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A Study on the Enamel Surface Texture and Caries Susceptibility in Interdentally Stripped Teeth

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To investigate the difference of texture exhibited on interproximal enamel surface with each different stripping method and the susceptibility of proximal enamel to demineralization after stripping and the application of a topical fluoride gel and sealant, one hundred human premolars, which were previously extracted for orthodontic reasons were evaluated by means of Scanning electron microscopy and laser fluorescence.

The results were as follows :

1. No matter what the initial stripping instrument was the furrows that resulted from all the stripping methods were not completely removed by careful polishing.
2. Among the enamel surfaces that were treated with three different initial abrasive instruments, followed by the same polishing method (Sof-Lex® disks), the enamel surfaces that were treated with 700 crosscut carbide bur showed the smoothest surfaces.
3. The stripped teeth, no matter what the initial stripping instrument was, were less resistant to initial demineralization than untreated teeth. But no difference in caries susceptibility according to differently stripped methods was found ($p < 0.001$).
4. Teeth treated with APF-gel or sealant were more resistant to demineralization than those treated without other treatment after stripping ($p < 0.001$).
5. Comparing groups treated with APF-gel to groups treated with sealant, the former was more resistant to demineralization than the latter ($p < 0.05$).

In conclusion, enamel surfaces that were stripped interproximally were less resistant to demineralization even though various attempts were made to produce smooth, self-cleaning enamel surfaces. Therefore, additional treatment-sealant or calcifying/ fluoridating solution to the stripped enamel surfaces is recommended.

Key Words : Interdental stripping, Caries susceptibility, SEM, Laser fluorescence.

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Interdental stripping is a technique used to remove controlled amounts of proximal enamel in order to gain arch length for retracting and aligning anterior teeth[1-4] and to solve Bolton discrepancy problem[5]. This treatment philosophy centers on overcoming the difficulties in adult extraction cases[6] and the instability of over expansion in non-extraction cases. Sheridan[3] stated that stripping possibly eliminates the need for extraction of permanent teeth in cases where the arch length discrepancy is less than 4mm, and then it is an alternative to extraction or arch expansion. Winter[7] stated that a posterior stripping strategy significantly reduced treatment time when compared with premolar extraction.

In addition, interdental stripping has many advantages. First, stripping creates flat and broadening contact surfaces, which help resist labiolingual crown displacement and eliminates the need for lower retention.[4,8-10] Second, a more favorable over-jet and over-bite relationship is produced, which improves anterior function in the mutually protected occlusion[4,5]. Third, the area of interproximal gingival recession (black triangle) can be improved. As a result of proximal enamel reduction, the bell-shaped contour of the crowns is reduced, allowing the proximal cervical area of adjacent teeth to be closer to one another and allowing a more natural looking interproximal gingival tissue.[4]

Even though there are many advantages of stripping, a number of in vitro investigations[11-16] have found adverse effects, significantly in the increase in rate of demineralization on abraded versus intact enamel. Especially, extending posteriorly into areas that are certainly more prone to caries, it may lead to increased caries susceptibility. These findings have led others to suggest that stripping should be done with caution and only in patients with good oral hygiene and a low caries susceptibility. Radlanski et al[15] suggested that it is impossible to produce an enamel surface free of the furrows that result from the initial abrasion caused by the coarse mechanical strips. Furrows that result from stripping are not removed by careful polishing, and accumulation of plaque in the furrows causes interproximal caries and periodontal diseases. Twesme et al[16] who examined lesion depth and mineral content on abraded and intact surfaces concluded that air-rotor stripping significantly increases the susceptibility of proximal enamel surfaces to demineralization. As a result, they suggested that the clinician should use caution in the application of this technique until the long-term effects on caries susceptibility have been determined.

Various attempts have been made to produce smooth, self-cleaning enamel surface[2-3,14,17-18] and many authors have recommended the use of fluoride treatment[19-21] for a lengthy period.

To obtain smoother surfaces, many different mechanical abrasive instruments have been proposed[2-3,14,17-18], chemical stripping[22] with phosphoric acid, which could overcome the limitations of mechanical stripping, and the use of sealants[23], which could provide sealing and flattening of furrows in the reduced enamel have been demonstrated.

The rationale for the caries preventive effect of fluoride has been known for many decades. The fact that fluoride incorporated into the crystalline lattice of the mineral in dental hard tissue results in a tissue less soluble in an acid environment has been the scientific cornerstone for caries prevention. Not only the reduction in solubility of the mineral hydroxyapatite after fluoride incorporation but also the precipitation of minerals at a high rate when in contact with a solution containing calcium and phosphate is important[24].

Laser fluorescence was used as a means in evaluating the extent of early demineralization for each group in our study. Fluorescence induced by laser light as a diagnostic method for early caries detection was introduced in 1982 by Bjelkhagen et al[25]. Incipient lesions show a loss of fluorescence to be expressed as a percentage of fluorescence radiance of sound tissue, and then appear as areas darker than the surrounding sound enamel[26-28]. A quantitative version of the laser fluorescence method was recently compared with longitudinal microradiography[29] and polarizing microscopy[30-31] for assessment of mineral change in artificially produced caries lesions. The results indicated that the laser fluorescence method had a higher sensitivity and lower discrimination threshold than longitudinal microradiography especially in early caries detection.

The objectives of this study are as follows. First, the difference of texture exhibited on interdental enamel surface with each different stripping method will be evaluated by means of scanning electron microscopy. Second, the susceptibility of proximal enamel to demineralization after stripping and the application of topical fluoride gel and sealant will be evaluated by means of laser fluorescence.

MATERIALS & METHODS

1. Difference of texture exhibited on interdental enamel surfaces with each different stripping method

For the first part of study, thirty human premolars, which were previously extracted for orthodontic reason and stored in 70% ethanol, were divided into group I, II, III, IV and V. The six premolars of each group were mounted in plaster blocks to simulate the human anterior arch form. Each group had 12 interdental surfaces that were to be stripped according to the different stripping methods. The stripping methods used were as follows:

Group I : Enamel was reduced with diamond-coated metal stripper (separating strips, single-faced, medium grit, 4mm wide. Dentaurum ®, German), followed by Sof-Lex® (Pop-On™, 3M Unitek, U.S.A) disks for polishing the enamel (20 strokes each of ultrafine, fine, medium and coarse).

Group II : Enamel was reduced with medium grit diamond bur (TR-11EF, MANI, Inc, Japan) operating in a water-cooled, high-speed hand piece, followed by Sof-Lex® disks for polishing the enamel.

Group III : Enamel was reduced with carbide bur (standard number 700, Kornet®, Germany) operating in a water-cooled, high-speed hand piece, followed by Sof-Lex® disks for polishing the enamel.

Group IV : Teeth were subjected to the same operation as Groups III and then chemical stripping were applied (38% phosphoric acid <Mono-Lok™, RMO®, U.S.A>, etched for 15 seconds, rinsed sufficiently)

Group V : Teeth were subjected to the same operation as Groups IV and then sealant (Excel® sealant resin part A and B, Reliance Orthodontic Products, Inc) were applied to stripped enamel surfaces with a small brush, and a gentle puff of warm air was directed at the sealant to decrease the film thickness (sealant was self-curing).

The teeth were stripped by the same operation. About 0.5mm interdental enamel was ground away. The reduction amount was monitored with calipers. Chemical etching and sealant applications were performed on plaster blocks to simulate clinical conditions. All the teeth were thoroughly washed under running water and rinsed in acetone to ensure the removal of surface deposits. All teeth were dehydrated and gold coated for SEM (JBOL, JSM-840A, made in Japan) observation.

2. Susceptibility of enamel surfaces to demineralization after stripping and the application of a topical fluoride gel and sealant

For the second part of the study, seventy human teeth, which were previously extracted for orthodontic reason and stored in 70% ethanol, were divided into groups A, B, C, D and control. Group B and C were subdivided again into subgroups a and b.

Group A : Teeth were subjected to the same operation as Groups II in the first part study with no fluoride application.

Group B-a : Teeth were subjected to the same operation as Groups III in the first part study with no fluoride application.

Group B-b : Teeth were subjected to the same operation as Groups III in the first part study -ation as Groups III in the first part study

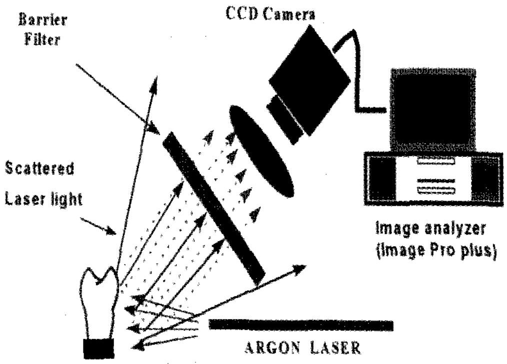


Fig 1. Diagram of the laser fluorescence method used to measure fluorescence radiance from artificial caries.

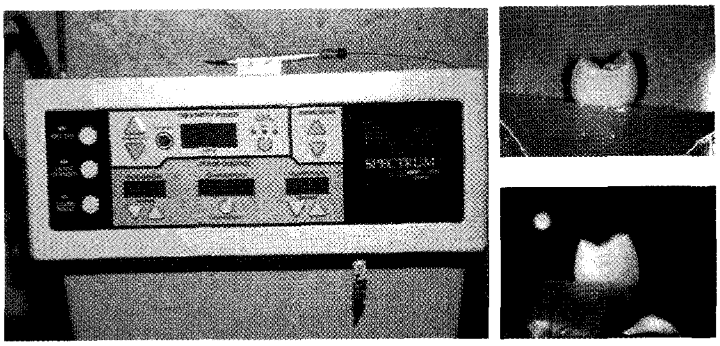


Fig 2. Argon laser(left) and initial caries lesion under ordinary light (upper right) and under laser fluorescence(lower right).

and 1.23% APF-gel was applied (Fluragel 60™, CADCO Dental products, Inc) four times at intervals of 24 hours, duration of five minutes.

Group C-a : Teeth were subjected to the same operation as Groups IV in the first part study with no fluoride application.

Group C-b : Teeth were subjected to the same operationas Groups IV in the first part study and 1.23% APF-gel was applied.

Group D : Teeth were subjected to the same operation as Groups V in the first part study with no fluoride application.

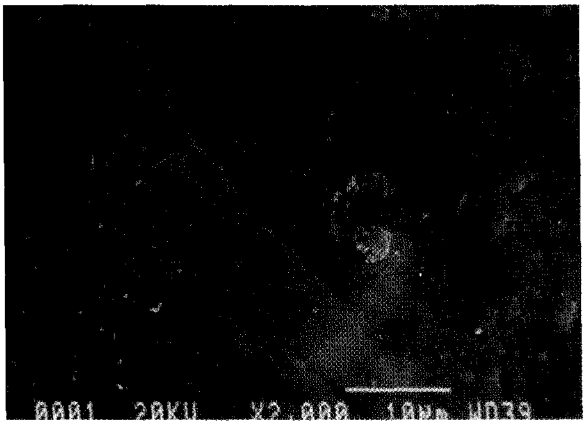
Control : No treatment teeth (These didn't have any demineralization (white or buccal spots) oneither the mesial or distal surfaces and restorations on any surfaces)

All teeth were covered with nail varnish except for a 3㎝2㎝ size block and stored in an artificial caries solution for 96 hours. The artificial solution was made of 50% saturated HAP (BioRad, Cat #130-0420), 0.1mol lactic acid (Mallinckroft, Lot #2676) and 0.2% Carbopol C907[32-34]. After 96 hours, the stripped enamel surface was illuminated by Blue-green laser light from an argon ion laser (HGM, SPECTRUM™, wavelength 488nm). The laser light was transmitted through an optical fiber (diameter 600m). A yellow high-pass filter was used to cut off light with a wavelength lower than 520nm in order to enable detection of the auto-fluorescence emitted by the teeth. The yellow filter was placed in front of the CCD camera. In this way the CCD camera could record the fluorescent images of the tooth surfaces.

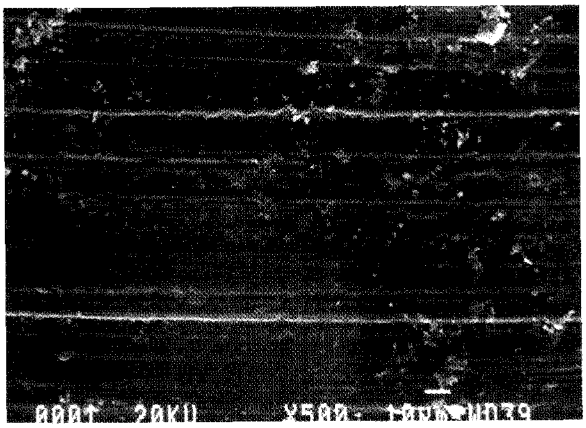
With a PC program (Image pro plus™, Media Cybernetics, CO. USA), it is possible to calculate the fluorescence loss in the lesion in relation to sound enamel. The program reconstructed the fluorescence enamel. The program reconstructed the fluorescence radiance at the lesion site from the fluorescence radiance of the surrounding sound enamel, which was assumed to be 100% (this is reconstructed fluorescence radiance). The difference between the reconstructed and the original fluorescence radiance represented the fluorescence loss at the lesion site.

3. Statistics and method error

We used the ANOVA test at 0.001% significance level to compare the fluorescence loss according to surface texture of differently stripped enamels. To evaluate the effects of APF-gel and sealant on caries susceptibility, the paired T-test at 0.001% and 0.05% significance levels were used. To determine the method error for part II of this study, fluorescence loss was re-measured five times on five randomly selected teeth.



(a)



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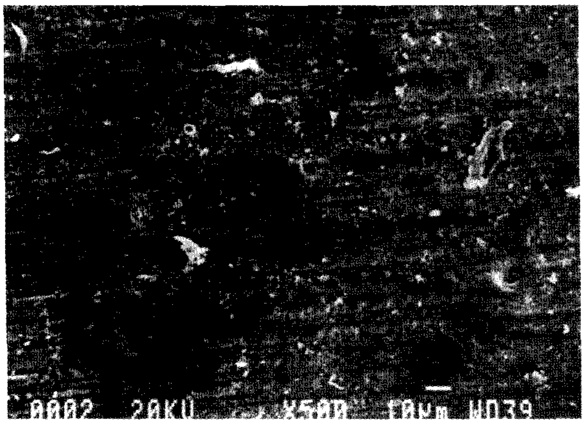

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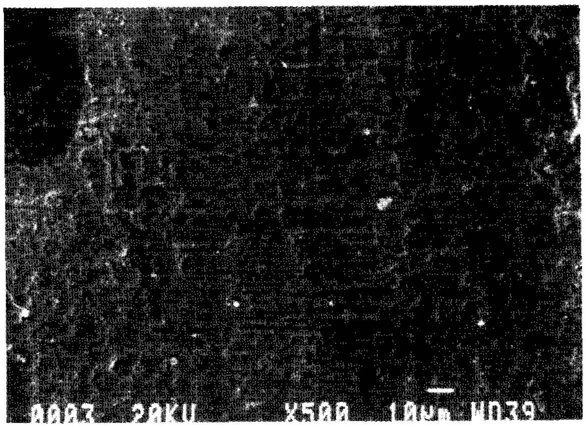

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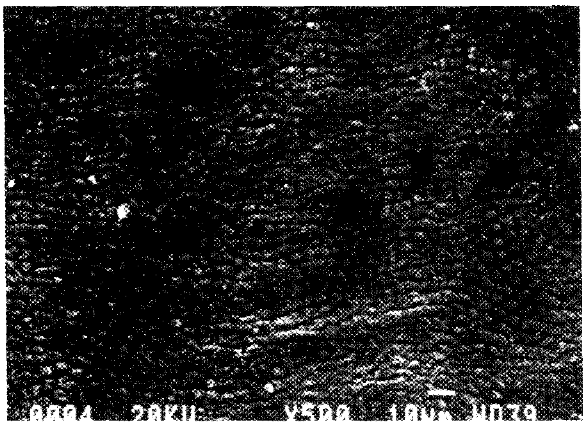

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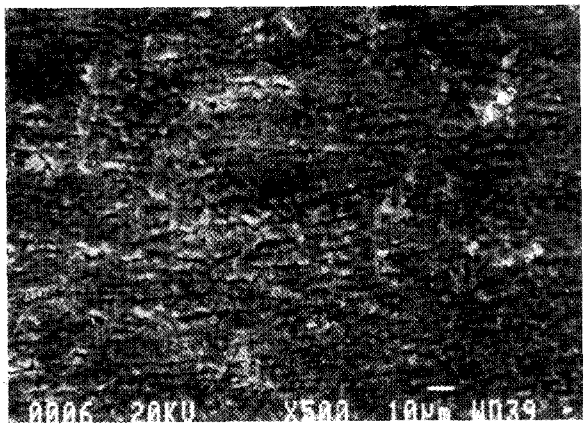

(f)

Fig 3. Enamel surface texture of each stripping method under SEM.
(a) no treatment
(b) diamond-coated metal stripper and sof-lex polishing
(c) diamond bur and sof-lex polishing
(d) carbide bur and sof-lex polishing
(e) carbide bur and sof-lex polishing and chemical stripping with 38% phosphoric acid
(f) carbide bur and sof-lex polishing and chemical stripping and sealant application

Table 1. Method error : he standard deviation of measurements of fluorescence loss determined by laser fluorescence

Method error	Standard Deviation
Laser fluorescence	0.3258

Table 2. Fluorescence loss of differently stripped groups

	N	Min.	Max.	Mean	SD
Control	20	13.90	16.67	14.8465	0.9260
Group A	20	15.87	21.87	18.3665	1.7404
Group B-a	20	14.71	24.74	19.4475	2.5290
Group B-b	20	9.32	14.62	12.5445	1.5336
Group C-a	20	16.38	22.51	19.3935	1.5212
Group C-b	20	9.69	14.88	12.5635	1.5811
Group D	20	12.72	17.92	14.7655	1.8457

RESULTS

1. Differences of texture exhibited on interproximal enamel surfaces by each stripping method

Figs. 3-a to 3-f show examples of the control and each stripping method under SEM. These figures represent the differences of texture on the stripped enamel surfaces. All the SEM figures are at magnification of 500, except for the control (2,000).

Fig. 3-a shows the untreated enamel surface. The enamel surface is worn and flat and has a few cracks and furrows due to abrasion. Fig 3-b shows the enamel surface after stripping with a medium grit diamond -coated metal stripper (medium grit, 4mm wide. Dentaurum©, German). Furrows that are the result of the passage of the bur are visible. They appear relatively regular and are uniformly distributed on the enamel surface. Fig 3-c shows the enamel surface after stripping with medium grit diamond bur (TR-11EF, MANI, Inc, Japan). The surface appears to have dense and irregularly distributed furrows with more visible debris than that of Fig 3-b. Fig 3-d shows enamel surface after stripping with a crosscut tungsten carbide bur (standard number 700, Kornet©Germany). The surface appears to have relatively fine, shallow furrows and hills composed of furrows disappear considerably due to Sof-Lex© (Pop-On™, 3M Unitek, U.S.A) disks. Fig 3-e shows the enamel surface after stripping with a crosscut tungsten carbide bur, followed by the chemical stripping with phosphoric acid. The furrows that are the result of the passage of the bur have almost completely disappeared, and the heads of the enamel prism can be seen on the surface. Fig 3-f shows the enamel surface after mechanical stripping with a crosscut tungsten carbide bur and chemical stripping, followed by the orthodontic sealant application as described previously. It appears that orthodontic sealant covers the etched enamel surface generally and irregular resin particles disperse randomly. In all, it does not cover the inter-prismatic space completely and does not appear very smooth. In conclusion, the furrows that result from all the stripping methods are not completely removed by careful polishing.

2. Susceptibility of the enamel surface to demineralization after stripping and the application of a topical fluoride gel and sealant.

To minimize errors in measurement of fluorescence, the distance between samples and the optical fiber transmitted laser light and the distance between samples and the CCD camera lens were maintained. To determine the method error for part II study, fluorescence loss was re-measured five times on five randomly selected teeth. Standard deviation for these measurements implies the reproducibility of the measurements determined by laser fluorescence (Table 1).

Description of the statistics of the fluorescence loss of differently stripped tooth groups is showed in Table 2. Group B-b, and C-b have the smallest mean, and Group B-a and C-a have the largest mean. To compare fluorescence loss against the surface textures of differently stripped enamel, we used the ANOVA test. The results showed that variation within groups is less

Table 3. Multiple comparison to the difference of fluorescence loss with respect to the surface texture of differently stripped enamel(Scheffe's test)

	Group A	Group B-a	Group C-a	Control
Group A		-1.0810	-1.0270	3.5200**
Group B-a			0.0540	4.6010**
Group C-a				4.5470**

Table 4. The effects of APF-gel and orthodontic sealant applications(paired student's T-test)

	Mean±SD	t-value
Group B-a vs Group B-b	6.9030±3.0167	10.233**
Group C-a vs Group C-b	6.8300±2.2318	13.686**
Group C-a vs Group D	4.6280±2.5437	8.137**
Group C-b vs Group D	-2.2020±3.0103	-3.271*

** : The difference in fluorescence loss between groups is significant at the 0.001 level.

* : The difference in fluorescence loss between groups is significant at the 0.05 level.

than variation between groups, and thus, it implies that the mean difference between groups is significant. Table 3 shows the results from within groups is less than variation between groups, and thus, it implies that the mean difference between groups is significant. Table 3 shows the results from Scheffe's test are subsequently employed in the multiple comparisons of means. In the stripped tooth groups, no matter what the initial stripping instruments were, have more fluorescence loss than the control group ($p < 0.001$), that is to say stripped teeth are less resistant to initial demineralization than untreated teeth. But, we can't find any difference of fluorescence loss among differently stripped methods ($p < 0.001$).

Table 4 shows that whether APF-gel and orthodontic sealant applications increase the resistance to demineralization. The groups treated with APF-gel and sealant have lower fluorescence losses ($p < 0.001$). That is to say the teeth that were treated with APF-gel and sealant are more resistant to demineralization than those not treated. Comparing groups which were treated with APF-gel with groups treated with sealant, the former is more resistant to demineralization than the latter ($p < 0.05$).

DISCUSSION

Previous studies suggested that artificially roughened enamel is less resistant to penetration of a lactate buffer. Kapur et al[12] found that demineralization rates increased 27%, relative to intact enamel, after abrading the surface and Brudevold et al[11] reported that the iodine permeability of abraded bovine enamel increased after short exposure to an acid buffer. However, after polishing the enamel, the rate of demineralization was reduced by 17%.[12] Unfortunately, many studies[13-16,22-23] have suggested that the furrows that result from coarse initial abrasive instruments are not removed by careful polishing, then accumulation of plaque in the furrows causes interdental caries and periodontal diseases. Therefore, it is important not to choose initial abrasive instruments that leave deep furrows. Sheridan[2] suggested that the bur of choice for initial reduction is a 699L, small, tapered crosscut fissure carbide bur. Piacentini and Stondrini[14] suggested that with the use of a 8-straight blade tungsten carbide bur followed by Sof-Lex® disks for polishing the enamel, it is possible to obtain well-polished surfaces. In our study, no matter what is the initial stripping instrument, the furrows are not completely removed by careful polishing and stripped tooth groups have more fluorescence loss than untreated groups. This means that stripped teeth are less resistant to initial demineralization than untreated teeth. Also, among the enamel surfaces which were treated using the three initial abrasive instruments in our study, followed by same polishing method (Sof-Lex® disks), enamel surfaces treated with a 700 crosscut carbide bur showed the smoothest surface and furrows considerably disappeared due to Sof-Lex® disks under SEM. According to the results from SEM, enamel surfaces treated with a carbide bur are more resistant to initial demineralization. But, in our study, even though enamel surfaces were treated with a medium grit diamond bur they have dense and irregularly distributed furrows with more visible debris, resistance to demineralization was not significantly different to those treated with a 700 crosscut carbide bur. As a guess, the reasons are that difference of surface smoothness between the two groups is not enough to effect the resistance to demineralization and our study is an in vitro study excluding plaque accumulation in real enamel surfaces.

In contrast to our study, there are opposite opinions[35-37] as to the deleterious effects of stripping on enamel. These are based on artificially stripped enamel surfaces recovering the original smoothness as a result from constant remineralization and interproximal wear [38-39]. They have found no increase in caries incidence after enamel stripping procedures in vivo studies that used bite-wing films and scanning electron microscopy. Radlanski et al[37] argued that one year after interdental stripping, the artificially produced furrows were still clearly visible especially in gingival areas and plaque accumulated in the furrows, but no incidence of caries was observed. Crain and Sheridan[35] did not find, from a statistical point of view, any relationship between interdental stripping and caries susceptibility or periodontal disease, using bite-wing radiographs to detect new evidence of caries and changes in crestal bone heights. El- Mangoury[36] performed SEM research and concluded that the enamel interproximal reduction in the posterior segments did not expose the teeth to pathologic caries, and that a spontaneous remineralization of the tissue followed after approximately a nine month period of demineralization. However, these studies did not consider individual oral hygiene of orthodontic patients and although there was no statistically significant difference between patients who have new caries and patients who don't, there was actually evidence of new caries in a small number of patients. Therefore, It is necessary that for the production of smooth, self-cleaning enamel surface, the use of fluoride treatment is needed for a lengthy period.

Air-rotor stripping using burs requires caution. Uncontrolled reduction of interproximal enamel produces poor marginal ridge heights or ledge formation and overzealous reduction may produce subgingival contact areas on the reproximated teeth with reduced space for the interproximal gingival papilla. These result in potential plaque trap and localized periodontal breakdown. For the prevention of clinical errors, separation is needed before reduction. Sheridan[2,3] suggested that a 0.020 brass indicator wire should be placed under the contact point of the interproximal surface to be reduced.

To overcome the limitation of mechanical stripping in smoothing surface textures, chemical stripping with 38% phosphoric acid was presented by Joeph et al[22] and sealant applications presented by Sheridan and Ledoux[23]. Joeph et al[22] pointed out that enamel surfaces treated by chemical stripping showed a flattened, etched surface free of furrows. These etched surfaces showed marked crystal growth at 5-10 hours after remineralization, suggesting the possibility of repair of the chemically etched enamel surfaces. On the contrary, in our study, although enamel surfaces that were treated by chemical stripping showed an etched surface free of furrows, they were not resistant to demineralization. As calcifying/ fluoridating solutions are applied (APF gel, in our study), it gains resistance to acid attack. We believe that the chemical stripping method may be a risk on the enamel surface because of rapid plaque accumulation and the therefore clinician should be able to apply calcifying/ fluoridating solution.

The major use of orthodontic sealant is the application on enamel surfaces adjacent to the orthodontic attachments as a method of preventing demineralization[41-42]. In Chae's study[41], light and self-cured orthodontic sealant around and beneath the orthodontic brackets had progressive inhibitory effects as well as preventive effects in enamel demineralization. For the diversity of sealant usage, Sheridan and Ledoux[23] claimed that the use of sealants could provide further sealing and flattening of furrows of the reduced enamel and prevent the interproximal caries. In our study, we replaced pit and fissure sealant, which Sheridan and Ledoux used, with fluoride releasing orthodontic sealant (Excel® sealant resin part A and B, Reliance Orthodontic Products, Inc.). Specimens app-lied with the sealant showed more resistance to demineralization compared with mechanically and chemically stripped specimens ($p<0.001$), but less resistance to demineralization than those with APF gel ($p<0.05$). Possible explanations for these results may be found in its placement and retention qualities. As we can see in Fig 3-f, self-curing sealant didn't perfectly cover the stripped enamel surface because the lightly filled resin was viscous and difficult to place with a brush. Moreover, because the adhesion capacity of the sealant to the enamel surface is weaker in self-cured sealants than in the light-cured ones[11], exfoliated or abrasive sealants were relatively increased during the preparation of specimens. The fate of a mineral in contact with a solution containing fluoride ions is as follows : The low concentration and long duration of fluoride treatment make enamel more resistant to bacterial acid attack by converting enamel hydro-xyapatite to fluorapatite[24] and the high concentration and short duration of professional fluoride treatments favor the formation of soluble calcium fluoride rather than fluorapatite.[43-44] The calcium fluoride slowly releases fluoride ions over several weeks, thus acting as a reservoir for the remineralization or as an anti-bacterial fluoride agent[45].

Of various professional fluoride application methods, the most commonly used topical solutions or gel are 2% neutral sodium fluoride(NaF) ; acidulated sodium fluoride phosphate(APF) at a PH of about 3 and containing 1.23% F ; 8-10% stannous fluoride(SnF_2). Of the compounds recommended, APF-gel is most popular at present. The APF-gel for professional application contain 1.2% F from sodium fluoride in a 0.1M phosphoric acid with an approximate PH of 3. Many studies[39,46-49] where APF-gel is compared with NaF or SnF_2 report that APF is more effective in caries prevention than NaF or SnF_2. Jeansonne and Feagin[47] suggested that in APF solution or gel the acidity may enhance the F-uptake by the enamel and that the excess phosphate appears to have the dual effect of depressing both enamel dissolution and the formation of calcium fluoride thus allowing F deposition in the form of fluorapatite. Zachrisson[40] suggested that the gel may be retained on the enamel surface for longer periods than in solution, and not washed away. In effect, the gel helps in maintaining an F ion reservoir on the enamel surface leading to further up-take. Also, Nelson et al[49] suggested that the APF-gel's effectiveness as a topical fluoride agent, in spite of its relatively low level of permanently bound fluoride and relatively thin CaF_2 layer, may be due to its filling of prism etch pits with CaF_2. These prism etch pits appear to be regions of high local solubility on the enamel surface, and CaF_2 in these pits would not be easily washed. The most important reason to select APF-gel in present study is that it is easy to apply and can be done easily as a routine preventive procedure in orthodontic practice, and it's not as critical to ensure that patients use calcifying-/ fluoridating agents themselves. In our study, 1.23% APF-gel (Flura-gel 60™ CADCO Dental products, Inc) was applied in Group B-b and C-b for five minutes, four times, in intervals of 24 hours showed significant resistance to early demineralization($p<0.001$). These results oppose the studies[50-51] which suggested that it was only effective in reducing demineralization induced by the colonization of S. mutans, but was ineffective that induced by lactate buffers. Based on this present study, we affirm that APF-gel is effective in reducing demineralization induced by lactate buffers.

CONCLUSIONS

To investigate the difference of texture exhibited on interproximal enamel surface with each different stripping method and the susceptibility of proximal enamel to demineralization after stripping and the application of a topical fluoride gel and sealant, one hundred human premolars, which were previously extracted for orthodontic reason, were evaluated by means of SEM and laser fluorescence.

The results were as follows :

1. No matter what the initial stripping instrument was, the furrows that resulted from all the stripping methods were not completely removed by careful polishing.

2. Among the enamel surfaces, which were treated with three different initial abrasive instruments followed by the same polishing method (Sof-Lex® disks), the enamel surfaces that were treated with 700 crosscut carbide bur showed the smoothest surfaces.
3. The stripped teeth, no matter what the initial stripping instrument was, were less resistant to initial demineralization than untreated teeth. But a difference in caries susceptibility according to differently stripped methods was not found ($p < 0.001$).
4. Teeth treated with APF-gel and sealant were more resistant to demineralization than those treated without other treatment after stripping ($p < 0.001$).
5. Comparing groups treated with APF-gel with groups treated with sealant, the former was more resistant to demineralization than the latter ($p < 0.05$).

In conclusion, enamel surfaces, which were stripped interproximally, were less resistant to demineralization even though various attempts were made to produce smooth, self-cleaning enamel surfaces. Therefore, additional treatment (sealant or calcifying/ fluoridating solution) to the stripped enamel surfaces is recommended. Because the sealant has several quality problems to do with placement and retention, we recommend APF-gel application as a routine procedure in orthodontic practice. Also, our study is an in vitro study not taking into account plaque accumulation in real enamel surfaces, the colonization of S. mutans or individual variation. Accordingly, additional studies are required.

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국문초록

치간삭제 후의 법랑질 표면조도와 치아우식 감수성에 관한 연구

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본 연구는 metal stripper, diamond bur, cross-cut carbide bur을 이용한 기계적 삭제방법과 산을 이용한 화학적 삭제방법 등의 서로 다른 방법으로 삭제된 치아에서 삭제방법에 따른 법랑질 표면조도의 차이를 비교하고, 삭제된 법랑질 표면에 국소적 불소도포와 교정용 전색제를 적용시 치아우식 감수성에 미치는 영향을 알아보기 위해 교정적인 목적으로 발치된 100개의 소구치를 대상으로 주사전자현미경과 레이저 형광법을 이용하여 연구한 바 다음과 같은 결과를 얻었다.

1. 치간삭제방법에 관계없이 인접면 삭제 후 법랑질 표면에 형성된 열구는 세심한 연마과정을 통해서도 제거되지 않았다.
2. 기계적인 치간삭제 방법 중에 가장 활택한 법랑질 표면조도를 보이는 군은 crosscut tungsten carbide bur로 초기삭제 후 sof-lex® disk로 연마한 군이었다.
3. 기계적 방법이나 기계적과 화학적 방법을 동반하여 치간 삭제한 모든 군의 치아우식 감수성은 대조군보다 높았다. 그러나 치간삭제 방법에 따른 치아우식 감수성의 차이는 보이지 않았다($p < 0.001$).
4. APF-gel 이나 sealant을 도포한 군은 치간삭제 후 다른 처치를 하지 않은 군에 비해 치아우식 감수성이 낮았다($p < 0.001$).
5. APF-gel을 도포한 군이 sealant을 도포한 군보다 치아우식 감수성이 낮았다($p < 0.05$).

결론적으로, 치간삭제 후 활택한 법랑질 표면을 얻고자 하는 노력에도 불구하고 치간삭제를 실시한 치아는 그 삭제 방법에 관계없이 정상치아에 비해 치아우식 감수성이 높았다. 따라서 치간삭제 후 주기적인 불소의 사용이 치아우식을 예방하는 최선의 방법이라고 생각된다.

주요 단어 : 치간삭제, 치아우식감수성, 주사전자현미경, 레이저 현광법