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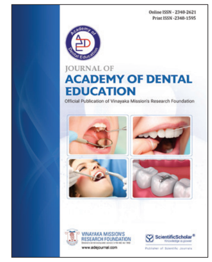

Review Article

Demineralization and remineralization in restorative dentistry

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ABSTRACT

The purpose of caries remineralization therapy is to arrest or reverse the caries process. This paper describes the importance of calcium and phosphate ions in tooth and bone health. The processes through which the demineralization–remineralization process occurs in both teeth and bone, as well as emerging therapies/technologies that can reverse demineralization or promote remineralization, are thoroughly reviewed.

Keywords: Demineralization, Remineralization, Fluorides, pH cycling, Fluoroapatite

INTRODUCTION

Natural composites comprising organic and inorganic components include enamel, dentin, cementum, and bone. Bone, cementum, and dentin are specialized connective tissues, whereas enamel is derived from the ectodermal layer of the skin. Collagen type I accounts for over 90% of the organic component in specialized connective tissues (bone, cementum, and dentin), with non-collagenous proteins accounting for the rest.[1,2]

Conversely, the organic matrix of enamel contains 90% amelogenin, a non-collagenous protein, and contains little to no collagen.[3] The inorganic component of these hard tissues is biological apatite, $Ca_{10}(PO4)_6(OH)_2$. Cementum (approximately 30%) and dentin (almost 70% each) contain more inorganic material than enamel (nearly 90% prismatic crystals) (45%).

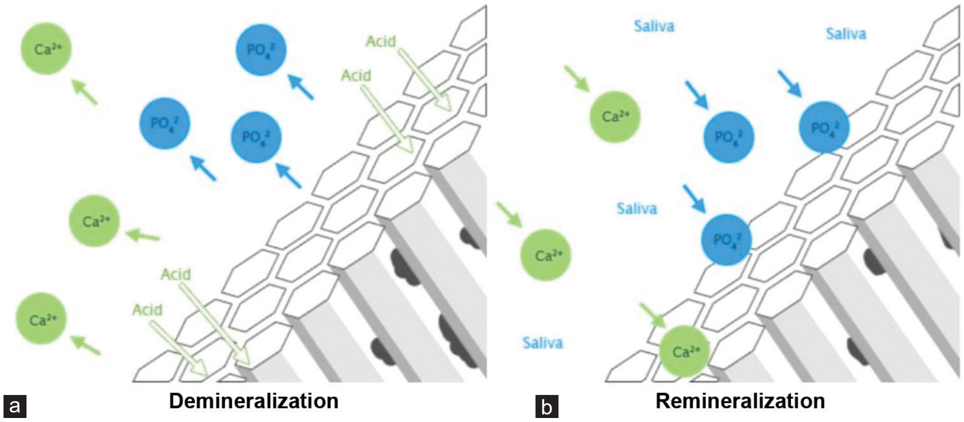
DEMINERALIZATION

The removal of minerals from enamel in the form of mineral ions is known as demineralization. The structural integrity of hydroxyapatite (HA) latticework can be preserved although a large number of mineral ions are eliminated. These minerals when dissolved in a greater ratio from a section of HA crystalline structure, a hollow is created, and the crystalline latticework structure of the HA is destroyed.

REMINERALIZATION

The process of supplying calcium and phosphate ions from a source outside the tooth to induce ion deposition into crystal gaps in demineralized enamel to achieve net mineral gain is known as remineralization.[4]

DEMINERALIZATION – REMINERALIZATION CYCLE



MECHANISM OF DEMINERALIZATION

Enamel, dentin, and cementum all include the mineral HA, which is predominantly made of $Ca_{10}(PO_4)6(OH)$. Saliva, which is saturated with Ca^{2+} and $(PO_4)^{3-}$ ions, serves as the local environment, and HA is in equilibrium with it in a neutral environment.

Phosphate groups in the nearby aqueous environment of the enamel crystal surface interact with H+ preferentially. The procedure can be described as $(PO_4)^{3-}$ to $(HPO_4)^2$ conversion, followed by H+ addition and buffering. The $(HPO_4)^{2-}$ cannot contribute to the normal HA equilibrium since it is made up of PO_4 rather than HPO_4, which causes the HA crystal to disintegrate.

MECHANISM OF REMINERALIZATION

The process of demineralization can be stopped if the pH is regulated and there are enough Ca^{2+} and PO_4 ions in the area. Salivary Ca^{2+} and $(PO_4)^{3-}$ ions can either buffer the apatite dissolution products or inhibit the dissolution process through the common ion effect. Reassembling partially broken-down apatite crystals is a process known as remineralization.

In most cases, remineralization is a surface phenomenon that self-limits and prevents ions from penetrating deep into the lesion, especially when fluoride is present. Rapid fluorapatite deposition produces a strong surface layer that resists future demineralization and the calcium and phosphate ions necessary for in-depth lesion repair. Due to some dye uptake, the white spot lesion is therefore frequently still discernible.[5]

RATIONALE FOR DEMINERALIZATION–REMINERALIZATION

The solubility of HA is affected by contaminants as well as the pH of the surrounding environment. The main force behind HA dissolution and precipitation is pH. The saturation concentration of calcium and phosphate ions in respect to apatite is higher in low pH environments than in high pH environments.

In saliva, as well as plaque fluid, HA is supersaturated at neutral pH. As a result, if a suitable precipitation nucleus is present, the mineral will precipitate.[6]

Consuming fermentable sugars causes the plaque to create acid, which lowers pH and boosts the necessary concentrations of calcium and phosphate for saturation. The fermentation (rate of acid generation) by oral bacteria is likewise slowed by the lower pH. The amount of calcium and phosphate in these liquids, as well as their pH, affect whether enamel and dentin disintegrate or mineralize.

Until the pH required for HA dissociation is attained, which is somewhere between pH 5.5 and 5.2, acid ions largely interact with the phosphates in saliva and plaque. Further, pH decreases cause acid ions to interact with the HA's phosphate groups, leading to partial or total disintegration of the surface crystallites.[7]

In this process, accumulated fluoride is released and combines with the breakdown products of Ca^{2+} and $(HPO_4)^{2-}$ ions to generate fluorapatite or fluoride-enriched apatite. The critical pH for fluorapatite dissolution is 4.5, below which even fluorapatite will dissolve.

The reverse process of remineralization occurs when acid ions are neutralized, but Ca^{2+} and $(HPO_4)^{2-}$ ions are maintained. The solution from which the apatite is precipitated; in this case, the plaque fluid determines the apatite's composition. The chemical makeup of the outer layers of enamel changes step by step as a result of this periodic pH cycling, becoming less soluble with time. Post-eruptive enamel maturation is the name given to this process.[8]

It is necessary for the upcoming generation to know about various technologies of remineralization that can enhance fluoride uptake and overcome the gap in its remineralizing activity which can help carious lesions to fully consolidate. Various non-fluoride remineralization agents may also facilitate dental products to be produced with less fluoride concentration, eliminating the concern of toxicity associated with high fluoride in consumer oral care products.[9]

MODERN CARIES MANAGEMENT

Caries in enamel is characterized by a progressive, active subsurface demineralization that, if left unchecked, results in cavitation and mechanical failure and, ultimately, a vicious cycle of restoration. Many dentists still employ the only restorative method, despite long-standing advice for employing a biological approach to caries control. This technique has been financially and clinically ineffective.

The main strategy of modern-day caries care is to "preserve the tooth structure and restore only when essential," according to a global consensus.[10] The need for conventional restorations can be reduced while tooth structure is preserved thanks to new remineralization technologies that either restore lesion body structure (such as biomimetic peptide scaffolds) or provide ions that encourage subsurface mineral growth.

The International Caries Detection and Assessment System (ICDAS), which includes lesions of non-cavitated enamel (ICDAS 1 and 2), is increasingly being used to detect disease, as opposed to the WHO's traditional DMFT criteria. As a result, the number of people identified with dental caries has increased, presenting a tremendous secondary preventative and non-operative dental care possibilities employing regenerative medicine-based dental techniques. Such minimally invasive remineralization methods are certainly needed in modern dentistry, not only to enhance therapeutic outcomes but also to support the happiness and wellbeing of patients.[11]

CONCLUSION

They constantly compete with one another during the dynamic process of demineralization and remineralization. Both procedures can partially occur on the surface of hard tissues. Due to this, they have an impact on the health of hard tissues, and the environment has a significant impact on which process prevails. Therefore, the key objective would be to maintain a setting that opposes demineralization and promotes remineralization.

In recent years, restorative dentistry has shifted its attention to a more conservative approach, with remineralization procedures emerging as the most desired and effective method of restoring lost tooth structure. The proactive method of early detection, conservation, and non-restorative treatment of incipient caries saves the patient time, money, and misery.

The majority of non-fluoride remineralizing solutions currently on the market are designed to lessen the risks associated with fluoride while increasing its effectiveness. The future of enamel regeneration may lie in a biomimetic method that generates organized enamel apatite crystals with high surface adherence to replace demineralized tissue.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

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