Original Research Paper

Volume - 14 | Issue - 01 | January - 2024 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Dentistry

COMPARISON OF WHITENING TOOTHPASTES ON ENAMEL ROUGHNESS AND MICRO-HARDNESS - AN INVITRO STUDY

Dr. Preeti S Navalagunda*	Post Graduate, MDS, Department of Conservative Dentistry and Endodontics, D A Pandu Memorial RV Dental College, Bangalore. *Corresponding Author
Dr. B. S. Keshava Prasad	MDS, Professor and Head of the Department, Department of Conservative Dentistry and Endodontics, D A Pandu Memorial RV Dental College, Bangalore
Dr. Tarun G S	MDS, Reader, Department of Conservative Dentistry and Endodontics, D A Pandu Memorial RV Dental College, Bangalore.
Dr. Rashmi G Shetty	MDS, Reader, Department of Conservative Dentistry and Endodontics, D A Pandu Memorial RV Dental College, Bangalore.
Dr Sahana Umesh	MDS, Lecturer, Department of Conservative Dentistry and Endodontics, D A Pandu Memorial RV Dental College, Bangalore.

ABSTRACT **Objective:** The growing demand for an enhanced aesthetic appearance has led to the development of whitening products in the market. The whitening effects are usually achieved by incorporation of bleaching and abrasive components. An ideal whitening toothpaste should remove stains effectively, with minimal effect on tooth structure. This study was done to evaluate the effects of different whitening toothpaste on enamel roughness and micro hardness. **Methodology:** 24 human premolar teeth were collected for this study and then randomly divided into 3 groups (n=8) Group I: Whitening toothpaste containing peroxide, Group II: Whitening toothpaste containing abrasives, Group III: Regular toothpaste. Tooth brushing was performed for 30 days and then subjected to surface roughness (Ra) and micro hardness test. **Results:** There were statistically significant differences in enamel roughness which had increased after 1 month equivalent tooth brushing between three groups. There were significant differences in enamel micro hardness values for all groups which showed a decrease in micro hardness. **Conclusion:** Brushing teeth with whitening toothpaste for an extended period of time increases enamel roughness and decreases enamel micro hardness, increasing the risk of caries.

KEYWORDS : Abrasives; Micro hardness; Peroxide; Stains, Surface roughness; Teeth whitening.

INTRODUCTION

During the last several years, there has been an advent growth in the field of dentistry because of increasing awareness about oral health, aesthetics, modern technology and the numerous materials available. Due to social influence and self-consciousness, the public has come to demand whiter, more perfect smiles, which boosts self-esteem, and in response, many choices for teeth whitening have come into existence.

The major indication for tooth whitening is discolouration. The colour of teeth is influenced by the intrinsic colour of the teeth as well as the presence of any extrinsic stains that may occur on the tooth surface[1]. Intrinsic stains are pigments inside the tooth tissues caused by medications such as tetracycline and fluorine; odontogenesis disorders such as amelogenesis and dentinogenesis imperfecta; dental trauma; and local causes such as pulpal necrosis or haemorrhage, poorly performed endodontic treatment, or root resorption. Extrinsic stains are associated with the deposition of chromogenic substances on the enamel surface, such as those from the diet, cigarette intake, or the spontaneous deposition of pigments produced by microorganisms in the biofilm[2-5].

Tooth whitening procedures can be broadly divided into two types: bleaching and routine prophylactic therapies such as brushing with whitening toothpaste[3]. Commercially, many products such as whitening toothpaste, OTC whitening strips and gels, whitening rinses and tray based tooth whiteners are available which are marketed as tooth whiteners. Whitening toothpaste removes the extrinsic stains either mechanically or chemically. Whitening paste either has abrasives such as hydrated silica, sodium bicarbonate or chemical such as hydrogen peroxide, calcium peroxide or optical modifiers such as blue covarine.

An effective whitening toothpaste should successfully remove stains while having minimal impact on tooth structure. As a result, the influence of whitening toothpaste on enamel characteristics is critical. Micro hardness and roughness are two important properties that are related to mineral content loss or gain in tooth structure.[3,6]

MATERIALS AND METHOD

This was an in-vitro experimental study.

Preparation of sample

A total of 24 premolar teeth extracted for periodontal and orthodontic purposes were collected for this study with informed consent. All teeth were carefully inspected to verify there were no cavities, fillings, or fractures (Figure 1).

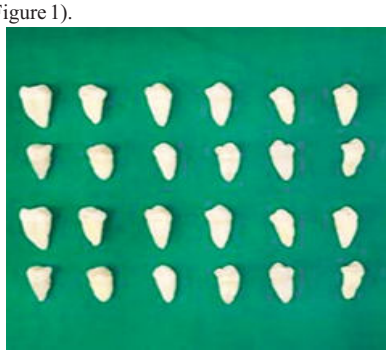


Figure 1: Sample collected

Figure 2: Teeth mounted in wax sheet by embedding the roots

Teeth were cleaned thoroughly, disinfected in 5% sodium hypochlorite solution for 1 hour and was stored in distilled water. Teeth were mounted in wax sheet by embedding the roots and lingual portion of crown(Figure 2). 24 premolar teeth were divided into 3 groups (n=8).

METHODOLOGY

Baseline data of surface roughness and micro hardness of enamel was collected for each sample before any intervention. Then tooth brushing was performed using an electric tooth brush for 5 seconds twice a day because a typical tooth surface in vivo will be brushed on an average for 5 seconds, twice a day. Samples in group 1 (n=8) were brushed with toothpaste containing abrasives as a whitening agent. Samples in group 2 (n=8) were brushed with toothpaste containing peroxide as a whitening agent and samples in group 3 (n=8) were brushed using toothpaste without any specific whitening agent in it which is kept as a control group. The samples from each group were dried using absorbent paper and then subjected to surface roughness and micro hardness tests after 30 days. Vicker's hardness tester (Figure 3) was used to determine enamel micro hardness and profilometer (Figure 4) was used to determine surface roughness and samples were observed under Scanning Electron Microscope (Figure 5) to compare surface roughness visually. One-way ANOVA test followed by Tukey's post hoc test was used to compare the mean Micro Hardness and surface roughness values between 3 groups.

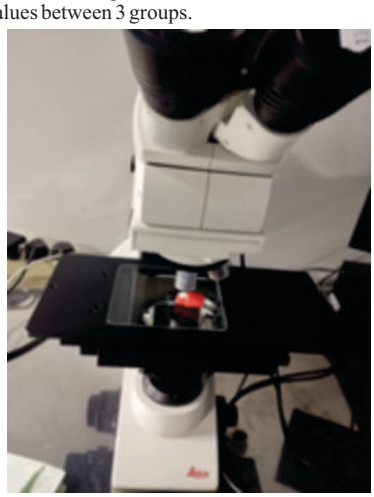


Figure 3: Vicker's hardness tester

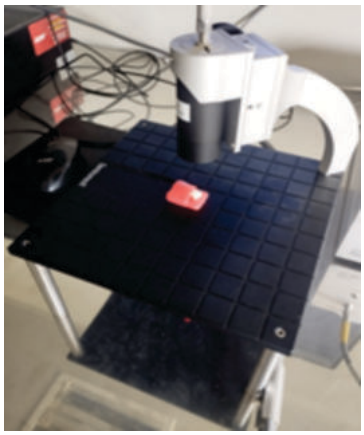


Figure 4: Profilometer

Figure 5: Scanning Electron Microscope

Composition of the toothpaste (Table 1)

Sl.no	Material	Composition
1	Whitening toothpaste containing abrasive	Aqua, sorbitol, silica, Xylitol, nano hydroxyapatite, glycerine, PEG8, PVP, cocamidopropyl betaine, Sodium ma=ethyl cocoyl taurate, potassium citrate,sodium tripolyphosphate, xanthane gum, zinc citrate, sodium hexametaphosphate, titanium dioxide, tetra-potassium pyrrophosphate, sodium saccharin, sodium benzoate, lactoferrin, fragrance, C1741160
2	Whitening toothpaste containing peroxide	Propylene glycol, calcium pyrophosphate, glycerin, PEG/PPG-116/66 copolymer, PEG-12, PVP, silica, flavor, sodium lauryl sulfate, tetra-sodium pyrophosphate,hydrogen peroxide, disodium pyrophosphate, silica, sodium saccharin, sucralose, BHT, water
3	Control group toothpaste	Calcium carbonate, hydrated silica,sodium lauryl sulphate, sorbitol, water, sodium silicate, cellulose gum, DMDM hydantoin, flavor, sodium saccharine, CI 77891, 1.12% sodium monofluorophosphate, potassium citrate

RESULTS

Surface micro hardness:

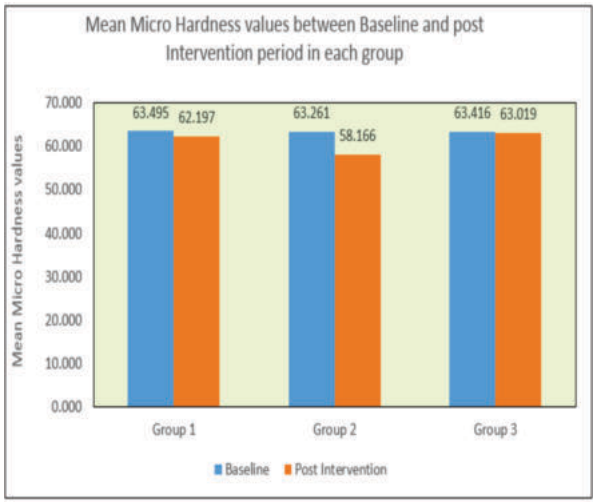
Mean Micro Hardness values between 3 groups at the Baseline period was done using One-way ANOVA Test and mean Micro Hardness values between 3 groups at post-intervention period was done using One-way ANOVA Test followed by Tukey's post hoc Test and then the mean Micro Hardness values between Baseline and post Intervention period in each group was done using Student Paired t Test.

Table 2 describes the changes in surface micro hardness values (Graph 1 shows graphical representation). There were statistically significant differences in micro hardness between the three groups after one month of tooth brushing. The mean Micro Hardness values did not show any significant difference between the 3 groups at Baseline period. The test results demonstrated that the mean Micro Hardness values showed a statistically significant difference between the 3 groups at the post-intervention period at $p<0.001$. Multiple comparisons between groups revealed that the mean values in Group 2 was significantly lower as compared to Group 1 and Group 3 and it was statistically significant at $p<0.001$. This was followed by Group 1 showing significantly higher mean Micro Hardness values as compared to Group 3 and it was statistically significant at $p=0.005$. This infers that the mean Micro Hardness values was significantly least in Group 2, followed by Group 1 and highest in Group 3.

The mean Micro Hardness values in all the 3 groups during Post-Intervention period showed significantly lesser values as compared to Baseline period and the mean differences were statistically significant at $p<0.001$ and $p=0.001$ respectively. However, the mean difference in Micro Hardness values for Group 3 was less as compared to Group 1 and Group 2.

Table 2: Comparison of mean Micro Hardness values between Baseline and post Intervention period in each Group using the Student Paired t Test

Groups	Time	N	Mean	SD	Mean Diff	p-value
Group 1	Baseline	8	63.495	0.464	1.2981	<0.001*
	Post Intervention	8	62.197	0.464		
Group 2	Baseline	8	63.261	0.343	5.0951	<0.001*
	Post Intervention	8	58.166	0.404		
Group 3	Baseline	8	63.416	0.508	0.3964	0.001*
	Post Intervention	8	63.019	0.506		



Graph 1: Mean Micro Hardness values between Baseline and post Intervention period in each group

Surface roughness

Mean Surface Roughness values between 3 groups at baseline period was done using the One-way ANOVA Test and mean Surface Roughness values between 3 groups at the post-intervention period using One-way ANOVA Test followed by Tukey's post hoc Test and then comparison of mean roughness values between Baseline and post Intervention period in each group was done using Student Paired t Test. Table 3 and 4 describe the changes in enamel roughness values (Graph 2 and 3 shows graphical representation respectively). There were statistically significant differences in roughness average between the three groups after one month of tooth brushing. The test results demonstrated that the mean Ra and Rq values did not show any significant difference between the 3 groups at Baseline period. The test results demonstrated that the mean Ra values showed a statistically significant difference between the 3 groups at post-intervention period at $p<0.001$. Multiple comparison between groups revealed that the mean Ra values in Group 2 was significantly highest as compared to Group 1 and Group 3 and it was statistically significant at $p<0.001$. This was followed by Group 1 showing significantly higher mean Ra values as compared to Group 3 and it was statistically significant at $p<0.001$. This infers that the mean Ra values was significantly highest in Group 2, followed by Group 1 and least in Group 3.

The test results demonstrated that the mean Rq values showed a statistically significant difference between the 3 groups at post-intervention period at $p<0.001$. Multiple comparisons between groups revealed that the mean Rq values in Group 2 was significantly highest as compared to Group 1 and Group 3 and it was statistically significant at $p=0.007$ and $p<0.001$. This was followed by Group 1 showing significantly higher mean Rq values as compared to Group 3 and it was statistically significant at $p<0.001$. This infers that the mean Rq values was significantly highest in Group 2, followed by Group 1 and least in Group 3.

Scanning electron microscope analysis

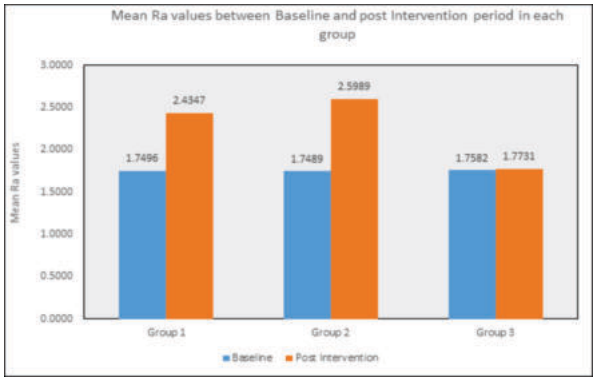
The difference in the topographic roughness of the enamel is shown in figure 6, which reveals the surface was smooth before intervention of the study when compared to post intervention. Surface roughness was highest in group 2, that is toothpaste containing peroxide, and then in group 1, that is toothpaste containing abrasives and least in the control group.

Table 3: Comparison of mean Ra values between Baseline and post Intervention period in each group using the Student Paired t Test

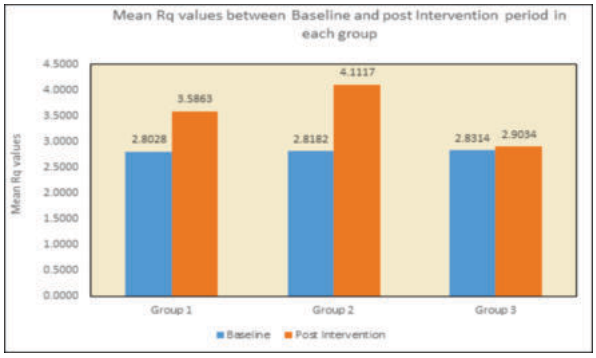
Groups	Time	N	Mean	SD	Mean Diff	p-value
Group 1	Baseline	8	1.7496	0.0170	-0.6851	<0.001*
	Post Intervention	8	2.4347	0.0761		
Group 2	Baseline	8	1.7489	0.0021	-0.8500	<0.001*
	Post Intervention	8	2.5989	0.0470		
Group 3	Baseline	8	1.7582	0.0358	-0.0150	0.002*
	Post Intervention	8	1.7731	0.0374		

Table 4: Comparison of mean Rq values between the Baseline and post Intervention period in each group using the Student Paired t Test

Groups	Time	N	Mean	SD	Mean Diff	p-value
Group 1	Baseline	8	2.8028	0.1760	-0.7835	<0.001*
	Post Intervention	8	3.5863	0.0663		
Group 2	Baseline	8	2.8182	0.1077	-1.2935	<0.001*
	Post Intervention	8	4.1117	0.5311		
Group 3	Baseline	8	2.8314	0.0559	-0.0720	0.01*
	Post Intervention	8	2.9034	0.0145		



Graph 2: Mean Ra values between Baseline and post Intervention period in each group



Graph 3: Mean Rq values between Baseline and post Intervention period in each group

SEM reveals the following

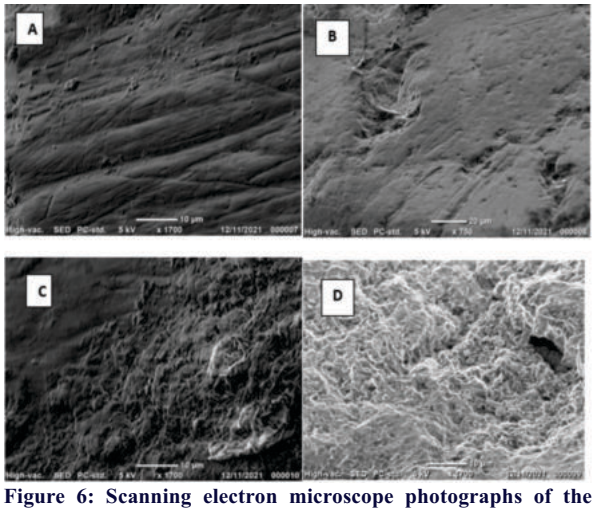


Figure 6: Scanning electron microscope photographs of the enamel. A- Baseline, B- Control group, C- Abrasive containing group, D- Peroxide containing group

DISCUSSION

Whitening toothpaste is easily accessible to patients who seek whiter

teeth at a lesser cost. The primary function of whitening toothpaste is to remove stains mechanically or chemically. Whitening toothpaste contains abrasives such as hydrated silica, calcium carbonate, and perlite, which, when combined with toothpaste bristles, remove externally discoloured plaque but do not change the colour of the teeth. Furthermore, whitening toothpaste may contain bleaching chemicals, most frequently calcium peroxide or hydrogen peroxide, to enhance stain removal. They have the ability to break down the stain molecule, resulting in a bleaching effect. However, because peroxide concentrations in toothpaste are low and only comes into contact with teeth for a brief period of time, there is no evidence that such toothpaste can improve internal tooth colour. They are certain to bleach the pellicle or stain on the tooth surface.[3] An effective whitening toothpaste should successfully remove stains while having little influence on tooth structure. As a result, the effect of whitening toothpaste on enamel characteristics is significant. Roughness and micro hardness are two essential properties of materials that are related to mineral content loss or gain in tooth structure[4,7,8].

The increasing roughness average of group 1 and group 2 compared to control group 3 and baseline data were caused by the mechanism of active ingredients in the toothpaste, either mechanical or chemical agent. Group 3, as the positive control, increased the enamel roughness because it contained abrasives, such as hydrated silica and calcium carbonate. Group 2, which contains peroxide as the whitening agent, had the highest increasing roughness average, but not statistically significant different compared with group 1, which also had increasing roughness, which contains abrasives as the whitening agent after a month of tooth brushing. This may promote plaque accumulation, maturation, and retention, increasing the risk of dental caries and periodontal inflammation and contributing to tooth discolouration [3,6,9-12].

In group 2, there was a decrease in enamel micro hardness value. It means that, there was a mineral loss in enamel specimens brushed with toothpaste containing peroxide as whitening agent. A decrease in enamel micro hardness value in group 1, is influenced by abrasive whitening agent present in the toothpaste. Group 3 toothpaste almost had no significant difference in micro hardness, although it contains some of the abrasive agents, could be because of the presence of fluoride in its composition.

Surface roughness and micro hardness are important indicators of mineral content loss or gain in tooth structure, and can be used to demonstrate the unfavourable effect of whitening toothpastes. It is crucial to emphasise that the whitening toothpaste's composition, as well as the amount and type of whitening agent used, may alter the surface roughness and micro hardness of the enamel surface. Furthermore, the simulation of toothbrushing, as well as the duration and frequency of its use also influence the outcome[4,13-15].

CONLUSION

Considering the limitations this in vitro study concluded that using tested whitening toothpaste for an extended period of time caused an increase in enamel roughness and a decrease in enamel micro hardness. As a result, whitening toothpaste should be used with caution due to its propensity to enhance the vulnerability of the enamel surface, increasing the risk of caries. Patients should be informed of the potential risks of tooth whitening and instructed on how to identify negative outcomes so that they can seek expert care if necessary.

REFERENCES

1) Hilgenberg SP, Pinto SC, Farago PV, Santos FA, Wambier DS. Physical-chemical characteristics of whitening toothpaste and evaluation of its effects on enamel roughness. Brazilian oral research. 2011;25:288-94.
2) de Freitas MR, de Carvalho MM, Liporoni PC, Fort AC, Moura RD, Zanatta RF. Effectiveness and adverse effects of over-the-counter whitening products on dental tissues. Frontiers in Dental Medicine. 2021 Jun 25;2:687507.
3) Anton R, Eva G, Grace R, Melissa A, Diah AM. Potential side effects of whitening toothpaste on enamel roughness and micro hardness. International Journal of Clinical Preventive Dentistry. 2015;11(4):239-42.
4) Jamwal N, Rao A, Shenoy R, Pai M, Aparna KS, Avinash BR. Effect of whitening toothpaste on surface roughness and microhardness of human teeth: a systematic review and meta-analysis. F1000Research. 2022;11.
5) Alpan AL, Özdede M. Investigation of the effects of whitening toothpastes on enamel and cementum surfaces. Journal of Stomatology. 2020 Mar 1;73(2):55-64.
6) Özkan P, Kansu G, Özak ŞT, KurtulmuŞ-Yilmaz S, Kansu P. Effect of bleaching agents and whitening dentifrices on the surface roughness of human teeth enamel. Acta Odontologica Scandinavica. 2013 Jan 1;71(3-4):488-97.
7) Shamel M, Al-Ankily MM, Bakr MM. Influence of different types of whitening tooth pastes on the tooth color, enamel surface roughness and enamel morphology of human teeth. F1000Research. 2019;8.
8) Suriyasangpetch S, Sivavong P, Niyatiwatchanchai B, Osathanon T, Gorwong P, Pianmee C, Nantanapiboon D. Effect of whitening toothpaste on surface roughness and colour alteration of artificially extrinsic stained human enamel: in vitro study. Dentistry Journal. 2022 Oct 13;10(10):191.
9) Joiner A. Whitening toothpastes: a review of the literature. Journal of dentistry. 2010 Jan 1;38:e17-24.
10) Nam SH, Kwun HS, Cheon SH, Kim HY. Effects of whitening toothpaste on color change and mineral contents of dental hard tissues. Biomed. Res. 2017 Jan 1;28:3832-6.
11) Shang R, Kaisarly D, Kunzelmann KH. Tooth whitening with an experimental toothpaste containing hydroxyapatite nanoparticles. BMC oral health. 2022 Dec;22(1):1-0.
12) Aydin N, Karaoglanoglu S, Oktay EA, Ersöz B. Determination of the whitening effect of toothpastes on human teeth. Odovtos-International Journal of Dental Sciences. 2022;24(1):67-75.
13) Epple M, Meyer F, Enax J. A critical review of modern concepts for teeth whitening. Dentistry journal. 2019 Sep;7(3):79.
14) Korsuwannawong S, Vajrabhaya LO, Teinchai C, Salee W. Comparison of Enamel Surface Roughness after Brushing with Herbal and Non-herbal Toothpastes. World Journal of Dentistry. 2020 Sep 30;11(3):215-20.
15) Benahmed AG, Gasmi A, Menzel A, Hrynovets I, Chirumbolo S, Shanaida M, Lysiuk R, Shanaida Y, Dadar M, Bjørklund G. A review on natural teeth whitening. Journal of oral biosciences. 2022 Mar 1;64(1):49-58.