PA Patil
AV Ankola
MI Hebbal
AC Patil

Authors' affiliations:
PA Patil, *AV Ankola*, *MI Hebbal*, Department of Public Health Dentistry, KLE VK Institute of Dental Sciences, Belgaum, India
AC Patil, Department of Conservative and Endodontics, KLE VK Institute of Dental Sciences, Belgaum, India

Correspondence to:
Dr P. A. Patil
MIG 11
"Sidha Nivas"
Mahantesh Nagar
Belgaum, Karnataka, India
Tel.: +919448358235
Fax: +918312470640
E-mail: drprati07@gmail.com

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Comparison of effectiveness of abrasive and enzymatic action of whitening toothpastes in removal of extrinsic stains – a clinical trial

Abstract: *Objective:* To compare the effectiveness of abrasive component (perlite/calcium carbonate) and enzymatic component (papain and bromelain) of whitening toothpaste in removal of extrinsic stains. *Methods:* This study is a randomized, triple blind and parallel group study in which 90 subjects aged 18–40 years were included. At baseline, stains scores were assessed by Macpherson's modification of Lobene Stain Index and subjects were randomly assigned to two groups with 45 subjects in each. Group 1 used whitening toothpaste with enzymatic action and group 2 with abrasive action. After 1 month, stain scores were assessed for the effectiveness of the two toothpastes and 2 months later to check the stain prevention efficacy. Wilcoxson's test was used to compare between baseline 1 and 2 months stain scores, and Mann–Witney *U*-test was applied for intragroup comparison. *Results:* The mean baseline total stain score for the subjects allocated to the enzymatic toothpaste was 37.24 ± 2.11 which reduced to 30.77 ± 2.48 in 1 month, and for the abrasive paste, total stain reduced from 35.08 ± 2.96 to 32.89 ± 1.95. The reductions in total stain scores with both the pastes were significant compared with baseline stain scores (at 1 month Group 1, $P = 0.0233$ and Group 2, $P = 0.0324$; at 2 months, Group 1 $P = 0.0356$). Both the toothpastes proved to be equally good in removal of extrinsic stains; however, the enzymatic paste showed better results as compared to abrasive toothpaste. *Conclusion:* Whitening toothpaste with abrasive action and enzymatic action are equally effective in removal of extrinsic stains; however, whitening toothpaste with abrasive action needs to be used with caution.

Key words: bromelain; Macpherson's Lobene stain index; papain; perlite; whitening toothpaste

Introduction

Aesthetic dentistry including tooth whitening continues to be expanding areas of interest that has been fuelled by the consumers demand for both healthy and cosmetically attractive smiles (1). The requirement for aesthetic benefits is highlighted by the various products for tooth whitening in the oral care market (2). They are based on optimized abrasive technology to remove and control extrinsic stains which forms in the acquired pellicle (3).

Extrinsic stains form naturally on the tooth surface when chromagens from dietary sources (e.g. tannins from tea, coffee, red wine) or habits (e.g. tar from smoking) are incorporated into the salivary pellicle (4).

Other factors, such as poor oral hygiene technique and the ability of a dentifrice to control stain by removal or prevention, also influence the accumulation of natural stains (5).

An important part of the evaluation process for whitening toothpaste is determining its clinical efficacy in terms of removing extrinsic tooth stains (6). Overall, the cleaning process is affected by the hardness, size, shape and concentration of the particles and the pressure used in brushing the teeth. The key components in current toothpastes for cleaning teeth by a process termed abrasion include hydrated silica, calcium carbonate, perlite, dicalcium phosphate dihydrate and sodium bicarbonate (7).

In the dental profession, some degree of abrasivity must be tolerated in a toothpaste if satisfactory cleansing of the teeth is to be achieved (8, 9). The International Standard Organisation (ISO) has set dentine abrasivity maximum, that is, Relative Dentine Abrasivity (RDA) not to exceed 250 (10, 11). Usually whitening toothpastes have medium (RDA – 60–100) or high (RDA > 100) abrasivity (12).

Joiner *et al*. in a 6-month *in situ* study to know enamel or dentine wear by the abrasive tooth paste found that perlite an abrasive was more effective in stain removal and prevention than standard silica toothpaste. In addition, the enamel wear was below clinically relevant values (13–15). Hence, in this study, the abrasive action toothpaste containing perlite was selected.

Tooth whitening can be achieved by various non-abrading whitening agents. Alternative component in whitening toothpastes can be the one with protective agent such as polyvinylpyrrolidone or detergent such as sodium lauryl sulphate or the recently evolved agent with optical properties – blue covarine (16). Natural enzyme extract from the plants has been incorporated in whitening toothpaste recently. One such enzymatic action whitening toothpaste that has natural proteolytic enzymes such as papain and bromelain is considered in this study. Papain is sufhydryl protease derived from *Carica papaya*, which is a proteolytic enzyme that breaks down protein pellicle on tooth surface. Bromelain from *Ananas cormosus* also is a proteolytic enzyme and offers anti-adhesive action on oral microorganisms (17). With this background, this study aimed at comparing the effectiveness of whitening toothpaste with commercially available abrasive component – perlite and enzymatic components – papain and bromelain in extrinsic stain removal.

Study population and methodology

Study population

This study was a triple blind randomized clinical trial conducted in the department of Public Health Dentistry of KLE VK Institute of Dental Sciences between June and September 2012. The subjects were males and females in the age group of 15–40 years who met the inclusion and exclusion criteria. The study consisted of 90 healthy individuals, who had at least 20 teeth including eight natural anterior teeth (incisors and canines) assessable for extrinsic stains (5). Subjects with anterior facial tooth restorations, with fixed orthodontic appliances and not willing to quit tobacco-related habits were excluded. All the subjects who were willing to participate signed the written informed consent. Ethical clearance was obtained from Institution Review Board of KLE University after the approval of study protocol, information pro forma and informed consent.

Selection criteria and procedure

At the first visit, an oral hard and soft tissue examination was carried out in the department of Public Health Dentistry. A trained examiner with the help of recording clerk recorded the stains scores as per the Macpherson modified Lobene Stain Index which was the baseline scores (18). Each tooth was divided into four areas for assessment: gingival, mesial, distal and body. The stain index measured area and intensity of extrinsic tooth stain on the facial surfaces of the anterior teeth. Five percentage of the subjects were re-examined to assess intra-examiner reproducibility, and the proportion of agreement was shown to be over 81%. To qualify for participation in the study, subjects were required to have a total stain score from 1.0 to 3.0.

Intervention

Ninety subjects who met the inclusion and exclusion criteria were randomized to two groups by lottery method with 45 subjects in each. The toothpastes were supplied to the study population in identical white 75 g tubes with the product codes as Toothpaste 1 and Toothpaste 2. Group 1 subjects received the whitening toothpaste 1 with enzymatic action (Glodent, Group Pharma; Meher Distributors Pvt. Ltd. Mumbai, India), and whitening toothpaste 2 with abrasive action toothpaste with perlite/hydrated silica (Pepsodent Whitening, Hindustan Unilever limited., Mumbai) was used by Group 2 subjects. Subjects were taught the proper brushing technique and were instructed to brush their teeth twice daily (morning and evening) for at least 1 min using respective toothpaste. Subjects were advised to refrain from other oral hygiene procedures and oral prophylaxis until the study was completed. To maintain uniformity, medium bristles toothbrushes were provided to all subjects. After the subjects had used the respective toothpastes for 1 month, re-evaluation of the stains was performed and the data were recorded.

After this period, the subjects discontinued the study toothpastes and switched to their regular toothpaste. To check the stain prevention efficacy or recurrence of extrinsic stain on the tooth surfaces, stain scores were assessed once again after 2 months.

Data collection

The structured pro forma was used to collect the information regarding the subjects' socio-demographic characteristics,

dentition status, stain scores at baseline, 1 and 2 months, respectively. The investigator, subjects and the statistician were blinded about the two toothpastes.

Statistical analysis

Data analysis was performed using Statistical Package for Social Science (Version 17; SPSS Inc., Raleigh, NC, USA). For all analyses, the level of statistical significance was $P < 0.05$.

Data pertaining to stain scores were collected at baseline, 1- and 2-month intervals. In this study, although the sample size was more than 30, the variables did not follow normal distribution; hence, statistical analysis was performed using nonparametric tests such as Mann–Whitney *U*-test and Wilcoxon matched-pairs test by ranks. Mann–Whitney *U*-test was used to assess the intergroup comparison of the stain scores between Group 1 and Group 2 at baseline, 1 and 2 months. Wilcoxon matched-pairs test by ranks was applied to assess the intragroup comparison or two-sample designs involving 'before' and 'after' measures.

Results

Of the total of 90 subjects, 45 subjects of Group 1 comprised of 37.78% males and 62.22% female subjects and among 45 subjects of Group 2, 47.78% were males and 52.22% were females as seen in Table 1.

Baseline data

The mean baseline stain score for the subjects using enzymatic toothpaste was 37.24 ± 2.11, while the mean total stain score for subjects using the abrasive toothpaste 35.08 ± 2.96. The difference between the two was not statistically significant. In addition, the comparison of the stain scores between groups at 1 and 2 months showed no significant difference (Table 2).

1-month data

Mean stain score for the subjects using enzymatic toothpaste was 30.77 ± 2.48 and 32.89 ± 1.95 for abrasive toothpaste after 1-month use. The reduction in mean stain scores observed for the enzymatic toothpaste, after 1 month of brushing was by 6.47 units and abrasive toothpaste reduced by 2.19 units. Both of these reductions in mean stain scores were statistically significant compared with baseline ($P < 0.001$), as seen in Table 3.

Table 1. **Distribution of the study subjects in Group 1 and Group 2**

Sex	Group 1	Percentage	Group 2	Percentage
Male	17	37.78	19	47.78
Female	28	62.22	26	52.22
Total	45	100.00	45	100.00

Table 2. **Comparison of stain scores of study subjects in Group 1 and Group 2 with respect to baseline, 1- and 2-month stain scores by Mann–Whitney *U*-test**

Variable	Group	Mean	SD	*Z*-value	*P*-value
Baseline	1	37.24	2.11	−0.9845	0.3249
	2	35.08	2.96		
1 month	1	30.77	2.48	−1.0854	0.2778
	2	32.89	1.95		
2 months	1	34.73	2.51	−1.363	0.173
	2	35.53	2.01		

$P < 0.05$ was statistically significant.

2-month data

After the subjects switched back to their regular toothpaste and continued to use it, the scores were 34.73 ± 2.51 and 34.58 ± 2.01 for enzymatic toothpaste and abrasive groups respectively. The difference in the mean stain scores after 2 months was statistically significant only for the enzymatic toothpaste from the baseline scores (Table 3).

Discussion

The effectiveness of any new whitening toothpaste can be evaluated by several methods: Removal of induced stain, prevention of induced stains, removal of pre-existing/natural stains or prevention of natural stain build-up (5). This study intended to compare the effectiveness of the two whitening toothpastes with different mechanisms (enzymatic and abrasive) in removal of pre-existing stains and prevention of natural stain build-up. The whitening effect in the enzymatic toothpaste (free of abrasives) was due to the proteolytic enzymes and in the abrasive toothpaste due to the hydrated silica (RDA – 96) (19).

In this study, it was observed that the enzymatic paste reduced the naturally occurring stains more efficiently than the

Table 3. **Comparison of baseline, 1- and 2-month stain scores in subjects in Group 1 and Group 2 by Wilcoxon matched-pairs test by ranks**

Group	Treatment	Mean	Standard deviation	Mean diff.	*P*-value
1	Baseline	37.24	2.11	6.47	0.0233*
	1 month	30.77	2.48		
2	Baseline	35.08	2.96	2.19	0.0324*
	1 month	32.89	1.95		
1	Baseline	37.24	2.11	2.51	0.0356*
	2 month	34.73	2.51		
2	Baseline	35.08	2.96	0.5	0.0535
	2 month	34.58	2.01		

*$P < 0.05$ was statistically significant.

abrasive paste, although not statistically significant. Abrasive action whitening toothpaste with the toothbrush bristles remove the outer stained plaque, but do not change the colour of the teeth. The problem with this is that the abrasive substances are effective only in places which can be reached by the toothbrush bristles. Hence, the effect is very slight on proximal surfaces and near the gum lines, as well as with compressed teeth (20). Whitening toothpaste with abrading action can be advised not more than 4 weeks, for safety of the enamel and dentine. Studies by various authors have led to results that abrasive whitening toothpastes can be effective between 2 and 4 weeks (9). Collins *et al.* and Koertge *et al.* showed that the calcium carbonate/perlite abrasive system significantly reduces stain over the relatively short time scale of 2 weeks (5, 21). However, Putt *et al.* (22) showed that a low abrasive, dual-phase, sodium bicarbonate toothpaste did not remove significantly more tooth stain after 2 weeks of brushing compared with a commercially available regular toothpaste, and significance was only obtained after 4 and 6 weeks of brushing.

However, abrasive toothpastes are known to cause some amount of dental tissue wear. Hence, to overcome this effect, enzymatic whitening toothpaste was considered in this study. To evaluate the effectiveness of enzymatic toothpaste, proteolytic enzymes such as papain and bromelain belonging to the group of proteases were considered (23). Most of the stain molecules are included in the pellicle, which contains protein. Therefore, enzymes such as protease and papain create a whitening effect. In recent *in vitro* study, there was significant stain removal reported with new whitening dentifrice containing papain and bromelain when compared with control (24). Enzymatic action whitening toothpastes affects all locations where the toothpaste penetrates including proximal surfaces and near gum lines which are difficult to reach with a toothbrush (8).

Papain and Bromelain hydrolyse the pellicle, and thereby preventing the bacteria and stain accumulation on the tooth surfaces (25, 26). Papain (*C. papaya*) is also considered a chemical debridement agent, which helps in the healing process and acts as an anti-inflammatory agent (27). It has not been shown to be cytotoxic and is biocompatible with oral tissues. The toothpaste that contains papain conveniently has a pH near to neutral, that is to say, approximately 7, with a view to guaranteeing the activity of the enzyme without demineralizing the enamel (28). Bromelain is derived from the ripe and unripe fruit, as well as stem and leaves of pineapple (*Ananas comosus*). Surface stains stick to the pellicle first, so Bromelain helps break down the protein pellicle on the tooth surface. Thus, for those patients with dentinal hypersensitivity where abrasive pastes are contraindicated, enzymatic whitening toothpaste is the best alternative for teeth whitening.

In the current study, it was also found that the enzymatic paste had a residual tooth whitening effect better than the abrasive paste as the stain scores after 2 months was significantly less compared with baseline scores (Table 2). The effect could be attributed to the antibacterial and the proteolytic action of the enzymatic toothpaste. This study concludes that natural enzymes such as papain and bromelain used in whitening toothpaste are effective in removing extrinsic tooth stains as compared to much established abrasive whitening toothpaste systems although not statistically significant. Conditions in which abrasive action toothpaste are contraindicated enzymatic action toothpaste can be used without the fear of enamel and/or dentin wear. However, studies related to the effect of these enzymes on oral health are sparse and research with an in-depth understanding of these enzymes is entailed.

Clinical relevance

Scientific rationale

Scientific rational: Whitening toothpaste products are sold as 'over the counter products' and have no professional involvement to choose the right one. Consumers look for brand name and not the content of the product.

Principal findings

The enzymatic whitening toothpaste has a better stain removal property and also prevents the occurrence of the stains as compared to abrasive action toothpaste although not statistically significant.

Practical implications

Practical implications: For maximum effect and minimal side effects, consumers should look for enzymatic action whitening toothpaste which is equally effective as the abrasive action ones.

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