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Research Article

The Effect of Glass-Ionomer Versus Composite Bonding System on White Spot Lesion (Wsl) Formation Adjacent to Orthodontic Brackets and the Effect of Fluoride Varnish Application on Re-Mineralization of the Wsl

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Abstract

White spot lesions (WSL) around orthodontic brackets are a well-known complication during and after orthodontic treatment. The aim of this in-vitro study was to determine if we can minimize or prevent this phenomenon by using different bonding systems and if we can re-mineralize the enamel using different fluoride enriched varnishes.

Extracted intact premolars were used- orthodontic brackets were bonded using a composite based bonding system, High Q Bond and a glass-ionomer bonding system, Fuji Ortho. Following brackets bonding, the teeth were placed in a cariogenic solution (pH around 4.0) for a period of 14 days. The effect of the cariogenic solution was observed using SEM at enlargements of 1000X. After demineralization process, two kinds of varnishes, MI varnish and Pro fluoride varnish were applied. The effect of the varnish application was demonstrated using SEM pictures and chemical analyses of the treated enamel. The results showed that after bonding with glass-ionomer based cement no demineralization occurred around the brackets, while around brackets bonded with composite based cement a significant demineralization was observed. Application of fluoride varnishes remineralized the surface enamel and a significant amount of fluoride was found in the surface enamel.

Conclusions: Bonding brackets with glass-ionomer based cement will reduce or prevent WSL and application of fluoride varnish during orthodontic treatment will remineralize the enamel and incorporate a high level of fluoride in surface enamel.

Keywords: Orthodontic Brackets; WSL; Glass-Ionomer; Composite; Varnish; Demineralization; Remineralization

Introduction

Tooth decay and the occurrence of demineralization can be attributed to the accumulation of microbial cells which are attracted by pellicle layers which forms on the enamel, dentin and cementum - the relevant oral surfaces of dental tissues.

These microbial cells are not a haphazard bacterial accumulation, but a community formed by the primary colonizers and secondary organisms that form an exo-polymer structure which the cells grow inside of. The community has a collective physiology which can solve the specific physicochemical problems posed by the environment at the site [1].

White Spot Lesions (WSL) are a well-known and very common complication in the field of orthodontic treatments and can be challenging for dentists [2-4]. WSLs are formed as a result of demineralization of the enamel due to plaque accumulation, microorganisms, and improper oral hygiene [2,3]. The caries process is initiated in the biofilm or dental plaque [5]. The process of demineralization of the enamel is most common and severe among orthodontic patients adjacent to orthodontic brackets cemented to the tooth [3], with the area directly next to the composite resin cement found to be the most severe affected. Scratching, loss of surface enamel and other disadvantages such as decalcification are due to acid etching before treatment and the use of bonding medium. The prevalence of WSL next to the brackets bonded with composite materials can range from 5% to 97% after orthodontic treatment [3,7]. To overcome the composite resin's disadvantages, glass ionomers were suggested for cementation [6].

There are a number of reliable methods to control of WSL, with the use of various materials. Saliva is the first and most natural line of protection against demineralization and has been shown to have strong potential in the aiding of remineralization [8]. However, following the natural progression or regression of white-spot lesions formed during orthodontic treatment, clinical studies found that although some lesions get smaller, the majority remain largely unchanged [9]. Additional remineralization by extrinsic calcium, phosphate, and fluoride ions is therefore required to augment the natural remineralization ability of saliva. For the maintenance of apatite in the teeth this is of great importance to those individuals with hyposalivation or low concentrations of calcium and phosphate ions in their saliva.

There are materials that only deal with preventing demineralization while others only deal with the aspect of remineralization, with the process of remineralization recently coming to the forefront of focus for dental practitioners and researchers [10]. This has created debate as to what is the best way to test for early indication of WSL in order to prevent further damage to the tooth surface and assist remineralization while still possible, in order to prevent the necessity of surgical intervention [2,3]. Fluoride has been shown to be an effective preventative of WSL [3,4] and therefore has been recommended in large doses both during and post orthodontic treatment [7]. During a typical orthodontic treatment, it is possible to provide fluoride to teeth through many different methods of topical application, including: pastes, mouthwashes, and varnish gels. Numerous advantages have been listed in connection to the use of fluoride varnish, such as safety, easiness of use, and stopping the demineralization of enamel while enhancing enamel remineralization [11].

In vitro research showed that the Pro fluoride (VOCO) varnish released fluoride at a higher rate in saliva after 5 minutes of acidic exposure, in comparison to the MI varnish (GC Japan) [12].

The MI varnish formulation contains CPP-ACP, an acronym for a complex of casein phosphopeptides and amorphous calcium phosphate, known to reduce the depth of caries lesions found in the area of orthodontic brackets, regardless of the assistance of normal preventative dental hygiene, such as brushing and mouthwash [13]. Additional protection to the orthodontic brace is provided by the fluoride varnish when the brackets are cemented using a composite resin; but when using a glass ionomer cement, no additional protections was observed [3]. Fuji Ortho GI was found to provide adequate strength in bonding between brackets and enamel [14]. The fluoride level release is stronger after glass ionomers cementation in comparison to bonding with composite and continues for an extended period of time [3].

Aim of the Study

a. To analyze the effectiveness of GI and composite cemen tation materials on initiation of WSL around orthodontic brackets.
b. To analyze the effectiveness of the MI varnish and Pro-fluoride varnish in controlling WSL formation around orthodontic brackets.
c. To analyze the chemical composition of enamel after for mation of artificial carries and following applications of 2 kinds of varnish.

Materials and Methods

Sample size

One hundred premolars extracted during orthodontic treatment were collected. The parents gave their approval for leaving the teeth in our clinic. The research was exempt from Helsinki approval since no personal data was used. The teeth were free of cracks, carious or developmental lesions. Upon collection, the teeth were frozen at -20 Celsius and stored at 100% relative humidity.

The premolars used were divided into two main groups and then divided again to form 2 subgroups:

- **Group A1:** Orthodontic brackets cemented on the buccal surface with composite material High Q Bond composite (BJM LAB-Israel) and treated with MI varnish (GC Japan).
- **Group A2:** Orthodontic brackets cemented on the buccal surface with Fuji ortho (GC Japan) and treated with MI var nish (GC Japan).
- **Group B1:** Orthodontic brackets cemented on the buccal surface with High Q Bond composite (BJM LAB-Israel) and treated with Pro fluoride varnish (VOCO).
- **Group B2:** Orthodontic brackets cemented on the buccal surface with Fuji Ortho (GC Japan) bonding material and treated with pro fluoride varnish (VOCO).

Tooth preparation: The buccal enameled surfaces were polished with non-fluoridated pumice and water. The buccal surfaces were rinsed with non-ionized water and dried with compressed air. The orthodontic brackets (Ormco corp. CA, USA) were cemented with GI or composite bonding system according to manufacturer instructions. The premolar crown was covered with wax leaving a rectangular area of 2.5 mm by 2 mm exposed on the cervical region beneath the brackets for the induction of the artificial demineralization process (Figure 1) [13].

Figure 1: *The premolar has been covered with wax, leaving a small rectangular area of 2.5 mm by 2 mm exposed on the cervical region beneath the bracket.*

Composite cementation process: Etching with 37% (Q-etch, Israel) phosphoric acid for 20 seconds, washing and drying. Bonding with Prime and Bond NT, (Dentsply Co) and light hardening for 20 seconds. The orthodontic brackets were placed at 2 mm gingival of the buccal cusp tip and at the center of the mesio-distal surface, cemented with High Q Bond (BJM Lab-Israel) and light cured for 40 seconds (D- LIGHT DUO). Cement residues were removed using a scaler. Glass Ionomer cementation process: No preparation was needed prior to application. The orthodontic brackets were placed at 2 mm gingival of the buccal cusp tip and at the center of the mesio-distal surface, cemented with GC Fuji ORTHO LC capsules (GC Co. JAPAN), and light-cured for 40 seconds.

Inducing demineralization: The teeth were placed in a cariogenic solution (pH around 4.0) for a period of 14 days. The cariogenic solution consisted of a 3.7g brain heart infusion culture and supplemented with 0.5g of yeast extract, 1.0g of glucose, and 2.0g of sucrose per 100 ml distilled water for the purpose of creating areas of white spot lesions. The solution was disinfected for 20 minutes at a temperature of 121° Celsius and then exposed to a young primary culture of *Streptococcus mutans* (ATCC 25175), after which the solution was then placed in an incubator in a microaerophilic environment at 37°C in a candle jar. This process was also done over a period of 14 days, during which the teeth being tested were transferred from one beaker to another on a 48 hour cycle. The new beaker also contained an artificial caries solution, but the new solution was not inoculated with new microorganisms [15].

Fluoride application: Following this period, the teeth were separated into groups "A" and "B", with each group receiving an application of fluoride in high concentration. Group "A" being MI varnish and group "B" being pro fluoride varnish, in order to induce remineralization.

SEM analyses: Processed teeth were analyzed with scanning electron microscope at different intervals. The first scan was performed 1 week after the end of cariogenic process. The second scan was taken 1 week after the application of the pro fluoride varnish and MI varnish. The third scan was taken 1 month after the second scan. The forth scan was taken 3 months later.

Results

SEM analyses after demineralization: Figure 2-5 shows the area gingival to the brackets after demineralization process. The area beneath the brackets cemented with composite material showed significant demineralization on the enamel surface (Figure 2 and 3) in comparison with the area beneath the brackets cemented with FUJI Ortho (Figure 4 and 5).

After application of MI and Pro Fluoride varnishes, following the demineralization process, the enamel beneath the brackets was observed under the scanning electron microscope to note the progress of remineralization. The following figures show the results of the aforementioned checks at periods of one week after fluoride varnishes application (Figure 6-9), after one month (Figure 10-13) and after 3 months (Figure 14-17).

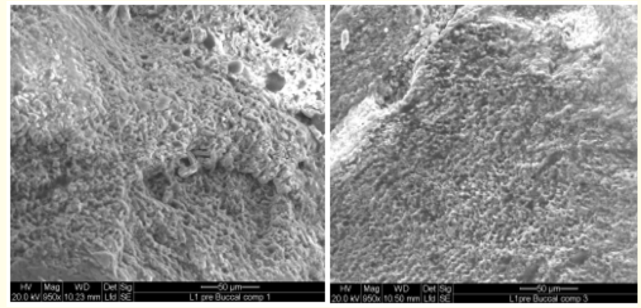

Figure 2 and 3: *The demineralization area beneath the brackets cemented with composite material. Note the extensive enamel demineralization (magnification X950).*

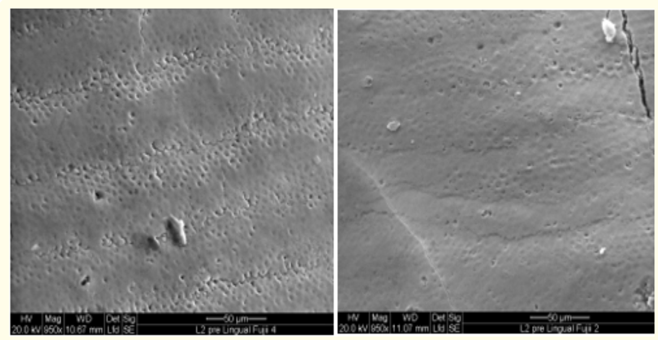

Figure 4 and 5: *The demineralization area beneath the brackets cemented with FUJI Ortho. No significant demineralization of the enamel surface can be observed (magnification X950).*

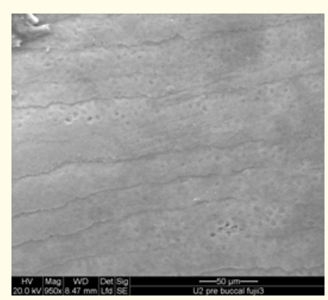

Figure 6: *Fuji cementation on the buccal surface and MI varnish application after one week (mag X950). Note the smoothness of the enamel.*

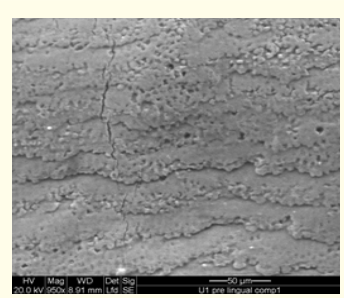

Figure 7:*Composite cementation on the buccal surface and application of MI varnish (mag X950). Note the improvement of enamel surface and the enhanced perikymata lines.*

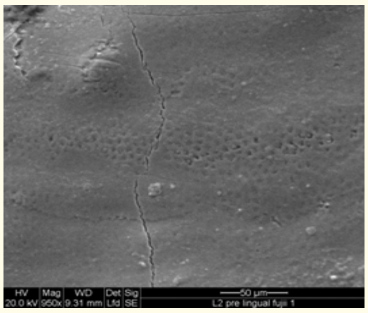

Figure 8: *Fuji cementation on the buccal surface and Pro Fluoride application after one week (mag X950). Note the smoothness of the enamel.*

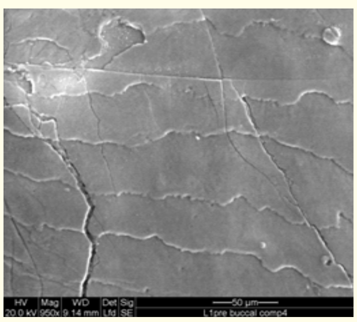

Figure 9: *Composite cementation on the buccal surface and application of Pro Fluoride varnish (mag X950). Note the improvement of enamel surface.*

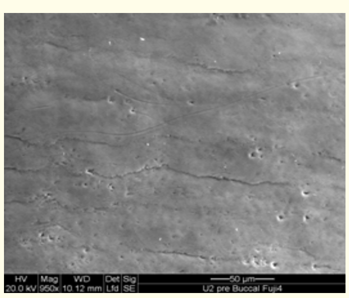

Figure 10: *Fuji cementation on the buccal surface and MI varnish application after one month (mag X950).*

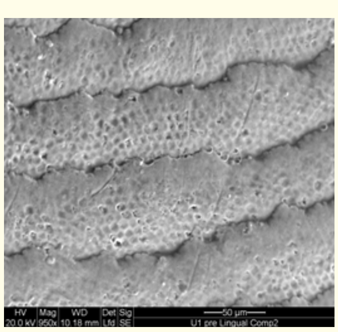

Figure 11: *Composite cementation and MI application after one month (mag X950). Note the improvement of the enamel surface and the enhanced perikymata lines.*

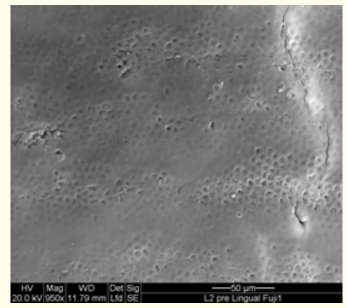

Figure 12: *Fuji cementation on the buccal surface treated with Profluoride varnish after one month (mag X950). No significant difference from figure 5.*

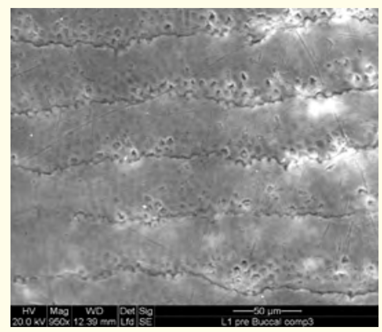

Figure 13: *Composite cementation on the buccal surface treated with Proflouride varnish after one month (mag X950). Note the improvement on enamel surface.*

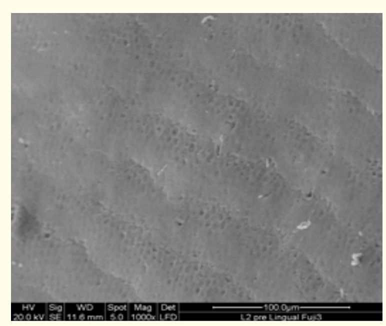

Figure 14: *Fuji cementation on the buccal surface treated with MI varnish after 3 months (mag X1000).*

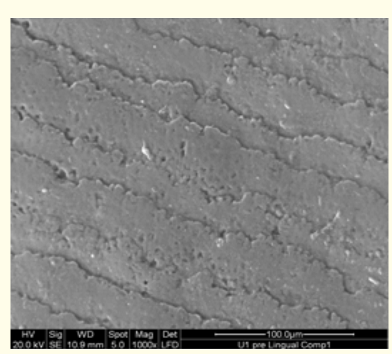

Figure 15: *Composite cementation on the buccal surface treated with MI varnish after 3 months (mag X1000).*

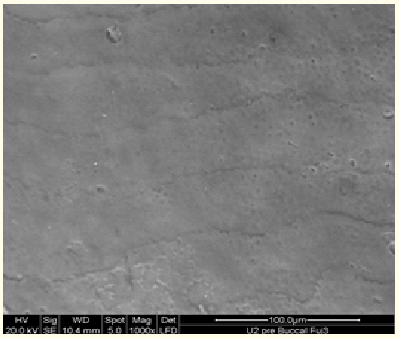

Figure 16: *Fuji cementation on the buccal surface treated with Profluoride varnish after three months (mag X1000).*

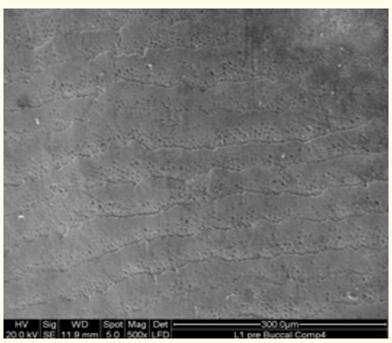

Figure 17: *Composite cementation on the buccal surface treated with Proflouride varnish after three months (mag X1000).*

Mineral content of enamel below the orthodontic brackets, after 3 months of Pro fluoride varnish and MI varnish application was determined using ESD program in the SEM [16].

Tables 1 and 2 shows the results for 4 teeth analyzed from each group. The highest amount of fluorine detected in the enamel was beneath the Fuji Ortho cement and application of Pro fluoride varnish. The ratio of Ca/P is related to the quality of the hydroxyapatite in the enamel and the residual compounds. The ratios were calculated and no significant differences between the groups were observed.

MI varnish			Pro Fluoride varnish		
F	**Ca**	**P (Ca/P)**	**F**	**Ca**	**P (Ca/P)**
0.90	38.0	15.50 (2.45)	2.02	34.64	16.03 (2.16)
1.73	44.8	18.12 (2.47)	11.31	30.56	12.82 (2.38)
0.50	39.24	16.60 (2.36)	11.87	37.56	15.16 (2.48)
1.18	40.18	18.11 (2.19)	10.66	29.96	13.97 (2.14)

Table 1: *Mineral content of enamel mW% after cementation with Fuji Ortho and 3 months application of fluoride varnishes.*

MI varnish			Pro Fluoride varnish		
F	**Ca**	**P**	**F**	**Ca**	**P**
2.07	38.45	16.90 (2.28)	0.46	39.76	17.16 (2.32)
0.85	37.04	17.40 (2.13)	1.01	41.41	18.20 (2.28)
0.54	42.60	17.70 (2.41)	0.7	41.40	17.7 (2.33)
0.96	38.18	16.98 (2.25)	0.80	43.53	18.72 (2.33)

Table 2: *Mineral content of enamel mW% after cementation with High Q Bond composite and 3 month of fluoride varnishes application.*

Discussion

The bonded brackets in orthodontic treatment are an important factor in carious activity and appearance of white spot lesions (WSL) around the brackets. No significant differences were found between a light cured composite, a conventional glass ionomer cement and a polyacid-modified resin composite for bonding brackets [17]. The bonding material may influence the effect of the carious attack on the surface enamel.

The primary aim of the study was to find brackets' bonding cement which would be suitable for orthodontic treatments and prevents or minimize demineralization after placed in a cariogenic solution (pH around 4.0) for a period of 14 days. This study showed that when bonding with Fuji ortho no WSL could be detected beneath the orthodontic brackets, while using composite bonding system, WSL was detected beneath all brackets.

The secondary goal was to check the effect of different high release fluoride materials (Pro fluoride varnish and Varnish MI) in controlling the severity of white spot lesions which had already formed around the orthodontic bracket. Our results showed that the demineralization areas (WSL) beneath the brackets bonded with composite bonding system were improved by the weekly application of both varnishes. Fallahinejad and associates compared the incidence of white spot lesions (WSLs) around 186 permanent first molars of orthodontic patients requiring orthodontic bands following the application of two glass ionomer (GI) cements namely GC Gold Label and GC Fuji Plus for six to 12 months. They found that WSLs were not detectable visually or by DIAGNOdent at intervals of six, nine or 12 months following the cementation of bands with two GI cements [18]. The fluoride content of the enamel treated by the varnish gels showed a higher concentration after bonding with Fuji ortho and using Pro-varnish.

Conclusions

No WSL were detected after bonding brackets with glass-ionomer bonding system and demineralization process. Beneath brackets bonded with composite system and demineralized WSL was detected beneath all brackets.

Pro varnish caused remineralization of WSL beneath brackets bonded with composite based material.

Bonding brackets with glass-ionomer cement and application of Pro-varnish increased the fluoride content of enamel significantly.

The best treatment to minimize WSL around brackets during orthodontic treatment is to use glass-ionomer boding system and pro-varnish application periodically.

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