IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

Revolutionizing Pediatric Dental Care with Bioactive Materials: A Narrative Review

[1]Chaya Chhabra, [2]Shraddha V. Shere, [3]Anita Choudhary, [4]Athira Prathapan, [5]Anandan Aditya

[1]Professor and Head, [2]PG Scholar, [3]Associate Professor, [4]PG Scholar, [5]PG Scholar

[1]Department of Pediatric and Preventive Dentistry,
[1]NIMS University Rajasthan, Jaipur, India
[2]Department of Pediatric and Preventive Dentistry,
[2]NIMS University Rajasthan, Jaipur, India
[3]Department of Pediatric and Preventive Dentistry,
[3]NIMS University Rajasthan, Jaipur, India
[4]Department of Conservative Dentistry and Endodontics,
[4]NIMS University Rajasthan, Jaipur, India
[5]Department of Conservative Dentistry and Endodontics,
[5]NIMS University Rajasthan, Jaipur, India

Abstract: Bioactive materials have had a great impact on restorative dentistry, favoring the longevity of restorations, cell stimulation for dentin repair, increasing adhesive resistance, and reducing the recurrence of cavities and bacterial microfiltration. This article focuses on different bioactive materials and their significance in pediatric dentistry because these materials are crucial to pediatric dentistry. By speeding up the regeneration and repair of damaged tissues, tissue bioengineering helps science create and expand new treatments and/or new biomaterials that restore, enhance, or stop the decline of compromised tissues' function. To develop bioactive materials that mimic and replace the natural structure of teeth and surrounding bone, more research is needed. Newer concepts of adhesion and incorporation may change dentistry and dental care in the future.

***Index Terms* -** Dental Materials, Bioactive materials, Regeneration, Remineralization

I. Introduction

The behavior of dental materials is changing at the moment; they are no more passive biomaterials that do not react positively or negatively in the body, but rather exhibit consistent bioactivity that produces an expected positive reaction, such as antibacterial activity or cellular stimulation. Many substances that produce bioactivity have been used in many fields of dentistry since the late 1960s, when the second generation of biomaterials was developed, Dr. Hench's study on bone regeneration was conducted, and bioactive glasses were introduced. "A material that forms a surface layer of a material similar to apatite in the presence of an inorganic phosphate solution" is the definition of bioactivity in dentistry, which is dependent on its clinical application. They can also be described as substances that have the ability to cause the host's tissue to react in a particular way. The composition of bioactive materials has changed throughout time, and they are now utilized in many dental and medical specialties.[1]

Dental caries is a chronic disease which can affect residents at any age. Till 5 years prevalence of dental caries gradually increases by 68.8% as it is multifactorial in nature.[2] Despite the teeth's continuous cycle of demineralization and remineralization, dental caries cannot be stopped by this natural remineralization

process. Therefore, in order to remineralize, repair, or regenerate the tooth's tissues, a biomaterial that is bioactive in nature must be added to the tooth.[3]
By speeding up the regeneration and repair of damaged tissues, tissue bioengineering helps science create and expand new treatments and/or new biomaterials that restore, enhance, or stop the decline of compromised tissues' function.[4] By encouraging the release of calcium, sodium, silica, and phosphate ions, which have angiogenesis and antimicrobial activity, bioactive materials should have the following ideal qualities: bactericidal and bacteriostatic, sterile, stimulate reparative dentine formation, and maintain pulp vitality.[1]
Uses of bioactive materials in pediatric dentistry

- Promotes tooth re-mineralization
- As pulp capping material
- For permanent restorations
- In apexification procedure
- Act as scaffold and helps in regeneration of bone tissue.[3]

This article focuses on different bioactive materials and their significance in pediatric dentistry because these materials are crucial to pediatric dentistry.

II. CLASSIFICATION OF BIOACTIVE MATERIALS BIOACTIVE MATERIALS ARE DIVIDED INTO 2 GROUPS:

Class A: Osteoproductive Materials:
In osteoproductive materials the bioactive surface is colonized by osteogenic stem cells. It triggers both an intracellular and an extracellular reaction at its contact. These substances are osteoconductive as well as osteoproductive. For instance, 45S5 Bioglass.
Group B: Osteoconductive Materials:
The osteoconductive materials offer a biocompatible surface for bone migration. When a substance only causes an extracellular reaction at its interface, it is said to have osteoconductive bioactivity. Synthetic hydroxyapatite (HA) is one example.[5]

III. BIOACTIVE MATERIALS IN PEDIATRIC DENTISTRY

Calcium hydroxide, mineral tri oxide aggregate (MTA), bio-dentine, bio-glass, bio-ionomer, calcium enriched mixture (CEM), amorphous calcium phosphate (ACP), bio-aggregate, TheraCal LC, and endo sequence root repair material (ERRM) are examples of bio-active materials used in juvenile dentistry.

Calcium hydroxide:

In 1990, HERMAN brought calcium hydroxide to the field of dentistry. Several materials and antimicrobial compositions used in different treatment techniques contain calcium hydroxide. Calcium hydroxide can cause a calcified barrier when employed as a pulp-capping agent and in apexification situations.[6]
Ca(OH)2's hydroxyl group produces an alkaline environment that encourages active calcification and repair. This stops the decomposition of dentine minerals by neutralizing the lactic acid produced by osteoclasts. Alkaline phosphatases, which are essential for the development of hard tissue, are also activated. The molecular unit of hydroxyapatite, calcium phosphate, is created when alkaline phosphatase breaks free inorganic phosphatase from phosphate esters and reacts with calcium ions.[3]
It is utilized in apexification procedures, pulp capping, and pulpotomy in juvenile dentistry.
The short hard tissue barrier induction time, incomplete barriers from vascular inclusions, dentin structural changes, and early zones of sterile pulp necrosis—which can result in pulpitis and necrosis from microleakage beneath restorations—are some of the drawbacks of calcium hydroxide.[7]

Mineral trioxide aggregate (MTA):

Torabinejadas, a root-end filler, created mineral trioxide aggregate (MTA) at Loma Linda University in the 1990s. The US Federal Drug Administration approved it, and ProRoot MTA (Tulsa Dental Products, USA) was released into the market. Both the grey and white versions of ProRoot MTA were the only commercially available types of MTA until recently. MTAAngelus (Angelus SolucọesOdontolo´gicas, Londrina, Brazil) has also recently joined the market.[8]

Apatite production is a frequent feature of MTA, a bioactive substance mainly made of calcium and silicate. When MTA is used as a pulp capping agent, it causes cytologic and functional alterations in pulpal cells, which leads to the production of reparative dentin and fibrodentin. Osteodentin and tertiary dentin development mineralize this unmineralized matrix.[9]

It is utilized in pediatric dentistry for operations such as root canal filling, pulp capping, pulpotomy, furcation perforation repair, and resorption repair.

The propensity for discolouration, the inclusion of hazardous components in the material composition, challenging handling properties, a lengthy setting time, high material cost, the lack of a known solvent for this material, and the challenge of removing it after curing are some of MTA's disadvantages.[10]

Biodentine:

Gilles and Olivier introduced biodentine, a calcium silicate-based substance, in 2010. In actuality, it is a dentin substitute that can be positioned in contact with the pulp as well as utilized as a coronal restorative material (for indirect pulp capping). Due to its quicker setting period, the crown can be restored immediately or made "functional" intraorally without worrying about the material deteriorating.[11]

Calcium-enriched mixture (CEM):

It was first introduced by Asgary and is also referred to as NEC. Calcium carbonate, calcium silicate, calcium phosphate, calcium oxide, calcium sulfate, and calcium chloride make up this substance. Calcium phosphate, CH, calcium sulfate, calcium silicate, calcium chloride, calcium carbonate, and calcium oxide are the several calcium compounds that make up calcium-enriched mixed cement. CEM cement is a white powder made up of hydrophilic particles that solidifies when a water-based solution is present. Powder undergoes a hydration process to form hydroxyapatite, a colloidal gel that solidifies in less than an hour. This cement takes five minutes to work and less than an hour to set. The range of 0.5 to 2.5 nm had the largest distribution of CEM particle sizes, which allowed the particles to enter dentin tubules and improve the seal.[12]

MTYA1 Ca-filler:

The powdered MTYA 1-Ca was combined with liquid (67.5% triethylene glycol dimethacrylate, 30.0% glyceryl methacrylate, 1.0% o methacryloyl tyrosine amide, 1.0% dimethyl amino ethyl methacrylate, and 0.5% camphorquinone) and contains 89.0% microfiller, 10.0% calcium hydroxide, and 1.0% benzoyl peroxide. Physically, MTYAl-Ca is good, and it was not less good than Dycalhistopathologically. A promising direct pulp capping material is MTYA1-Ca.[13]

TTCP:

It can be used for biomedical purpose as it contains bioresorbablepolylactide composite that was incorporated with more basic filler for biomedical application. It was proved that it reduces inflammation and allergic effect resulting from acidic substances.[12]

Sol-gel derived Ag-BG:

Bioactive glass-ceramic materials generated from sol-gel have a significant role in the field of dental restoration and repair. The biological surface needed for the selective spread and attachment of particular cell types capable of promoting tissue attachment may be provided by dental ceramics that develop a cement-like behavior. In the system SiO2(58.6), P2O5(7.2), Al2O3(4.2), CaO(24.9), Na2O(2.1), and K2O(3) (wt%), a novel sol-gel generated bioactive glass ceramic with appealing mechanical and physicochemical properties has already been demonstrated.[14]

Calcium Phosphate:

Because of their nontoxicity, biocompatibility, and capacity to promote the creation of mineralized tissue, calcium phosphate biomaterials are advantageous in endodontic therapy. They are bioactive and have the ability to trigger particular tissue reactions, which encourages dentin bridging and neo-osseous development. Additionally, they maintain cellular deterioration and encourage osteoconduction, which permits osseous cells to colonize areas of bone or dental pulp implantation.

Endosequence root repair materials:

Using bioceramic technology, Brasseler USA has launched Endo Sequence Root Repair Material (RRM) and Endo Sequence Root Repair Putty (RRP). With 50% of the material being nano, these premixed goods give doctors a uniform, homogenous substance with a big particle size of 0.35 µm. This decrease has outstanding physical and biological qualities and resolves user issues regarding handling characteristics. The products have a high pH, are hydrophilic, insoluble, radiopaque, and aluminum-free.[15]

HX-BGC:

It is a new BAG-ceramic that contains SiO_2-P_2O_5-CaO-Na_2O-SrO and is sold as powder. It functions by obstructing dentinal tubules and was used to decrease dentine permeability.[16]

Theracal:

TheraCal LC is a fourth-generation calcium silicate that is a light-curable resin-modified tricalcium silicate[17] liner that has used to protect and insulate the dentin-pulp complex. It can serve as a protective base or liner beneath cements, amalgams, composites, and other base materials in both direct and indirect pulp capping. This substance was found to have a low solubility and a higher calcium release when compared to ProRoot MTA and Dycal.[5] It is stated that TheraCal LC is a hydraulic silicate substance that solidifies through hydration. The chemical process that causes hydrophilic cement to set is called hydration. When the substance and water come into contact, the setting begins. Water is not included in TheraCal LC for material hydration. It is dependent upon the amount of water absorbed from the surroundings and how it diffuses through the substance. Therefore, applying the substance to moist dentin is part of the manufacturer's instructions.[18]

Bioaggregate:

BioAggregate is a new water-based cement made in a lab (Innovative Bioceramix, Vancouver, BC, Canada). A clean and fine white hydraulic cement-like powder made of contamination-free bioceramic nanoparticles, BioAggregate is the first nanoparticular mineral cement to be launched to the dentistry market. It is created under regulated conditions.Calcium silicate, calcium hydroxide, and calcium phosphate make up the majority of this insoluble, radiopaque, and aluminum-free substance. When utilized for root-end filling, BioAggregate has demonstrated exceptional sealing capabilities.[5]

Resin impregnation with titanium oxide (Tio2):

Dental resins like dentin bonding adhesives and dental monomers can contain TiO_2 nanoparticles impregnated in them. The strength and antibacterial properties of these restorations have been discovered to be further enhanced by the promotion of hydroxyapatite production. By filling in the small spaces, these nanoparticles aid in the remineralization of dentin and enamel. As a result, it lowers the frequency of secondary caries and other implant surface characteristics.[12]

Emdogain (EMD):

The commercial product Emdogain Gel contains the proteins amelogenin, amelin, and enamel matrix derivative (EMD), which are involved in the differentiation of odontoblasts and the creation of dentine during dentinogenesis. It is composed of water, propylene glycol alginate as a carrier, and enamel matrix derivative. Non-amelogenin proteins such as ameloblastin, tufelin, and enamelin are also present in EMD. It also contains a growth factor that is similar to BMP and chemicals that are either TGF-b1 or TGF-b-like.[19]

IV. CONCLUSION:

In the modern era of regeneration, demineralized dental hard tissue must be remineralized. Despite advances in technology, the search for biomimietic materials to maintain and protect tissue health continues. Understanding the characteristics of current bioactive compounds is essential to their positive impacts. To develop bioactive materials that mimic and replace the natural structure of teeth and surrounding bone, more research is needed. Newer concepts of adhesion and incorporation may change dentistry and dental care in the future.

V. REFERENCES

1. Luis Gabriel Ladino, Alejandra Bernal, Daniel Caldero n and Diego Corte s. "Bioactive Materials in Restorative Dentistry: A Literature Review". SVOA Dentistry 2:2 (2021) pages 74-81.
2. Sen, Sourav[1]; Deolia, Shravani[2]; Chhabra, Kumar Gaurav[1,]; Chakraborty, Rakashree[3]; Chhabra, Chaya[4]; Rathi, Anushree[2]. Analysis of food frequency and acquired dietary allowance (ADA) in relation to dental caries and dental erosion affecting dental postgraduate students of Sawangi: A cross-sectional survey. Journal of Family Medicine and Primary Care 8(6):p 2084-2088, June 2019. | DOI: 10.4103/jfmpc.jfmpc_242_19.
3. Raju SS, Srujana MP, Kiranmayi M, Reddy ER, Sai S. Bio active materials in pediatric dentistry: A review. International Journal of Applied Dental Sciences. 2021 Jan 1;7:345-51.
4. Francine B. Bioactive materials in dentistry. New york: Ed Nova Science Publishers; 2019.
5. Asthana G, Bhargava S. Bioactive material: A Comprehensive Review.Sch. J. App. Med. Sci., 2014; 2(6): 3231-3237.
6. Mohammed Mustafa, Saujanya KP. Role of Calcium Hydroxide in Endodontics: A Review. GJMEDPH 2012;1(1):66-70.
7. Mohammadi Z, Dummer PMH, et al. Properties and applications of calcium hydroxide in endodontics and dental traumatology. International Endodontic Journal 2011;44(8):697-730.
8. Camilleri J and Pitt Ford TR. Mineral trioxide aggregate: a review of the constituents and biological properties of the material. International Endodontic Journal 2016; 39(2): 747 - 754.
9. Macwan C, Deshpande A. Mineral trioxide aggregate (MTA) in dentistry: A review of literature. J Oral Res Rev 2014; 6(1): 71 - 74.
10. Glickman GN, Koch KA. 21st-century endodontics. J Am Dent Assoc 2000;131:39S-46.
11. Seltzer S, Bender IB. The dental pulp, 2nd edn. Philadelphia, PA: JB Lippincott 1975, 260.
12. Sonarkar S, Purba R, "Bioactive materials in conservative dentistry. International Journal of Contemporary Dental and Medical Reviews, Vol.2015.
13. Niinuma A. Newly developed resinous direct pulp capping agent containing calcium hydroxide (MTYA1- Reference: Ca). International Endodontic Journal 1999; 32: 475 - 483.
14. Chatzistavrou X et al. Development of new sol-gel derived Ag-doped biomaterials for dental applications. Materials Research Society 2012; 1417: 39 – 46.
15. Al-Sanabani JS, Madfa AA, Al-Sanabani FA. Application of Calcium Phosphate Materials in Dentistry. International Journal of Biomaterials 2013; 32(5): 312 - 324.
16. Pathak SD et al. Advances in Pulp Capping Materials: A Review. IOSR Journal of Dental and Medical Sciences 2017; 16(2): 31 - 37.
17. Dutta A, Saunders W. Calcium silicate materials in endodontics, Dental Updates 2014;41(8):708-722.
18. Naji Ziad Arandi, Tarek Rabi. TheraCal LC. From Biochemical and Bioactive Properties to Clinical Applications. International Journal of Dentistry, 2018.
19. Dowling A.P. Development of nanotechnologies. Nano Today, 2004, December,30.