A Scaning Electron Microscope Investigation Into White Spot Lesion Removal with Microabrasion Approach

Beyaz Mine Lezyonlarının Mikroabrazyon Yöntemiyle Kaldırılmasının Taramalı Elektron Mikroskop Yöntemi ile İncelenmesi

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ABSTRACT Objective: The objective of this Scanning Electron Microscope (SEM) study was to investigate the effect of enamel abrasion technique on the removal of in vitro-formed enamel lesions. **Materials and Methods:** In this study 12 extracted and intact human premolar teeth were used. White spot lesions were formed, considering the severity of the decalcification using an artificial caries solution. According to this, four groups were established: Group 1: no white spot lesion, Group 2: mild lesion, Group 3: severe lesion, and Group 4: cavitation lesion. In all groups, only the mesiobuccal part of each premolar underwent microabrasion for 1 to 4 times and compared with the untreated distobuccal side using SEM. **Results:** The SEM investigation demonstrated that there was no sign of wear between treated and untreated surfaces for the Group 1. The microabrasion application at various times helped the surfaces with lesion to gain a more regular appearance compared to the untreated parts for Groups 2 and 3. However, there was no change between both parts for Group 4 regardless of the number of microabrasion application. **Conclusion:** This study confirmed that local enamel decalcifications can be eliminated sufficiently by the microabrasion technique and the application did not create any damage effects on the enamel. However, in the case of cavitated lesions, this technique was not effective irrespective of the application number.

Key Words: Dental caries, enamel microabrasion, tooth remineralization, tooth demineralization

ÖZET Amaç: Bu çalışmanın amacı, mikroabrazyon tekniği kullanılarak in vitro oluşturulan beyaz mine lezyonlarının kaldırılmasının etkinliğini taramalı elektron mikroskop yöntemi (SEM) ile incelemektir. **Gereç ve Yöntemler:** Bu çalışmada 12 adet çekilmiş insan premolar dişi kullanıldı. Suni bir çürük solüsyonu kullanılarak çeşitli dekalsifikasyon şiddetlerinde beyaz mine lezyonları oluşturuldu. Dört grup oluşturuldu; Grup 1: beyaz lezyon, Grup 2: orta lezyon, Grup 3: şiddetli lezyon ve Grup 4: kavitasyon lezyonu. Tüm gruplarda her premoların sadece meziobukkal kısımları 1 defadan 4 defaya kadar mikroabrazyonla ile işlem gördü ve SEM yardımıyla, tedavi edilmeyen distobukkal kenarla kıyaslanması yapıldı. **Bulgular:** SEM incelemesi, Grup 1'de tedavi edilen ve edilmeyen yüzeylerde aşınma işareti göstermedi; Grup 2 ve 3'te ise, tedavi edilmeyen kısımlara oranla, farklı zamanlarda mikroabrazyon uygulanmış lezyonlu yüzeylerin daha düzenli bir görünüm kazandığını gösterdi. Bununla birlikte, mikroabrazyon uygulama sayısı ne olursa olsun, Grup 4'te bölgeler arasında farklılık izlenmedi. **Sonuç:** Bu çalışma, bölgesel mine dekalsifikasyonlarının mikroabrazyon tekniğiyle yeterince uzaklaştırılabileceğini ve uygulamanın mine üzerinde hasar etkisi göstermediğini doğruladı. Ancak kavitasyon lezyonlarında uygulama sayısına bakmaksızın, tekniğin lezyonlar üzerinde etkili olmadığı görüşü doğrulandı.

Anahtar Kelimeler: Çürük, mine mikroabrazyon, diş remineralizasyonu, diş demineralizasyonu

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White spot lesion formation is a situation of unbalance between enamel demineralization and remineralization whenever bacterial plaque is retained on the enamel surface for a prolonged period, and may be a clinical problem in a number of patients treated with

fixed orthodontic appliances.[1] The presence of archwires, especially using multiple loops and different types of elastics complicates cleaning around the bands and brackets during orthodontic treatment. The lesion of the facial surfaces on both anterior and posterior teeth represents an unaesthetic side effect of orthodontic treatment that may counteract the beneficial result of the treatment as such.[2]

The white spot area is slightly softer than the surrounding sound enamel. Various experimental techniques such as microradiography, polarized light microscopy, microhardness, and electron microscopy have been used to explore the characteristics of carious enamel.[1-5] Clinical observations and quantitative studies of the incidence, areas of susceptibility and prevention of decalcification have been reported.[3-9] In addition; researchers have tested different methods which can practically and effectively treat the white spot lesions.

McCloskey found that brown fluorosis stain can permanently be removed by rubbing the enamel with an 18% hydrochloric acid-soaked cotton pellet wrapped around an amalgam condenser.[10]

Croll and Cavanaugh, Croll and Bishara experimented with a 5 second wooden stick pressure applications of 18% hydrochloric acid and pumice with intermittent water rinsing between applications.[11-15] It was thought that with pressure application of an abrasive in combination with the acid, the chief mechanism of stain removal would be limited to enamel abrasion rather than enamel dissolution by the acid. Gelgor and Buyukyilmaz conducted a study on 178 teeth with white spots at the mild, severe and cavitation levels and their removal using an electric toothbrush and a 18% hydrochloric acid-pumice-glycerin gel.[1] Their results showed that all mild lesions could be completely removed after one or two applications while severe lesions were improved to an acceptable level after three or 4 applications.

From these studies, it became apparent that clinically the 18% hydrochloric acid and pumice mixture can successfully remove superficial white enamel opacities, multicolored defects and streaks, regardless of their etiology, with insignificant and unrecognizable enamel loss. However, the ultrastructural surface changes were yet to be determined.

Thus, the present study aimed to investigation the changes on white spot lesions at mild, severe and cavitation levels after microabrasion applications using scanning electron microscopy.

MATERIAL AND METHODS

Twelve recently extracted caries-free human premolars were collected and stored in 0.1% aqueous thymol solution and used within four weeks. All calculus, bone, and soft tissues were removed with a scaler and razor blade. The enamels were cleaned with a rubber prophylaxis cup at slow speed with a mixture of nonfluoridated pumice and water. All teeth were rinsed copiously with deionized water, and then randomly assigned to the groups.

All teeth surfaces, except the experimental buccal surfaces, were covered with wax. The teeth were stored in artificial saliva solution[16] consisting of 20 mmol/L of $NaHCO_3$, 3 mmol/L of NaH_2PO_4, and 1 mmol/L of $CaCl_2$ at room temperature, neutral pH, and constant circulation. This solution was changed every other day during the experiment, and each group was cycled in a separate beaker of solution throughout the experiment. All teeth were kept in artificial saliva solution for 12 hours before initial exposure to the artificial caries solution to simulate clinical condition. The following day, cycling between artificial saliva and artificial caries challenge solutions began. Teeth were cycled between artificial saliva and artificial caries challenge for 37 days.

All teeth except one were subjected to an artificial caries solution consisting of 2.2 mmol/L of Ca_2+, 2.2 mmol/L of PO_4-, 50 mmol/L of acetic acid at pH 4.4, room temperature, and constant circulation for 1 hour, two times daily.[17] After cycling between artificial saliva and artificial caries, the teeth were dried thoroughly and evaluated for erosion with naked eye. This procedure continued until the desired lesions were established in each tooth. Then the wax was removed from the surfaces mechanically which gave no harmful effect to the teeth surfaces. The lesions were scored according to Gorelick et al and grouped as mild, severe and cavitation (Figure 1).[17]

A custom-made abrasive gel was prepared with %18 hydrochloric acid, fine powdered pumice

and glycerin. The acid was obtained by diluting 38% hydrochloric acid (Ak-Kim Company, Izmit, Turkey) with extra 110 ml distilled water. Then, distobuccal surfaces of all of teeth were covered with a nail varnish (Figure 2). The abrasive gel was applied to mesiobuccal surfaces of every tooth, using an electric toothbrush (Braun Oral-B Plaque Control 3D, Germany), for 4 min as described in a previous study and rinsed for 1 min.[1] For mild lesions 1 to 3 cycles, for severe lesions and cavitations up to 4 cycles were carried out. Microabrasions were repeated monthly and the teeth were stored in artificial saliva between the applications.

PREPARATION OF TEETH FOR SEM

The nail varnish was removed from the surfaces with a plastic excavator that gave no harmful impressions to the teeth surfaces. The crowns of the teeth were first removed from the roots with a carborundum disk (Batch No. 0976, S.S. White Limited, Harrow, England). Then each crown was cut on a mesiodistal line from occlusal to cervical with the same disk, and the buccal surfaces were retained for the study (Figure 2). This procedure was done in order to facilitate the orientation of the teeth for the Sacrning Electron Microscope (SEM) (MK III, Cambridge Stereoscan). The teeth surfaces were then mounted to aluminum stubs with a silver paste. Each specimen was prepared for SEM by sputtering with gold palladium to a thickness of 10 nm in a Polaron E-5000 sputter coating unit. The microscope was operated at 20 KV at a working distance from the specimens of 8 to 10 mm.

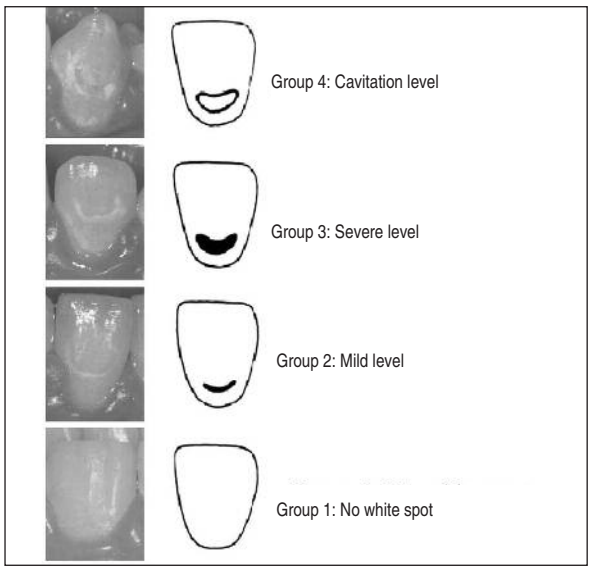

FIGURE 1: Scoring of the lesions.

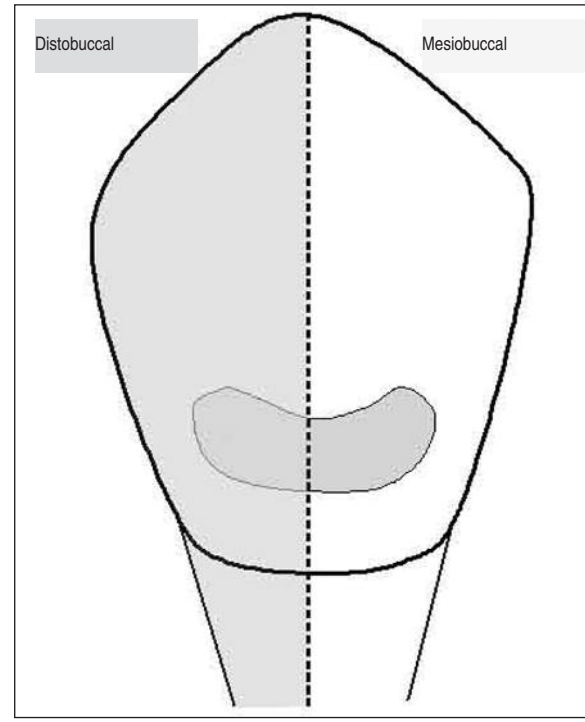

FIGURE 2: Untreated (left) versus treated lesions (right). After lesion was formed, half of the lesion was covered with nail varnish and acted as untreated control. Microabrasion was applied to the right half of the lesion.

METHOD OF EVALUATION UNDER SEM

All specimens were scanned from the occlusal to the cervical area. Microphotographs were taken off the mesial and distal-cervical and middle third of the crown, as the mesial cervical and middle third of the crown was the area where the lesion was treated with microabrasion technique, and the distal cervical and middle third of the crown was the area where lesion was not treated (Figure 2). Microphotographs were taken at a magnification of × 35, and × 500 (Figures 3 to 7). A total of 48 microphotographs of 12 samples (four specimens/ groups) were taken. Enamel surface with normal appearance was also scanned to serve as a control.

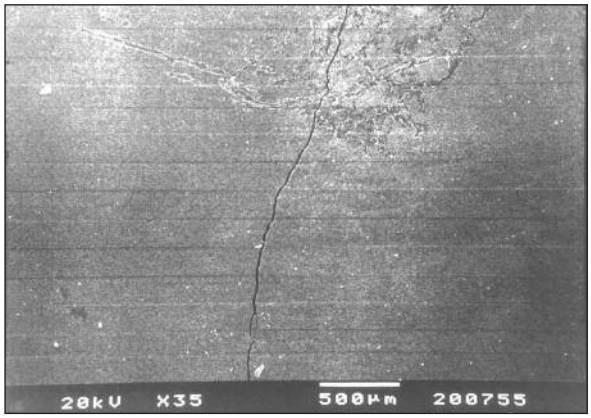

FIGURE 3: Intact enamel in both left (control) and right side after microabrasion from the no lesion group (Group 1).

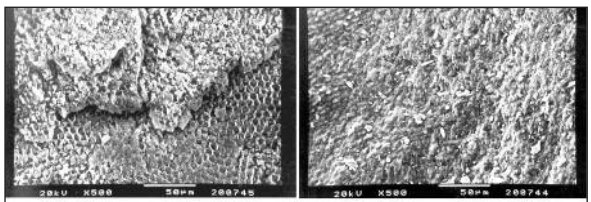

FIGURE 4a: Change in enamel surface structure in mild group (Group 2) after one microabrasion cycle (right) compared with control (left).

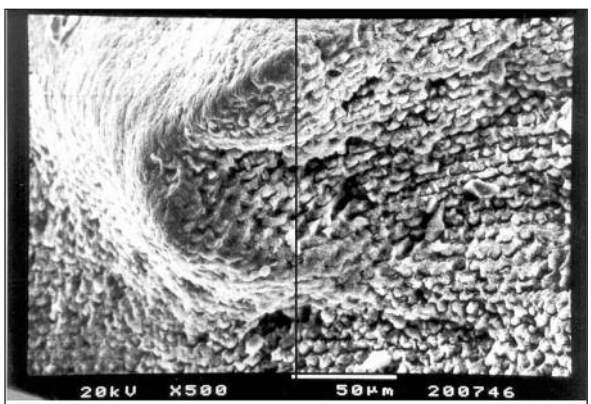

FIGURE 4b: After two microabrasion applications the left; superficially demineralized area, and elimination of the original fish-scale appearance of the intact enamel surface, and the right; original fish-scale appearance of the intact enamel surface from the mild group.

RESULTS

In Group 1 without white spot lesions, there were no clear differences between treated and untreated surfaces. A natural tooth surface was seen on each part with an enamel crack. There were no signs of wear or pits caused by abrasion cycle (Figure 3). Figure 4a shows the result of one step microabrasion cycle in Group 2. In the distobuccal part of the teeth (not treated), distinct dissolution of individual crystals caused formulation of extensive grooves. In mesio-buccal area microabrasion reduced the lesion into quite shallow grooves and caused a more regular surface, but with more visible debris. After two cycles, the debris remaining and the grooves were removed. The "heads" of the enamel prisms could still be seen at the surface (Figure 4b). Figure 4c shows the different structures of the area among the untreated enamel after 3 cycles of treatment. The treated lesion surface ap-

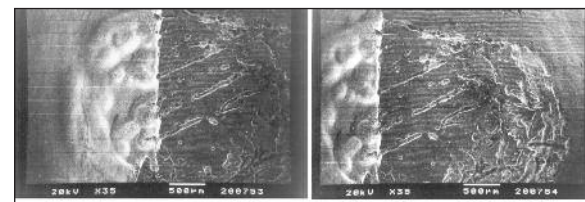

FIGURE 4c: After three microabrasion applications localized demineralization area in each parts, and the appearance same as intact enamel in mesiobuccal part from the mild group.

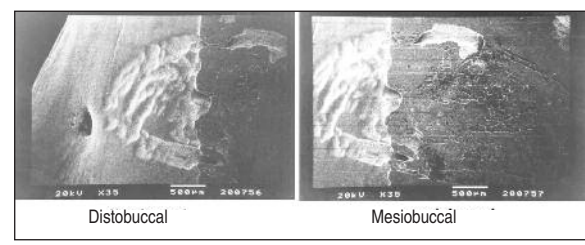

FIGURE 5a: After one microabrasion application localized demineralization area in each parts, and the appearance same as intact enamel in mesiobuccal part from the severe group (Group 3).

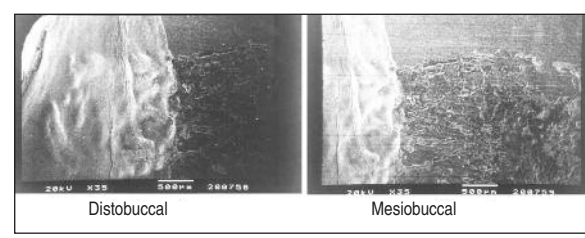

FIGURE 5b: After two microabrasion applications localized demineralization area in each parts, and the appearance same as intact enamel in mesiobuccal part from the severe group (Group 3).

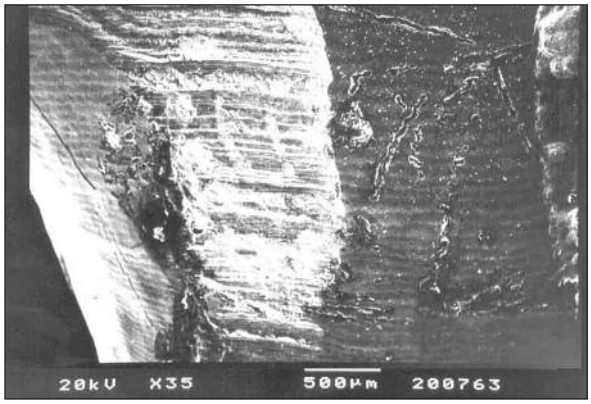

FIGURE 5c: After three and four microabrasion applications the appearance same as intact enamel in mesiobuccal part according to distobuccal part from the severe group.

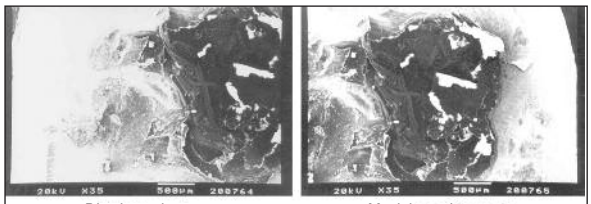

FIGURE 6a: After one microabrasion applications the shallowed demineralized area of the microcavity after microabrasion from the cavitated group (Group 4).

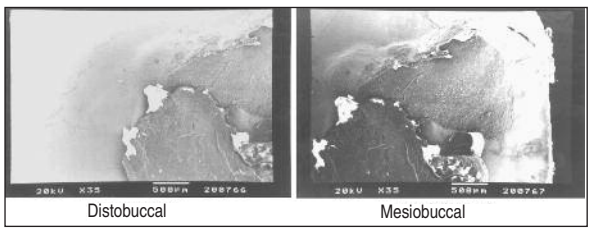

FIGURE 6b: After two microabrasion applications, appearance of the border of the shallow microcavity and intact enamel (distobuccal), and the bottom of the shallow cavity (mesiobuccal) in the cavitated group (Group 4).

peared finely, less rough than the untreated lesion area, and the grooves or furrows were relatively smooth. In the severe group, the enamel lesions gradually disappeared after more treatment cycles. Figures 5a to c are showing the enamel surfaces after one to four times of microabrasion applications. Deep grooves and recesses were straightened at different rates depending on lesion depths. Figure 5c illustrates the final result of four microabrasion cycles. The enamel surface was crossed by fine and shallow furrows alternating with polished areas. All the specimens from cavitated group persisted in revealing discernible demineralized areas even after multiple microabrasion cycles (Figures 6a-c). After four cycles, depth and width of cavities and grooves did not change. In addition, the sharply-cut edges of the microcavities did not disappear even after multiple treatment cycles (Figure 7).

DISCUSSION

In this study, the SEM photographs confirmed the macroscopic findings from our previous study that while the microabrasion technique was effective in removing mild and/or severe demineralized enamel, white spots and streaks.[1] There was no excessive mineral loss by using this technique.

Croll reported that the acid-abrasive action of the compound gives enamel surfaces a superfine polishing as a microscopic layer of enamel

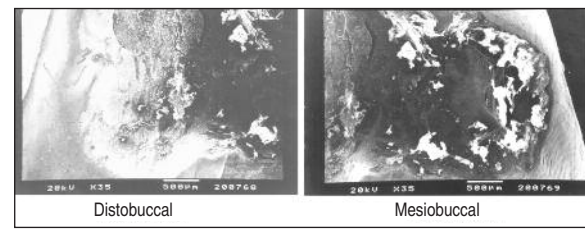

FIGURE 6c: After three microabrasion applications in the cavitated group, intact enamel through to demineralization area (distobuccal), and completely demineralized area (mesiobuccal).

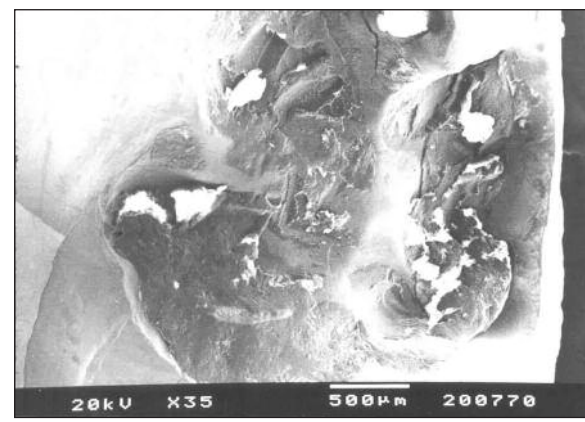

FIGURE 7: After four microabrasion in the cavitated group, elimination of semi-demineralized area and the bottom of the microcavity.

is removed.[18] This is in line with our results obtained in the groups 1 to 3 (no lesion, mild and severe). One microabrasion cycle in Group 1 did not harm or damage the enamel structure. That intact enamel structure is preserved in the left side as to the right after microabrasion. This suggests that in principle, microabrasion can be applied to remove brown-yellow enamel discolorations and superficial scrapes without harming the enamel structure.

Bishara recommended this procedure for treating superficial enamel discoloration to a maximum depth of 100 μm. Although in our study, the depth of the lesions has not been measured, this size is deep enough to explain our SEM observations, especially seen in the mild lesion group.[15] Moreover, despite that the exact amount of mineral loss after microabrasion was not reported, several authors found the enamel loss to be clinically unrecognizable.[5-11]

As in accord with the macroscopic observations in our previous study, in SEM observations, mild and severe lesions showed a considerable improvement after one or more treatment cycles. However, in cavitated lesions, irrespective of the application number, enamel surface revealed insufficient change after microabrasion. These observations are parallel with some other in vivo results of microabrasion studies.[1,10-15]

The clinical significance of the present study is that removing the enamel surface by microabrasion seems to be sufficient to flatten lesion. In specific cases, it can be thought that the microabrasion application is detrimental, not only for enamel surfaces but also to dentine pulp-complex.[11-15] This possibility has previously been pointed out by Croll that hydrochloric acid can not penetrate enamel completely and thus cannot reach the dentine tubules including reparative dentine formation.[18]

Griffen et al tested radioisotope phosphorus-32 labeled, 30% hydrogen peroxide, 36% hydrochloric acid, isotonic saline, and a mixture hydrogen peroxide, hydrochloric acid and diethyl ether, and none of the solutions could penetrate the enamel to dentino-enamel junction.[19] They also showed that neither hydrochloric acid nor a hydrogen peroxidehydrochloric acid-diethyl ether combination increases enamel or dentin permeability in extracted teeth. Baumgartner et al showed that applying a mixture of 36% hydrochloric acid, 30% hydrogen peroxide and diethyl ether to human premolars in the mouth has no effect on the pulpal-dentin complex.[20] In our previous study following the completion of all the microabrasion applications, no patients complained of dentinal or pulpal sensitivity.[1]

A distinct disadvantage of fixed orthodontic therapy is the formation of decalcification, or white spots, adjacent to brackets during the course of the treatment. This SEM study evaluated the effects of the microabrasion technique on the enamel while removing the lesions. A clear evidence of this application is that it has no harmful effects on the enamel.

CONCLUSION

The SEM photographs confirmed the macroscopic findings of the clinical studies that local enamel decalcifications can be sufficiently removed by the microabrasion technique applied in this study. This application has not damaging effects on the enamel structure. However, when confronted to cavitated lesions, irrespective of the treatment cycles, the enamel surfaces revealed insufficient change after the microabrasion technique.

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REFERENCES

1. Gelgör IE, Büyükyılmaz T. A practical approach to white spot lesion removal. World J Orthod 2003;4:152-6.
2. Pretty IA, Pender N, Edgar WM, Higham SM. The in vitro detection of early enamel de- and re-mineralization adjacent to bonded orthodontic cleats using quantitative lightinduced fluorescence. Eur J Orthod 2003;25(3):217-23.
3. Kimura T, Dunn WJ, Taloumis LJ. Effect of fluoride varnish on the in vitro bond strength of orthodontic brackets using a self-etching primer system Am J Orthod Dentofacial Orthop 2004;125(3):351-6.
4. Melrose CA, Appleton J, Lovius BB. A scanning electron microscopic study of early enamel caries formed in vivo beneath orthodontic bands. Br J Orthod 1996;23(1):43-7.
5. Artun J, Thylstrup A. Clinical and scanning electron microscopic study of surface changes of incipient caries lesions after debonding. Scand J Dent Res 1986;94(3):193-201.
6. Gorton J, Featherstone JD. In vivo inhibition of demineralization around orthodontic brackets. Am J Orthod Dentofacial Orthop 2003;123 (1):10-4.
7. Gorelick L, Geiger AM, Gwinnett J. Incidence of white spot formation after bonding and banding. Am J Orthod 1982;81(2):93-8.
8. Derks A, Kuijpers-Jagtman AM, Frencken JE, Van't Hof MA, Katsaros C. Caries preventive measures used in orthodontic practices: An evidence-based decision? Am J Orthod Dentofacial Orthop 2007;132(2):165-70.
9. Ahn SJ, Lim BS, Lee SJ. Prevalence of cariogenic streptococci on incisor brackets detected by polymerase chain reaction. Orthod Dentofacial Orthop 2007;131(6):736-41.
10. McCloskey RJ. A technique for removal of fluorosis stains. J Am Dent Assoc 1994;109(1): 63-4.
11. Croll TP, Cavanaugh RR. Enamel color modification by controlled hydrochloric acid-pumice abrasion. I. Technique and examples. Quintessence Int 1986;17(2):81-7.
12. Croll TP, Cavanaugh RR. Enamel color modification by controlled hydrochloric acid-pumice abrasion. II. Further examples. Quintessence Int 1986;17(3):157-64.
13. Croll TP, Cavanaugh RR. Hydrochloric acid-pumice enamel surface abrasion for color modification: results after six months. Quintessence Int 1986;17(6):335-41.
14. Croll TP. Enamel color improvement: all things considered. Quintessence Int 1986;17(5):271-5.
15. Bishara SE, Deheney GE, Goepferd SJ. A conservative postorthodontic treatment of enamel stains. Am J Orthod Dentofacial Orthop 1987;92(1):2-7.
16. Birkeland JM. The effects of pH and the interaction of fluoride and salivary ions. Caries Res 1973;7(1):11-8.
17. ten Cate JM, Duijsters PP. Alternating demineralization and remineralization of artificial enamel lesions. Caries Res 1987;16(3):201-10.
18. Croll TP. Enamel microabrasion: the technique. Quintessence Int 1989;20(6):395-400.
19. Griffin RE Jr, Grower MF, Ayer WA. Effects of solutions used to treat dental fluorosis on permeability of teeth. J Endod 1977;3(4):139-43.
20. Pugh G Jr, Zaidel L, Lin N, Stranick M, Bagley D. High levels of hydrogen peroxide in overnight tooth-whitening formulas: effects on enamel and pulp. J Esthet Restor Dent 2005;17(1):40-5.