Baking soda as an abrasive in toothpastes

Mechanism of action and safety and effectiveness considerations

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ABSTRACT

Background. Toothpastes can be formulated with different abrasive systems, depending on their intended clinical application. This formulation potentially affects their effectiveness and safety and, therefore, requires proper understanding. In this article, the authors focused on abrasive aspects of toothpastes containing sodium bicarbonate (baking soda), which have gained considerable attention because of their low abrasivity and good compatibility, while providing clinical effectiveness (further detailed in the other articles of this special issue). The authors first appraised the role of toothpaste abrasivity on tooth wear, exploring some underlying processes and the existing methods to determine toothpaste abrasivity.

Types of Studies Reviewed. The authors reviewed the available data on the abrasivity of toothpastes containing baking soda and reported a summary of findings highlighting the clinical implications.

Conclusions. On the basis of the collected evidence, baking soda has an intrinsic low-abrasive nature because of its comparatively lower hardness in relation to enamel and dentin. Baking soda toothpastes also may contain other ingredients, which can increase their stain removal effectiveness and, consequently, abrasivity.

Practical Implications. Even those formulations have abrasivity well within the safety limit regulatory agencies have established and, therefore, can be considered safe.

Key Words. Baking soda; toothpaste; enamel; dentin.
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The success of an oral hygiene regimen depends primarily on its ability to properly remove food debris and biofilm formed on dental surfaces without disrupting the physical and chemical integrity of these surfaces. Many factors contribute to achieving this goal, including brushing technique and behavior, as well as specific toothpaste-related aspects. Toothpastes function as vehicles for active ingredients with therapeutic and cosmetic functions and inactive ones such as detergents, humectants, and flavors.[1,2] Among therapeutic agents, fluoride is probably the most important, with strong evidence on dental caries and dental erosion prevention; fluoride not only shifts the mineral equilibrium between the tooth and the surrounding environment toward the remineralization phase but also makes the tooth more resistant to demineralization. Other relevant constituents include antimicrobials to inhibit biofilm growth, tartar control compounds to inhibit calculus formation, and antisensitivity agents. Abrasive components are fundamental to removing dental surface stains, but they also improve toothbrushing efficiency. Historically, abrasives in the form of tooth powders or toothpastes have been used for dental cleaning purposes since ancient times. As previously reported,[1,3] ancient Egyptians scrubbed their teeth with a mixture of ox hoof ashes, burned eggshells, and pumice; later, their medical Ebers Papyrus reported a toothpaste made of ground pebbles, honey, verdigris, incense, and pulverized fruits. Ancient Greeks used a mixture of burned shells, coral, talc, salt, and honey, and ancient Romans used a blend of crushed bones and oyster shells plus powdered charcoal and bark. More recently, in the 18th century, reports indicated that the British included brick dust and crushed china in their tooth powder.

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Over time, the selection and incorporation of abrasives in toothpastes have been optimized, and attention has been given to some specific abrasive systems. However, despite the considerable historical background, the large variety of toothpastes available with different abrasive properties requires a proper understanding of their clinical applications, as well as of potential effectiveness and safety concerns. In particular, the use of sodium bicarbonate (baking soda) has attracted attention because it has relatively low abrasivity. In this article, we review the effect of toothpaste abrasivity on tooth wear, evidencing some mechanisms of abrasive action; the existing evaluation methods used to determine toothpaste abrasivity; and the literature on the abrasive level of toothpastes containing baking soda, highlighting some of the clinical implications.

DENTAL ABRASIVES AND TOOTHPASTE FORMULATION

From a safety standpoint, toothpaste abrasives often are investigated for the potential deleterious effects they cause during toothbrushing. The ideal toothpaste should have enough abrasiveness to remove surface stains properly without damaging the tooth. Therefore, excessively abrasive materials can abrade the tooth surface away, resulting in undesirable tooth wear. Many factors define the degree of abrasivity of a given compound, including its hydration level; the size, hardness, shape, and concentration of its particles; source; purity; and how it has been treated physically and chemically.[1] Some clinical factors modulate the effect of these abrasives on the tooth surface, such as toothbrush stiffness, toothbrushing pressure and frequency,[4] and enamel and dentin mineralization level. Some of the dental abrasives currently used include hydrated silica, hydrated alumina, calcium carbonate, dicalcium phosphate dihydrate, calcium pyrophosphate, sodium metaphosphate, perlite, nanohydroxyapatite, diamond powder, and baking soda.[2]

Ideally, abrasives should not interact chemically with the active ingredients in the toothpaste. For instance, a calcium carbonate–based toothpaste should not be formulated in conjunction with sodium fluoride because chemical binding may occur between the 2 components reducing the amount of available fluoride.[2] In that case, a more chemically stable fluoride compound such as sodium monofluorophosphate is preferable. From this perspective, hydrated silica abrasive and baking soda systems are advantageous because they are compatible with most active ingredients.[2,5,6]

Because of the different properties of each of these abrasives and the intended clinical application of the toothpaste, the amount added in each formulation varies.[2] For instance, the most common abrasives, hydrated silica and calcium carbonate, may be used in the range of 8% to 20% weight per weight; alumina and perlite, however, are added in lower concentrations of 1% to 2% weight per weight, given their higher abrasivity in relation to enamel. In ideal circumstances, the toothpaste formulation should be abrasive enough only to aid properly in the removal of dental plaque and stains from dental surfaces.[7] This makes baking soda a particularly interesting option because it long has been regarded as 1 of the least, if not the least, abrasive material, allowing it to be added in much higher concentrations, often exceeding 50% weight per weight.

TOOTH WEAR AND TOOTHPASTE ABRASIVITY

Wear can be defined as the progressive loss of material because of relative motion between surfaces and contacting substances. Four main types of wear are relevant to dental surfaces; namely, abrasive, corrosive (caused by chemical agents), fatigue, and adhesive wear.[8]

In abrasive wear, material is removed or displaced from a surface by the action of hard particles either moving between surfaces in relative movement or embedded in 1 of the surfaces in relative movement.[8-10] The latter arrangement describes 2-body abrasion, exemplified by bruxism, also called *dental attrition*. The former mechanism describes 3-body wear, when particles are interposed between the surfaces. Examples are wear resulting from toothbrushing and mastication. Corrosive wear occurs in situations in which the environment surrounding a sliding surface interacts chemically with it and reaction products are worn off from the surface.[8-10] In the oral cavity, corrosion best describes dental erosion or erosive tooth wear, which results from the tooth's exposure to nonbacterial acids of intrinsic or extrinsic origin. Fatigue wear occurs by means of intermittent loading, resulting in repeated stressing and unstressing, which in time may lead to the formation and eventual break off of microcracks at or below the surface.[8-10] Fatigue has been the primary mechanism behind dental abfraction lesions. Adhesive wear refers to the process in which 2 surfaces contact each other under load, leading to the local welding at the tips of the major asperities of the surfaces.[8,9] This type of wear has been related to thread disengagement, screw loosening, and preload reduction in dental implant systems.[11]

Dental abrasive wear is of particular importance because it may result from toothbrushing, the main intervention universally performed to remove dental plaque and control caries and periodontal disease.[4] Toothbrushing abrasion may be an issue for dentin surfaces,[12] more than for sound enamel,[12-14] because the latter is harder than almost all abrasives in toothpastes

ABBREVIATION KEY. ISO: International Organization for Standardization. **NA:** Not available. **RDA:** Radioactive (or relative) dentin abrasivity. **REA:** Radioactive (or relative) enamel abrasivity.