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# AN OVERVIEW OF ADVANCES IN DENTAL HARD TISSUE REMINERALIZATION: ROLES OF NURSES AND TECHNICIANS

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**Abstract:**
*Dental caries is not a linear and one-way process of mineral phase demineralization, but rather a cyclical occurrence involving periods of demineralization and remineralization. Remineralization is a natural mechanism that repairs and restores minerals in their ionic forms to the hydroxyapatite (HAP) crystal lattice. This process takes place under almost neutral physiological pH circumstances, in which calcium and phosphate mineral ions are re-deposited within the caries lesion from saliva and plaque fluid. As a result, larger and more acid-resistant hydroxyapatite (HAP) crystals are formed. A wide range of demineralizing substances and procedures have been extensively studied and are currently being employed in clinical practice, yielding highly reliable and good outcomes.*

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## INTRODUCTION:

Dental caries is a widespread disease that affects the teeth. It is defined by the loss of minerals and the formation of cavities, which can eventually cause discomfort and agony. This can lead to difficulties in performing normal activities and can also damage the appearance of the face [1].

The majority of children acquire the bacteria, primarily Streptococcus mutans, from their mothers or caretakers through contact with saliva during the eruption of their first teeth, which typically occurs between the ages of 6 and 30 months. This period is referred to as a distinct window of susceptibility to infection [2,3]. Caries is not a linear and uninterrupted process of mineral phase demineralization, but rather a cyclical occurrence involving alternating periods of demineralization and remineralization. Cavitation occurs when the demineralization process becomes dominant [4].

The demineralization process entails the depletion of minerals at the leading edge of the lesion, situated below the enamel surface. This occurs due to the movement of acid ions from the plaque towards the leading edge, and the transfer of mineral ions from the leading edge towards the plaque [5]. Remineralization is a natural mechanism that repairs and restores minerals in their ionic forms to the hydroxyapatite (HAP) crystal lattice [6]. Under situations of almost neutral physiological pH, a process takes place in which calcium and phosphate mineral ions are redeposited within the caries lesion from saliva and plaque fluid. This leads to the development of larger and more acid-resistant hydroxyapatite (HAP) crystals [7].

The demineralization-remineralization process has a similar chemical base for enamel, dentin, and root cementum. Nevertheless, the varying compositions and proportions of mineral and organic tissue in each of these materials result in notable disparities in the characteristics and advancement of the carious lesion [8].

**Review:**

Tooth loss is a prevalent and concerning issue that poses a threat to both society and the overall well-being of patients [9]. The diminished masticatory capacity largely impacts the overall health and well-being of the individual. The primary reason for children and adolescents to visit the dentist is carious lesions in their primary teeth. These lesions cause pain, chewing difficulties, pulp inflammation, tooth mineralization disorders, and post-traumatic damage to dental tissues. Caries, along with hereditary illnesses and periodontal diseases, is a leading cause of tooth loss and is often recognized as the most prevalent disease globally [10].

The tooth is an intricate organ composed of many hard, mineralized tissues including enamel and dentin, along with soft tissues such as dental pulp [11]. It is crucial to highlight that the external enamel layer cannot undergo biological repair, except through the process of remineralization. Fluoride ions can strengthen and restore enamel tissue. Volponi et al. [12] noted that newly generated hydroxyapatite typically lacks the mechanical qualities and structure found in natural enamel. Consequently, the primary difficulty in the entire process lies in replicating the hierarchical structure of natural enamel.

Several previous endeavors have been made throughout history to achieve complete tooth regeneration. Young et al. [13] successfully regenerated the first tooth, together with other tissues like enamel and dentin, by utilizing porcine third molar tooth buds. Nevertheless, the regenerated tissues had flawed characteristics.

The enamel, which is the outermost covering of the teeth and the toughest substance in the human body, is exposed to significant chewing forces, fluctuations in pH levels, and the risk of tooth decay [14]. Regeneration is unnecessary in cases where the enamel is compromised at an early stage without the formation of a cavity. Subsequently, it just necessitates the process of remineralization by the inclusion of amelogenins and the utilization of biomimetic pathways [15]. The true benefit arises when there is a necessity for enamel regeneration, as it is difficult to direct the process of regeneration to arrange hydroxyapatite (HAp) crystals and prisms in a structure resembling that of natural teeth. This requires multiple steps to achieve enamel tissue from ameloblasts undergoing odontoblasts differentiation [16].

Dentin has been effectively produced through the indirect creation of odontoblast-like cells, utilizing postnatal mesenchymal cells like dental papilla stem cells or bone marrow mesenchymal stem cells [17].

The unique structure and composition of tooth pulp make it the most difficult tissue to regenerate in the field of dentistry. The access to it is restricted because it is enclosed within the tooth by dentin. Despite being rich in nerves and blood vessels, it does not have alternative pathways for blood flow, resulting in restricted immune system action in eliminating contaminated cells [18].

In the field of dentistry, there exist a multitude of techniques for the repair and replacement of damaged dental tissue. The examples shown in this scientific study are not conclusive, owing to the ongoing and swift advancements in biomaterials within the field of medicine, particularly in dentistry. The current dental treatments for carious lesions use conservative techniques that utilize inorganic materials. Certain techniques prioritize the replacement of missing biological tissues with synthetic alternatives. Nevertheless, techniques involving the utilization of stem cells exhibit considerable potential for the restoration of biological tissues following the extraction of decayed lesions. It is important to emphasize that these methods are currently being studied in scientific research, although their exceptional potential is supported by multiple scientific research studies [17,18].

In 1993, Reynolds first documented the use of casein phosphopeptides (CPPs) as a means to prevent tooth decay and reduce the formation of dental calculus. In 1996, amorphous calcium phosphate (ACP)-filled methacrylate composites were also reported to have these properties [19]. Dr. Tung commercially launched Enamelon toothpaste in 1999, utilizing ACP technology [20]. In 2003, sugar-free chewing gums and mouth rinses containing CPP-ACP were being used. These products have been proven to effectively remineralize subsurface enamel lesions [21].

The introduction of sodium calcium phosphosilicate, a type of bioactive glass ceramic material, has proven to be effective in providing calcium, sodium, and phosphate ions for the formation of hydroxyl carbonate apatite (HCA). This material can bind to the tooth surface and release ions to facilitate the process of remineralization. Dr. LenLitkowsky and Dr. Gary Hack developed a toothpaste called "NovaMin" using this specific recipe. The latest studies on remineralization focus on biomimetic remineralization materials, which were first proposed by Moradian in 2001 [22].

Fluoride and toothpaste containing fluoride

Soi et al. have identified and described four distinct pathways by which fluoride exerts its effects [23]. Fluoride prevents the loss of minerals by making the fluorapatite crystals, which are produced when it reacts with enamel apatite crystals, more resistant to acid erosion than HAP crystals. Furthermore, fluoride facilitates the process of remineralization by accelerating the formation of new fluorapatite crystals through the aggregation of calcium and phosphate ions. Furthermore, it hampers the function of acidogenic cariogenic bacteria by disrupting the synthesis of phosphoenol pyruvate (PEP), a crucial stage in the glycolytic pathway of bacteria. Additionally, $F^-$ adheres to dental hard tissue, the oral mucosa, and dental plaque in order to reduce demineralization and promote remineralization [23].

Toothpastes may contain fluoride in many chemical compositions, primarily as sodium fluoride (NaF), sodium monofluorophosphate (Na2FPO3), amine fluoride (C27H60F2N2O3), stannous fluoride (SnF2), or a combination of these compounds. Sodium fluoride immediately supplies unbound fluoride ions. Sodium monofluorophosphate is the preferred fluoride compound when abrasives containing calcium are utilized. The released fluoride is adsorbed onto the mineral surface, forming either a CaF2 or a CaF2-like deposit, either in a free or bound state. Stannous fluoride supplies both fluoride and stannous ions, with the stannous ions serving as an antibacterial agent [24].

In a study conducted by Fowler et al., it was discovered that toothpaste containing 1426 ppm of sodium fluoride or 1400 ppm of amine fluoride provided a substantial safeguard for dental enamel against erosive acid exposure in laboratory conditions. This protection was observed to be much greater compared to toothpaste without any fluoride content [25]. The presence of a basic amino acid in fluoride pastes with zinc and amino acids prevents the production of insoluble zinc fluoride. Zinc, which is present, helps prevent erosion, decrease bacterial colonization and biofilm formation, and enhances the teeth's shine. Pradubboon et al. found that using a 0.05 NaF mouth rinse in combination with twice-daily usage of fluoride toothpaste can successfully improve the remineralization of early-stage tooth decay [26].

Another method of delivering fluoride is through light-activated fluoride (LAF) treatment. This involves applying fluoride to the surface and then using intense monochromatic light sources, such as light emitting diodes (LED) or halogen curing lights (470–500 nm) and blue argon ion laser (488 nm), immediately afterwards. A study conducted by Mehta et al. in living organisms has demonstrated the efficacy of a light-curable fluoride varnish (Clinpro T) in avoiding demineralization. The varnish was applied only once during the study [27].

**Calcium phosphate compounds**

Calcium phosphate is the primary kind of calcium present in cow milk and blood. The quantities of calcium and phosphate in saliva and plaque, which are the main components of hydroxyapatite (HA) crystals, have a significant impact on the processes of dental demineralization and remineralization [28]. An ideal rate of enamel remineralization can be achieved when the calcium/phosphate ratio is 1.6, given the same level of supersaturation. The Ca/P ratio in the plaque fluid is roughly 0.3. Increasing the amount of calcium provided can enhance the process of enamel remineralization.

Research has demonstrated that the incorporation of TCP in conjunction with fluoride can enhance the process of enamel remineralization and promote the formation of minerals that are more resistant to acid compared to fluoride alone. When incorporated into toothpaste formulations, a protective barrier is formed around the calcium, enabling its coexistence with the fluoride ions. When toothbrushing, the TCP substance interacts with saliva, leading to the dissolution of the protective barrier and the subsequent release of calcium, phosphate, and fluoride [28].

Functionalized TCP refers to a calcium phosphate system that is added to a topical fluoride formulation, which can be either in a single-phase aqueous or non-aqueous form. This addition is done at low doses. It acts as a protective shield, preventing early interactions between TCP and fluoride, and also enables a precise distribution of TCP to the teeth [28].

### Composites packed with Dicalcium Phosphate Dihydrate (DCPD) and Amorphous Calcium Phosphate (ACP)

DCPD serves as a precursor for apatite, which easily transforms into fluorapatite when exposed to fluoride [29]. Studies have demonstrated that the addition of DCPD in a toothpaste enhances the concentration of free calcium ions in the fluid surrounding dental plaque. These enhanced levels persist for a duration of 12 hours following brushing, in comparison to traditional silica toothpastes [28].

ACP, which stands for amorphous calcium phosphate, is the first solid phase that forms when a calcium phosphate solution becomes extremely supersaturated. ACP can easily transform into stable crystalline phases like octacalcium phosphate or apatitic products. It functions as a precursor to bioapatite and as a temporary stage in biomineralization [30]. The process of converting ACP to apatite at physiological pH can be described as follows: initially, ACP dissolves, followed by the reprecipitation of a temporary OCP solid phase through nucleation growth. Finally, the transient OCP phase undergoes hydrolysis to form the more stable apatite through a topotactic reaction [29,31].

Skrtic introduced a restorative material that contains ACP as a filler enclosed in a polymer binder. This material can promote the restoration of tooth structure by releasing substantial quantities of calcium and phosphate ions. It releases calcium and phosphate ions into saliva and deposits them into tooth structures as an apatitic mineral, which closely resembles the naturally occurring hydroxyapatite (HAP) present in teeth and bones [30].

Eric Reynolds and his colleagues developed a protein nanotechnology involving CPP, a protein derived from milk. This technology stabilizes clusters of ACP by forming CPP-ACP complexes. The "acidic motif" in CPP, which is a highly charged region, can bind to minerals like $Ca^{2+}$, $Zn^{2+}$, $Fe^{2+}$, $Mn^{2+}$, and $Se^{2+}$ at neutral pH. CPP–ACP is a biphasic system that, upon mixing, undergoes a reaction to produce ACP material. This material then precipitates onto the tooth structure and increases calcium levels in the plaque fluid. GC Tooth Mousse Plus™ and MI Paste Plus™ are products that contain CPP–ACP along with fluoride at a concentration of 900 ppm. The inclusion of fluoride enhances the ability to prevent tooth decay, as demonstrated by additive effects [29]. It can be obtained in the form of toothpastes, chewing gum, lozenges, and mouth rinses. Prestes et al. conducted an in situ investigation which demonstrated that chewing gum containing CPP-ACP can greatly improve the mineral precipitation of early bovine enamel lesions, leading to a considerable recovery in its microhardness [32].

According to Reynolds et al., the inclusion of 2% CPP-ACP in the 450 ppm fluoride mouth rinse leads to a notable enhancement in the absorption of fluoride into plaque. Oliveira et al. have shown that combining CPP-ACP with fluoride has a stronger preventive effect against demineralization on smoother surfaces, compared to using CPP-ACP alone [34].

## CONCLUSION:

Recently, restorative dentistry has shifted its attention towards a conservative approach, with remineralization techniques being the preferred and most effective method for regenerating lost tooth structure. The proactive strategy of identifying, preserving, and providing non-restorative treatment for early-stage tooth decay not only reduces the need for dental professionals and costs, but also minimizes discomfort for the patient.

This review aims to examine the different remineralization materials and technologies currently used for the purpose of remineralizing enamel and dentin. At first, only fluoride formulations were used to rebuild the hydroxyapatite (HAP) crystals by providing the ions that were partially lost from the lattice network. Subsequently, the researchers were able to effectively develop advanced biomimetic remineralization products that can generate apatite crystals within entirely demineralized collagen fibers.

## REFERENCES:


1. Edelstein B. The dental caries pandemic and disparities problem. *BMC Oral Health.* 2006;6(1):S1–S2.
2. Berkowitz RJ, Turner J, et al. Maternal salivary levels of *Streptococcus mutans* and primary oral infection of infants. *Arch Oral Biol.* 1981;26:147–149.
3. Caufield PQ, Cutter GR, et al. Initial acquisition of mutans streptococci by infants: evidence for a discrete window of infectivity. *J Dent Res.* 1993;72:37–45.
4. Carounanidy U, Sathyanarayanan R. Dental caries: a complete changeover (part I). *J Conserv Dent.* 2009;12(2):46–54.
5. Robinson C, Shore RC, et al. The chemistry of enamel caries. *Crit Rev Oral Biol Med.* 2000;11(4):481–495.
6. Hemagaran G. Remineralisation of the tooth structure—the future of dentistry. *Int J PharmTech Res.* 2014;6(2):487–493.
7. Naveena Preethi P, Nagarathana C, et al. Remineralising agent—then and now—an update. Remineralising agent—then and now—an update. *Dentistry.* 2014;4(9):1–5.
8. Zhang X, Deng X, et al. *Chapter Nanotechnology in Endodontics: Current and Potential Clinical Applications.*Switzerland: Springer International Publishing; 2015. Remineralising Nanomaterials for Minimally Invasive Dentistry. pp. 173–193.
9. Li Z.Y., Wang H.M., Bao T.W. Tissue engineering teeth using bone marrow mesenchymal stem cells with odontogenic potential compounding collagen/nano-hydroxyapatite composite scaffold. *Int. J. Oral Maxillofac. Surg.* 2009;38:525–526.
10. Jones F.H. Teeth and bones: Applications of surface science to dental materials and related biomaterials. *Surf. Sci. Rep.* 2001;42:75–205.
11. Shuai Y., Ma Y., Guo T., Zhang L., Yang R., Qi M., Liu W., Jin Y. *Advances in Experimental Medicine and Biology.*Volume 1107. Springer; New York, NY, USA: 2018. Dental stem cells and tooth regeneration; pp. 41–52.
12. Volponi A.A., Pang Y., Sharpe P.T. Stem cell-based biological tooth repair and regeneration. *Trends Cell Biol.* 2010;20:715–722.
13. Mironov V., Visconti R.P., Markwald R.R. What is regenerative medicine? Emergence of applied stem cell and developmental biology. *Expert Opin. Biol. Ther.* 2004;4:773–781.
14. Zafar M.S., Khurshid Z., Almas K. Oral tissue engineering progress and challenges. *Tissue Eng. Regen. Med.* 2015;12:387–397.
15. Khurshid Z., Tariq R., Asiri F.Y., Abid K., Zafar M.S. Literature search strategies in dental education and research. *J. Taibah Univ. Med. Sci.* 2021;16:799–806.
16. Çolak H., Dülgergil Ç., Dalli M., Hamidi M. Early childhood caries update: A review of causes, diagnoses, and treatments. *J. Nat. Sci. Biol. Med.* 2013;4:29–38.
17. Mendes F.M., Braga M.M. Caries detection in primary teeth is less challenging than in permanent teeth. *Dent. Hypotheses.* 2013;4:17.
18. Mejàre I., Stenlund H., Zelezny-Holmlund C. Caries Incidence and Lesion Progression from Adolescence to Young Adulthood: A Prospective 15-Year Cohort Study in Sweden. *Caries Res.* 2004;38:130–141.
19. Zhao J, Liu Y, et al. Amorphous calcium phosphate and its application in dentistry chemistry. *Cent J.* 2011;5(40):2–7.
20. Tung MS, Eichmiller FC. Dental applications of amorphous calcium phosphates. *J Clin Dent.* 1999;10:1–6.
21. Reynolds EC. Retention in plaque and remineralisation of enamel lesions by—various forms of calcium in a mouthrinse or sugar-free chewing gum. *J Dent Res March.* 2003;82(3):206–211.
22. Moradian-Oldak J. Amelogenins: assembly, processing and control of crystal morphology. *Matrix Biol.* 2001;20:293–305.
23. Soi S, Vinayak V, et al. Fluorides and their role in demineralisation and remineralisation. *J Dent Sci Oral Rehabil.* 2013 Jul-Sep;:19–21.
24. Duckworth RM. Pharmacokinetics in the oral cavity: fluoride and other active ingredients; in van Loveren C: toothpastes. *Monogr Oral Sci.* 2013;23:121–135.
25. Fowler C, Wilson R, et al. *In vitro* microhardness studies on a new anti-erosion desensitizing toothpaste. *J Clin Dent.* 2006;17:100–105.
26. Pradubboon SS, Hamba H, et al. Sodium fluoride mouthrinse used twice daily increased incipient

caries lesion remineralisation in an otu model. *J Dent March*. 2014;42(3):271–278.
27. Mehta A, Paramshivam G, et al. Effect of light-curable fluoride varnish on enamel demineralisation adjacent to orthodontic brackets: an *in vivo* study. *Am J Orthod Dentofacial Orthop*. 2015;148(5):814–820.
28. Li X. The remineralisation of enamel: a review of the literature. *J Dent*. 2014;42:S12–S20.
29. Walsh LJ. Contemporary technologies for remineralisation therapies: a review. *Int Dent*. 2009;11(6):6–16.
30. 22. Kalra DD, Kalra RD, et al. Non fluoride remineralisation: an evidence-based review of contemporary technologies. *J Dent Allied Sci*. 2014;3(1):24–33.
31. Bennett T, van AC, et al. Fluorides and non-fluoride remineralisation systems. *Monogr Oral Sci*. 2013;23:15–26.
32. Skrtic D, Antonucci JM, et al. Effect of the monomer and filler system on the remineralising potential of bioactive dental composites based on amorphous calcium phosphate. *Polym Adv Technol*. 2001;12:369–379.
33. Prestes L, Souza BM, et al. *In situ* effect of chewing gum containing CPP–ACP on the mineral precipitation of eroded bovine enamel: a surface hardness analysis. *J Denti*. 2013;41(8):747–751.
34. Oliveira P, Fonseca A, et al. Remineralising potential of CPP–ACP creams with and without fluoride in artificial enamel lesions. *Aust Dent J*. 2016;61:45–52.