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Smart restorative materials used in dentistry - A review

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Abstract

The expression "Smart restorative material" alludes to those that can be changed in controlled style for example, stress, temperature moisture, pH and electrical or attractive fields. The need of great importance is to present dental materials that have biomimicking properties of regular tooth structure. Different biocompatible materials have been presented and generally utilized in numerous fields of dentistry. Smart restorative behaviour of substances occurs while it detects a few improvements from the overall circumstance and responds to it in a helpful, reproducible and for the maximum element reversible way. A key component of smart conduct incorporates its capacity to come back to the first state. A portion of these materials utilized are altered glass ionomers, calcium phosphate discharging pit and fissure sealants, smart composites, smart ceramic, compomers, orthodontic shape-memory alloys, amalgams, smart impression materials, smart sutures, smart burs, smart endodontic files and so forth. These materials have changed the dentistry and are the start of another part in Biosmart Dentistry.

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INTRODUCTION

Generally, materials intended for long term use in the body or all the more explicitly in the oral cavity are thought to endure longer in the event that they are 'latent' and have no cooperation with their condition. McCabe Zrinyi characterized the materials as "Materials that can be changed by improvements and change again into the first state subsequent to expelling the upgrades." (Mccabe *et al.*, 2009). Materials such as amalgam, composites and dental cement are regularly used in managing the various oral conditions. Maybe the principal tendency that functioning as opposed to 'latent' material could be appealing was the acknowledgement of the advantage of fluoride discharge from materials. A material is supposed to be "smart" on the off chance that it can extend the rest of the tooth structure to cavity preparation can be done in the most moderate manner. These materials have residences which may be modified at some point of a managed sample like pressure, temperature, moisture and pH, electric or attractive motion (Janani *et al.*, 2020). A key component of brilliant conduct incorporates its capacity to come back to the principal state considerably after the stimuli have been expelled. As of late, there has been a neces-

sity of quickening the wellbeing of a framework in biomedical and engineering elements. (Manohar and Sharma, 2018). This has prompted a quick increment inside the improvement of keen therapeutics and structures, the degree of small scale and nanoscale. The usage of smart material has likewise been ventured into some regular things, and in this manner the quantity of uses for them is developing consistently. The present dental materials that are improvised makes them smarter. The utilization of the smart materials has revolutionised dentistry which incorporates the utilization of restorative material like smart composites, smart ceramic, compomers, resin modifiers, glass ionomer, amorphous phosphate releasing pit and fissure sealant and other materials like orthodontic shape memory alloys, smart impression materials, smart sutures, smart bur etc.

The numerous types of smart restorative materials utilised within the sector of dentistry are from memory alloys or shape memory polymers, hydrogen ion concentration sensitive polymers, chemical compound gels. A material is claimed to be ”smart” if it possesses a great capacity to sense and answer any environmental change. Hence, these materials also are referred to as ”responsive materials” (Mangaiyarkarasi *et al.*, 2013). Previously our team conducted numerous studies evaluating the properties in the effect of various dental materials used regularly by means of clinical trials (Ramamoorthi *et al.*, 2015; Nasim *et al.*, 2018). We also did review studies on the effects of various dental materials (Noor and Pradeep, 2016; Teja and Ramesh, 2019). As a step towards discovering new technologies as well as a new innovation in existing literature, the aim of this review is to summarise the current understanding of smart restorative material as an update on the currently used and to present an overview of its merits, demerits, types and so on to get an understanding of its technique and properties and use in clinical dentistry.

Properties of smart restorative materials

Smart restorative materials sense changes within the environment around them and responds in an exceedingly inevitable manner. In general, the properties are, Piezoelectric property - when a kinetic pressure is applied, an electric flow is created. Shape memory property - flexible at whatever point required and can return back to a unique shape once power/expenditure of stress applied is expelled. Thermochromic property - change in shading of light when exposed to heat. Photochromic property - these materials change shading because of changes in light conditions. Magnetorheological property - these are liquid materials that become strong when set in an attractive field (Stayton *et al.*, 2005).

pH sensitive property - when the potential of hydrogen of the environmental factors gets adjusted and there is a difference in the shape of the material. Biofilm occurrence property - the nearness of biofilm on the outside of material adjusts the cooperation of the surface with nature (Gil and Planell, 1998).

Classification of smart restorative materials

Passive Smart Restorative Materials: They sense the external change and respond to it without external control. They likewise have self - fixing property. It includes GIC, resin modified cement, compomers and smart dental composites. Active Smart Restorative Materials: Active restorative materials sense change in nature and react to them. Use a feedback loop to empower that to work as a cognitive response through a controlled instrument or framework (Rolland *et al.*, 2006; Manappallil, 2016). In Restorative and Prosthetic Dentistry materials used are smart GIC, smart composites materials, smart preparation burs, smart bonding agent system, smart ceramic materials and smart dental impression materials. In Orthodontics materials used includes smart shape memory alloys and smart orthodontic adhesive materials. In Pediatric and Preventive Dentistry, the materials used are fluoride releasing pit and fissure sealants and ACP releasing pits and fissure sealants. In Endodontics the Niti Rotary Instruments and smart seal obturation system are employed. In Periodontics the smart antimicrobial peptides and in Implant Dentistry, smart coatings on implants are tried. In Oral surgery cases, novel smart sutures are used.

Amorphous calcium phosphate (ACP)

Aaron S. Posner depicted ACP for the essential time in 1963. At impartial or high pH, ACP stays in its unique structure. In any case, at or beneath 5.8 (basic pH), demineralisation of tooth surface will occur. Therefore, ACP gets changed over to translucent Hydroxyapatite (HAP), in this manner supplanting the HAP crystals lost by corrosive (Ramanathan and Solete, 2015; Siddique *et al.*, 2019).

These free particles will get combined and structure gel-like structures in seconds. In 2 minutes this gel-like structure discharges calcium and phosphate particles. These calcium and phosphate particles neutralize and buffer the pH, which legitimizes its utilization in bone repair materials, smartly coated implants, dental varnish (Enamel Pro varnish), chewing gums, dentifrices, mouthwashes, dental

cement and orthodontic cement (Aegis Ortho), pit and fissure sealants, composites and dental adhesives (Rajendran *et al.*, 2019).

Casein phosphopeptide (CPP)

A milk subsidiary, in blend with ACP (CPP-ACP complex) is utilized for the emulsification and beginning whitish mark lesion in certain dentifrices under the name ReCaldent (Stayton *et al.*, 2005). It is advertised as GC tooth mousse in addition to - (The University of Melbourne, Victoria, Australia) and another GIC containing 3%(w/w) CPP-ACP (Fuji VII EP)

Smart glass ionomer cement (GIC)

Smart behaviour was seen for the first time in GIC by Davidson. On admission of warm or chill food and liquids, these restorative materials may show heat expansion or contraction on heat stimulus. The heat expansion and contraction between restoration and the tooth structure may bring stress that can be associated, and this can cause prompt microleakage, these matters indicated a significant compression occurs when exposed to heat. The clarification for this conduct is that the normal development of heat is remunerated by a liquid stream to the outside of the matter to cause an adjusting of the proportion and it differs. On cooling, this procedure is turned around, the rapid loss of water on heating outcomes in the observed contraction. Thus, very little dimensional change is observed on heating in wet conditions and a marked contraction is noted in dry conditions. The two outcomes can be clarified by a stream of fluid in the dentinal tubules. (Ravinthar and Jayalakshmi, 2018). Thus, GIC materials can be supposed to impersonate the conduct of dentin through a sort of smart restorative behaviour. Consequently, glass ionomer cement is portrayed as smart restorative materials as for their thermic nature. Additional smart behaviour conduct of GIC is fluoride discharge which helps in caries avoidance. On account of glass ionomer cement, the fluoride discharge estimate can be insignificantly seven days. Be that as it may, this issue can be handled. There is proof that the fluoride discharged from salt stages can be altered when the substance is washed in a high convergence of fluoride as may happen in toothpaste or mouthwash. This drawn out fluoride discharge is a higher priority than the underlying 'burst' for a brief timeframe. As the substance gets exhausted of its inborn fluoride it is intriguing that the 'spikes' of fluoride subsequent to reviving seem to increment marginally with duration. Different examinations have indicated that the paces of fluoride discharge and reviving are inversion reactive. Thus, quicker reviving can be achieved by utilizing warm fluoride consisting arrangements and this can create an increased supported discharge at oral inversion (Ramesh *et al.*, 2018). Resin modified GIC, compomer or giomer all show these smart restorative nature (Kelly and Denry, 2008). Ex: GC Fuji IX GP EXTRA (Zahnfabrik Bad Säckingen, Germany).

Smart composites

The smart composite contains Amorphous Calcium Phosphate. ACP at nonpartisan or high pH remains ACP. At the point when decreased acidic value i.e., at or underneath 5.8 happens during a cavity assault, Aluminium composite panels change over into hydroxyapatite and precipitates, hence changing the hydroxyapatite disoriented to the acids. So, when the acidic level in the oral cavity dips under 5.8, these particles converge inside in no time to shape a gel. In under 120 seconds, the gel becomes undefined crystalline, bringing about Ca and PO^{3-} ions (Zhao *et al.*, 2011). Ariston pH control - presented by Ivoclar-Vivadent. It is a light-enacted alkalescent, nano filled glass alleviative substance. It discharges Ca, F, and OH group particles when intraoral acidic value dips under the basic acidic of 5.5 and checks the abnormal loss of mineral salts of the tooth surface and furthermore helps in remineralisation. The matter can be sufficiently restored in size thickness up to 4 mm. It is suggested for the rebuilding class 1 and class 2 injuries in both primary and permanent teeth (Jose *et al.*, 2020).

Self-repairing or self-healing composites

This is an epoxy system which consists of resin filled microcapsules. In the event that a split happens in the epoxy composite material, a portion of the microparticle is destroyed near the break to liberate resin (Nasim and Nandakumar, 2018). The resin particles along these lines pack the space and respond with a Grubbs catalyst scattered in the epoxy composite, bringing about integrity copolymeric of the resin and fix of the space. Comparative frameworks were shown to have a fundamentally longer obligation cycle under mechanical stress insitu contrasted with comparable frameworks with the self-repair.

Smart pit and fissure sealants

On the way that occlusal sides comprise just 12% of the crown part, they are many times as risky as smooth surfaces to caries (Rajakeerthi and Nivedhitha, 2019). Along these lines, the anticipation of occlusal caries accepts the central significance of the conservation of dentition part. The main suitable for the arrangement of occlusal sealants is not long late outbreak of the lasting molars, in light of the fact that as of late outbreak of dentition are

low in calcification and tooth has additionally not matured the advantages of growth development of the enamel and makes resistant to increased exposure of acid attacks (Kumar and Antony, 2018). So, fluoride discharging and ACP discharging pit and fissure sealants are utilized for this reason.

Fluoride releasing pit and fissure sealants

Two regular methods for fluoride consolidation into sealant are by the anion exchange system and expansion of fluoride salt to the unpolymerized resin. Models are Fluoroshield and Deltonplus, it has NaF^- and discharges F^- particles as the mineral breaks down. The component of fluoride discharge from the fluoride sealant stays theoretical. Fluoride discharge may happen from the impenetrable sealant substance and matters because of permeability. It may likewise happen in light of the fact that the F^- ions or the F^- glass is not firmly bound to the integrity copolymer resin atoms. Release in fluoride glass containing sealants may also be due to fluoride glass grains depositing on the surface of the resin.

CONCLUSION

In the 21^{st} century, science and innovation depend intensely on the advancement of new substances and matters that are relied upon to react to the natural alteration and show their possess capacities as indicated by the ideal conditions. Smart materials are a response to this prerequisite of condition neighbourly and receptive matters, which change their properties to perform explicit capacities. It has altered dentistry, for example, materials used to like smart composite, smart ceramic, compomer resin changed glass polymer, $Ca_3(PO_4)_2$ discharging pit and fissure sealants and so forth. Because of a quick advancement of science, keen therapeutic substance and matter hold a decent guarantee for the hereafter and in the development of the novel department of bio smart dentistry. Dental experts ought to know about these imaginative materials to empower their utilization and use their ideal properties in everyday practice to give quality and successful answers for dental issues.

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Conflict of Interest

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