Feasibility of Using Sodium Bicarbonate Solution as a Damage-limiting Strategy for Erosion Lesions

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Purpose: One of the recommended measures to prevent and control dental erosion is the oral rinse with sodium bicarbonate solution, which would neutralise the dietary acids. However, the prescription of this aqueous suspension has been made on an empirical basis. The aim of this *in vitro* study was to evaluate whether the demineralisation caused by erosive episodes could be controlled by the potential neutralising effect exerted by a sodium bicarbonate solution.

Materials and Methods: Bovine enamel slabs were embedded in epoxy resin, ground/polished and tested for initial surface microhardness. Twice daily for 2 days, specimens were subjected to an erosive challenge with orange juice in an orbital shaker. Following each erosive episode, specimens (n = 15) were immersed for either 30 or 60 seconds in a sodium bicarbonate solution or deionised water. The negative control group was left untreated. For the remaining daily time, specimens were kept in artificial saliva. New microhardness indentations were then made as described for the initial measurements.

Results: ANOVA applied to the percentage of surface microhardness change (%ΔSMH) showed no statistically significant difference among treatments ($P = 0.5810$).

Conclusion: The use of sodium bicarbonate solution, at least under *in vitro* conditions, may not be a feasible strategy for managing enamel erosion.

Key words: dental enamel, erosion lesions, microhardness, sodium bicarbonate solution

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Following a decline in dental caries, an increased longevity of teeth has yielded a rise in the clinically deleterious effects of wear, especially of erosion (Zero and Lussi, 2005). Erosive tooth wear has become a common condition (Jaeggi and Lussi, 2006), caused mainly by the frequent consumption of acidic beverages (Imfeld, 1996a; Zero, 1996). For this reason, extensive research efforts have been devoted to the preventive management of dental erosion.

One of the recommended measures to prevent and control erosion is to neutralise acidic substances, through the use of alkaline buffering agents, such as sodium bicarbonate (Amaechi and Higham, 2005; Imfeld, 1996b; Lussi and Hellwig, 2006). This presumed neutralising effect has provided a rationale for prescribing aqueous suspensions of sodium bicarbonate for rinsing the mouth following acidic episodes (Imfeld, 1996b; Walsh, 2000; Amaechi and Higham, 2005; Lussi and Hellwig, 2006). An additional benefit of using this sodium bicarbonate solution would be the mouth refreshment from the acidic taste (Amaechi and Higham, 2001).

Despite the plausible theoretical basis for prescribing the sodium bicarbonate solution, no previous studies that appraised whether its use is legitimate – and, if so, for how long – were found in the literature. Therefore, this *in vitro* investigation was undertaken to eval-

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uate the ability of a sodium bicarbonate solution, applied for 30 or 60 seconds, to provide protection to enamel against erosion.

MATERIALS AND METHODS

Experimental design

The experiment was set up as a blind, randomised complete block design, with 15 replicates per group. The factor under study was treatment of eroded enamel at five levels (30- or 60-second immersions in sodium bicarbonate solution and deionised water, and no treatment, as negative control). The experimental units were 75 specimens, randomly assigned into five experimental groups (n = 15). The response variable was the percentage of surface microhardness change (%ΔSMH).

Preparation of enamel specimens

Fifty freshly extracted bovine incisors were cleaned of remaining debris and stored in 0.1% thymol solution. Using a low-speed water-cooled diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA), teeth were sectioned at the cementoenamel junction. Each crown was cut into two rectangular slabs measuring 3 x 2 x 2 mm. These sections were embedded in epoxy resin (Epoxicure Resin, Buehler), with the enamel surface facing up. Grinding and polishing were performed with a water-cooled mechanical grinder (Beta Grinder-Polisher, Buehler) with aluminum oxide abrasive papers (400-, 600- and 1200-grit) and a 0.3-μm alumina suspension. Subsequently, specimens were ultrasonically cleaned (T1440D, Odontobrás, Ribeirão Preto, SP, Brazil) in deionised water for 10 minutes to remove any residues of the polishing procedure, and stored at 37°C in 100% relative humidity.

Baseline microhardness measurements

Knoop microhardness indents were carried out using a HMV-2 microhardness tester (Shimadzu, Kyoto, Japan). Five indentations (25 g, for 30 seconds) spaced 200 μm apart were made 500 μm from the edge of each embedded slab and measured with the aid of dedicated software (New Age, Software Cams, South Ampton, PA, USA). A total of 75 out of 100 specimens were selected based on their average microhardness values.

Erosion lesion formation and application of treatments

Prior to commencing the erosive episodes, the 75 specimens were allocated into five groups, as follows: 1) 30-second immersion in sodium bicarbonate solution; 2) 60-second immersion in sodium bicarbonate solution; 3) 30-second immersion in deionised water; 4) 60-second immersion in deionised water; and 5) untreated negative control.

Twice daily (at 8:30 a.m. and 12:30 p.m.) for two days, specimens were subjected to an erosive regimen followed by one of the five different treatments, as listed above. Erosive challenges consisted of immersing the specimens in 20 ml of pure orange juice (pH 3.84) (Fazenda Bela Vista, Tapiratiba, SP, Brazil) in an erlenmeyer flask, which was then placed in an orbital shaker (CT155, Cientec, Piracicaba, SP, Brazil), with stirring velocity around 100 rpm for 5 minutes at room temperature (25°C). Specimens were then taken out of the orange juice and individually immersed in 20 ml of their respective medium (sodium bicarbonate or deionised water) for the time periods indicated (30 or 60 seconds), or left untreated, according to the group to which they were initially assigned. Immediately afterwards, specimens were stored in 20 ml artificial saliva (Amaechi et al, 1999) at 37°C until the following erosive episode.

Based on previous literature (Walsh, 2000), the sodium bicarbonate solution was prepared using the proportion of one teaspoon of the salt in a tumbler of water, which was found to correspond to approximately 6.2 g of pure sodium bicarbonate in 240 ml of water.

Final microhardness measurement

Final microhardness measurements were achieved as previously described, but at 500 μm right from the baseline measurements. The %ΔSMH was calculated using the following formula: %ΔSMH = (baseline SMH – final SMH) x 100 / final SMH.

Statistical analysis

After the assumptions of equality of variance and normal distribution of errors had been checked by Bartlett's and Shapiro-Wilks tests, respectively, data were analysed using one-way analysis of variance (ANOVA) at a significance level of 5%. Statgraphics Plus was used to perform the statistical calculations.

RESULTS

A summary of the results is presented in Fig 1, in the form of a box-plot diagram. ANOVA did not indicate significant differences among treatments ($P = 0.5810$).

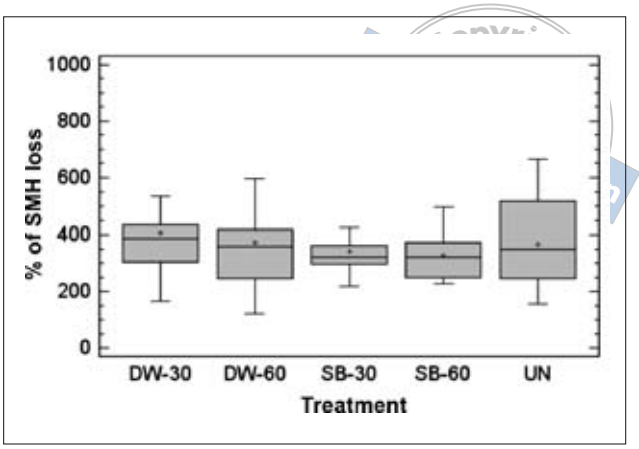

Fig 1 Box-plot diagram of the percentage of surface microhardness change (%ΔSMH) for each treatment. DW-30, deionised water for 30 seconds; DW-60, deionised water for 60 seconds; SB-30, sodium bicarbonate solution for 30 seconds; SB-60, sodium bicarbonate solution for 60 seconds; UN, untreated.

DISCUSSION

This *in vitro* study was designed to evaluate whether the demineralisation caused by erosive episodes could be controlled by the potential neutralising effect exerted by an aqueous sodium bicarbonate suspension. Because the neutralising effect, if any, of this solution would probably be more evident at the early stages of enamel erosion, the hypothesis of this investigation was tested using surface microhardness measurements (Barbour and Rees, 2004). Since the protocol used for erosion lesion formation has been originally proposed for microradiographic examinations (Amaechi et al, 1999), preliminary tests were carried out to check the methodology. The adjustment consisted of reducing the number of acidic challenges (twice daily for 2 days vs six times for 24 days) to allow indentation measurement.

The sodium bicarbonate solution was prepared following recommendations of Walsh (2000). Even so, it was deemed necessary to reliably standardise the corresponding quantity of the salt. Through preliminary tests, it was established that 6.2 g of sodium bicarbonate should be dissolved in 240 ml of deionised water.

According to the present findings, the sodium bicarbonate solution was demonstrated to not play a significant role as a damage-limiting strategy for erosion lesions in enamel. The lack of neutralising activity of the sodium bicarbonate solution may be found in its probable inability to counterbalance either an immediately previous or a subsequent erosive episode. Despite the fact that erosion has been suggested to have a ten-fold rise in magnitude under *in vitro* conditions (West et al, 1998), causing erosion lesions to demineralise enamel deeper than intraorally, in contrast to caries experiments, erosion has been considered more a surface phenomenon (Lussi, 2006). In carious enamel, sodium bicarbonate has been shown to confer protection against subsequent demineralisation, probably due to its penetration into the subsurface lesion, working as buffer agent and inhibiting the decrease in pH (Tanaka and Ijima, 2001). In eroded enamel, the sodium bicarbonate may have been in a more superficial location, and it can be presumed that this salt would have been cleared more easily by oral fluids. In the present study, it is very likely that sodium bicarbonate was removed from the surface by the artificial saliva. In doing so, bicarbonate ions were unavailable to neutralise acids from a subsequent erosive challenge.

A further contributing role of the artificial saliva in causing the lack of difference among treatments may be related to the storage of specimens not only between erosive challenges but also during all the remaining experimental periods. As a supersaturated solution, the artificial saliva may have caused deposition of minerals on eroded enamel. This process may have levelled the difference among treatments, masking any possible protective role of the sodium bicarbonate solution.

In contrast to carious enamel, in which sodium bicarbonate may concentrate within the dental biofilm, being available to neutralise bacterial acids, in eroded enamel retention of sodium bicarbonate may be compromised, since in general biofilm is not present (Meurman and ten Cate, 1996).

Other aspects that may have accounted for the inability of the sodium bicarbonate solution to control erosion were the short exposure time (30 and 60 seconds) and the static testing method (as opposed to swish). Although so far no previous reports have suggested for how long rinsing with sodium bicarbonate solution should be performed, the 30- and 60-second periods were chosen as suitable times, because mouthrinsing generally lasts approximately 1 minute (Hughes et al, 2004).

Although *in vitro* studies are useful as a first step in the development of clinical protocols, one should bear in mind that uncertainty still arises whether the present results hold true under *in vivo* conditions. This is because it can be speculated that bicarbonate ions arising from the sodium bicarbonate aqueous solution used as a mouthrinse may act synergistically with the salivary bicarbonate buffer, improving its capacity to neutralise dietary acids. In this sense, it would be valuable to carry out an *in situ* experiment to ascertain the validity of such a hypothesis. An intraoral study is currently being developed by our group and will be reported in a forthcoming publication.

At least under laboratory conditions, regardless of the time, sodium bicarbonate solution used as a mouthrinse was found to be ineffective as a damage-limiting strategy for enamel erosion.

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