Remineralizing the Demineralized: A Review

Saman Seraj[1], Deepshikha Rajput [2]
PG Student[1],Senior lecturer[2]
Department of Pedodontics & Preventive Dentistry, Teerthanker Mahaveer Dental College and Research Centre, Delhi Road, Moradabad (UP)

ABSTRACT:
Re-mineralization is the natural process of repair of a carious tooth whereas demineralization is reversible loss of enamel minerals by acid attacks from cariogenic bacteria. The teeth undergoes a process of de-mineralization & re-mineralization, but this natural re-mineralization is not sufficient to stop progression of dental caries & therefore we require a material which is bio-active in nature to remineralize, repair or regenerate the lost tooth structures. With this quest to develop an ideal restorative material, bio-active materials came into existence as a promising alternative to bioinert substances used earlier. This article mainly focuses on the concept of bio-activity and numerous bio-active materials available for use in daily practice.
Keywords*:* Remineralization, Demineralization, Bioactive Materials

INTRODUCTION

The hard tissues of teeth are made up of mineralized structures (i.e. Enamel and Dentin) constituting of inorganic components such as hydroxyapatite (90% of enamel) responsible for structural strength of tooth. Hydroxyapaptite (a form of calcium apatite) is a naturally occurring mineral that helps in remineralization of tooth enamel, reducing the risk of cavities and erosion. While it occurs naturally, dentists often use it synthetically to enhance the anticariogenicity and also biocompatibility along with the maintenance of pulp health. [1]

Several organic acids, mainly lactate, acetate, etc are produced by cariogenic bacteria which has the ability to dissolve these mineralized structures and causing demineralization. Contrary to this, saliva because of its neutralizing action & buffering action on acids forms a protective layer on the surface of tooth (k/a pellicle) and provides Ca^{2+}, PO_4^{3-} & fluoride to enamel & dentin to promote remineralization, which is not adequate to prevent occurrence of caries and therefore lead to the introduction of bioactive materials. [2] Bioactive materials are nothing but an artificial replica of natural remineralizing agent of the tooth. Since its development, bioactive materials are continuously under study by clinicians.

This review article is an additional information to the clinician's knowledge of bioactive materials as a guide for which material is favourable for which clinical scenario and also the importance of these materials to pediatric dentist.

HISTORICAL ASPECT

- The ceramics made up of calcium phosphate were the first known materials with bio-activity and currently such materials are most commonly used in dentistry for biomedical purposes.
- The first generation of biomaterials introduced in 1950s were bio-inert and were limited to stimulating the mechanical properties of surrounding tissue.[3]
- The second generation of biomaterials started in 1960s were GIC with anticariogenic properties were introduced by Wilson & Kent and later Bioglass ("Bioglass 45SS") by Larry L. Hench (1969) acting on the adjoining tissues without generating a response.[4]
- The third generation started in 1990s with the introduction of CPP-ACP and MTA lately.[2]

This is how bioactive methods have changed in recent years, progressing from relatively specialised, low strength, highly biocompatible

Correspondence address: Dr. Saman Seraj, Department of Pedodontics and Pediatric Dentistry, Teerthanker Mahaveer Dental College and Research Centre, Moradabad, Uttar Pradesh, India.
Email: zaraseraj@gmail.com
How to cite this article: Seraj S, Bailwad SA, Bhatnagar A. Remineralizing the Demineralised. TMU J Dent 2024; 11(1): 33-38.
Submitted: 16 Mar 2023 Revised and accepted: 30 Mar 2023
Doi: https://doi.org/10.58358/tmujd.ped11105r

dental materials to currently appearing in product compositions for extended clinical purposes in restorative dentistry. In the recently emerging area of dental materials, more advances are planned to satisfy additional restorative clinical needs.[5]

DEFINITION

In 1969, the concept of "bioactivity" was introduced by ***Hench.*** Bioactivity means "the ability of a material to elicit a response in living tissue". [6]

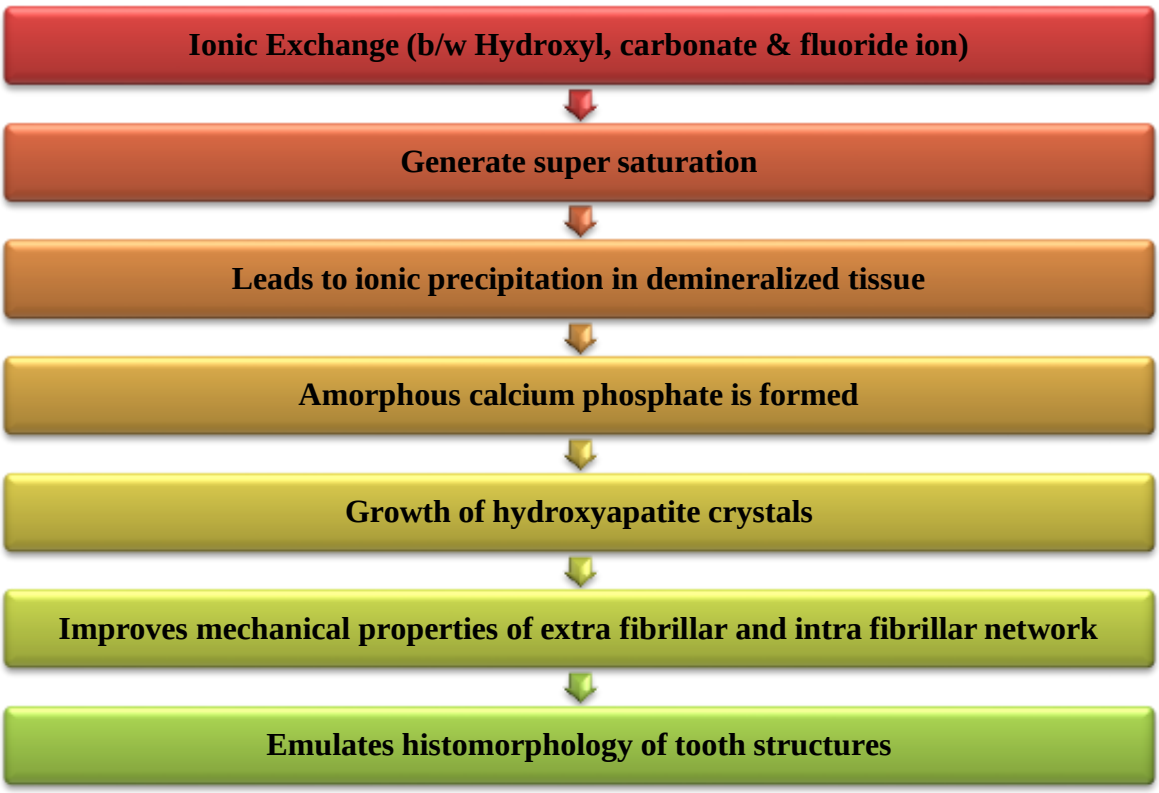
Bioactive Materials are defined as "materials that has an effect on or eliciting a response from living tissue, organisms or cell such as inducing the formation of hydroxyapatite." [6]

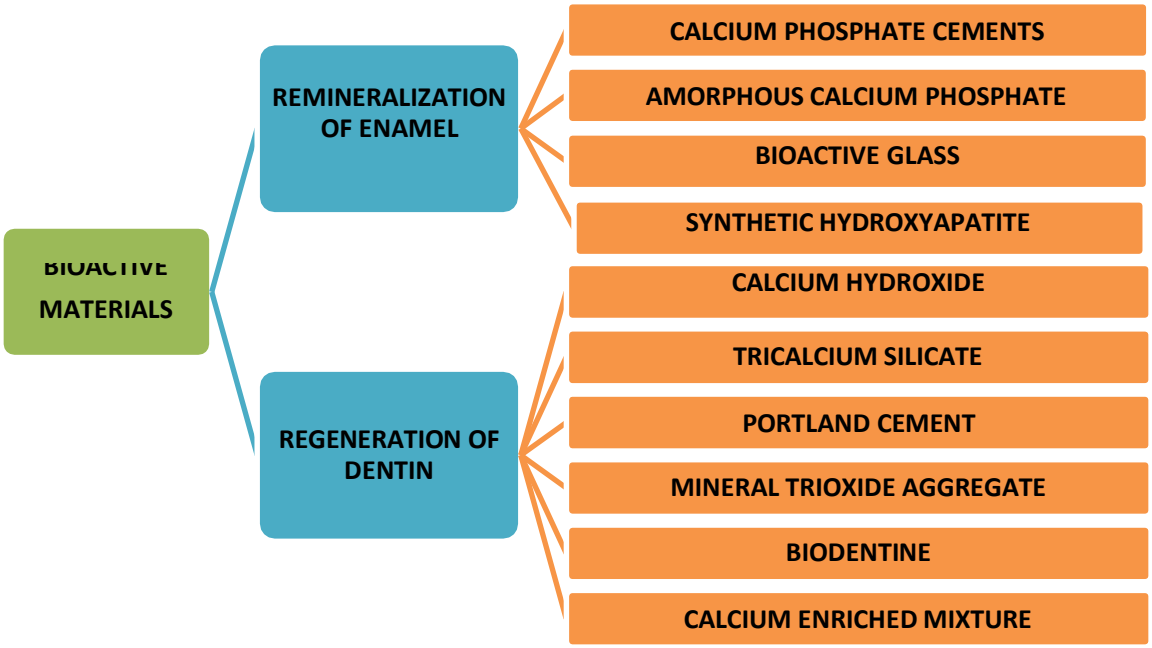
IDEAL PROPERTIES

1) Maintain pulp health and vitality
2) Bactericidal and Bacteriostatic
3) Sterile
4) Stimulate reparative dentin formation

MECHANISM OF ACTION

The aim of bioactive material is to promote the process of remineralization of dental structures by the following mechanism:-[4]



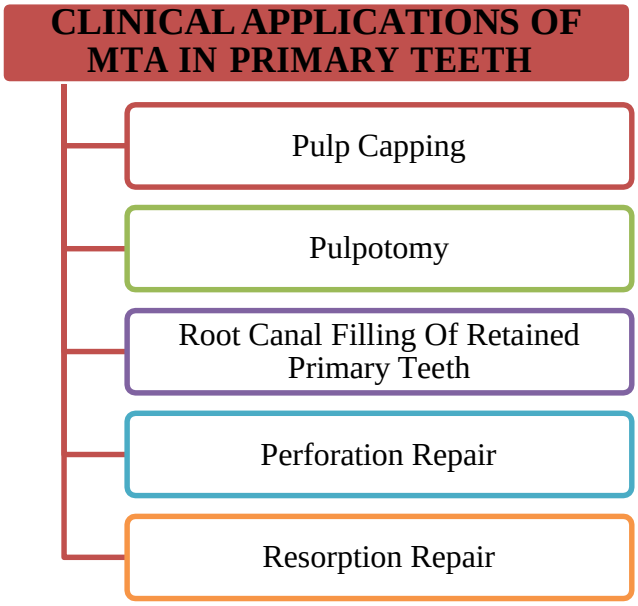


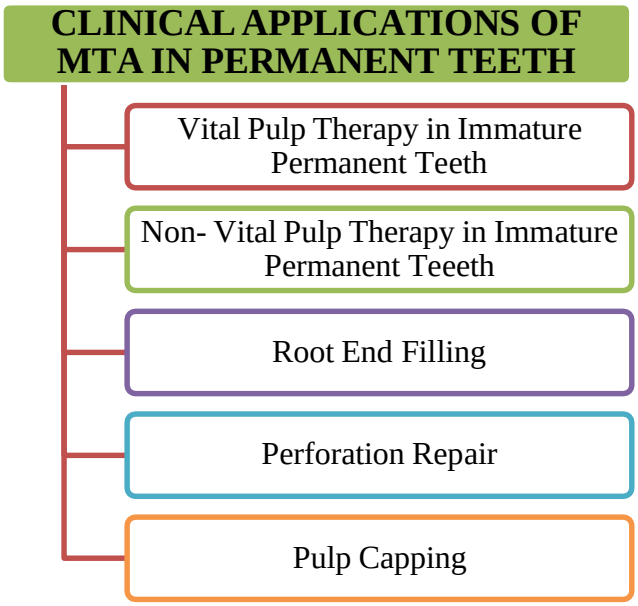
BIOACTIVE MATERIALS IN PEDIATRIC DENTISTRY

1) **<u>Mineral Trioxide Aggregate</u>** :

MTA is introduced as a bioactive material by ***Torabinejad in 1993*** as surgical root repair material.[7]

- Composed of:
  a) Portland cement
  b) Bismuth oxide
  c) Gypsum
  d) Traces of calcium oxide, potassium sulphate, silicone oxide & magnesium oxide.
- Properties :
  - Induces minimal inflammation if it exceeds the apex
  - Antibacterial effect on some facultative bacteria
  - Compressive strength – 70MPa
- Research on ***MTA*** show that it not only has strong biocompatibility, a good long-term prognosis, and a relative ease of manipulation, but also encourages tissue regeneration. [8]
- It has an initial pH of 10.2 and after 3hrs of immersion in solution it has a pH of 12.5. [9]
- ***Jessie et al*** "assessed certain signaling molecules related to the inflammatory process and the biomineralization ability of MTA to evaluate host-biomaterial interactions in vivo".[10]
- ***Mente et al***. "analysed the clinical treatment of ***MTA*** and concluded that it appears to be more effective than $Ca(OH)_2$ for maintaining long-term pulp vitality after direct pulp capping." [11]
- The limitations of ***MTA*** includes its discoloration potential, long setting time, high material cost and the difficulty of its removal after curing.





2) **Biodentine :**

- In ***2011, Biodentine*** was introduced by ***Septodent (SaintMaur des Fosses-France).***
- It is a quick-setting calcium silicate based dental cement.
- Biodentine is a 2-component material:

Powder Component

- Tricalcium silicate
- Dicalcium silicate
- Calcium carbonate

Liquid Component

- Calcium carbonate (setting accelerator)
- Water (Reducing agent)

- Radiopacifier: Di-calcium silicate, Calcium carbonate, Zirconium dioxide
- Clinical Applications :- It acts as a dentin substitute under a composite restoration
  - As a Pulp capping agent
  - In Pulpotomy procedure
  - In Apexification procedure

- Specific Features of Biodentine:

a) Can be placed in close contact with pulp

b) It has a capacity to improve with time, over several days; until it reaches 300MPa after a month.[12] This value is in close proximity to compressive strength of natural dentin (i.e. 270MPa).[13]

- Advantage of Biodentin over MTA : Relatively short setting time (around 12min)

3) **Bioactive Glass :**

- Bioactive glasses were first introduced by ***Hench et al. in 1969.***
- Bioactive glass constitutes of synthetic mineral containing Na, Ca, PO_4 & silica which are already in the body.
- It act by coming in contact with saliva or water, by releasing Na, Ca & PO_4 ion into the saliva which facilitate in re-mineralization of the tooth.
- By physically occluding dentinal tubules, ***NovaMin*** was created to cure hypersensitivity.
- As bioactive glass have the ability to precipitate hydroxyapatite, hence when applied as prophy powder they induce rapid remineralization of dentin.
- ***Andersson&Kangasniemi in 1991*** showed that osteoconductivity and osteoinductivity is responsible for remineralization.

4) **Amorphous Calcium Phosphate :**

- ***ACP*** was first described by ***Aaron S. Posner in 1960s***
- ***ACP*** precipitates from a highly super saturated calcium phosphate solution.
- It can easily transform to octacalcium phosphate and/or apatitic products. [6]
- Properties of ACP :-
  - Osteoconductive
  - Biodegradable
  - Excellent bioactivity
  - High cell adhesion
  - Non- Cytotoxic

- Clinical Applications:-
  - ACP in Biomineralization
  - ACP- filled polymeric Composites
  - CPP-ACP (Caseinphosphopeptide)
  - Incorporation of ACP as a filler in glass ionomer cement
  - Mouth rinses
  - Food Products
  - Tooth pastes (G C Tooth Mousse)
- ACP can also be used as a filler to composites which releases calcium and phosphate ion into saliva. [1]

5) **Theracal L C** :

- ***TheraCal LC (Bisco, Schaumburg, USA)*** was introduced in 2011
- It is a ***light curable resin-modified tricalcium silicate***.
- It is classified as a ***fourth generation Ca silicate material.***
- It is a ***single-paste calcium silicate-based substance*** used as a protective liner for use with restorative materials, cement, or other base materials, as well as a pulp capping agent.[3]
- ***Properties of Theracal LC*** :
  - Shorter setting time
  - Better Sealing Ability
  - Higher pH
  - Good antimicrobial activity
  - Less solublity

RECENT ADVANCES IN BIOACTIVE MATERIALS

- Recently, ***Activa™ BioActive-Restorative (Pulpdent Corp., Watertown, MA, USA)***; has been introduced as a new bio-active material. The purpose of this substance is to emulate the physical & chemical characteristics of natural teeth by fusing the strength and aesthetics of composites with all the advantages of ***GIC*** [14].
  Components of Activa™ are:-
  a) Bio-active GIC
  b) Bio-active ionic resin
  c) Rubberized resin

CONCLUSION

This review of the literature leads to the conclusion that remineralization of demineralized dental hard tissue is a crucial requirement in the current era of regeneration. Bio-active materials have rapidly evolved in recent years with applications involving various areas of dentistry and specially emerged as a material of choice in pediatric dentistry by meeting patients' expectations and offering them best results with minimal isolation requirements. Pediatric dentistry faces daily challenges while performing restorative procedures for caries affecting tooth especially with cases of primary molars. It is a challenging task to encourage such patients to cooperate on dental chair for long procedures and also to achieve proper isolation for proper adaptation of restorative materials. Hence, bioactive materials came as a boon for pediatric patients where good adaptability of material occurs with minimal isolation. These materials have the combining benefits of glass ionomers and composites. Therefore, further study in the field of biomimetic is required to produce synthetic materials (bioactive materials) based on biological principles that can imitate the natural hard structure of teeth and the surrounding bone.

REFERENCES

1) Neeta S, Kundabala M. Biominerals in restorative dentistry. J Of Interdiscipl Dent 2013; 3(2): 64-70.
2) Francine B. Bioactive Materials in Dentistry.New York: Ed Nova Science Publishers: 2019
3) Martinez, Estelrich M. Bioactivity in restorative dentistry. Fac.Odontol Uncuyo. 2016; 7-12
4) Luis GL,Alejandra B, Daniel C and Diego C. Bioactive Materials In Restorative Dentistry: A

Literature Review : SVOA Dentistry 2:2 (2021); 74-81
5) Steven R J. Bioactive and Biomimetic Restorative Materials: A Comprehensive Review Part 1: Journal Of Esthetic and Restorative Dentistry 2014; 26(1): 14-26
6) Raju SS, Srujana MP *et al*. Bioactive Materials in Pediatric Dentistry: A review: Int J of Appl Dent Sci 2021; 7(1): 345-351
7) Geeta A, Shaveta B. Bioactive Materials: A Comprehensive Review: Sch J Of Appl Med Sci (SJAMS), 2014; 2(6E): 3231-3237
8) Lee SJ, Monsef M, Torabinejad M. Sealing ability of a mineral trioxide aggregate for repair of lateral root perforations. J Endod 1993; 19:541-544
9) Savin et al. Mineral Trioxide Aggregate use in children's primary and permanent teeth. Int J of Med Dent; 23(3): 235-239
10) Reyes CJF, Santos AS, Figueiredo CP, Baggio CH, Felippe MC, Felippe WT; Host–mineral trioxide aggregate inflammatory molecular signaling and biomineralization ability. J Endod., 36(8): 1347-1353
11) Mente J, Geletneky B, Ohle M, Koch MJ, Friedrich Ding PG, Wolff D, et al. Mineral trioxide aggregate or calcium hydroxide direct pulp capping: An analysis of the clinical treatment outcome. J Endod 2010; 36: 806-13
12) Septodont scientific file: Biodentine. Available from http://www.septodont.fr/fichiers_upload/biodentinescientificfile.pdf
13) O'Brien W; Dental Materials and their Selection. 4th edition, Quintessence Publishing, 2009
14) Lee J, Seo S, Kim H. Bioactive glass-based nanocomposites for personalized dental tissue regeneration. Dent Mater J. 2016 1; 35(5): 710-720
15) Dr. Vipin Arora *et al*. Bioactive dentin replacement. J of Dent and Med Sci 2013; 12(4): 51-57
16) Vaibhav Sharma et al. Biomineralization process in hard tissue. ActaBiomaterilia by Elsevier Ltd. 2020; 1-18Dutta A, Saunders W. Calcium silicate materials in endodontics, Dental Updates 2014; 41(8): 708-72
17) Lisa Lardani, GiacomoDerchi, Vincenzo Marchio, Elisabetta Carli. One- Year Clinical Performance of Activa Bioactive Restorative Composite in Primary Molars. Children 2022; 9(433); 1-14.