

Review Article

Smart Materials: Smart Think

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Abstract

Smart Materials are the Recent Advances in Dentistry. Now a days various biomaterials play an important role in day-to-day life. These materials have their own importance towards dentist as well as patient. these materials do not harm the oral mucosa and supporting structures of the oral cavity. Smart materials have their own specialty in various fields of dental sciences. They are the materials with less chances of fracture and long duration of stability. Newer materials in dentistry change the concept of dentistry into digital sciences technology. The older materials in dentistry get replaced with these biomaterials. They are with well structural properties that make them popular in routine practices. Smart materials improved the durability of material and efficiency in the future of dentistry.

Keywords: Smart Materials; Smart Technology; Piezoelectricity; Smart Structures

Introduction

The advances in smart materials have proved to be a boon for the field of dentistry especially for treating the prevalent dental diseases as dental caries. Dental caries is the most progressive microbial disease in the world [1]. If dental caries does not get treated it will lead to the destruction of the dental and periodontal structures, causing the bone loss and damage to the periapical tissues. To treat the dental caries various restorative materials are used, such as dental amalgam, composites, glass ionomer cement. The main disadvantage of silver filling is poor tensile strength. It cannot withstand the masticatory as well as occlusal forces that direct along the long axis of the tooth [2]. To overcome all these problems smart materials are developed. Smart materials play a dynamic role in dental as well as medical science. Smart materials are those materials which can never be changed with stimuli, temperature, heat, PH

and moisture. These materials are friendly with dentist as well as make the patient comfortable. Restorations with these materials not only results with fair prognosis but also with less chances of secondary caries [3]. Smart materials are comfortable to the patient with regards to cost as well as treatment along with less chair time.

Digital technology in dental sciences makes these materials more with advanced features so that each one of individual should get benefits from these in daily practices. Use of these materials makes the patient more aesthetics with good smile [4]. Various smart materials are there in science of dentistry, some of them include piezoelectric materials, which work on voltage current. They can work in respond to stimuli by altering one or more of their properties. Smart materials works when some stimulus from the environment can reach it and these materials react to it in an useful, reversible and reproducible manner [5]. Because of these properties, there are various beneficial applications in dental field. Shape memory alloys, zirconia and smart seal are examples of materials that behave in smart manner in dentistry [6]. These materials would bring the new change with outstanding results in the field of dentistry.

Stimulus such as thermal, chemical, mechanical as well as physical affects the properties of restorative material. Due to these

stimuli, there are various effects on restorative materials used in dentistry [7]. As compared to previously used restorative material, effects of these various stimulus on smart materials are less. The main property of smart materials is that they cannot change their shape after the removal of stimulus. Smart materials resist the progression of the disease and hence the severity of the disease is not much and very less amount of destruction of supporting tissues [8]. Smart materials not only show their intelligence in dentistry but also in other medical fields. In medical sciences digital technologies play an essential role. Artificial intelligence, machine learning, and cognitive learning helps in the development of smart materials [9]. Due to these smart materials chances of recurrent rate of metastatic diseases are decreased. When the smart materials apply on the tooth surface, they react with the ions present in the tooth, as they react the ions are released and get flow into the undercut areas these will create the micromechanical bonding with tooth and restorative material [10]. Due to these tooth surface can withstand occlusal load directed on it. It will no less injury or harm to the patient. There are various advantages of smart materials, such as comfortable to the patient, not technique sensitive, less injury to the oral tissues, and biocompatible with soft and hard tissues of the oral cavity, long lasting structural durability, less chances to occlusal trauma. All the mention advantages are beneficial for both dentist as well as patient [11]. Now day's smart materials come into routine practice in dentistry.

Smart materials are also beneficial for the pulp. Some restorative material may produce injury to the pulp or fracture of the amalgam [12]. These smart materials do not damage the remaining tooth structure which will be left after cavity preparation and filling of materials. These will create a positive attitude in the operator during the procedure. Clinical examination, diagnosis and treatment planning are done only when the operator has the idea to apply the knowledge of smart materials based on findings of the individuals [13]. Smart materials have neutral impact in the mouth. Most of the material are similar to the natural tooth structures like enamel and dentin. The use of these smart materials has change the idea or view towards the dentistry which includes the material such as smart composites, smart ceramics, compomers, resin modified glass ionomer cement, amorphous calcium phosphate, apart from these others include, orthodontic shape memory alloy, smart burs, smart sutures which cause less injury to the superficial as well as deep structures ,and smart impression material which helps in improving the handling quality of the impression material [14].

Classification of Smart Materials

1. Passive materials
2. Active materials

Passive materials are those materials which can respond to the outer environment with respect to the surrounding [15]. Active materials are those which feel the change in the environment and respond to them. Passive materials include Resin modified glass ionomer cement, Smart composites, compomer. Active materials include Smart composites and smart ceramics etc. Passive smart materials have a self-repairing property [16]. If the materials are designed for long term use in the body or in the mouth thought to be live long if they are passive, have no interactions with the environment [17]. Materials such as amalgam, composites and cements are often used in dentistry because of their ability to survive without having any interactions with the oral environment. Nowadays active materials catch attention of the clinicians because of benefit of the release of the fluoride from material [18]. With the help of these smart materials chances overcutting of the tooth are less (Table 1).

Restorative Materials	Types
Prosthodontics	Smart impression material
Orthodontics	Shape memory alloys
Pediatric and Preventive Dentistry	ACP releasing pits and fissure sealants
Dental materials	Smart composites; Smart ceramics
Conservative Dentistry and Endodontics	Ni-Ti rotary instruments; Smart prep burs
Oral Surgery	Smart suture
Periodontics	Smart antimicrobial peptide
Laser Dentistry	Smart fibers

Table 1: Restorative materials and its types.

Properties of Smart Materials

The following are the properties of smart materials:

1. Piezoelectric - when mechanical stress is applied an electric current is generated
2. Shape memory - This is the most important property of smart materials. They can come back to their original shape after removal of stimulus or deformation
3. Thermochromic - As the temperature changes, the color of the material also gets changed for e.g- Thermochromic brushes
4. Photochromic - As there is changes in light condition, the color of the material also gets changed e.g.- Clinpro sealant
5. Biofilm formation- Presence of biofilm on the surface of materials alter the bonding of the surface with the environment.
6. Magnetomic - these are fluid materials that become solid after kept in magnetic field
7. Ion release and recharging - These is the most important property of smart materials. Glass ionomer cement contains fluorides which inhibit the progression and severity of the dental caries. So, presence of fluorides in the glass ionomer cement makes it anticariogenic restorative material

Apart from its uses in the dentistry the other biomedical application of smart materials are as, therapeutics, tissue engineering, cell culture, bio separations, biomimetics actuators, immobilized biocatalyst, drug delivery and thermoresponsive surfaces. Smart sutures play the major in maxillofacial trauma [19]. They are made up of thermoplastic materials that have both shape memory and biodegradable properties. As the heat transition temperature is close to the human body temperature, this has its own clinical significance [20]. When the temperature is raised above the thermal transition temperature, the suture shrinks and tightens the knot, applying the optimum force providing the best results [21]. This will help the tissues to heal properly within the specific time period [22,23]. In Endodontics, these smart materials are useful during the biomechanical preparation the procedure of root canal treatment. Endodontic emergencies can be reduced with the help of these smart materials [24,25]. Smart Ni-Ti files prepare the lateral and apical wall in such a manner that chances of perforation of the root apex is less and the root canal filling material such as gutta percha fits properly in that prepared canal [26,27]. In orthodontics the recent advances include Invisalign brackets that are not visible to the other people other than patient [28,29]. In all the possible ways these smart materials have tremendous applications in health sciences in future.

Conclusion

In the recent years, there is progressive improvement in the materials used in dentistry. As the restorative materials are the bread and butter of dentistry, with the involvement of smart materials they become central to the oral and dental care for field of dental sciences by improving the treatment with successful report and results. the better future can be envisaged with the advancements in the smart material using the engineering tools.

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Conflict of Interest

The authors have no conflict of interest to declare.

References

1. Badami V, Ahuja B. Biosmart materials: breaking new ground in dentistry. *The Scientific World J.* 2014;14:1-7.
2. McCabe JF, Yan Z, Al Naimi OT, Mahmoud G. Smart materials in dentistry. *Aust Dent J.* 2011;56(1):3-10.
3. Gautam P, Valiathan A. Bio-Smart Dentistry: stepping into the future. *Trends Biomater Artif Organs.* 2008;21(2):94-7.
4. Zrinyi M, Szilagyi A, Filipcsei G, Feher J, Szalma J, Moczar G. Smart gel-glass based on the responsive properties of polymer gels. *Polymers for Advanced Technologies.* 2001;12:501-5.
5. Dube M, Ponnappa KC. Smart ART!!. *J Int Oral Health.* 2009;1:52-7.
6. Shanthi M, Sekhar EVS, Ankireddy S. Smart materials in dentistry: think smart. *J Pediatr Dent.* 2014;2:1-4.
7. Ahuja K, Pannu R, Pal N, Aggarwal N, Berwal V. Biosmart Dentistry-A Revelation: A Review. *J Adv Med Dent Sci Res.* 2017;5(10):15-8.
8. Allameh SM, Akogwu O, Collinson M, Thomas J, Soboyejo WO. Piezoelectric generators for biomedical and dental

- applications: Effects of cyclic loading. J Mater Sci Mater Med. 2007;18:39-45.
9. Gil FJ, Planell JA. Shape memory alloys for medical applications. Proc Inst Mech Eng H. 1998;212:473-88.
 10. Lendlein A, Langer R. Biodegradable, elastic shape-memory polymers for potential biomedical applications. Science. 2002;296:1673-6.
 11. Stayton PS, El-Sayed ME, Murthy N, Bulmus V, Lackey C, Cheung, et al. 'Smart' delivery systems for biomolecular therapeutics. Orthod Craniofac Res. 2005;8:219-25.
 12. Rolland SL, McCabe JF, Robinson C, Walls AW. *In-vitro* biofilm formation on the surface of resin-based dentine adhesives. Eur J Oral Sci. 2006;114:243-9.
 13. Shaw A, McCabe JF, Carrick TE. Fluoride release from glass ionomers and compomers. J Dent. 1998;26:355-60.
 14. Momoi Y, McCabe JF. Fluoride release from light-activated glass ionomer restoration cement. Dent Mater. 1993;9:151-4.
 15. McCabe JF, Carrick TE, Sidhu SK. Determining low levels of fluoride released from resin-based dental materials. Eur J Oral Sci. 2002;110:380-4.
 16. Anson T. Shape memory alloys: Medical applications. Materials World. 1999;7(12):745-7.
 17. El Feninat, Laroche G, Fiset M, Mantovani D. Shape memory materials for biomedical applications. Adv Eng Mater. 2002;4:91-104.
 18. Gautam, Valiathan A. Bio-smart Dentistry: stepping into the future. Trends Biomater Artif Organs. 2008;21(2):9-97.
 19. Revathi M, Rao CVN, Lakshmi Narayanan. Revolutions in endodontic instruments- a review. Endodontol. 2001;13:43-7.
 20. Xu HH, Weir MD, Sun L, Takagi S, Chow LC. Effects of calcium phosphate nanoparticles on calcium phosphate composite. J Dent Res. 2007;86:378-83.
 21. Skrtic D, Antonucci JM, Eanes ED. Amorphous calcium phosphate-based bioactive polymeric composites for mineralized tissue regeneration. J Res National Institute of Standards and Technol. 2003;108(3):167-82.
 22. Jandt KD, Sigusch BW. Future perspectives of resin-based dental materials. Dental Materials. 2009;25(8):1001-6.
 23. Terry DA, Leinfelder KF, Lee EA, James A. The impression: A blueprint for restorative success. Int Dent SA. 2006;8:12-21.
 24. Davidson CL. Glass ionomer cement, an intelligent material. Bull Group Int Rech Sci Stomatol Odontol. 1998;40:38-42.
 25. Dammaschke T, Schafer E. Efficiency of the polymer bur smart prep compared with conventional carbide bud bur in dentin caries excavation. Operative Dentistry. 2006;31(2):256-60.
 26. Eckert R, He J, Yarbrough DK, Qi F, Anderson MH, Shi W. Targeted killing of *Streptococcus mutans* by a pheromone-guided "smart" antimicrobial peptide. Trends Antimicrob Agents Chemother. 2006;50:3651-7.
 27. Economides N, Gogos C, Kodonas K, Belts C, Kolokouris I. An *ex-vivo* comparison of the push-out bond strength of a new endodontic filling system (Smartseal) and various gutta-percha filling techniques. Odontol. 2012;100(2):187-91.
 28. Bai X, More K, Rouleau CM, Rabiei A. Functionally graded hydroxyapatite coatings doped with antibacterial components. Acta Biomaterialia. 2010;6(6):2264-73.
 29. Konorov SO, Mitrokhin VP, Fedotov AB, Biryukov DAS. Hollow-core photonic-crystal fibers for laser dentistry. Phys Med Biol. 2004;49(7):1359-68.

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