The effect of three whitening oral rinses on enamel micro-hardness

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SUMMARY
The purpose of this study was to determine the effect on human enamel micro-hardness of three over-the-counter whitening oral rinses available in South Africa. Enamel fragments were gathered into three groups of 15 each. One group was exposed to Colgate Plax Whitening Blancheur, the second group to White Glo 2 in 1 and the third to Plus White, in each case for periods recommended by the respective manufacturers. Surface micro-hardness of all groups was measured before and after a 14 day treatment period. pH levels of the oral rinses were also determined with a combination pH electrode. Pre- and post- treatment data were analysed by the Wilcoxon Signed Rank Sum Test. According to the micro-hardness values no significant (p>0.05) enamel damage was found as a result of treatment. However, it was observed that Colgate Plax and White Glo decreased the enamel hardness, an early sign of enamel damage, while Plus White showed a small increase in hardness. The three whitening oral rinses on the South African market do not damage the tooth enamel significantly when used as recommended by the manufacturers. However, extending the contact period and increasing the frequency of application might lead to damage of enamel.

Key words: enamel micro-hardness, oral rinses, whitening.

INTRODUCTION
Today’s society has the expectation that people should have exceptionally white (and straight) teeth. Oral rinses have become a popular means for whitening the teeth.

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ACRONYMS
OTC: over-the-counter
VHN: Vickers Hardness Values

Different bleaching techniques have been advocated over time. The demand in dental practice for tooth whitening to lighten discoloured teeth has increased exponentially over the last decade.¹ Most whitening methods include the use of peroxide bleaching agents.² Tooth bleaching occurs by the diffusion of the bleaching agent in and through enamel/dentine where oxidation takes place with a resulting decomposition of organic pigments, particularly within the dentine.³ Tooth whitening therefore involves direct contact of a bleaching agent with the enamel/dentine for periods of time which vary according to the directions determined by the manufacturers. This occasioned concerns about the possible adverse effects of such strong oxidising agents on enamel/dentine. The available literature is contradictory.² Some studies reported changes in the surface morphology of enamel following bleaching with carbamide peroxide or hydrogen peroxide products, while others reported no alterations.⁴⁻¹² For example, Hegedûsa et al, in an atomic force microscopy study, demonstrated that carbamide peroxide and hydrogen peroxide were capable of causing alterations in the enamel surface.¹³ According to Pugh, low concentrations of hydrogen peroxide are not expected to adversely affect the enamel and pulpal enzymes.¹⁴ However, a recent study revealed that Opalescence products having four different peroxide concentrations, (from 3.35-15% H₂O₂), all damaged enamel, which was most severe when teeth were treated for longer periods.³ From the literature it becomes clear that variations in the different bleaching products and their concentrations, as well as the specific bleaching agent and its pH; the application periods; heat and light sources; as well as the type of original tooth discoloration; all influence the effect on enamel or dentine.²

Sales of over-the-counter (OTC) tooth-whitening products have escalated because of heightened consumer demand for aesthetic care together with energetic promotion by product manufacturers. The items are available in pharmacies, department stores and on the Internet. Many are marketed directly to consumers. The cost is much less than in ot-
A mouthrinse is necessary to control the remaining bacteria and plaque that’s left in the mouth after brushing and flossing.²,³

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Tooth whitening treatment delivered by a dental health professional. The availability of these products is not controlled in South Africa nor in many other countries. One study did find that enamel surfaces treated with over-the-counter bleaching products did not show any significant colour improvement whilst no significant changes in micro-hardness values from baseline were recorded. However, over-the-counter bleaching products have not undergone rigorous testing and hence their efficacy and safety have not been explored. On the South African market only a few oral rinses for tooth whitening are available OTC. Therefore, the purpose of this in vitro study was to determine the effect of three OTC whitening oral rinses on human enamel micro-hardness.

**MATERIALS AND METHODS**

**Specimen preparation**

Freshly extracted, non-carious human molar teeth were collected and stored in water, with a few preservative thymol crystals. The roots were removed using a double-sided diamond saw driven by a low-speed motor (Metaserv, Universal Polisher, UK). Enamel blocks of 5x5 mm² sectioned longitudinally to the crowns, were examined under a stereomicroscope (10x magnification) and any with stains or cracks were discarded. Forty five selected enamel blocks were individually embedded in acrylic in one cm high PVC rings which had been cut from 25mm diameter electrical tubing. The samples were set horizontally with the enamel surface exposed above the acrylic. The enamel was finely polished using water cooled carbide paper up to a grit of 1200. The specimens were randomly divided into three treatment groups with 15 specimens each.

One group was exposed to Colgate Plax Whitening Blancheur (Colgate-Palmolive, Brazil) (CPW) for 1 minute twice a day, the second group to White Glo 2 in 1 (Sunpac Ltd, Gauteng, South Africa) (WG) for 30s twice a day and the third to Plus White (CCA Industries Inc, USA) (PW) for 30s twice daily. The exposure times were according to the manufacturer’s instructions. The trial extended over 14 days. Between applications the samples were stored in artificial saliva.

**Micro-hardness measurement**

Surface micro-hardness of the enamel specimens was measured on each, using a digital hardness tester with a diamond indenter (Zwick Roell Indentec, ZHV; Indentec UK). The saliva stored specimens were gently wiped with a tissue paper, rinsed with distilled water and tissue blot-dried before each micro-hardness measurement. Before any treatment, four indentations were made on the polished enamel surface of each enamel block with a 300g load applied for 15 seconds. This enabled the determination of baseline hardness values. The process was repeated after 14 days of active bleaching treatment, with the new indents being placed about 10µm from the baseline indents. All data were saved as Vickers Hardness Values (VHN), destined for statistical analysis (Wilcoxon Rank Sum Test). The before and after data were compared, each sample serving as its own control.

The pH levels of the oral rinses were also measured, using an Orion Expandable ion Analyzer EA940 (Orion Research Inc, MA, USA) and an Orion 9165BNWP Sure-Flow®, Epoxy-body combination pH electrode (Thermo Electron Corporation, Beverly, MA, USA). The pH electrode was calibrated using three buffer solutions of pH values 3.0, 4.0 and 7.0 (Beckman Instruments Irvine, CA, USA) and the electrode response to the buffer solutions was checked (and recalibrated if neces-
sary) after every six sample measurements. Three samples of each product were measured, and the electrode was then completely cleaned by thorough washing and rinsing with distilled water before the next set of readings was taken. The mean pH values were recorded and noted (Table 1).

RESULTS

The median Vickers micro-hardness values of the test specimens before and after the 14 day treatment period are reflected in Table 2. Box and Whisker plots were prepared to indicate the distribution of the micro-hardness values (Figure 1) for the groups treated respectively, by Colgate Plax Whitening Blancheur, White Glo 2 in 1 and Plus White. In Figure 1, the top line shows the maximum and the bottom line, the minimum hardness values, while the box part shows the location of 50% of the values. The line in the box depicts the median hardness value of the micro-hardness between base-line and after treatment.

The Wilcoxon Signed Rank Sum Test showed no statistical significant differences, (at a 5% level), between baseline values and the values obtained after a 14 day treatment period for all three different oral rinses.

DISCUSSION

It is evident from the literature that many factors such as different bleaching agents with differing concentrations, type and concentration of acid, pH, temperature, exposure time and frequency of exposure, can all contribute to enamel erosion/demineralisation.2,3,16-19 The initial stage of caries development has been identified as surface-softening of enamel.15,16,20 Today it is generally accepted that micro-hardness determinations give a reliable indication of this softening, (damage/demineralisation), of enamel or dentine and this criterion is now employed worldwide for this purpose.2,3,16-19

Most solutions with low pH levels are known to soften and erode enamel.21,22,23,24 According to Goldstein, the acidic property of the bleaching agents can also cause changes in the mineral content of enamel and may therefore result in damage to dental structures even under prescribed conditions.21 Minor alterations of the enamel may facilitate the future penetration of bacteria, debris or staining substances, affecting the success of bleaching.2 The pH values of the three oral rinses used in this study, ranged from 3.59 to 5.00 (Table 1). Such acidic levels would normally be considered as hazardous towards teeth and could be expected to decrease the enamel hardness. Significant enamel demineralisation and root resorption have been reported when the pH falls below 5.2.22 Some studies reported demineralization of enamel at a pH below 5.2, while others reported a pH of 5.5 as the critical pH.23,24 However, Dawes recently reported that the critical pH at which enamel starts to, should rather be regarded as being in a range of 5.1 to 6.5, depending also on the concentrations of calcium and phosphate present in the solution.25 Most solutions/beverages which are known to soften enamel and produce dental erosion have low pH levels.26-28 In an in vitro study, Hunter et al observed that increasing the frequency of exposure to a drink having a low pH resulted in a non-proportional increase in dental erosion.29 Reducing the frequency of exposure by half did not result in a similar reduction in tissue loss.

The pH of whitening products changes inside the oral cavity during the bleaching process. However, it is not known if the change in pH occurs at the same rate for products containing hydrogen peroxide (H2O2) or carbamide peroxide (CH6N2O3) or if this pH change would adversely affect oral soft and hard tissues.22 Of the three oral rinses tested, Colgate Plax contains hydrogen peroxide while the other two probably depend mainly on the acidity of the rinse to whiten teeth (Table 1). An overall lowering in the median enamel hardness values as a result of the normal treatment by the three rinses was demonstrated, although these changes were not statistically significant (Figure 1). The sample treated with Colgate Plax recorded the greatest decrease in enamel hardness, followed by the White Glo sample. These two oral rinses have the lowest pH values (3.74 and 3.59; Table 1) which gives an indication of a strong relationship between acidity and the extent of enamel damage by demineralisation. On the other hand, treatment with Plus White (Table 1), with a higher pH of 5.0, gave a small increase in the hardness for the third group. Perhaps it is of relevance that the total exposure time of Colgate Plax (28 min) was twice that of the other two products. That may be expected to contribute to the relatively greater softening of enamel by Colgate Plax in comparison with the effects seen in the sample treated with White Glo, even though that product has a somewhat lower pH (3.59 vs 3.74).

The whitening effects of the three oral rinses, (Colgate Plax Whitening Blancheur, White Glo 2 in 1 and Plus White), have been reported to be unsuccessful when applied according to the manufacturers’ instructions.30 It is likely that if users cannot see changes in the whiteness of their teeth they will tend to practise longer exposure periods to the oral rinses and to reduce the intervals between rinses. This will diminish the time when teeth are bathed in saliva, thereby reducing the associated remineralisation effects and increasing the chances of significant damage to enamel.

CONCLUSION

This study confirms that over the counter whitening rinses do affect the enamel surfaces and cautions users not to extend the application periods and frequency of use beyond the recommendations of the manufacturers because of possible enamel damage.

Ethics statement: For the purpose of this study only extracted teeth were used. These were all discarded specimens collected from the Department of Maxillofacial and Oral Surgery, Faculty of Dentistry, UWC.

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References