©Operative Dentistry, 2013, **38-1,** 57-62

Efficacy of Mouth Rinses and Toothpaste on Tooth Whitening

CRG Torres • LCCC Perote • NC Gutierrez
CR Pucci • AB Borges

Clinical Relevance

Several tooth whitening products are available to consumers on the market. This study questions whether the use of whitening mouth rinses and toothpaste can result in bleaching efficacy similar to that of the 10% carbamide peroxide at-home bleaching technique.

SUMMARY

Objectives: **People increasingly desire tooth whitening. Considering the wide range of whitening products on the market, this study evaluated the efficacy of whitening toothpastes and mouth rinses compared with the 10% carbamide peroxide (CP) whitening gel.**

Methods: **We obtained 120 cylindrical specimens from bovine teeth, which were darkened for 24 hours in a coffee solution. The color measurement was performed by a spectrophotometer using the CIE L*a*b* system, and specimens were divided into six groups according to the use of the following agents: group 1, conventional fluoridated toothpaste; group 2, Close Up White Now; group 3, Listerine Whitening; group 4, Colgate Plax Whitening; group 5, experimental mouth rinse with Plasdone; and group 6, 10% CP Whiteness Perfect. After the simulation of 12 weeks of treatment for groups 1 to 5 and 14 days of treatment for group 6, the specimens were subjected to a new color reading.**

Results: **Data were subjected to one-way analysis of variance (α=0.05), which showed significant differences among groups after 12 weeks for ΔE (p=0.001). Results of the Tukey test revealed that groups 3, 4, and 6 presented significantly higher color alteration than groups 1, 2, and 5.**

Conclusions: **The whitening toothpaste Close Up White Now and the experimental mouth rinse with Plasdone showed similar color alteration as conventional toothpaste after a 12-**

*Carlos R G Torres, DDS, PhD, UNESP Univ. Estadual Paulista, Restorative Dentistry, São Paulo, Brazil

Letícia C C C Perote, DDS, UNESP Univ. Estadual Paulista, Restorative Dentistry, São Paulo, Brazil

Natália C Gutierrez, DDS, MS, UNESP Univ. Estadual Paulista, Restorative Dentistry, São Paulo, Brazil

Cesar R Pucci, DDS, MS, PhD, UNESP Univ. Estadual Paulista, Restorative Dentistry, São Paulo, Brazil

Alessandra B Borges, DDS, MS, PhD, UNESP Univ. Estadual Paulista, Restorative Dentistry, São Paulo, Brazil

*Corresponding author: São Paulo State University, Restorative Dentistry, Av. Eng. Francisco José Longo, 777 Jd. São Dimas, São José dos Campos, SP 12245-000, Brazil;

e-mail: carlosrgt@fosjc.unesp.br

DOI: 10.2341/11-360-L

week treatment simulation. These groups presented significantly lower color alteration compared with whitening mouth rinses Listerine and Colgate Plax Whitening, which showed similar results to those observed after 14 days of bleaching with 10% CP treatment.

INTRODUCTION

Today, patients are demanding more than a healthy mouth; they want a perfect smile.[1] Esthetics has become central; thus, treatments that focus on esthetics have been gaining more visibility and interest in all society.

The color of permanent teeth is mainly determined by the dentin and modified by the thickness and translucence of enamel. The deposition of a variety of pigments into or onto the tooth may change its color. These changes are usually classified as intrinsic or extrinsic, depending on the source of the stain. Therefore, attempts to improve the color of teeth should be directed to each type of stain.[2]

Tooth discoloration may cause social and cosmetic problems for patients. Thus, dentists and patients spend large amounts of money and time trying to improve the appearance of teeth.[3] Therefore, the demand for whitening treatments has grown considerably in recent years, as they are not invasive and are relatively simple to carry out. There are three fundamental approaches of tooth whitening: dentist-supervised home bleaching; in-office bleaching; and mass market products, also known as over-the-counter (OTC) products.[4,5]

The mechanism of action of mass market products are mainly two: bleaching intrinsic stains by using oxidizing agents that break down the pigments in the tooth structure, and removing and controlling extrinsic stains using abrasive agents. OTC products usually contain low levels of whitening agent (3%-6% hydrogen peroxide) that are self-applied to the teeth via gum shields, strips, paint-on products, toothpastes, or mouth rinse products. The removal and control of extrinsic stains are via so-called whitening toothpastes that contain abrasives and chemicals to maximize cleaning. Some products claim to possess optical brighteners, which are dyes that deposit on the teeth and result in an increase in the measurement and perception of tooth whiteness.[5–7]

Considering the wide range of mass market products and the scarce evidence of their efficacy, the aim of this study was to evaluate the effectiveness of four commercially available whitening products (one toothpaste and three mouth rinses) compared with the 10% carbamide peroxide whitening gel used for dentist-supervised home bleaching. The null hypothesis tested is that the whitening products tested have no effect in the color change of teeth.

MATERIALS AND METHODS

Specimens Preparation

The specimens were prepared according to the method described by Wiegand and others.[8,9] From 60 extracted nondamaged bovine incisors, we obtained up to two specimens of 3 mm in diameter and 2.2 mm in height from the buccal surface with a trephine drill.

The dentin and enamel thickness were standardized at 1 mm each by polishing with aluminum oxide abrasive papers (1200-grit FEPA-P, Struers, Ballerup, Denmark) in a polishing device (DP-10, Panambra Industrial e Técnica SA, São Paulo, Brazil). The enamel surface was polished with sequential abrasive papers (1200, 2400, and 4000-grit, Struers), applied for 20 seconds each.

The specimens were placed on a silicon support, leaving only the enamel exposed, and were immersed in a coffee solution prepared with 25 g of soluble coffee (Nescafé Tradição, Nestlé Brazil Ltda, Araras, SP, Brazil) in 100 mL water for 24 hours.[3] After this, they were rinsed in deionized water and ultrasonically cleaned for 2 minutes. The color measurement was then performed.

Color Measurement

Color reading of each specimen was performed at standardized ambient condition using a Spectrophotometer CM 2600d (Minolta, Osaka, Japan). The color and spectral distribution were measured according to the CIE L*a*b* system, using Spectra Magic NX software CM-S100w (Konica Minolta, Osaka, Japan). The D65 illuminant standard was set, with the reflectance mode and ultraviolet light included. The angle of observation was set to 2°, and the specular component was included. The specimens were slightly dried with absorbent paper and immediately placed into an individually prepared white rubber holder containing a hole the same size as the specimen.

A standard white background (Ceram, Staffordshire, UK) and an optical coupling using 400 polyethyleneglycol were used. The device was set to make three consecutive readings, automatically calculating the mean values of L*a*b*, as established by Commission Internationale de l'Éclair-

Table 1: *Products, Manufacturers, and Their Components*

Product	Manufacturer	Components
Close Up White Now	Unilever, Ipojuca, PE, Brazil	Sorbitol, aqua, silica PEG-32, sodium lauryl sulfate, aroma, cellulose gum, sodium fluoride, sodium saccharin, PVM/MA copolymer, trisodium phosphate, MICA, CI 74160, limonene
Colgate Fluoridated Toothpaste	Colgate-Palmolive, São Bernardo do Campo, SP, Brazil	Calcium carbonate, aqua, sorbitol, sodium lauryl sulfate, sodium monoflouophosphate, cellulose gum, aroma, tetrasodium pyrophosphate, sodium silicate, sodium saccharin, methylparaben, propylparaben
Listerine Whitening	KIK Custom Products, Etocicoke, Canada	Water, 8% alcohol, hydrogen peroxide 2%, sodium phosphate, poloxamer 407, sodium lauryl sulfate, sodium citrate, mint aroma, menthol, eucalyptol, sodium saccharin, sucralose
Plasdone 2%	International Specialty Products, Wayne, New Jersey, USA	Polyvinylpyrrolidone K29/32, water
Colgate Plax Whitening	Colgate-Palmolive, São Bernardo do Campo, SP, Brazil	Water, sorbitol, ethanol, hydrogen peroxide 1.5%, poloxamer 338, polysorbate 20, methyl salicylate, menthol, sodium saccharin, CI 42090
Whiteness Perfect 10%	FGM, Joinville, SC, Brazil	Carbamide peroxide, neutralized carbopol, potassium nitrate, sodium fluoride, humectant (glycol), deionized water

age.[10] The L* value of each specimen was used for stratified allocation of all samples among the experimental groups.

Group Divisions

Table 1 shows all products used in this study, including manufacturers and their components. Six groups of 20 specimens each were divided according to the proposed treatment:

- Group 1: Brushing with conventional fluoridated toothpaste (Colgate Fluoridated Toothpaste), the negative control.
- Group 2: Brushing with whitening toothpaste (Close Up White Now).
- Group 3: Immersion in whitening mouth rinse (Listerine Whitening - hydrogen peroxide 2%) for 1 minute, followed by brushing with conventional fluoridated toothpaste.
- Group 4: Immersion in whitening mouth rinse (Colgate Plax Whitening - hydrogen peroxide 1.5%) for 1 minute, followed by brushing with conventional fluoridated toothpaste and new immersion in Colgate Plax Whitening for 1 minute.
- Group 5: Immersion in experimental whitening mouth rinse prepared using 2 g polyvinylpyrrolidone (K29/32 Plasdone 2%) diluted in 100 mL of distilled water for 1 minute, followed by brushing with conventional fluoridated toothpaste.
- Group 6: Application of whitening gel (Whiteness Perfect - 10% carbamide peroxide) for 2 hours and immersion in artificial saliva for 22 hours. The procedure was performed once a day for 14 days and served as the positive control.

For brushing, stained specimens were brushed with soft electric toothbrushes. Eighty-four cycles of brushing were performed using 10 mL of a suspension containing 33% toothpaste[11] and artificial saliva. This was meant to simulate a six-week treatment period of two daily brushings of two minutes each.[12] Specimens were rinsed with water and color was measured. Then, 84 additional cycles were performed, corresponding to a 12-week treatment period, and the final color was measured.

The mouth rinses were used according to the manufacturer's recommendation. Artificial saliva was prepared according to the formulation of Gohring and others.[13] Specimens were stored in artificial saliva in the intermediate periods between testing procedures for all groups.

With L*a*b* values after the darkening of teeth (baseline values) and the values obtained after different periods of tested treatments, it was possible

Table 2: *Means and Standard Deviations Relative to Evaluated Parameters at Each Time*

Groups	ΔE		ΔL		Δb	
	6 weeks	12 weeks	6 weeks	12 weeks	6 weeks	12 weeks
1	3.92 ± 1.66[a]	3.47 ± 1.00[a]	–0.47 ± 2.70[abc]	–0.20 ± 1.36[a]	–2.59 ± 1.84[a]	–3.15 ± 0.96[a]
2	3.34 ± 1.09[a]	3.45 ± 0.99[a]	–0.79 ± 1.21[ac]	–0.27 ± 1.16[a]	–3.03 ± 1.04[a]	–3.22 ± 0.99[a]
3	4.49 ± v1.17[a]	6.12v ± 1.31[b]	1.12 ± 2.00[ab]	3.71 ± 2.18[bc]	–3.86 ±v1.09[ab]	–4.20 ± 1.70[ab]
4	4.36 ± 0.81[a]	6.30 ± 1.95[b]	1.15 ± 1.56[ab]	4.96 ± 2.70[c]	–3.82 ± 1.08[ab]	–3.05 ± 1.46[a]
5	4.28 ± v1.94[a]	3.93 ± 1.73[a]	–1.39 ± 2.48[c]	0.27 ± 2.53[a]	–3.38 ± 1.63[a]	–3.02 ± 1.65[a]
6	6.24 ± 2.73[b]	6.24 ± 2.73[b]	1.49 ± 3.22[b]	2.54 ± 2.43[b]	–5.07 ± 2.74[b]	–5.07 ± 2.74[b]

[a-c] *For a given time, values with different letter designations are significantly different ($p<0.05$).*

to calculate ΔE and then determine the efficacy after simulated treatments of 6 (ΔE1) and 12 weeks (ΔE2), according to the following formula:

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

On the other hand, Δb was calculated by subtracting the value of b* obtained after darkening and after different simulated periods of treatments, resulting in Δb1 for 6 weeks and Δb2 for 12 weeks. The same was done for ΔL and Δa.

For group 6, the ΔE, ΔL, Δa, and Δb values were calculated after 14 days of treatment. The data were statistically analyzed using one-way analysis of variance (ANOVA) to compare the color of darkened specimens with the color obtained after the use of different tested products for a simulated 6 and 12 weeks of treatment in groups 1 to 5, and 14 days in group 6. For identifying the differences, a Tukey test was applied ($\alpha = 0.05$).

RESULTS

The application of one-way ANOVA revealed significant differences among groups for ΔE, ΔL, and Δb for both 6 and 12 weeks (p=0.0001). For Δa, there were no significant differences for groups evaluated after the simulated 6 weeks (p=0.2434) and 12 weeks (p=0.1903).

Results of the Tukey test for ΔE1 and ΔE2 are shown in Table 2. After the simulated 6 weeks of treatment, groups 1 to 5 showed no significant differences among themselves and significantly lower color change than that obtained by group 6. After the simulated 12 weeks of treatment, groups 3 and 4 reached color changes similar to that of group 6.

The Tukey test for Δb1 revealed that specimens of group 6 presented significant differences compared with groups 1, 2 and 5 but did not show significant differences compared with groups 3 and 4. After the simulated 12 weeks of treatment, group 6 showed similar Δb values compared with group 3 and significantly higher values than other groups (Table 2).

After the simulated 6 weeks of treatment, group 6 presented significant differences of ΔL means compared with groups 2 and 5. After the simulated 12 weeks of treatment, groups 3, 4, and 6 showed better results than all other groups (Table 2).

DISCUSSION

Many substances have been used to produce staining *in vitro*, with coffee, red wine, and tea showing the best results.[14,15] In this study, a 24-hour coffee darkening period was chosen because maximum staining was obtained in a previous study with this time.[3]

We evaluated the effects of four whitening products in color of bovine teeth: three commercially available and one experimentally manipulated. Such products were compared with the 10% carbamide peroxide whitening gel (positive control) and to brushing with toothpaste without bleaching substances (negative control).

In the color space L*a*b*, L* indicates lightness, and a* and b* represent chromaticity coordinates: +a* indicates the red direction, –a* indicates the green direction, +b* indicates the yellow direction, and –b* indicates the blue direction. The increase in the a* and b* direction means that the point moves away from the center and increases color saturation.[16]

The toothpaste Close Up White Now has Blue Covarine Foam Technology[17] as the active agent, which has been shown to be deposited onto the tooth surface, altering the optical properties of the tooth by shifting the b* parameter from yellow to blue, which results in a visual perception of whitened tooth.[6] The efficacy of silica as an abrasive for gradual removal of extrinsic stains has been demonstrated previously.[18] Nevertheless, in the present study, the whitening blue covarine-based dentifrice presented no significantly different results for ΔE, ΔL, and Δb parameters compared with conventional fluoridated toothpaste.

Polyvinylpyrrolidone (PVP) (Plasdone K-29/32, ISP, Wayne, New Jersey, USA) is a water-soluble homopolymer, and it can be presented in various molecular weights and with several applications. PVP forms complexes with catechins, just as it does with many other compounds that cause discoloration, removing them from enamel. Although this polymer is thought to bind and remove stains in several oral care applications and to inhibit stain redeposition,[19] in this study, the mouth rinse manipulated with Plasdone K29/32 presented results that did not differ statistically from brushing with conventional fluoridated toothpaste. Because few studies have investigated this agent, it is suggested that further studies be performed with Peroxydone (ISP), which is the PVP associated with hydrogen peroxide.

The effectiveness of whitening mouthwashes are not discussed enough in literature. In a previous study, no significant bleaching effect was observed with the use of different peroxide-based whitening rinses on stained teeth after a 21-day treatment period.[20] On the other hand, Hasturk and others[21] showed that a 1.5% hydrogen peroxide mouth rinse used for 6 months was effective in reducing gingivitis and whitening teeth. In this study we obtained similar results with Colgate Plax Whitening and Listerine Whitening, as they showed color alteration similar to the 10% carbamide peroxide whitening gel.

Although Listerine Whitening and Plax Whitening have been effective as tooth whitening agents, care should be taken as the active agent in both mouth rinses is hydrogen peroxide. Because there is a concern regarding the possible tumor-promoting ability of this agent with the tobacco carcinogen DMBA (9,10-dimethyl-1,2-benzanthracene), patients should avoid alcohol and smoking during the treatment.[22] Nevertheless, hydrogen peroxide is present in low concentrations in both products (1.5% in Plax Whitening and 2% in the Listerine Whitening), which would not damage the mucosa.[21] Indeed, in a previous study, strong evidence for the safety of low-concentration, hydrogen peroxide–containing products was suggested, with no damage in oral hard and soft tissues and no significant risk of adverse long-term effects.[23]

The 10% carbamide peroxide was used as positive control because this substance has proved in previous studies to be safe and effective for dentist-supervised home bleaching. In addition, the bleaching effect caused by carbamide peroxide has been stable and long lasting.[24,25] Although 10% carbamide peroxide results in release of 3.5% hydrogen peroxide,[25] which is greater than that found in the mouth rinses tested, it is a safer alternative because it is applied in the form of gel in a tray, thus restricting the contact of hydrogen peroxide to the teeth and minimizing contact to adjacent gums. On the other hand, the mouth rinse is in contact with all the oral mucosa.

This *in vitro* study showed that simulated 12 weeks of treatment with mouthwashes containing hydrogen peroxide at low concentrations (Listerine Whitening and Plax Whitening) had results similar to treatment with 10% carbamide peroxide for 14 days. However, clinical studies are needed to confirm these results, as dilution of mouth rinses by the presence of saliva may alter their whitening effect. In addition, the longevity and stability of the whitening achieved with these products also need to be further investigated.

CONCLUSION

Within the limitations of this *in vitro* study, it can be concluded that

- The use of Listerine and Colgate Plax Whitening mouth rinses for 12 weeks presented similar color alteration compared with 14 days of 10% carbamide peroxide bleaching.
- The use of fluoridated conventional toothpaste, whitening toothpaste White Now, and experimental mouth rinse with Plasdone for 12 weeks showed

lower bleaching results for ΔE and ΔL parameters compared with other groups,.

Conflict of Interest

The authors certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 9 March 2012)

REFERENCES

1. Joiner A (2004) Tooth colour: a review of the literature *Journal of Dentistry* **32(Supplement 1)** 3-12.
2. Sharif N, MacDonald E, Hughes J, Newcombe RG, & Addy M (2000) The chemical stain removal properties of "whitening" toothpaste products: studies in vitro *British Dental Journal* **188 (11)** 620-624.
3. Sulieman M, Addy M, & Rees JS (2003) Development and evaluation of a method in vitro to study the effectiveness of tooth bleaching *Journal of Dentistry* **31(6)** 415-422.
4. Heymann HO (2005) Tooth whitening: facts and fallacies *British Dental Journal* **198(8)** 514.
5. Joiner A (2006) The bleaching of teeth: a review of the literature *Journal of Dentistry* **34(7)** 412-419.
6. Joiner A, Philpotts CJ, Alonso C, Ashcroft AT, & Sygrove NJ (2008) A novel optical approach to achieving tooth whitening *Journal of Dentistry* **36(Supplement 1)** S8-S14.
7. Collins LZ, Maggio B, Liebman J, Blanck M, Lefort S, Waterfield P, Littlewood D, Naeeni M, & Schafer F (2004) Clinical evaluation of a novel whitening gel, containing 6% hydrogen peroxide and a standard fluoride toothpaste *Journal of Dentistry* **32(Supplement 1)** 13-17.
8. Wiegand A, Vollmer D, Foitzik M, Attin R, & Attin T (2005) Efficacy of different whitening modalities on bovine enamel and dentin *Clinical Oral Investigations* **9(2)** 91-97.
9. Wiegand A, Drebenstedt S, Roos M, Magalhaes AC, & Attin T (2008) 12-month color stability of enamel, dentine, and enamel-dentine samples after bleaching *Clinical Oral Investigations* **12(4)** 303-310.
10. Bureau Central de la CIE (1978) Commission Internationale de L'Eclairage: Recommendations on uniform color spaces. Color difference equations. Psychometric color terms *Paris: Bureau Central de la CIE* pub 15 (E-13.11) 1971/(TC-1971.1973).
11. Ashcroft AT, Cox TF, Joiner A, Laucello M, Philpotts CJ, Spradbery PS, & Sygrove NJ (2008) Evaluation of a new silica whitening toothpaste containing blue covarine on the colour of anterior restoration materials in vitro *Journal of Dentistry* **36(Supplement 1)** S26-S31.
12. McCracken GI, Janssen J, Swan M, Steen N, de Jager M, & Heasman PA (2003) Effect of brushing force and time on plaque removal using a powered toothbrush *Journal of Clinical Periodontology* **30(5)** 409-413.
13. Gohring TN, Zehnder M, Sener B, & Schmidlin PR (2004) In vitro microleakage of adhesive-sealed dentin with lactic acid and saliva exposure: a radio-isotope analysis *Journal of Dentistry* **32(3)** 235-240.
14. Konica Minolta Sensing (2007) Precise color communication: Color control from perception to instrumentation *Osaka, Japan: Konica Minolta Sensing Inc*.
15. Bagheri R, Burrow MF, & Tyas M (2005) Influence of food-simulating solutions and surface finish on susceptibility to staining of aesthetic restorative materials *Journal of Dentistry* **33(5)** 389-398.
16. Omata Y, Uno S, Nakaoki Y, Tanaka T, Sano H, Yoshida S, & Sidhu SK (2006) Staining of hybrid composites with coffee, oolong tea, or red wine. *Dental Materials Journal* **25(1)** 125-131.
17. How Closeup White Now Works (2011); Retrieved online June 6, 2011 from: http://www.closeupwhitenow.com/.
18. Joiner A, Philpotts CJ, Ashcroft AT, Laucello M, & Salvaderi A (2008) In vitro cleaning, abrasion and fluoride efficacy of a new silica based whitening toothpaste containing blue covarine *Journal of Dentistry* **36(Supplement 1)** S32-S37.
19. ISP Corporation (2011) Polymers for oral care – Products and applications guide; Retrieved online June 6, 2011 from: http://online1.ispcorp.com/Brochures/Oral%20Care/Polymers%20for%20Oral%20Care.pdf/
20. Potgieter E, & Grobler SR (2011) Whitening efficacy of three over-the-counter oral rinses *South African Dental Journal* **66(3)** 128-131.
21. Hasturk H, Nunn M, Warbington M, & Van Dyke TE (2004) Efficacy of a fluoridated hydrogen peroxide-based mouthrinse for the treatment of gingivitis: a randomized clinical trial *Journal of Periodontology* **75(1)** 57-65.
22. Naik S, Tredwin CJ, & Scully C (2006) Hydrogen peroxide tooth-whitening (bleaching): review of safety in relation to possible carcinogenesis *Oral Oncology* **42(7)** 668-674.
23. Walsh LJ (2000) Safety issues relating to the use of hydrogen peroxide in dentistry. *Australian Dental Journal* **45(4)** 257-269; quiz 89.
24. Meireles SS, Santos IS, Bona AD, & Demarco FF (2010) A double-blind randomized clinical trial of two carbamide peroxide tooth bleaching agents: 2-year follow-up *Journal of Dentistry* **38(12)** 956-963.
25. American Dental Association (2011) Retrieved online Jun 6, 2011 from: http://www.ada.org/sections/about/pdfs/HOD_whitening_rpt.pdf