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Demineralization and Remineralization: The Battle to keep teeth strong and healthy

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Demineralization and remineralization have a crucial impact on the hardness and strength of tooth enamel. The battle to keep teeth strong and healthy is dependent upon the ratio between demineralization and remineralization. Demineralization occurs at a low pH when the oral environment is undersaturated with mineral ions, relative to a tooth's mineral content. The enamel crystal, which consists of carbonated apatite, is dissolved by organic acids (lactic and acetic) that are produced by the cellular action of plaque bacteria in the presence of dietary carbohydrates. Remineralization allows the subsequent loss of calcium, phosphate, and fluoride ions to be replaced by fluorapatite crystals.[1,2] These crystals are more resistant to acid dissolution and are substantially larger than the original crystals, thereby providing a more favorable (smaller) surface to volume ratio. Thus, larger apatite crystals in remineralized enamel are more resistant to enamel breakdown by the resident organic acids.

In the development of dental caries, the relationship between demineralization and remineralization is influenced by the presence of saliva, which facilitates the transportation of ions, oral bacteria, and fermentable carbohydrates to the exposed surfaces of teeth. It is this complex interrelationship that we must understand better in order to fight the battle of maintaining tooth integrity.

This article discusses current calcium phosphate technologies and other factors affecting an imbalance with the mineralization ratio.

Saliva

Saliva contains a supersaturated solution of calcium and phosphate, which neutralizes acids. Many factors might affect the quantity and quality of saliva, as evidenced by the numerous salivary diagnostic tools available, such as Saliva-Check by GC America, Inc. The production of saliva may be influenced by systemic diseases that damage the salivary glands, such as sarcoidosis and Sjogren's syndrome; by therapeutic head and neck radiation, which causes atrophy and fibrosis of salivary glands; and by prescription medications.

Each may have a long- or short-term effect on the production of saliva. Numerous medications that cause xerostomia as a side effect include those used for Parkinson's disease, some hypertensive medications, antihistamines, and those used for the treatment of psychiatric conditions. One medication that may help with chronic xerostomia conditions by mimicking the action of acetylcholine on muscarinic receptors includes pilocarpine HCl (Salagen), but is of limited use. It is recommended that patients with xerostomic conditions hydrate with water or non-cariogenic beverages or use a saliva substitute to replenish resting oral pH and restore the proper ratio of remineralization.

Antimicrobial agents

Antimicrobial agents are effective against the infective process of caries. Chlorhexidine (CHX) (PerioGard, Colgate Oral Pharmaceuticals, Peridex OMNII Products, PerioRx, Discus Dental) is extensively used as a mouthrinse to reduce the bacterial load intraorally. The strong cationic properties of biguanides allow it to adhere to most intraoral surfaces. This allows for a sustained release (substantivity) of the drug that ultimately disrupts the bacterial cell membrane. The patient is instructed to rinse with a .12 to .2 percent CHX solution for 30 seconds before bed for each of 14

nights.[3] Concerns regarding alcohol-based rinses have been addressed by creating an effective CHX rinse without alcohol but with the same efficacy (GUM® Brand CHX Rinse, Sunstar Butler). Xylitol-containing gum (Spry Xlear Inc., Epic Industries) stimulates saliva, inhibits plaque, and is a five-carbon sugar alcohol that cariogenic bacteria cannot use for energy production.[3] These patient-delivered systems rely on patient compliance. Fluoride is the No. 1 public health preventive measure. It has an antimicrobial effect on the bacteria that cause dental caries and plays a role in tipping the ratio towards remineralization and creating acid-resistant tooth structure. At an acidic pH of 5.0, fluoride is primarily an ionized HF molecule that can cross the bacterial cell membrane and affect the cell's metabolic process. Low-dose fluoride (1,000 to 11,100 ppm) in a dentifrice has been reported to reduce caries by maintaining a low concentration of salivary fluoride available for remineralization with daily uses.[4] Mouthrinses (0.05 percent sodium fluoride) available for purchase over the counter are also retained in the saliva and dental plaque and help to prevent dental caries when used daily or weekly.

Unfortunately, this level of fluoride clears rapidly from the oral cavity. Prescription-strength fluoride is available at a higher potency (5,000 ppm dentifrice or 2.0 percent NaF rinse) and gives the patient additional caries protection, but is also dependent on patient compliance. Professionally applied topical fluoride in the form of acidulated phosphate fluoride (1.23 percent) provides a long-term, low-fluoride-release source from calcium fluoride. It can slowly release fluoride and maintains the salivary fluoride level. Varnishes such as Cavity Shield by OMNII Products, Duraflor by Medicom, Duraphat by Colgate Oral Pharmaceuticals, and FlorOpal by Ultradent Products, Inc., offer a high concentration (5 percent sodium fluoride at 22, 600 ppm) of fluoride that adheres to the tooth structure, is applied professionally, and creates a film of CaF, which is then released in a timed manner. The disadvantages in color and taste of these varnishes have recently been changed with new formulations of white varnishes (Vanish®, OMNII Products) with various flavors.

Calcium phosphate technologies

New technologies exist that create remineralization through various means of providing calcium and phosphate into saliva, thereby changing the balance of the ratio toward remineralization. NovaMin® is a "synthetic mineral composed of calcium, sodium, phosphorous, and silica, which binds to the tooth surface and releases rapid and continuous deposition of a natural crystalline hydroxyl carbonate."[5] It can be found in Oravive Revitalizing paste and Butler NuCare products. Recaldent® (Casein phosphopeptide and amorphous calcium phosphate CCP-ACP) "is a milk-derived peptide that is bound to amorphous calcium phosphate that binds to the tooth structure and is released during acidic challenges."[5] This is available as Prospec™ MI Paste® (GC America) and Trident Gum® (Cadbury Adams). It has been shown in studies to be "effective in remineralizing caries lesions and interfering with the adhesion of some bacteria to the tooth surface."[6] Sensistat® (GC America) is "arginine bicarbonate, an amino acid complex that binds to calcium carbonate, slowly dissolves and releases both calcium and phosphate."[5] Products on the market include Denclude® (Ortek) that is marketed as a dentist-dispensed sensitivity paste. ACP (amorphous calcium phosphate) is "made by combining soluble salts of calcium and phosphorous that precipitates on the tooth surface."[5] Arm & Hammer Enamel Care® toothpaste (Church & Dwight) has ACP as one of the components. It claims to be "liquid calcium that fills the tooth surface and restores luster."[5]

Conclusion

Demineralization of the tooth is a condition that is affected by diet, bacteria, and limited use of protective agents found in fluoride, salivary buffers, and antimicrobial agents. With a clearer understanding of the implementation of these effective agents and new technologies accessible to dentists, we can create a more favorable relationship in which remineralization occurs more often than demineralization.

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