRoot SP is another calcium silicate based sealer which demonstrated similar push-out bond strength compared to AH Plus epoxy resin sealer[14].The introduction of EndoSequence BC sealer allows taking full advantage of bioceramics and not limiting them to root repairs and apical retrofills. This has been possible due to the recent developments in nano technology which make the bioceramic sealers have a particle size which is so fine (less than 2 μ) that it can be delivered with a 0.012 capillary tip. This material has been shown to cause lower cytotoxicity than AH Plus or a ZOE sealer, Tubli-Seal EWT^{TM}.[15] Synchronised hydraulic condensation is a feature of some bioceramic sealers. In this there is a formation of a true bond between the canal wall and the master cone. The sealers can be placed with the help of intracanal tips which are flexible and allow the user to have better access to the root canal. Capillary tips are also available for the purpose. The tip should be inserted only till the coronal one third and then the sealer is injected slowly. The thin sealer is then coated on the master cone after removing the tip. By using the synchronised gutta percha, sufficient material can be carried and placed in the apex till the final working length[16]. The constant taper of the canal along with the precise fit of the gutta percha help to achieve excellent hydraulics. The glass components in the bioceramic sealers bond to the Activ GP cones. Thus during the setting process there is formation of two chemical bondings: one to the root canal wall by hydroxyapatite formed by the sealer and the other between the ceramic particle in the sealer and the ones on the sealer coated cones[5]. The degree of residual moisture affects the bonding ability of the sealers but in the case of bioceramic sealers the presence of slightly moist canals is preferable.

Setting Reaction

Dentin is composed of approximately 20% water by volume. This water is utilised in the initial hydration reaction of the material thereby shortening the setting time.The calcium silicates in the powder hydrate to produce calcium silicate hydrate gel and calcium hydroxide. This calcium hydroxide then reacts with the phosphate ions to produce hydroxyapatite and water. The water continues to react with calcium silicate to produce calcium silicate hydrate gel and the hydroxyapatite is a non toxic bone repair and reconstruction material.The hydration reactions (A, B) of calcium silicates and precipitation reaction (C) of calcium phosphate are[17, 18]:

(A) $2[3CaO.SiO2] + 6H2O \text{ ---->} 3CaO.2SiO2.3H2O + 3Ca(OH)2$

(B) $2[2CaO.SiO2] + 4H2O \text{ ---->} 3CaO.2SiO2.3H2O + Ca(OH)2$

(C) $7Ca(OH)2 + 3Ca(H2PO4)2 \text{ ---->} Ca10(PO4)6(OH)2 + 12H2O$

RETREATMENT OF BIOCERAMIC CASES

Bioceramic sealer cases are retreatable. In order to remove the bioceramic sealers along with gutta percha, piezoelectric ultrasonic and conventional treatments can be used. Retreatment of cases where glass ionomer is used becomes difficult due to difficulty in retrieval. Similar condition occurs during retreatment of bioceramics[19]. The key point one should remember is that Bioceramics should be used as sealers than complete fillers. They can be used along with a core material that facilitates retrievability in cases where retreatment is required. Further the constant taper of the root canals minimises the amount of endodontic sealer thereby facilitating retreatment. During retreatment, copious amounts of water should be used along with ultrasonics down the canal to approximately half its length followed by a solvent such chloroform or xylol. Then an EndoSequence file (#30 or 35/0.04 taper) is run at an increased rate of speed. The file is run upto the working length using solvent when required. An alternative is to use hand files for the final 2-3 mm and then removal of gutta percha with a rotary file[5].

BIOCERAMIC AS A ROOT REPAIR MATERIAL

In endodontics, various materials have been used for root repair: amalgam, zinc oxide eugenol, calcium hydroxide, composites, glass-ionomers and MTA. One example of a bioceramic root repair material is EndoSequence root repair material. This material is available in two forms either as premixed putty or a premixed syringe. Studies have proven that this material shows equal biocompatibility as MTA[20] with very less cytotoxicity[21]. Another study showed that the putty and syringable paste had similar anti bacterial efficacy when compared to white MTA against ten strains of E.faecalis[22]. It has also shown to have equal sealing ability when compared to white MTA against E.faecalis[23]. However, pH is comparatively lower than MTA[24] and MTA has also been shown to set faster in the presence of blood[25]. According to the Clinicians Report (November 2011) the advantages of this EndoSequence root repair material are:

-easier to use and place than previous similar products
-no mixing required
-radiopacity
-easy dispensing (tip/syringe)
-multiple uses in a variety of clinical conditions

BIOCERAMICS IN PERIAPICAL SURGERY

Periapical surgery is done to remove the etiologic agent and to restore the functional health of tissues. Following curetting the bone defects can be filled with the help of graft materials to promote bone formations. Enamel and bone have hydroxyapatite as a natural component. Tricalcium phosphate although not a natural component of bone, is considered desirsable for repairs of morphologic site due to it's partially bio resorbable nature[26]. These bio materials are non toxic and become functionally integrated with bone with no fibrous encapsulation[27]. They provide a suitable physical matrix for deposition of new bone[28]. Biphasic calcium phosphate has both β-tricalcium phosphate and hydroxyapatite which together allow control over bioactivity due to their properties[29, 30, 31]. This biphasic calcium phosphate maintains both the osteoconductive potential of hydroxyapatite along with the control over resorbability of tri calcium phosphate[26]. It is hypothesised that biphasic calcium phosphates initiate cell growth and differentiation and also have the property of osteoinductivity[32].

BIOCERAMICS FOR PULP CAPPING

MTA has been shown to be superior to calcium hydroxide in terms of predictability and thickness of dentin bridging to maintain pulp vitality[33]. Biodentine is a bioactive dentine substitute suitable for pulp capping. It has been shown to produce dentine bridging similar to MTA with an absence of inflammatory pulp response[34]. Due to its restorative properties and favourable setting time it is considered to have great potential as pulp capping agent and dentine substitute restorative material. Due to its ease of use and availability in the form of premixed syringe, pulpal therapies or pulp capping in young patients can be better managed and with ease. The technique for direct pulp capping with bioceramic root repair material is as follows: isolation of the tooth with the help of rubber dam followed by disinfection of the exposure site with a cotton ball and NaOCl. Then a small amount of the bioceramic repair material is placed either from the syringe or from the putty jar over the exposure area. It is then covered with a compomer or glass ionomer restoration. Etching can be carried out if required. Single visit pulp capping can also be done[5].

COMPARISON WITH OTHER CEMENTS

Bioceramics have been found to have antibacterial and antifungal properties[22]. Their biocompatibility and cytotoxicity levels are comparable to mineral trioxide aggregate (MTA) [35, 36]. MTA has been used in immature apices cases to act as a scaffold for formation of dentin when placed over a blood clot[37]. Bioceramics having similar biocompatibility and setting in the presence of moisture, it may also be used for the purpose.Internal and external resorptions are managed with non surgical therapy using calcium hydroxide. This commonly involves multiple appointments which can be eliminated using bioceramics.Vitapex (calcium hydroxide and iodoform paste) is used in pulp therapy of reimplanted teeth having external resorption with apical and lateral radiolucency[38]. The advantage of bioceramics over vitapex is the sealing ability, the lack of recall of patient and change of dressing thereby reducing the chair side time.

FUTURE USES AND OTHER DENTAL APPLICATIONS

Bioceramics can be used in dental implants, periodontal treatment, alveolar ridge augementation[1], sinus obliteration[39], maxillofacial applications and correction of orbital floor fracture[40].Bioglass has been used in implants to maintain the alveolar ridge of edentulous patients, for maxillofacial reconstruction to correct conductive loss of hearing by replacing the bones of the middle ear. They are also used to provide stable ridge for construction of dentures following tooth extraction and to support the labial and lingual plates following natural tooth loss[1].In periodontal treatments, bioceramics such as PerioGlas have been used in cases of infrabony defects. They have also been used for treating dentinal hypersensitivity. Bioglass material of fine particle size is incorporated into the toothpaste or can be used by means of an aqueous vehicle over the exposed surfaces thereby relieving the pain[1]. The future of bioceramics involves the introduction of faster set materials (eight to ten minutes) as well as bioceramic putty for pediatric use. With the introduction of Ceramir Crown & Bridge in prosthodontics, the future of bioceramics is promising.

CONCLUSION

Bioceramics have been of use not only to endodontics but also for surgical and prosthodontic applications. Their properties help us to be more conservative during endodontic shaping by allowing us to preserve natural tooth structure. With the numerous advantages they provide, they seem to have a promising future in dental medicine. With further research, bioceramics has the potential to become the preferred materials for the various endodontic procedures.

CONFLICTS OF INTEREST

Conflicts of interest declared none.

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