

Bleaching effect on surface roughness and microhardness of dentin

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ABSTRACT

The main objectives of this study were to determine the effects of the bleaching solutions on the surface characteristics of dentin namely, microhardness and surface roughness. Sixteen dentin samples were prepared for the measurements. Teeth mounted in an acrylic resin blocks for microhardness measurements and surface roughness. The bleaching was performed by immersion of each sample in (35%) hydrogen peroxide at (37)°C in an incubator for a period of one hour. Vicker's microhardness instruments used for microhardness measurements and profilometer testing machine was used to evaluate surface roughness. Two measurements were taken from each samples one before and the other after bleaching procedure. The data were collected and analyzed using analysis of variance and t-test. The results showed that the microhardness of dentin is greater before bleaching than the mean after bleaching procedures. This indicated that the bleaching solution used in this study reduced the microhardness of the dentin in vitro. There are slight changes in the mean value of the surface roughness of dentin after bleaching, which is statistically not significant.

Key Words: Bleaching, roughness, microhardness.

الخلاصة

يعتبر التغيير في لون الأسنان مشكلة جمالية تواجه المرضى، ويوجد عدة طرق لحل هذه المشكلة من ضمنها عملية تبييض الأسنان باستخدام محلول القصر H_2O_2 بتركيز مختلفة. لقد أثبتت الدراسات السابقة أن لمحلول القصر تأثير سلبي على سطح السن. الهدف من هذه الدراسة هو لبيان مدى تأثير محلول القصر H_2O_2 بتركيز (35%) على الصلادة المجهرية والخشونة السطحية للعاج. تم اختيار (16) سن عشوائياً استخدمت لغرض إجراء القياسات، تم صبها في قوالب من مادة الراتنج سريع التفاعل واستخدمت لقياس الصلادة المجهرية. أما بالنسبة لبقية النماذج فاستخدمت لقياس الخشونة السطحية. تم استخدام جهاز (Vickers hardness) لقياس الصلادة المجهرية، وجهاز (Profilometer) لقياس الخشونة السطحية. تم أخذ قراءتين من كل نموذج: إحداهما قبل التبييض والأخرى بعد التبييض وتمت المقارنة بينهما. عملية القصر أو التبييض تمت بغمس كل من النماذج السابقة في وعاء يحتوي على محلول التبييض المركّز H_2O_2 بتركيز (35%) لمدة ساعة واحدة وبدرجة (37°) مئوية في الحاضنة.

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- تم جمع القراءات وتحليلها احصائياً باستخدام (ANOVA) وأيضاً (t-test). النتائج التالية تم تجميعها من الدراسة:
- معدل الصلادة المجهرية للعاج قبل التبييض كان أعلى من المعدل بعد التبييض. هذا يدل على أن محلول القصر المستخدم في هذه الدراسة له تأثير سلبي على الصلادة للعاج مختبرياً.
 - كان هنالك تغيير طفيف في معدل الخشونة السطحية للعاج بعد التبييض وهذا التغيير لم يكن واضحاً من الناحية الإحصائية.

INTRODUCTION

The effects of the bleaching solution on the human dentin surface differ from one study to another. Thirty five percent hydrogen peroxide solution applied to an unetched human dentin will form a precipitate due to the interaction with the surface layer. Etched human dentin after treatment with hydrogen peroxide will show minor deposition of the material on dentin surface. Exposure of the cut human dentinal surface to acid etched and then to concentrated hydrogen peroxide does not seem to alter the surface morphology to the same degree that similar treatment altered the enamel.⁽¹⁾ The difference in the appearance probably reflects the inherent difference in structure, that is the degree and pattern of mineralization that is present in the two different tissues⁽²⁾. Haywood and Heymann⁽³⁾ concluded that the effects of the bleaching process extended to the portions of the tooth that are not indirect contact with the solution. This finding was supported by other researchers who reported an extensive movement of hydrogen peroxide through both enamel and dentin⁽⁴⁾. Bowles *et al.*⁽⁵⁾ indicated that dental hard tissue exhibit substantial permeability to H₂O₂ and the permeability increases with increased temperature. Because of this unhindered movements of the hydrogen peroxide through the teeth it was decided to examine dentin surface characteristics.

Djalma *et al.*⁽⁶⁾ studied the effect of different bleaching agents on dentin microhardness after (72) hours treatment. All bleaching agents used in the study showed significant reduction in dentin microhardness. This result was supported by others⁽⁷⁾. A scanning electron microscope research studied the effects of H₂O₂ on the cut human dentin, examination of the specimens revealed that the smear layer on the surface of cut dentin was not removed by H₂O₂ alone, and that a dense amorphous precipitate was formed on the surface of the smear layer and this surface deposit on the dentin may result in interference with the adhesion of the bonding resin to the dentin surface⁽²⁾.

It is obvious that there is no general agreement on the effect of bleaching materials on and dentin. The purpose of this in vitro study is to determine if the bleaching solution (35% H₂O₂) is causing any changes in the microhardness and surface roughness of the treated dentin.

MATERIALS AND METHODS

Sixteen premolars extracted for orthodontic purpose were collected and stored in (0.1%) thymol solution (BDH Chemicals Ltd. England) at room temperature to avoid dehydration and microbial growth. Teeth were examined with an explorer for any softness, catch or defect, any tooth exhibiting any of these features was excluded.

Each tooth was cleaned from debris with hand scalers. The teeth were sectioned at cemento-enamel junction to separate the crown from the root. A piece of sticky wax was placed at the area of cutting to be isolated from the effective reagents throughout the steps of the experiment. The occlusal 1/3 of each tooth was removed with high-speed rotary instrument with water cooling, thus exposing the dentin.

Each sample was placed in a rapid polymerizing acrylic block (Kulzar and Co GmbH, D-63 93, Germany). After polymerization of the resin, each block was smoothed slightly with sandpaper of (400), (500) and (600) grit. The block was placed in recipient containing deionized distilled water in an incubator (Hot Box Oven, Gallen Kamp, England) at (37)°C until time for measurements. Microhardness was measured with Vicker's hardness (Axioverl 405 M, Zeiss, West Germany). Testing was performed with diamond pyramid indentors, which have square base. The test is normally determined by using load for specific time, the geometry of the Vicker type indentation is independent of load, a load of (1) Newton (100 gm) for a time of (15) seconds applied for the specimens. This load and time are constant for all samples throughout the study. Six measurements from each sample were made in randomly selected sites before the application of the bleaching solution. The specimens were stored in deionized distilled water in an incubator at (37)°C until the time of bleaching. Commercially available (35%) concentrated solution of hydrogen peroxide (Hydrogen peroxide, medical solutions (35%, 2077, E. Merck Darmstadt, Germany), was obtained for the study and stored in a refrigerator at 4°C in a dark tightly capped bottle. The pH of the solution was measured and equals to (4.2).

Bleaching was made by immersing the samples in a recipient containing hydrogen peroxide of (35%) concentration at (37)°C in an incubator for one hour. Then the samples were washed with deionized water to remove the bleaching agent. Each sample was measured for microhardness after bleaching, six measurements were obtained from each one. The data were collected and evaluated.

The other eight specimens were prepared in a similar way for the microhardness and used for surface roughness measurements, which were performed with profilometer (Perthometer S5p, Fien pruf GmbH Company, Gottingen, West Germany). Each sample was placed in profilometer before the application of the bleaching solution for surface roughness measurement. The measurement was made with cut-off setting of (0.08) mm and a transverse length of (1.5) mm. Four measurements from each sample were taken two in the same direction and the other two at (90)° to the first direction. The mean measurement was obtained from the four reading and recorded, then the sample was placed in deionized distilled water at (37)°C until time of bleaching. Bleaching was performed according to the procedure mentioned in the microhardness test. Another measurement for surface roughness after bleaching was recorded in the same way. The data were collected and evaluated.

Separated two-ways analysis of variance was carried out to test the effects of (35%) hydrogen peroxide bleaching agent on the microhardness and surface roughness of dentin. The analysis of variance (ANOVA) was used followed by t-test.

RESULTS

The mean of microhardness together with their standard deviation before and after bleaching is shown in table (1).

Table (1): Mean and standard deviation of microhardness and roughness measurements

Test	Before		After	
	Mean	±SD	Mean	±SD
Microhardness (VHN*)	63.34	4.37	51.44	9.39
Roughness Ra (µm)	0.20	0.11	0.17	0.15

*VHN Vicker hardness number

The results of (ANOVA) and t-test for microhardness are shown in table (2).

Table (2): Microhardness ANOVA and t-test for dentin
ANOVA Summary Table $p < 0.01$

Source	DF	SS	Mean	F Value	Pr>F
Time	1	3399.83	3399.83	73.59	0.0001*
Error	94	4342.53	46.19		
Total	95	7742.36			

t-test for Dentin

 $p = 0.01$ df = 94 mse = 45.19

Source	Mean**	N***	T-Grouping
Before Bleaching	63.34	48	A****
After Bleaching	51.44	48	B

*: Source of significance

**: Mean microhardness

***: Number of sample x number of observation i.e., 8x6

****: Mean with the same letters are not significant

The microhardness of dentin before and after bleaching showed statistical differences in the mean values. The results indicated a dramatic decrease in the microhardness of dentin after bleaching at a significant level of $p = 0.01$.

The mean measurements of surface roughness of dentin, together with their standard deviation before and after bleaching are shown in table (1). The results of (ANOVA) and t-test for dentin surface roughness are shown in table (3). The mean of roughness before and after bleaching for dentin indicated no significant alteration in the surface roughness at a significant level of $p = 0.01$.

Table (3): Surface roughness ANOVA and t-test for dentin
ANOVA Summary Table $p < 0.01$

Source	DF	SS	Mean	F Value	Pr>F
Time	1	0.0159	0.0159	1.02	0.316*
Error	62	0.9704	0.0159		
Total	63	0.986			

T-Test for Dentin

 $p = 0.01$ df = 62 mse = 0.015

Source*	Mean**	N***	T-Grouping
Before Bleaching	0.202	32	A****
After Bleaching	0.172	32	A

*: Source of significance

**: Mean surface roughness

***: Number of sample x number of observation i.e., 8x4.

****: Mean with the same letters are not significant

DISCUSSION

Bleaching of teeth is nothing more than a chemical process of oxidation-reduction and numerous techniques have been reported and all used potent oxidizing agents. Several investigators have studied the effects of the bleaching agents on the oral tissue.

In this study, we examined the surface characteristic of dentin after bleaching using (35%) hydrogen peroxide (H_2O_2) solution, which are the most commonly used bleaching agents.

A time of (60) minutes was chosen for this study because from clinical point of view for bleaching vital teeth, certainly, it was possible that the cumulative time (after several appointments) may equal or exceed one hour. A study of hydrogen peroxide treated enamel had shown that changes in the surface morphology were presented at this time⁽⁸⁾.

Immersion of the samples rather than surface application of H_2O_2 was performed to ensure a uniform exposure of the test surfaces at a constant temperature, which is the body temperature 37°C.

The approach of using the same tooth as control for measurement was adopted, because in comparison of dentin surface roughness or hardness between any two different teeth, there are certain inherent differences in their surfaces⁽⁹⁾.

This study was designed to examine dentin that is because several investigators concentrated on the enamel, surface alteration, but it is likely that subsurface structural alteration, physiological and physical changes can occur in both enamel and dentin as a result of bleaching⁽¹⁰⁾. These changes may affect adhesion of resin composite to dentin⁽²⁾. The results of this study indicated that the mean value of the microhardness of dentin decreased after bleaching with (35%) H_2O_2 , i.e., there were surface alterations of dentin after bleaching. We believe that such alteration may be due to low pH of the solution, which is (4.2). Previous study believed that the bleaching appeared to be effective through demineralization of the enamel caused by acid in the bleaching mixture⁽¹¹⁾.

Ernest *et al.*⁽¹²⁾ believed that H_2O_2 decreased oral pH values and might cause severe demineralization similar to that produced by different acidic beverages. And there were light morphological changes of the enamel surface in contact with bleaching agents containing H_2O_2 . This effect was also observed in dentin surface in this study.

The results of the microhardness in this study are in agreement with the results of several researchers who investigated the enamel and dentin hardness after bleaching and concluded that bleaching resulted in a decrease in microhardness of enamel and dentin^(6,7).

Djalma *et al.*⁽⁶⁾ verified a decrease in human dentin microhardness after application of the following bleaching agents for (72) hours (sodium perborate + water, sodium perborate + 3% H_2O_2 , sodium perborate + 30% H_2O_2 , endoperox, proxigel, and 30% H_2O_2). The results revealed that (30%) H_2O_2 caused the greatest decrease in dentin microhardness as compared with other bleaching agents.

Few studies showed that bleaching solution did not cause any significant changes in the surface morphology of either enamel or dentin in such study. The authors used low concentrated solution of H_2O_2 containing agents^(3,9).

The profilometric result of this study is not obvious, because it is technically difficult to compare profile measurements after bleaching on precisely the same surface examined before bleaching. Also because the profilometer probe is best designed for measurement of surface texture of flat surface, the tooth present with

curved surface, and any procedures of flattening the tooth surface result in an increase in the surface roughness which may alter the result of the study⁽¹⁰⁾.

Topographic alterations of the surface of bovine enamel have been demonstrated, after treatment with (35%) hydrogen peroxide⁽¹⁾. Other investigations evaluated the effects of different bleaching agents on the enamel under both scanning electron microscope and profilometer, the scanning electron microscopic surface alterations were irregular and varied with each solution, while the profilometric result was incapable of detecting the particulate changes observed on the SEM⁽¹⁰⁾.

Finally, although it was assumed that this in vitro model, using extracted teeth, is representative of the in vivo process, it was unknown how closely it was if compared with in vivo absorption of H₂O₂ by teeth with vital pulp during bleaching process.

CLINICAL IMPLICATIONS

The importance of the present study from the clinical point, in which the surface changes and demineralization of the tooth structure may permit further penetration of the bacteria, chemical or staining substances (tea and coffee) result in caries or discoloration of already bleached teeth. In this study, the reduction in the microhardness is related to the action of peroxide on the organic matrix of the tooth as reported by Covington *et al.*⁽¹³⁾ and due to the acidic pH of the bleaching agent used in this study. The decrease in the oral pH value produced with (35%) hydrogen peroxide might cause severe demineralization similar to that produced by different acidic beverages. As a result of this harmful effect of (35%) hydrogen peroxide, researchers must search for oxidizing or reducing agents, which do not have such harmful effects.

Clinically, bleaching may be indicated before an aesthetic composite restoration is placed, to overcome any changes, which may occur in the tooth or restoration during bleaching, and also to obtain a more pleasing final shade for the case. If composite restorations are already present, several factors play a role in deciding whether the present restoration will be replaced or not; among those the size, number, location of the restoration and the anticipated shade change. Defective restorations should be repaired to prevent unwanted penetration of the bleaching agents through open margins.

In conclusion, the mean values of the microhardness of dentin were found to be greatly decreased after bleaching with (35%) hydrogen peroxide. The alteration in the surface roughness of dentin needs further investigations.

Further studies are needed to evaluate the effects of saliva and the oral hygiene of the patient during the bleaching on the remineralization of the tooth surface. Other bleaching agents need to be evaluated by the same procedures.

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