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The Effect of Bleaching Agent on the Surface Texture of Light Curing Nanoionomer Restorative Material- An in Vitro Study Under Scanning Electron Microscope

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Abstract: *Objective of the study:* The objective of this in-vitro study is to evaluate the effect of 15% Carbamide peroxide on the surface texture of the light curing nano-ionomer restorative material, under scanning electron microscope, after bleaching at different time periods after bleaching. *Methodology:* 80 samples of Light-curing nano-ionomer restorative material were randomly divided into 4 groups. Each group consists of 20 samples. Out of these 20 samples, 10 were cured under Mylar Strip and 10 samples were polished with Soflex. Bleaching gel was applied on the top surface of 60 samples. Bleaching was done for duration of 8 hours per day for a period of 7days. The prepared samples were tested at different time intervals of 8 hours, 24 hours and 1 month after bleaching procedure is completed. Surface texture of each sample before and after bleaching will be seen under Scanning electron microscope at 200x and 2000x magnification. *Results:* Fischer's exact test shows that there was no effect of bleaching on the surface texture of Soflex polished samples of Nano-ionomer restorative cement while the Mylar finished samples were affected by bleaching.
Key words: Nano-ionomer restorative material, Mylar strip, Soflex, Carbamide peroxide.

Introduction

Discolored teeth, especially in the anterior region, can result in considerable cosmetic impairment. Besides invasive therapies, such as crowns or the placement of veneers, the whitening of teeth is an alternative therapeutic method. In contrast to crowns or veneering, whitening of teeth is relatively non-invasive and conserves dental hard tissue [1]. Although bleaching is safe to soft tissues from a procedural standpoint, but it may not be safe for dental materials. The effects of such strong oxidizing agents on the physico-mechanical properties of restorative materials have, however not been widely studied. Surface roughness of restorations is one clinical important physical property that warrants investigation [2]. As surface roughness of the restoration plays a major role in the formation of biofilms and bacterial adhesion that may lead to gingival inflammation and caries [3]. Glass-ionomer cements were first developed by Wilson and Kent in 1969 and have been widely used in dentistry in a variety of applications [4]. Recently, a new category of glass ionomer cements were developed and named nanoGIC. Due to their small size, the incorporation of nanoparticles into glass powder of glass ionomers, led to wider particle size distribution (the average particle size of glass ionomer particles were around 10-20µm) which resulted in higher mechanical values. Consequently they can occupy the empty spaces between the Glass ionomer particles and act as reinforcing material in the composition of the glass-ionomer cements [5]. Although restoratives that are cured against a Mylar strip are not devoid of surface flaws, they impart the smoothest surface possible. Despite careful placement of matrixes, the removal of excess material and contouring of restorations is usually necessary clinically. This requires some degree of finishing and polishing that violates the smoothness obtained with a matrix [6]. Proper finishing and polishing of dental restorations are important aspects of clinical restorative procedures that enhance both esthetics and longetivity of restored teeth [7]. The present study evaluated the effect of 15% Carbamide peroxide on the surface texture of Mylar strip cured samples and Soflex polished samples of light curing nano glass ionomer cement at different time intervals under a Scanning electron microscope.

Materials and Methods

This study was carried out in the Department of Conservative Dentistry and Endodontics, and Department of Oral Pathology, Krishnadevaraya College of Dental Sciences, Bangalore and Indian Institute of Science. Thermoforming sheets were used for preparation of the sample. Each sheet measured 5 inches in length and 5 inches in breadth and 2mm in thickness. 40 holes were drilled in thermoforming sheets; each hole measured about 5mm in diameter and 2mm in depth. *Restoration of the sample:* Ketac N 100 nano ionomer primer was applied to the walls of the hole using a fiber tip. The primed surface was dried by air syringe for 10 seconds. After drying, the primed surface it was light cured for 10 seconds as per manufacturer's instruction. Then the sheet was positioned on transparent matrix strip lying on a glass slab. Two pastes of the nano ionomer restorative material were mixed for 20sec using a cement spatula. Mixed cement was then inserted into the prepared hole in one increment of 2mm thickness. After inserting the material into the holes, a transparent plastic matrix strip was put over them and a glass slide was secured in order to flatten the surface. Every sample was light-cured for 40 seconds as per manufacturer's instruction. A total of 40 samples were prepared from the thermoforming sheet. The samples were then removed from the sheets and each sample was divided into two halves using a disc mounted on a micromotor hand piece such that 80 samples were obtained, which were semicircle in shape with radius of 2.5mm and 2mm thickness. These 80 samples were randomly divided into 4 groups. Each group consists of 20 samples. Out of these 20 samples, 10 samples which were cured under Mylar Strip was kept aside and 10 samples were polished with Soflex. *Polishing procedure:* For Soflex polishing, the discs in the kit were attached by a metal hub to the autoclavable metal mandrel. Polishing motion was unidirectional using light pressure, keeping the surface of the sample and discs dry. The medium grit disc was used for gross contouring. The fine grit and superfine grit disc was used to finish. The time period and number of strokes was according to manufacturer's instruction. After the groupings were made bleaching procedure was initiated. Group 1(control group) no bleaching was performed. The following groups were bleached: Group 2, 3 & 4. *Bleaching procedure:* All samples were stored in distilled water at room temperature for 24hours before bleaching procedure was initiated Bleaching was done for a duration of 8 hours per day for a period of 7days. Bleaching gel was applied on the top surface of 60 samples. The amount of bleaching agent used was such that it covered the top surface of the samples. At end of every bleaching procedure, the treated specimens were washed under distilled water using a soft toothbrush and placed in fresh distilled water until the next application. After the end of every test procedure, the samples were cleaned in an ultrasonic cleanser for 5 minutes. The prepared samples were tested at different time intervals of 8 hrs, 24 hrs and one month later (Table 1).

Table 1: The prepared samples were tested at different time intervals as follows:

	Sample size	Polishing system	Tested time intervals
Group 1	20	10 samples cured under Mylar strip. 10 samples polished using Soflex	No bleaching is performed
Group 2	20	10 samples cured under Mylar strip. 10 samples polished using Soflex	Evaluated 8 hours after bleaching procedure is completed.
Group 3	20	10 samples cured under Mylar strip. 10 samples polished using Soflex	Evaluated 24 hours after bleaching procedure is completed
Group 4	20	10 samples cured under Mylar strip. 10 samples polished using Soflex	Evaluated 1 month after bleaching procedure is completed

They were then attached to aluminum stubs and sputter coated with gold. Surface texture of each sample before and after bleaching was seen under SEM at 200x and 2000x magnification and observations are made as follows:

The SEM observations were evaluated and classified into 3 categories:

-Without any change (0)

-With minor changes (1)

-With major changes (2)

The criteria that were used for differentiating the minor from major changes were as follows:

Minor changes were scored as 1: It showed negligible changes in surface texture. It showed a minor alteration in surface morphology / surface roughness. These changes would not require replacement of the restorations in clinical practice.

Major changes were scored as 2: It showed loss of resin parts or those that were detrimental to the material and would require replacement of the material, if used in a restoration**.** The readings obtained were tabulated. The results were evaluated statistically by Fisher's Exact test.

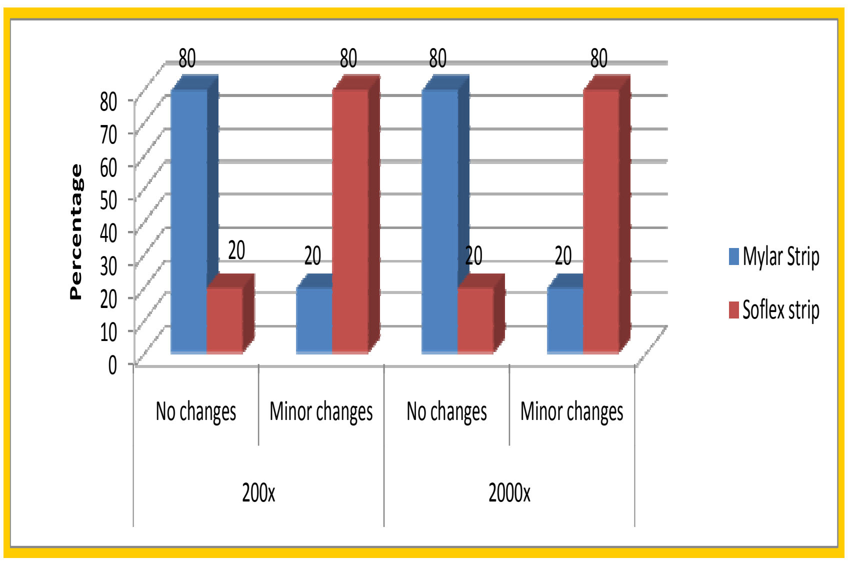
Results

On comparing SEM pictures of group 1, 20% of samples cured under Mylar strip had minor changes in the surface texture; where as 80% of Soflex polished samples had minor changes both at 200x and 2000x magnification. This difference in surface texture between samples cured by Mylar strip and Soflex was found to be statistically significant using fisher's exact test, $p<0.05$ (Table 2, graph 1 and Figures 1, 2, 3 and 4).

Table 2: Comparision of Sem Scores for Group 1 (without bleaching):

			200X			2000x		
			0	1	n	0	1	n
Study method	Mylar strip	Count	8	2	10	8	2	10
		% within finishing procedure	80.0%	20.0%	100.0%	80.0%	20.0%	100.0%
	Soflex	Count	2	8	10	2	8	10
		% within finishing procedure	20.0%	80.0%	100.0%	20.0%	80.0%	100.0%
Total		Count	10	10	20	10	10	20
		% within finishing procedure	50.0%	50.0%	100.0%	50.0%	50.0%	100.0%

Graph 1: Comparision of Sem Scores for Group 1



Figures: Mylar strip finished samples

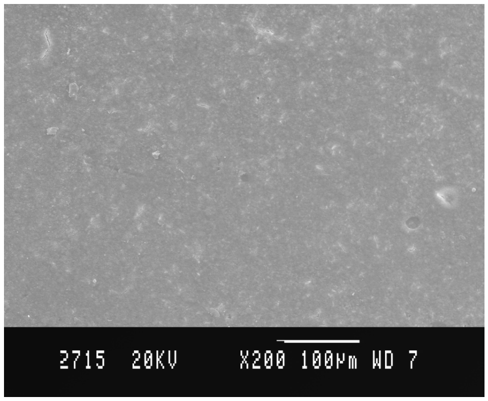


Figure: 1 at 200X

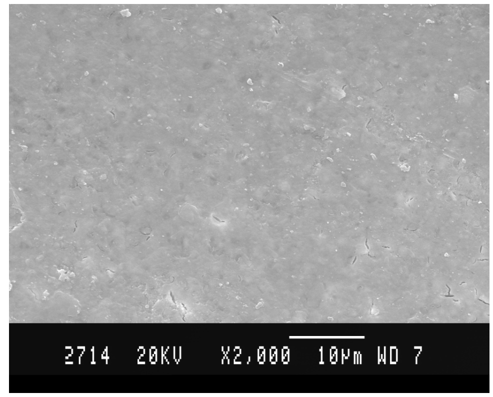


Figure: 2 at 2000X

Soflex polished samples

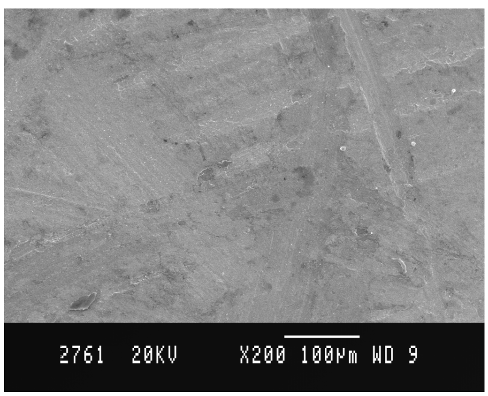


Figure: 3 at 200X

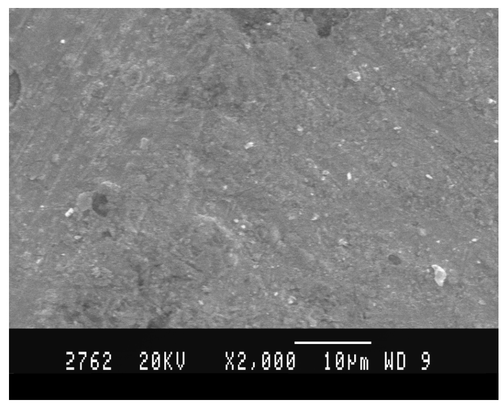


Figure: 4 at 2000X

On comparing SEM pictures of group 2, 70% of samples cured under Mylar strip had minor changes in the surface texture, where as all Soflex polished samples had minor changes both at 200x and 2000x magnification. This difference in surface texture between samples cured by Mylar strip and Soflex was not found to be statistically significant using fisher's exact test, $p>0.05$(Table 3).

Table 3: Comparision of Sem Scores for Group 2 (8 hours after bleaching):

			200X			2000x		
			0	1	n	0	1	n
Study method	Mylar strip	Count	3	7	10	3	7	10
		% within finishing procedure	30.0%	70.0%	100.0%	30.0%	70.0%	100.0%
	Soflex	Count	0	10	10	0	10	10
		% within finishing procedure	0%	100.0%	100.0%	0%	100.0%	100.0%
Total		Count	3	17	20	3	17	20
		% within finishing procedure	15.0%	85.0%	100.0%	15.0%	85.0%	100.0%

On comparing SEM pictures of group 3, 70% of samples cured under Mylar strip had minor changes in the surface texture at 200x and 80% had minor changes at 2000x. However all Soflex polished samples had minor changes at both magnifications. This difference in surface texture between samples cured by Mylar strip and Soflex was not found to be statistically significant using fisher's exact test, $p>0.05$ (Table 4).

Table 4: Comparision of Sem Scores for Group 3 (24 hours after bleaching):

			200X			2000x		
			0	1	n	0	1	n
Study method	Mylar strip	Count	3	7	10	2	8	10
		% within finishing procedure	30.0%	70.0%	100.0%	20.0%	80.0%	100.0%
	Soflex	Count	0	10	10	0	10	10
		% within finishing procedure	0%	100.0%	100.0%	0%	100.0%	100.0%
Total		Count	3	17	20	2	18	20
		% within finishing procedure	15.0%	85.0%	100.0%	10.0%	90.0%	100.0%

On comparing SEM pictures of group 4, all samples in both the categories had minor changes at both magnifications (Table 5).

Table 5: Comparision of Sem Scores for Group 4 (1 month after bleaching):

			200X		2000X	
			1	Total	1	Total
Study method	Mylar strip	Count	10	10	10	10
		% within finishing procedure	100.0%	100.0%	100.0%	100.0%
	Soflex	Count	10	10	10	10
		% within finishing procedure	100.0%	100.0%	100.0%	100.0%
Total		Count	20	20	20	20
		% within finishing procedure	100.0%	100.0%	100.0%	100.0%

Discussion

Home vital tooth bleaching, over last decade, has attracted the interest of patients and dentists due to its high success rates, ease of use and media publicity. This procedure utilizes low concentrations of hydrogen peroxide (3% to7%) or Carbamide peroxide (10% to 20%).[2] Carbamide peroxide is also known as perhydrol urea, hydrogen peroxide Carbamide, urea peroxide, percarbamide and urea hydrogen peroxide [8]. These Carbamide peroxide solutions are very unstable and immediately dissociates into their constituent parts on contact with tissue or saliva [9]. Carbamide peroxide solution breaks down into urea and hydrogen peroxide. The 10% to 16% Carbamide peroxide solution dissociates into 3% to 5% hydrogen peroxide and 7% to 9% urea. The urea further breaks down into carbon dioxide and ammonia. Hydrogen peroxide breaks down into oxygen and water, and liberates the chemically reactive free radical HO2- perhydoxyl for short periods [8]. Hydrogen peroxide acts as a strong oxidizing agent through the formation of free radicals, reactive oxygen molecules, and hydrogen peroxide anions. These reactive molecules attack the long-chained, dark-colored chromophore molecules and split them into smaller, less-colored and more diffusible molecules [10]. In the present study, 15% Carbamide peroxide was applied on the surface of newly introduced esthetic restorative materials i.e. nano-ionomer restorative material (KETAC N 100, 3M ESPE) for 8 hours per day, for one week, following the manufacturer's recommendation The effect of this bleaching agent on the surface texture was checked at different time intervals under Scanning electron microscope at 200X and 2000X magnifications. The surface texture of tooth-colored restorative materials affects the lifespan of the restorations. The presence of surface irregularities on the surface of materials may influence appearance, plaque retention, surface discoloration and gingival irritation [11]. As nano glass ionomer cement is newly introduced it necessitates studying the effect of bleaching agent on the surface texture of nano glass ionomer cement. Nanotechnology, also known as molecular nanotechnology or molecular engineering, is the production of functional materials and structures in the range of 0.1 to 100 nanometers-the nonoscale. Today, the revolutionary development of nanotechnology has become the most highly energized disciple in science and technology [12]. The intense interest in using nanomaterials stems from the idea that they may be used to manipulate the structure of materials to provide dramatic improvements in electrical, chemical, mechanical and optical properties [13] in dentistry. Ketac Nano Light-Curing Glass Ionomer Restorative is the first paste/paste, resin-modified glass ionomer material developed with nanotechnology. Because it adds benefits not usually associated with glass ionomers, it has resulted in a whole NEW category of glass ionomer restorative: the *nano-ionomer*. The technology of Ketac Nano restorative represents a blend of fluoraluminosilicate (FAS) technology and nanotechnology. This combination offers unique characteristics of wear and polish as claimed by the manufacturer. It is supplied as two paste system in a clicker dispenser with a primer. Filler particle size can influence strength, optical properties and abrasion resistance. By using nano-sized fillers and nanoclusters, along with FAS glass, Ketac Nano restorative provides enhanced aesthetics as well as the benefits of glass ionomer chemistry [13]. The cure of top surfaces of light-activated materials is not greatly affected by either the intensity or duration of exposure. However, curing of the inner aspects of the material is problematic. The material itself reflects, absorbs and scatters the curing light beam, thus reducing its intensity. For this reason, visible light activated materials should always be placed and cured in increments of 2mm or less. In the present study hence 2mm thick increments were placed in the holes of the thermoforming sheets [14]. The most commonly used matrix for anterior restorations involving proximal contact is the clear plastic matrix [15]. Clear matrices possess an advantage over metallic matrices in that they allow visualization of the restorative material as the matrix is being manipulated, ensuring that no voids have been created during the placement process and polymerization through the matrix possible [16] so in the present study clear matrices were used during restoration of the sample. Visible resin-modified nano glass-ionomer cements contain light-curable monomers and a photo-initiator in addition to the traditional poly (acrylic acid) and may be finished immediately because they are light-cured. The appearance of visible resin-modified nano glass-ionomer cements is similar to that of resin composite; water sensitivity is reduced, and their mechanical properties are enhanced [16]. Finishing refers to the gross contouring or reduction of restorations to obtain the desired contour, while polishing refers to the reduction of roughness and scratches created by the finishing instruments. In this study one operator performed all the finishing and polishing procedure to simulate clinical procedure and to reduce the variation of the force used on the specimen. The number of strokes as well as the handpiece speed was also standardized so that the variation of the roughness could be kept to a minimum. In the present study, the samples were stored in distilled water, at room temperature, during the testing periods. Campos et al. (2003) kept their control specimens in artificial saliva for the time period that the test samples were kept in the bleaching agents. They used saliva to simulate oral conditions. It is reported that the substances present in saliva may act as accelerators in degrading carbamide peroxide and may minimize its adverse effects by means of the salivary remineralising potential. Because the aim of the present study was to examine the effect of the bleaching agents without the parallel effect of other parameters (saliva), distilled water was chosen as storage solution. The surface texture of all the Nano-ionomer restorative materials were made. These observations were based on scanning electron microscopic evaluations of samples. The same evaluator, made observations of the status of the material and performed all evaluations. Scanning electron microscopy is considered to be the simplest way to assess visually the surface topography of the specimens. The nano glass ionomer cement control specimens were found to have extensive cracking that could have been due to dehydration occurring during the time they were kept in the desiccators before being sputter-coated. The crack size of the control specimens should be subtracted from the bleached specimens to assess true bleach-induced cracking [17]. It can be observed that in group 1, 20% of samples cured under Mylar strip had minor changes in the surface texture; where as 80% of Soflex polished samples had minor changes both at 200x and 2000x magnification. This difference in surface texture between samples cured by Mylar strip and Soflex was found to be statistically significant. This finding was consistent with the results obtained in several previous studies conducted for comparison of surface finish of new esthetic restorative materials by AUJ Yap et al., that for all materials, the smoothest surfaces were produced when restorations were allowed to cure against a Mylar strip [6, 11]. As curing under a Mylar strip makes the surface matrix-rich. Despite careful placement of matrices, some degree of finishing and polishing of restorations is usually necessary. This inevitably violates the smoothness achieved with a matrix [6, 11, 12].It can be observed that application of 15% Carbamide peroxide on the Soflex polished samples of group 2, 3 and group 4 respectively, no alterations were observed. This comes in agreement with the results of Yap and Wattanpayungkul, who found slight but no significant difference in surface roughness between the control (group 1) and bleached groups (group 2,3 and 4). Whereas, on the Mylar finished samples of group 2, 3 and 4 minor alterations were observed after the application of 15% Carbamide peroxide, because curing under pressure makes the uppermost layer matrix-rich, and this layer is unstable. Polishing removes the unstable layer, and the material is then less susceptible to chemical dissolution. The polished surface is filler rich and is also characteristic of the bulk material. Clinically, glass ionomers contoured and polymerized under a Mylar strip with pressure may experience more softening and loss of marginal integrity as a result of the high matrix content and decreased wear resistance. It will therefore be advisable for glass ionomer restorations to be finished and polished after placement [19]. The results of he present study are in line with studies of O Polydorou [20] and Turker and Biskin, who observed only slight changes of the surface of the restorations after bleaching with Carbamide peroxide 10% -16%. Bailey and swift suggested that the surface changes could have been caused by complex interactions within multi-component bleaching products. Roughening was suggested to result from the loss of matrix, rather than filler particles.

Conclusion

- Polishing of the samples had a significant influence on the effect of the bleaching on the surface texture. The polished samples were found to be more stable concerning the detrimental effect of bleaching agents.
- According to the results of the present study there is no reason to avoid bleaching, when Nano-ionomer aesthetic restorative materials are present in the oral cavity.

In the present study it was shown that bleaching did not have a significant effect on the polished materials, and that the surface changes were very slight. These slight changes could lead to further alterations like abrasion caused by tooth brushing or coloring of the materials. Further clinical research is necessary, keeping in mind the results of this in-vitro study.

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