Clin Oral Invest (1997) 1: 191–194

ORIGINAL ARTICLE

Adrian Lussi · Peter Portmann · Beatrice Burhop

Erosion on abraded dental hard tissues by acid lozenges: an in situ study

Received: 9 June 1997 / Accepted: 13 September 1997

Abstract The aim of this study was to analyse the erosive effect of acidic lozenges and to compare it with that of orange juice, known to have the capacity to cause erosion. Two acidic, sugar-free lozenges and orange juice were tested in situ in nine patients. Changes in surface Knoop microhardness and change in the surface texture were assessed. The results revealed that orange juice and one acidic lozenge were – under the conditions of this experiment – capable of significantly softening abraded enamel ($P \leq 0.017$). It was concluded that excessive consumption of acidic lozenges could have the potential to enhance existing dental erosion.

Key words Dental erosion · Knoop microhardness · Acid lozenges

Introduction

Dental erosion is the dissolution of dental hard tissue due to a chemical process without bacterial involvement [3]. Erosion does not appear to be a great public health problem in general, although there is concern about the increasing prevalence of this dental hard tissue defect [9]. The increase in prevalence could be due to changing patterns in dietary and oral habits. However, recent epidemiological studies on dental erosion are scarce. Järvinen et al. [7] found a prevalence of 5% in a group of about 100 dental patients. In our own investigation of 391 randomly selected subjects, it was found that 7.7% of the younger age group (26–30 years) and 13.2% of the older age group (46–50 years) showed at least one tooth affected with facial erosion with involvement of dentin. Overall, 16% of the participants had at least one tooth with signs of facial erosion; occlusally, at least one severe erosion with involvement of dentin was observed in 29.9% of the younger and 42.6% of the older sample, whereas only 2% of the older and none of younger subjects showed severe lingual erosions [10]. Both of these studies showed that consuming acidic fruits and acidic juices or drinks were the most important external risk factors for developing dental erosion.

The consumption of acidic, sugar-free ("safe for teeth") lozenges which contain citric or lactic acid is quite common in Europe. Meurman and Frank [14] found citric acid to be more erosive than phosphoric acid for a demineralization period of 15 min, and so acidic candies or lozenges might have erosive potential in dental hard tissue when other circumstances such as low buffering capacity and low flow rate of saliva are present [2, 8, 16].

The purpose of the present study was to analyse the erosive effect of acidic, sugar-free candies and lozenges on abraded dentin and enamel in situ and to compare it with that of orange juice, known to have the capacity to cause such erosion in humans.

Materials and methods

Preparation of specimens

Healthy human teeth extracted as a part of orthodontic treatment were taken from a sample pool to prepare dentin and enamel slabs. After brushing the teeth with distilled water, the buccal side of the tooth was ground flat with a wet silicon carbide paper disk (30 μm) under water cooling on a rotating polishing machine (Knuth-Rotor, Struers, Copenhagen, Denmark). From this flat buccal area of the tooth, a piece of enamel was cut out, also under water cooling, with a diamond disk (Horico Superdiaflex, Berlin, Germany). This piece was then cut into small slabs. The dentin slabs were prepared in the same way except that instead of using the buccal surfaces, the interradicular faces of the root were taken. The slabs were embedded in a planoparallel resin mould (Paladur, Bad Homburg, Germany) and then serially polished on a Knuth Rotor polishing machine (Struers, Copenhagen, Denmark) with silicon carbide paper discs of 18-μm and

A. Lussi · P. Portmann · B. Burhop
Department of Operative, Preventive and Pediatric Dentistry, University of Bern, School of Dental Medicine, Bern, Switzerland

A. Lussi (✉)
Klinik für Zahnerhaltung, Freiburgstrasse 7,
CH-3010 Bern, Switzerland
Tel.: +0041-31-632-25-10; Fax: +0041-31-632-98-75

6-µm grain. Before polishing with 3-µm and 1-µm diamond abrasive on Buehler polishing cloth, the embedded enamel blocks were taken out of the planoparallel mould. The inner diameter of a mould was 4 mm. Between two polishing steps and after the final polishing, all slabs were rinsed and sonicated for at least 2 min in distilled water. The preparation removed 500±200 µm enamel. To prepare dentin slabs root cement was ground away to expose the dentin. Up until the test day, the slabs were stored at 100% humidity.

Knoop microhardness of the surface

The embedded enamel blocks were fixed on a glass slide with double-sided (non-resilient) adhesive tape. Surface microhardness (SMH) measurements were performed with a Knoop diamond under a load of 50 g for enamel and 15 g for dentin on a Leitz hardness tester (Miniload 2, Leitz, Wetzlar, Germany). These loads have been shown to be appropriate in measuring initial mineral change in enamel and dentin [5]. The distance between the indentations (five per slab) was 25 µm for enamel and 40 µm for dentin in order to avoid cracks. The lengths of the indentations were measured with the integrated optical system and transferred to a computer and the Knoop SMH calculated. Knoop microhardness was measured in enamel immediately after each experiment was concluded. Due to relaxation, SMH in dentin is time dependent, and therefore the length of the indentations in dentin slabs were measured 24 h after finishing the experiment [6]. Before every experiment the apparatus was calibrated according to the manufacturer's instructions.

Study design

Eight healthy subjects (mean age 24.8±11.4 years) with normal salivary flow rate and buffering capacity and one subject with decreased flow rate due to radiotherapy in the pharynx area (subject no. 9, age 49 years) volunteered for the study. None wore appliances or dentures and all but one (subject no. 9) were in good health. The subjects were not paid for their participation and informed consent was obtained after the procedure and the possible risks and benefits were explained. Removable acrylic appliances for each patient were prepared from plaster models of both arches.

Because there is no relaxation in enamel [6], enamel microhardness was measured longitudinally. In order to decrease variability, the dentin control slabs were taken adjacent to the test slabs and kept under humid conditions during the experiment. With enamel, it was possible to assess changes in microhardness on the same slabs. Four enamel slabs and four dentin slabs per subject and test solution were attached to the appliances in a cross-over design in the region of the premolars.

The patients put the appliances over their teeth and sucked one lozenge or drank 3 dl of orange juice (Table 1). No definite time limitation was given, but the experiment was not allowed to continue for more than 20 min. The subjects were requested to suck or to swallow as usual. One test per panelist and per day was undertaken; the other tests were made on different days but always approximately 2 h after a meal. After finishing the experiment the appliances were taken off. The slabs were thoroughly rinsed under running water and dried and the enamel SMH measurements immediately carried out. The test and control indentations in dentin were measured 24 h later. As enamel was tested longitudinally, only the dentin slabs were further processed for examination with the scanning electron microscope.

Flow rate, pH and buffering capacity of stimulated saliva (Dentobuff, Vivadent, Schaan, Liechtenstein) were measured on different days but, again, 2 h after the last meal. Stimulated flow rate for the eight healthy subjects varied from 1.0 to 4.0 ml/min (mean=2.2 ml/min) and pH ranged between 7.2 and 8.1 (mean=7.7). The buffering capacity was high for six subjects and medium or low for two subjects. The patient with hyposalivation (stimulated saliva flow rate=0.4 ml/min) due to radiotherapy had a pH of 6.3 and a low buffering capacity of the saliva.

Change in micromorphology

The coded dentin slabs were scored independently by two investigators. Differences in scoring were discussed until a consensus was reached. To do so, the specimens were dried with increasing acetone concentrations, mounted on specimen stubs, sputter coated (Sputter SCD 050, Balzers, Liechtenstein) and examined with a scanning electron microscope (Cambridge, Stereoscan 200):

Score 0: No erosion (Fig. 1a).
Score 1: Surface texture is partially attacked and tubules begin to open (Fig. 1b).
Score 2: Surface texture is more severely attacked and tubules are more open and more numerous (Fig. 1c).
Score 3: Surface texture is clearly attacked and tubules are large and numerous (Fig. 1d).

Statistics

Mann Whitney-U-test was used to compare independent values before and after the experiment, and the Wilcoxon test was used for paired data values. Tables were analysed using the chi-square test. Statistical significance was set at $P \leq 0.05$.

Results

Knoop SMH

Significant softening of enamel was found with orange juice (P=0.001) with a mean difference in SMH of 18.4 and for the sugar-free, acidic lozenge "Happy Citron" (P=0.017) with a mean difference of 15.0 SMH (Table 2).

Table 1 Test product, manufacturers, pH-values and amount of base necessary to raise the pH to 5.5 of acid lozenges (20 w %, 50 ml) and orange juice (pure, 50 ml)

Product	Weight	Manufacturer per piece	pH-value	ml NaOH [1N] to pH 5.5
Lemocin Citron	1.3 g	Sandoz-Wander AG, 3000 Bern, Switzerland	2.45	5.1 ml
Happy Citron	4.8 g	Disch AG, 5504 Othmarsingen, Switzerland	2.50	1.8 ml
Orange juice	–	Migros, Switzerland	3.52	2.3 ml

Table 2 Mean change of Knoop microhardness of the surface (SMH) of enamel and dentin after exposure to test substances in situ

	n	Δ SMH	P-value
Enamel			
Lemocin Citron	24	–7.9	Not significant
Happy Citron	29	–15.0	$P<0.05$
Orange juice	29	–18.4	$P \leq 0.001$
Dentin			
Lemocin Citron	24	1.4	Not significant
Happy Citron	29	1.7	Not significant
Orange juice	27	3.7	Not significant

Knoop SMH for sound enamel and sound dentin are approximately 320 and 60, respectively

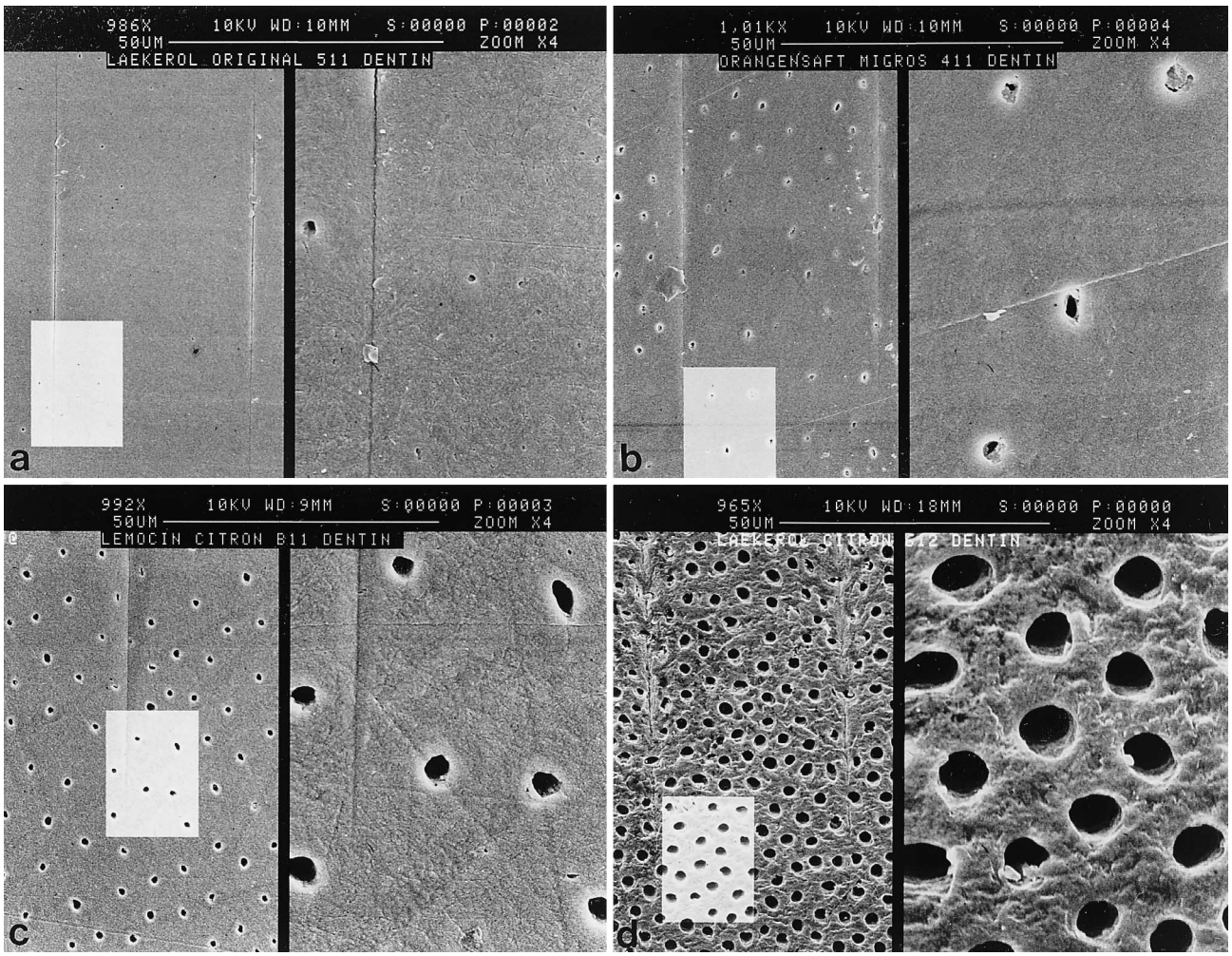

Fig. 1 Scoring of dentin: **a** score 0: no erosion; **b** score 1: surface texture is partially attacked and tubules begin to open; **c** score 2: surface texture is more severely attacked and tubules are more open and more numerous; **d** score 3: surface texture is clearly attacked and tubules are large and numerous

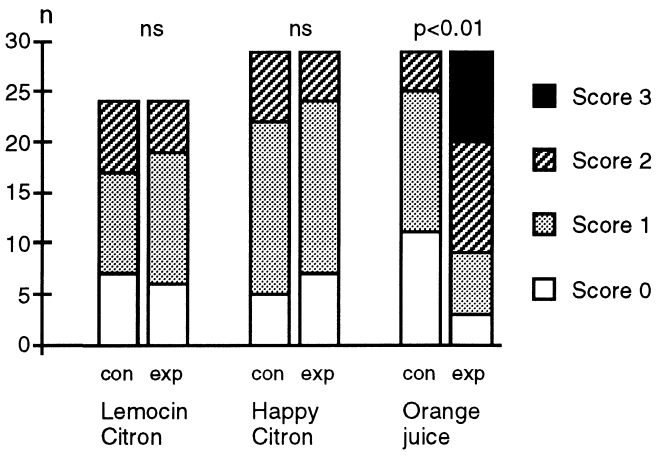

Fig. 2 Scanning electron microscope scoring on dentin surface. Control (*con*), test slabs (*exp*) and *P* values are given

No significant differences in SMH were found on dentin.

In the one subject with hyposalivation due to radiotherapy, the changes for enamel were slightly greater than in the subjects with normal saliva values: 21.3 SMH for orange juice (compared to 18.4 SMH with normal saliva values) and 20.2 SMH for "Happy Citron" (normal: 15.0 SMH). The decrease in dentin, however, was more marked, with 5.6 SMH for orange juice and 7.3 SMH for "Happy Citron".

Change in micromorphology

The scanning electron microscope scores are shown in Fig. 2. Only orange juice changed the surface texture of dentin significantly ($P<0.01$).

Discussion

This study showed that the acidic candy "Happy Citron" has the capacity to significantly soften an abraded enamel surface, although the effect of orange juice was more pro-

nounced. This influence could be assessed both by measuring surface hardness and by changes in the surface texture. Lemocin Citron, the most erosive substance in preliminary in vitro experiments [11], did not cause in vivo demineralization. This could be due to the different mass of these two lozenges (Table 1), which did not influence the in vitro tests in which similar concentrations (20 weight %) were used in all experiments.

To test initial demineralization, characterized by surface softening, SMH is an appropriate and sensitive technique, provided that the lesions are less than 50 µm deep at any time during the study [4]. This was the case in the present study as well as in other experiments [12]. The surface texture measurements in general confirmed the SMH measurements, although the technique did not seem to be as sensitive as Knoop hardness measurements.

In vivo, lozenges appear to be less effective in stimulating saliva than chewing gum [1]. As lozenges – in contrast to chewing gums – are not chewed and do not cause as much mechanical stimulation as chewing does, they probably are more detrimental to dental hard tissues than chewing gums with the same composition.

Saliva with its buffering capacity is a important host defence factor for erosion of the teeth, and it has been shown in vitro that salivary pellicle developed over a week protects the underlying tooth enamel from gross erosion [13]. There is evidence that a reduced, unstimulated salivary secretion is an additional risk factor for developing dental erosion as the buffering, dilution and rinsing of acids is also reduced [7, 15]. A reduced salivary secretion rate and buffering capacity was most probably the reason why the subject with hyposalivation showed a marked decrease in SMH after consuming the acidic candy “Happy Citron”. This is in agreement with results of other investigators who have shown that patients with low buffering capacity have a greater risk of enamel erosion if they take acidic lozenges frequently [2].

Deeper layers of enamel are more susceptible to demineralization than superficial ones [14]. By grinding and polishing the specimens in the present investigation, the outermost surface layer was removed and subsurface enamel was exposed. Subsurface enamel is more homogeneous than surface enamel. This reduces the variation in the model which, in turn, increases its sensitivity.

In summary, this study showed that acidic lozenges and candies were capable of softening abraded enamel in situ, although orange juice was more erosive in dental hard tissue. It is assumed that excessive consumption of acidic lozenges, when linked with low salivary flow rate and low buffering capacity, could enhance existing dental erosion.

References

1. Dawes C, Macpherson LMD (1992) Effect of nine different chewing-gums and lozenges on salivary flow rate and pH. Caries Res 26:176–182
2. Distler W, Brönner H, Hickel A, Petschelt A (1993) Die Säurefreisetzung beim Verzehr von zuckerfreien Fruchtbonbons in der Mundhöhle in vivo. Dtsch Zahnarztl Z 48:492–494
3. Eccles JD (1979) Dental erosion of nonindustrial origin. A clinical survey and classification. J Prosthet Dent 42:649–653
4. Featherstone JDB (1992) Consensus conference on intra-oral models: evaluation techniques. J Dent Res 71:955–956
5. Featherstone JDB, ten Cate JM, Shariati M, Arends J (1983) Comparison of artificial caries-like lesions by quantitative microradiography and microhardness profiles. Caries Res 17: 385–391
6. Herkströter FM, Witjes M, Ruben J, Arends J (1989) Time dependency of microhardness indentations in human and bovine dentin compared with human enamel. Caries Res 23:342–344
7. Järvinen VK, Rytömaa I, Heinonen OP (1991) Risk factors in dental erosion. J Dent Res 70:942–947
8. Lussi A (1996) Dental erosion: clinical diagnosis and case history taking. Eur J Oral Sci 104:191–198
9. Lussi A, Schaffner M (1996) Incidence of dental erosion over a six-year period (115). Caries Res 30:304
10. Lussi A, Schaffner M, Hotz P, Suter P (1991) Dental erosion in a population of Swiss adults. Community Dent Oral Epidemiol 19:286–290
11. Lussi A, Portmann P, Burhop B (1991) Effects of sugar-free sweets on microhardness of enamel- and dentin-softening (Nr. 214). J Dent Res 70:766
12. Lussi A, Jaeggi T, Schärer S (1993) The influence of different factors on in vitro enamel erosion employed by two methods. Caries Res 27:387–393
13. Meurman JH, Frank RM (1991) Scanning electron microscopic study of the effect of salivary pellicle on enamel erosion. Caries Res 25:1–6
14. Meurman JH, Frank RM (1991) Progression and surface ultrastructure of in vitro caused erosive lesions in human and bovine enamel. Caries Res 25:81–87
15. Wöltgens JHM, Vingerling P, de Blieck-Hogervorst JMA, Bervoets DJ (1985) Enamel erosion and saliva. Clin Prev Dent 7:8–10
16. Zero DT (1996) Etiology of dental erosion – extrinsic factors. Eur J Oral Sci 104:162–177