

The Role of Abrasives in Dentifrices

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Abstract

Dentifrices are oral health care products that are used by individuals on a daily basis to promote personal oral hygiene. Toothpastes serve as essential vehicles to carry biologically active and inert substances that provide therapeutic and cosmetic benefits. They offer several advantages such as anti-bacterial action, reduce hypersensitivity and improve remineralization of teeth. Despite the benefits, toothpastes also have the potential to bring about both hard and soft tissue destruction by virtue of their ingredients. Dental professionals are always faced with the challenge of advising their patients the most effective dentifrice based on the evidences available. This review emphasizes on the benefits and drawbacks of abrasives, one of the inactive ingredient of dentifrice. Further it highlights about the tooth whitening dentifrices and the various means by which it works.

Keywords: Abrasives, Relative dentin Abrasivity, Toothpastes, Whitening toothpastes

INTRODUCTION

The most common oral hygiene practice among general public is tooth brushing with a dentifrice. Dentifrice or toothpaste is a substance used with a toothbrush or other oral hygiene device to clean the teeth, tongue and gingiva and to deliver cosmetic and therapeutic agent for the teeth and oral environment.[1] The term dentifrice is derived from dens (tooth) and fricare (to rub). They are marketed as tooth powders, tooth-pastes and gels. Individuals brush their teeth for multiple reasons like to avoid bad breath, to refresh themselves, to prevent dental diseases and to have an attractive smile. Most often, people consult oral health care professionals seeking the most appropriate and effective toothpaste for their oral health.

Several toothpastes are available in the market however each is different and are designed for a specific purpose such as caries control, dentinal hypersensitivity reduction, tooth whitening etc.[2] Dentists therefore will have to make their recommendations based on the nature of oral health problem and the specific requirement of the patients. Nowadays toothpastes are designed to serve multiple purposes so that the users can get oral health benefits in one package. However, when toothpastes are not properly selected for use it can act as risk factor by causing erosion or abrasion leading to dentin hypersensitivity.[3,4]

COMPOSITION OF DENTIFRICES

Toothpastes are composed of active and inactive ingredients that must be compatible with each other to be effective and acceptable. The active ingredients have therapeutic benefits and help to improve the oral hygiene status. The inactive ingredients are necessary to make the formulation thick, bind the components together, and have a specific color or flavor for appeal.[5] Components of Dentifrices are listed in Table I.

ABRASIVES

Abrasive agents are meant to clean and polish teeth by enabling the removal of soft deposits and extrinsic stains adequately thereby achieving a smooth and glistening surface. The abrasive capacity of a tooth paste is required to be optimum. If the abrasive capacity is very low, the agent is not effective in removing the soft deposits or

stains. On the contrary, if it is very high, abrasion of the teeth results. The abrasive component in dentifrices should be adequate enough to remove any stains but at the same time should not damage tooth structures.[5,6] Phosphates, carbonates and silicas are the most common abrasives incorporated in dentifrices.

Phosphates – They give the teeth a clean and white appearance. Dicalcium phosphate dihydrate and calcium pyrophosphates are commonly used. Calcium pyrophosphates are often used in toothpastes along with tin fluoride (SnF₂)

Carbonates- They clean the teeth, remove mouth odour and have bactericidal properties. Sodium carbonates and calcium carbonates are the two forms available. The calcium present in the abrasive agent tends to react with the ionic fluorides thereby limiting their availability in toothpaste. Hence, in toothpastes that utilize calcium carbonate as abrasive agents, the fluoride formulation is mostly sodium monofluorophosphate (MFP) since this form of fluorides gets hydrolyzed only after contact with the saliva and its enzymes. However, sodium carbonates are compatible with Sodium fluoride (NaF) containing dentifrices.[7]

Silicas- They mechanically clean the teeth as well as thicken the dentifrices. Hydrated silica is inert and is compatible with NaF and MFP. Silicas are currently the frequently used abrasives in toothpastes. They are regarded as more expensive compared with other abrasive materials. Mohs in 1812 proposed a 10 – point scale of mineral hardness with 1 being the softest and 10 being the hardest. This scale is used to compare the hardness of tooth structure and the hardness of abrasive agents.[8] The hardness of dentin is 2-2.5 whereas that of enamel is 4-5. Therefore in patients with gingival recession where the roots are exposed, dentifrices with abrasive levels of <2 is to be recommended to prevent tooth sensitivity. The hardness of abrasive agents are given in the Fig.I The hardness values of sodium bicarbonate, dicalcium phosphate dihydrate (2.5) is lesser than of alumina (9.25). Harder abrasives like alumina are highly effective in the removal of extrinsic stains however, there is a risk of the tooth being abraded leading to dentinal hypersensitivity.

The abrasiveness of dentifrices can be modified by factors such as particle size, shape and hardness. Even high abrasives can be made safe by altering their particle size and shape. The larger the particles, the more they wear away the tooth structure. A round particle is less detrimental to the tooth whereas irregular shape is more

likely to abrade the dental surfaces. The harder the particles the more the tooth is abraded. Several other variables also affect the abrasive potential of the dentifrice they are : the brushing technique, the pressure on the brush, the hardness of the bristles, the direction and the number of strokes.

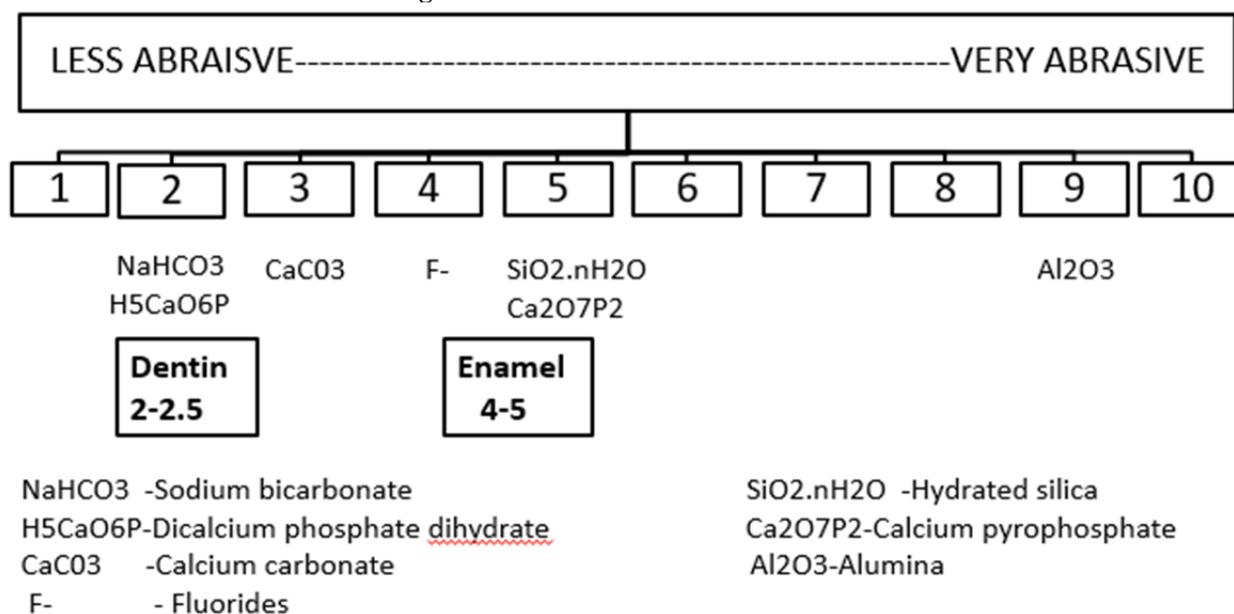
Table I. Composition of Dentifrices

Inactive ingredients	Functions	Examples
Abrasives (10-40%)	Clean and polish the teeth	Eg. Calcium carbonate, sodium bicarbonate, calcium pyrophosphate etc.
Humectants(20-70%)	Retains moisture and prevents air drying	Eg. Glycerin, sorbitol, mannitol
Binders (1-2%)	Prevents liquid and solid ingredients from separating	Eg. Carboxymethylcellulose, polyethylene glycol
Water (5-30%)		Sodium lauryl sulfate, N-lauryl sodium sarcosinate
Detergents (1-3%)	Foaming agents or surfactants	Distilled water, deionized water
Flavouring agents(1-2%)	Acts as refreshener	Essential oils, menthol
Preservatives (2-3%)	Improves the shelf life	Alcohols, sodium benzoates, methyl paraben
Sweeteners (2-3%)	Pleasant taste	Sorbitol, glycerin, sodium saccharin
Dyes or coloring agents (2-3%)	Makes the product attractive	Titanium dioxide
Therapeutic agents(0.1 -0.5%)	Reduces caries, sensitivity and gingival inflammation	Sodium fluoride, potassium nitrate, triclosan, pyrophosphates

Table II. RDA value of dentifrices.[10]

Toothpaste	RDA Value
Colgate regular	68
Colgate Total	70
Sensodyne	79
Close up	80
Pepsodent complete care	80
FDA upper limit	200
ADA upper limit	250

Figure I. Hardness of abrasive materials



Relative Dentin Abrasivity

The abrasivity of dentifrices is determined by the Relative Dentin Abrasivity (RDA).[9] The higher the score, the more abrasive the dentifrice. The upper limit recommended by the US Food and drug administration is 200 and the American Dental Association is 250. Low abrasive dentifrices have RDA value below 70-80. If the RDA value is over 100 the dentifrice is highly abrasive and it may damage the enamel, dentin and cemental surfaces. The RDA value of some of the commonly used dentifrices is given in Table II

Generally, highly abrasive agents are found in tooth whitening dentifrices. These agents are mainly incorporated to remove the extrinsic stains. Extrinsic discoloration results when the external chromogens from food products get deposited on the tooth surface or within the pellicle layer. This creates cosmetic issues and the public invest their time and money for a more esthetically appealing appearance and smile.[11]

Abrasives in Whitening Toothpastes

At present, there is increased interest and awareness among individuals towards whiter teeth with the perception that it contributes to pleasant smile and great physical appearance. Whiter shades of teeth have been shown to positively correlate with social acceptance and oral health.[12,13] The esthetic and social benefit associated with whiter teeth has led to the demand for tooth whitening products. As the marketing and the use of over-the-counter whitening toothpaste has been increasing there is a requirement that the public and oral health care professionals be aware of the potential risks and benefits associated with its use.[14]

Whitening toothpastes utilize chemical or mechanical means to remove the extrinsic stains caused by tea, coffee, red wine and smoking. One of the fundamental ingredients incorporated into these toothpastes is the high abrasive agents to remove the extrinsic stains and to smoothen the tooth surface. As a result, when light interacts with the tooth surface it gives the perception that the tooth is whiter. Finer, rounded abrasives are used for this purpose. Generally, a combination of abrasive materials is used in the whitening toothpaste.[15] For instance Perlite, an amorphous glassy silicate is processed to fine particles and is mixed with a low abrasive material. Perlite has superior stain removal as well as polishing properties.[16,17] Sodium bicarbonate, amorphous calcium phosphate, sodium hexametaphosphate are other abrasive materials that smoothen the enamel surface and improve the luster.[18] The ultimate effect is achieved by the combined effect of abrasives and the toothbrush bristles. By removing the stained pellicle, the tooth regains its original color. Mostly, tooth whitening toothpastes have RDA values of between 90 and 150.

Certain whitening toothpastes contains chemical agents like hydrogen peroxide, calcium peroxides, pyrophosphates and protease as their whitening ingredient. Carbamide peroxide breaks down to form hydrogen peroxide and urea. Hydrogen peroxide (1%) works by generation of oxygen bubbles that helps to remove the stains from tooth surface.[19] Proteases and papaine are the enzymes added

to these dentifrice for their ability to degrade protein in the pellicle that causes stains. Citrates, pyrophosphates, polyphosphates, EDTA act on the enamel surface by chelating with calcium and desorb the stain molecules from the pellicle.[20,21] Polyphosphates have surface binding properties and they work by blocking the stain molecular receptors and desorption of stain molecules from pellicle and enamel surfaces.

Whitening toothpastes are usually recommended in subjects presenting with extrinsic stains caused by nicotine, and tannin rich food. But there are some adverse effects associated with its use such as enamel and dentin abrasion. This may result in tooth sensitivity which increases proportionately with the concentration of abrasives present. Whitening toothpastes are not to be recommended for patients with erosion, abrasion or recession and for patients with a history of gastroesophageal reflux.[22] It is also advisable to avoid its use after consuming acidic beverages.

CONCLUSION

Home use agents such as tooth brush and dentifrice play a crucial role in plaque control. Nowadays, dentifrices are marketed for different purposes and the public should be guided appropriately to make their choice. It is the responsibility of the dentists to know the safety and efficacy of each toothpaste based on the scientific evidences available. Moreover they should also be aware whether the products are approved by regulatory organizations like IDA (Indian Dental Association), ADA (American Dental Association) or FDI (Federation Dentaire Internationale) even before recommending it for a given patient. This knowledge further helps to motivate their patients towards maintaining better oral hygiene.

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