JOURNAL OF DENTISTRY 36S (2008) S32–S37

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.intl.elsevierhealth.com/journals/jden

In vitro cleaning, abrasion and fluoride efficacy of a new silica based whitening toothpaste containing blue covarine

Andrew Joiner [a,*], *Carole J. Philpotts* [a], *Alex T. Ashcroft* [a], *Massimo Laucello* [b], *Angela Salvaderi* [b]

[a] *Unilever Oral Care, Quarry Road East, Bebington, Wirral CH63 3JW, UK*
[b] *Unilever Oral Care, Via Lever-Gibbs, 3/a, 26841 Casalpusterlengo, Lodi, Italy*

ARTICLE INFO

Keywords:
Tooth colour
Extrinsic stain
Tooth whitening
Wear
Dentine
Enamel

ABSTRACT

Objectives: To investigate the stain removal ability, abrasivity towards enamel and dentine, and fluoride efficacy of a new silica based blue covarine whitening toothpaste *in vitro*.

Methods: Stain removal was assessed by brushing artificially stained bovine specimens with slurries of either the new toothpaste or one of two whitening products or a non-whitening silica product. Toothpaste abrasivity was assessed by brushing enamel/dentine specimens with slurries of either the new toothpaste, a whitening toothpaste or a non-whitening toothpaste and measuring the wear via a combination of changes in geometry of Knoop indents and surface profilometry. Fluoride efficacy was assessed using remineralisation, demineralisation and fluoride-uptake methods.

Results: The *in vitro* cleaning study showed that the silica based blue covarine whitening toothpaste removed significantly ($p < 0.05$) more stain than the non-whitening toothpaste and was as effective as the two marketed silica based whitening toothpastes. This enhanced tooth whitening benefit did not give rise to a concomitant statistically significant increase in the level of wear to enamel and dentine compared to the non-whitening silica based toothpaste. The fluoride efficacy was superior to a non-fluoridated control and was as effective as a clinically tested formulation containing the same fluoride source.

Conclusions: The studies show that the new whitening toothpaste is effective in extrinsic stain removal, does not have an undue degree of abrasivity to enamel or dentine compared to other relevant commercially available products, and is an efficacious source of fluoride.

1. Introduction

In recent years, patient and consumer interest in tooth whitening products has grown tremendously. These products are marketed in many different formats, but one of the most accessible products for many patients and consumers is toothpaste and the growth in the whitening toothpaste market mirrors the growth in the whole tooth whitening sector.[1]

The active ingredients in current whitening toothpastes are based on formulations which contain optimised abrasive and chemical components to maximise cleaning and stain removal/prevention.[2] The abrasive components typically include hydrated silica, calcium carbonate, dicalcium phosphate dihydrate, alumina and perlite. Their mode of action is based on abrasion, whereby the abrasive particles are momentarily trapped between the toothbrush and stained tooth surface and effect a physical removal of the stain. A number of chemical components have also been described and used in toothpaste formulations including surfactants, calcium chelators, enzymes, polymers and oxidising agents,

* *Corresponding author*. Tel.: +44 151 641 3000; fax: +44 151 641 1800.
E-mail address: andrew.joiner@unilever.com (A. Joiner).
0300-5712/$ – see front matter
doi:10.1016/j.jdent.2008.02.003

and these are proposed to act by a number of different mechanisms in order to aid stain removal and/or prevention.[2]

It is now widely accepted that toothpastes require a certain amount of abrasivity in order to remove or prevent extrinsic stain from forming, since if a very low abrasive toothpaste is used then extrinsic stain usually accumulates on the surfaces of teeth.[3–5] However, the abrasivity of the toothpaste needs to be moderated in order to prevent excessive wear to the underlying enamel and dentine. Thus, it is not only important to investigate the stain removal properties of a whitening toothpaste but also its potential wear to enamel and dentine.

The benefits of fluoride on oral health are now well established and twice-daily brushing with a fluoride containing toothpaste is one of the most convenient and effective ways of delivering this benefit. *In vitro* models and methods are widely accepted as a means for studying the demineralisation and remineralisation of enamel as well as the effects fluoride can have on these processes.[6,7] Their main strength is that experimental conditions can be well defined and subsequently controlled throughout the duration of a study, e.g. pH, flowrate, solution composition.

A new fluoridated tooth whitening toothpaste has been developed that contains an optimised silica abrasive system and blue covarine as a new optical approach to tooth whitening via its ability to change the optical effects of the tooth surface and hence enhance the measurement and perception of tooth whiteness.[8,9] Although the new toothpaste uses novel technology to provide a completely new route to making teeth appear whiter, it must still be able to deliver the performance that consumers would expect of a whitening toothpaste. The aims of the current *in vitro* studies are to investigate the stain removal, enamel/dentine wear and fluoride efficacy of this new silica based blue covarine whitening toothpaste.

2. Materials and methods

The following sections describe the *in vitro* methods used to evaluate the functional performance of the new silica based blue covarine whitening toothpaste. Stain removal was established *in vitro* using a modified pellicle cleaning ratio (PCR) method, while abrasivity was measured via a brushing protocol and a combination of a microhardness tester and surface profilometry. The ability of this toothpaste to provide fluoride protection to enamel was established using standard demineralisation and remineralisation protocols as well as by measuring fluoride uptake from the toothpaste into preformed lesions.

2.1. *In vitro stain removal*

One of the best-known and most accepted laboratory methods world-wide for assessing the stain removal ability of a toothpaste was developed at Indiana University by Stookey et al.[3] The method used in the current study was a slight modification of the Stookey et al.[3] method and has previously been described by Pickles et al.[1] In outline, this method involves embedding cut bovine teeth into autopolymerising methacrylate resin such that only the enamel surfaces are exposed. The enamel specimens are polished and acid etched and then slowly rotated through a trough of aqueous staining media consisting of coffee/tea/mucin and air at 50 °C for 4 days. The baseline colour of the stained enamel blocks was measured using a Minolta CR-321 Chromameter (Minolta Camera Co. Ltd., Japan) in the CIELAB mode.[10] The stained enamel blocks were then mounted in a modified Martindale brushing machine (Goodbrand-Jeffreys Ltd., Stockport, UK) fitted with flat-trimmed medium toothbrushes. In this apparatus the brush heads describe Lissajous figures, which combine linear and elliptical motions to ensure comprehensive coverage of the brushed sample. An oscillation rate of 150 cycles per minute and a brushing load of 175 g were used. Nine stained enamel blocks were randomly assigned to one of the toothpaste treatments. The toothpastes tested were the silica based blue covarine whitening toothpaste, two marketed silica based whitening toothpastes (A and B) and a non-whitening silica toothpaste. The toothpastes were dispersed in water (38.5% aqueous toothpaste slurry) and the slurry (10 ml) added to each well of the brushing machine. The stained enamel blocks were brushed for 400 cycles, rinsed with water, air-dried and the colour remeasured. Finally, all traces of stain were removed using flour of pumice, on a soft cloth and a grinder/polisher. The pellicle cleaning ratio (PCR) (i.e. stain removed) was calculated from:

$$\mathrm{PCR} = \frac{L^*(\mathrm{brushed}) - L^*(\mathrm{stained})}{L^*(\mathrm{pumiced}) - L^*(\mathrm{stained})} \times 100$$

where L^*(stained) is L^* value of stained enamel blocks; L^*(brushed) is L^* value after brushing, and L^*(pumiced) is L^* value after polishing with pumice.

2.2. *Toothpaste abrasivity on enamel and dentine*

Enamel–dentine blocks (approximately 4 mm × 4 mm × 2 mm) were cut from extracted human teeth, collected prior to the enactment of the Human Tissue Act, using a method which has previously been described so that the test surface was approximately 50:50 enamel:dentine.[11] In outline, the roots of incisors and molars were removed and the facial surface flattened using a high abrasive disc (Tycet Ltd., Hemel Hempstead, Herts, UK) until it was flat enough to fit a block of enamel and dentine split approximately 50:50, of size 4 mm × 4 mm. The lingual part of the tooth was cut to leave a slice approximately 2 mm thick, and a 4 mm × 4 mm block was then cut from this slice. The blocks were polished planar parallel with a final polish of 0.25 μm diamond suspensions (Kemmet International Ltd., Maidstone, Kent, UK). For each specimen, the enamel half was indented with a Knoop diamond under a load of 50 g using a Mitutoyo HM122 Microhardness Tester (Mitutoyo Corp., Japan). Four indents per specimen were made and the lengths measured using the optical system of the microhardness tester. In addition, the surface topography of the specimens was measured using a contact surface profilometer (Mitutoyo SV2000, Mitutoyo Corp., Japan) at three points across the enamel–dentine junction.

The specimens were mounted in a modified Martindale brushing machine (Goodbrand-Jeffreys Ltd., Stockport, UK) fitted with flat-trimmed toothbrushes. Specimens were