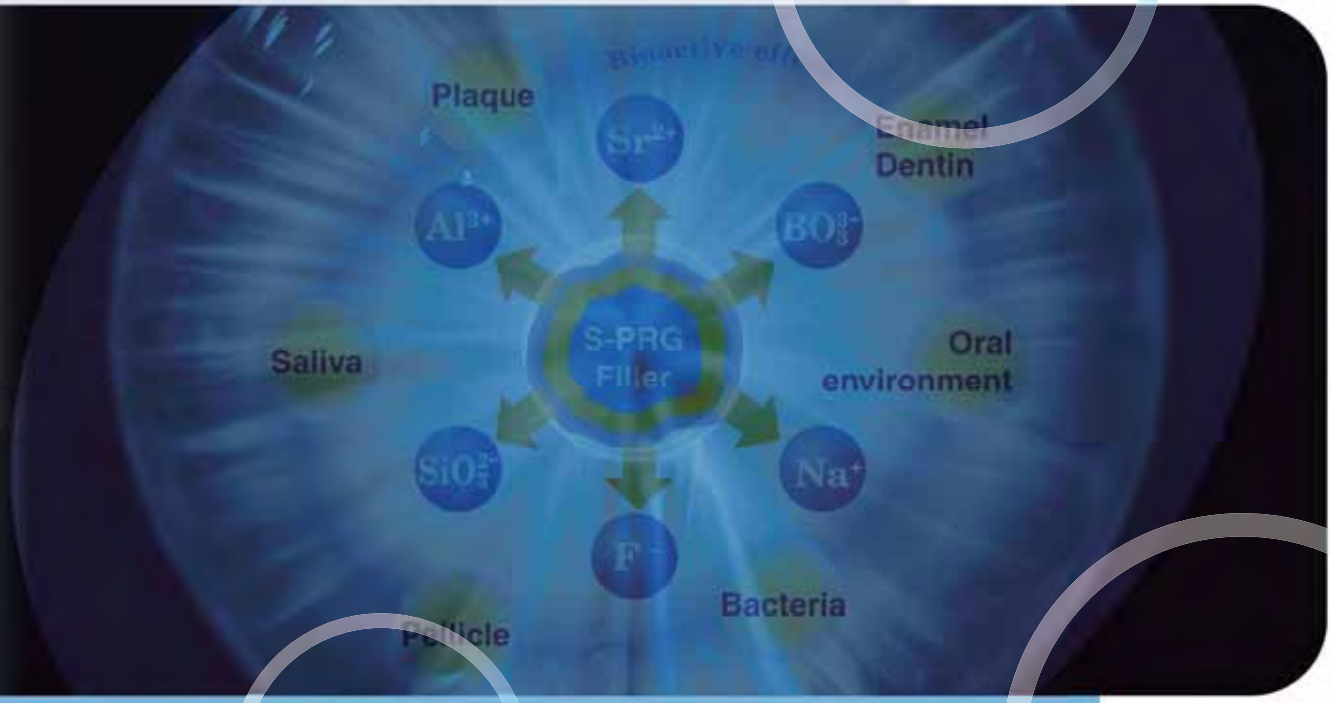
English

SCIENTIFIC EVIDENCE

Ver.2



PRG Technology

Giomer

SHOFU INC.

Contents

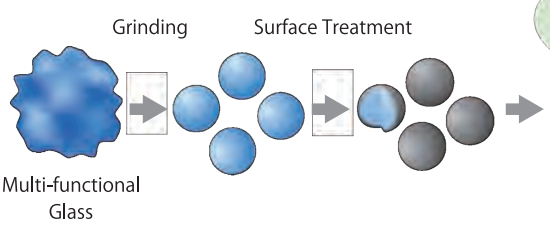
Contents

Pediatric dentistry, Orthodontic dentistry, and Preventive dentistry

We had developed "Pre-Reacted Glass-ionomer (PRG) Technology", where a glass-ionomer reaction (acid-base reaction) between surface-treated multi-functional glass (fluoroboroaluminosilicate glass) filler and polyacrylic acid aqueous solution is employed to preliminarily form a stable glass-ionomer phase on the surface of the glass core, i.e. the inner layer under the surface-modified layer of the glass filler. Developed with the PRG technology, S-PRG filler is a new three-layer bioactive filler material with the ability to release 6 types of ions (Na^+, Sr^{2+}, Al^{3+}, F^-, BO_3^{3-} and SiO_3^{2-}).

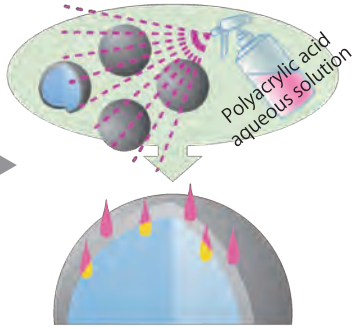
S-PRG Filler

Multi-functional Glass Filler



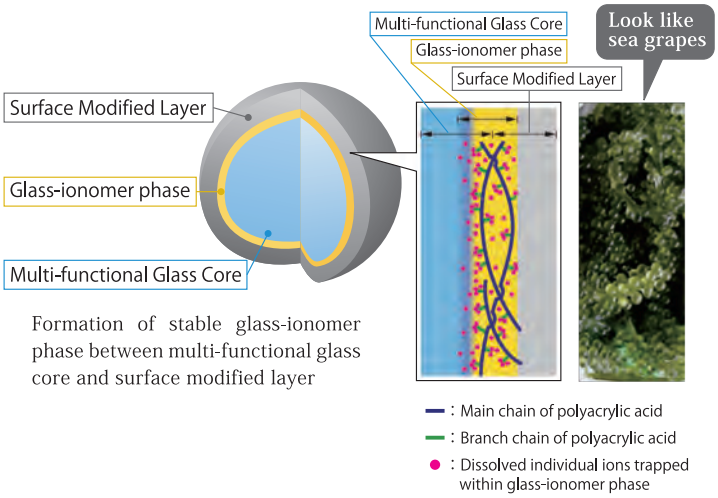
Surface modified layer based porous SiO_2 glass, formed on the multi-functional glass core

PRG Technology



Molecules of polyacrylic acid aqueous solution go through the surface modified layer and glass-ionomer phase is formed by acid-base reaction immediately after the molecules reach the multi-functional glass core

S-PRG Filler (three layer structure)



Formation of stable glass-ionomer phase between multi-functional glass core and surface modified layer

Proposing a new material category "Giomer" as a collective term for dental materials which incorporate S-PRG filler therein, we have been advancing the development of Giomer products for use in various dental fields.

Functions of S-PRG filler

■ Acid-buffering capacity
■ Ion release & recharge

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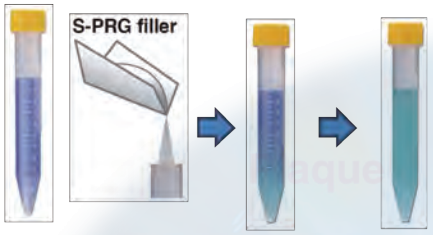

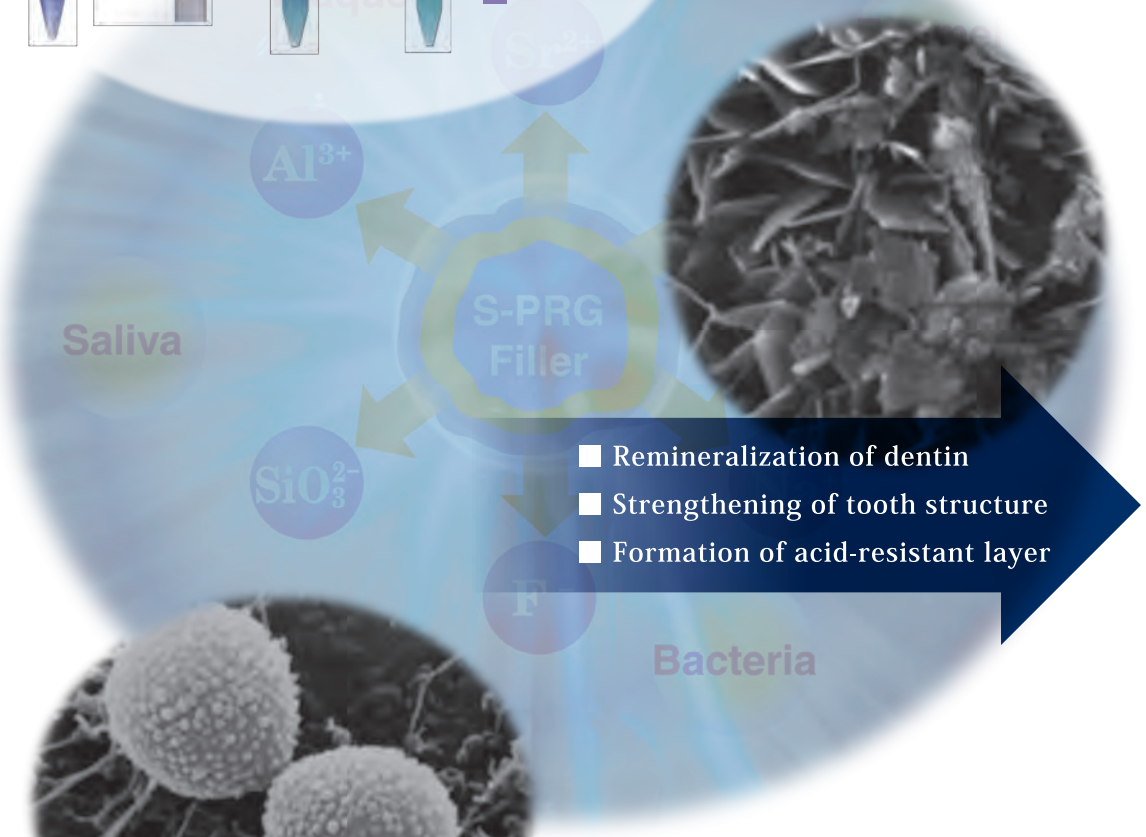

■ Remineralization of dentin
■ Strengthening of tooth structure
■ Formation of acid-resistant layer

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■ Anti-plaque effect
■ Inhibition of enzymatic activity of bacteria

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S-PRG filler

EVIDENCE

Antibacterial Effect of Surface Pre-Reacted Glass Ionomer Filler and Eluate–Mini Review

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Section of General Dentistry, Department of General Dentistry, Fukuoka Dental College

Pharmaceutica Analytica Acta Journal, 6 (3), (2015)

Table Antibacterial effect of S-PRG

Authors	Target	Assay methods	Function	Result
Nishio et al.	human dental plaque	SEM[1]	plaque formation	less plaque formation
	S. oralis	SEM, labeled bacterial count	adherence	no difference
Honda et al.	human dental plaque	SEM	plaque formation	less plaque formation
	huma saliva	EDS	film-like interfface substance	anti-bacterial layer formation
Hirose et al.	Streptococci	SEM	adherence	less *S. sanguinis* adherence
	albumin	^{125}I-labeled albumin	albumin adsorption	more albumin adsorption
Tamoto et al.	human dental plaque	SEM	plaque formation	less plaque formation
		EDS	film-like interfface substance	Al, Si, and Sr were detected from the thin layer
Han et al.	*P. acnes, A. israelii, E. faecalis*	agar difusion method	antibacterial test	anti-bacterial effect on *P. acnes, A. israelii*
Daneshmehr et al.	*S. mutans*	SEM	biofilm formation	less biofilm formation
Yoshida et al.	human dental plaque	SEM	plaque formation	less plaque formation
	S. sanguinis, S. salivarius, S. oralis	^{3}H-labeled bacterial count	adherence	no difference
Idono et al.	human dental plaque	SEM	plaque formation	less plaque formation
	S. oralis	SEM	adherence	less adherence
	S. oralis	colony count	antibacterial test	no difference
Saku et al.	*S. mutans*	SEM, ^{3}H-labeled bacterial count	adherence	less adherence
	S. mutans	colony count	antibacterial test	no difference
Tamura et al.	*S. sanguie* and *S. oralis*	growth curve examination	growth inhibition	growth inhibition
Kimyai et al.	*S. mutans*	SEM, bacterial count	adherence	less adherence
Ma et al.	*S. mutans*	pH electrode	pH change	less pH decrease
	S. mutans	micro-CT scanning, SEM	demineralization	less demineralization
Yoneda et al.	*S. mutans*	safranin-based micoplate assay	adherence	less adherence
	P. gingivalis	BAPNA[2], gelatin film assay	enzyme activities	less enzyme activities
	P. gingivalis and *F. nucleatum*	coaggregation assay	coaggregation	less coaggregation
Hotta et al.	*S. mutans*	SEM, labeled bacterial count	adherence	less adherence
	S. sanguinis	SEM, ^{3}H-labeled bacterial count	adherence	no difference
Kuramochi et al.	huma saliva	bacterial count of PM biofilm[3]	biofilm formation	less biofilm formation
Hahnel et al.	*S. mutans*	MTT-based microplate asay	biofilm formation	less biofilm formation
Suzuki et al.	huma saliva	colony count	antibacterial test	less viable bacteria
	huma saliva	safranin-based micoplate assay	biofilm formation and disruption	less biofilm formation and biofilm disuruptive effect
	oral molodor	halimeter assay	VSCs[4]produciton	less VSCs production

[1] scanning electron microscopy [2] Na-benzoyl-L-arginine 4-nitroanilide hydrochloride [3] polymicrobial biofilm [4] volatile sulfur compounds

A composite resin containing surface pre-reacted glass ionomer (S-PRG) has become widely used as filler or other dental materials in dental treatment. In this mini-review, we briefly summarize the antibacterial activities of S-PRG on different oral bacteria. The inhibitory effect of S-PRG on plaque formation in the oral cavity has been observed. *Streptococcus mutans* adherence has been shown to be inhibited by S-PRG. S-PRG is also considered to be effective in caries prevention because S-PRG eluate could inhibit biofilm formation and disrupt salivary mature polymicrobial biofilm. S-PRG eluate has suppressed the protease and gelatinase activities of *Porphyromonas gingivalis*, which is one of the most important periodontopathic bacteria. Coaggregation by *P. gingivalis* and *Fusobacterium nucleatum* was also inhibited by S-PRG eluate. Other work has shown that an endodontic sealer containing S-PRG had an antibacterial effect on some endodontic bacteria. Oral rinsing with S-PRG eluate was also effective in reducing oral malodor production. In this way, S-PRG has antibacterial effect, and it will be further applied for various dental materials and contribute to preventing oral diseases.

Effect of S-PRG Eluate on Biofilm Formation and Enzyme Activity of Oral Bacteria

Yoneda M[1)] , Suzuki N[2)], Masuo Y[2)] , Fujimoto A[2)] , Iha K[2)] , Yamada K[2)] , Iwamoto T[2)] , Hirofuji T[2)]

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International Journal of Dentistry. ID814913, 6pages (2012)

TRecently, the antibacterial activity of a composite resin containing prereacted glass ionomer (S-PRG) filler was revealed. We examined the effect of an S-PRG eluate on various biologic activities of *Streptococcus mutans* and *Porphyromonas gingivalis*. Adherence ability of *S. mutans* was evaluated by microtiter plate assay; protease and gelatinase activities of *P. gingivalis* were examined by synthetic substrate hydrolysis and gelatin film spot assay, respectively. Coaggregation of *P. gingivalis* with *Fusobacterium nucleatum* was also examined. S-PRG eluate was found to suppress streptococcal adherence. S-PRG eluate inhibited the protease and gelatinase activities of *P. gingivalis* and the coaggregation between *P. gingivalis* and *F. nucleatum*. These results indicate that S-PRG eluate suppresses streptococcal adherence and inhibits the protease and coaggregation activities of *P. gingivalis*. These findings may prompt research into novel strategies for preventing caries and periodontitis.

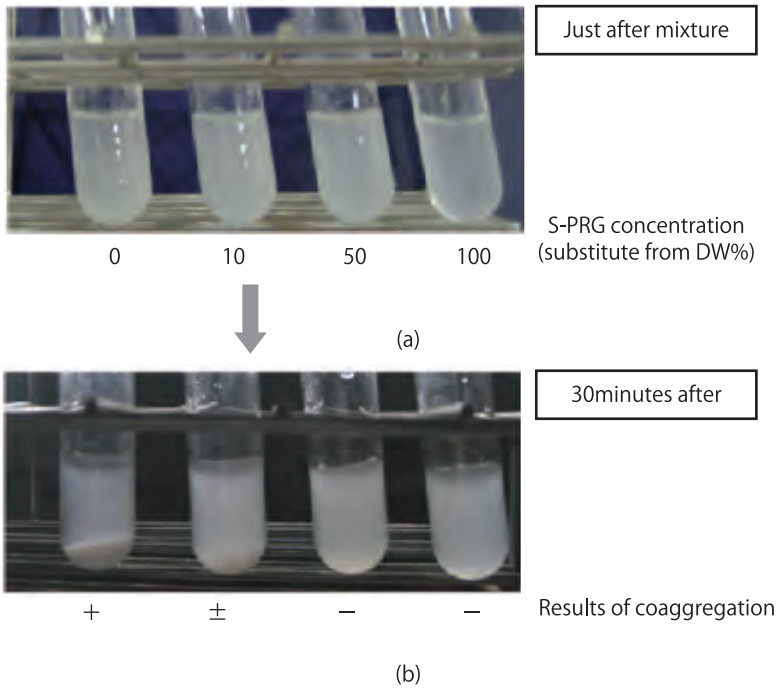

Fig. Coaggregation between *P. gingivalis* and *F. nucletum* in the presence and absence of S-PRG eluate.
(a):photographs of coaggregation.(b):results of coaggregation assay.

Antibacterial effects of S-PRG filler eluate to Streptococcus mutans

Kurashige Y[1], Uehara O[2], Shudo K[1], Murai Y[1], Hayashi Y[1], Takai R[3], Matsuoka H[2], Harada F[4], Nagayasu H[5], Abiko Y[3], Chiba I[2], Saitoh M[1]

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2) Division of Disease Control and Molecular Epidemiology, Department of Oral Growth and Development, School of Dentistry, Health Sciences University of Hokkaido
3) Division of Oral Medicine and Pathology, Department of Human Biology and Pathophysiology, School of Dentistry, Health Sciences University of Hokkaido
4) Social medical corporation Keiyu-Kai Sapporo Hospital, Department of Dentistry and Oral Surgery
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Journal of Japanese Society for Evidence and the Dental Professional, 6(1), 31-37, 2014

Surface pre-reacted glass ionomer(S-PRG) filler consisting of fluoroaluminosilicate glass which have ability to react acid can release several kinds of ions including fluoride ion. Those ions have antibacterial effects to oral bacteria and are applied as ingredients of caries prevention material in clinical setting.

The purpose of this study is to evaluate effects of S-PRG filler eluate to *S.mutans* in Minimum Inhibitory Concentration (MIC), Minimum Bactericidal Concentration (MBC), Biofilm inhibitory effect, the proliferation inhibitory ability and gene expression of Glucosyltransferases (gtf).

The results from MIC, MBC and proliferation ability indicated that S-PRG filler eluate inhibited proliferation of *S.mutans* and decreased the formation of biofilm. Furthermore gene expressions of gtf-B and gtf-C were reduced.

In conclusion, this study suggested that S-PRG filler eluate has the ability of inhibitory effect to plaque formation and leads to inhibit the matured plaque formation. Therefore S-PRG filler is assumed beneficial material as caries prevention material.

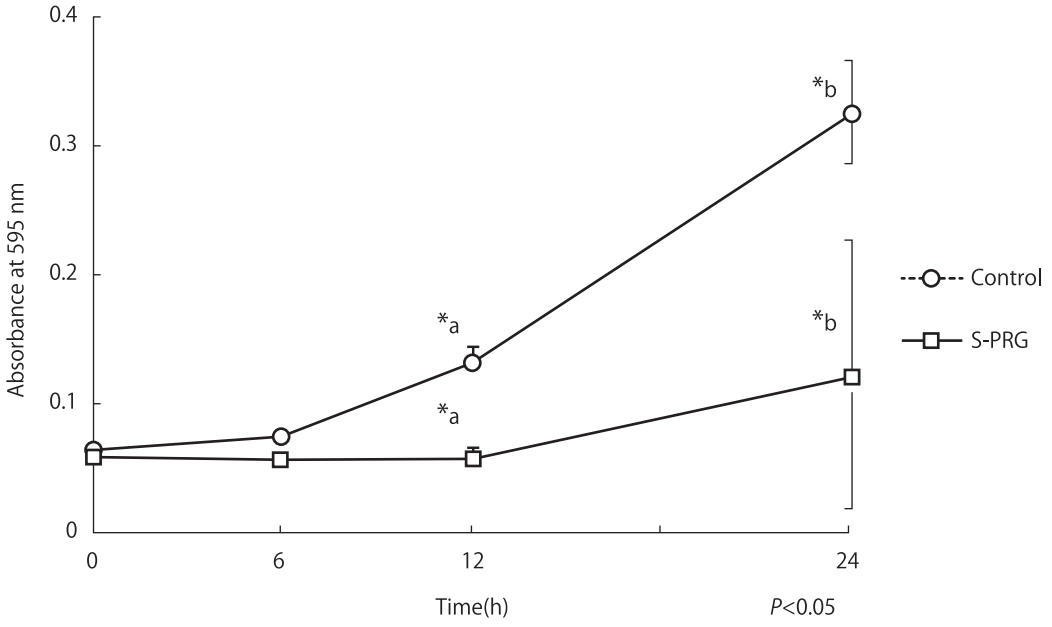

Fig.Suppression of *S.mutans* growth with S-PRG filler eluate

Effects of surface reaction-type pre-reacted glass ionomer on oral biofilm formation of Streptococcus gordonii

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2)Department of Microbiology, The Nippon Dental University School of Life Dentistry

Odontology, August 30 (2015)

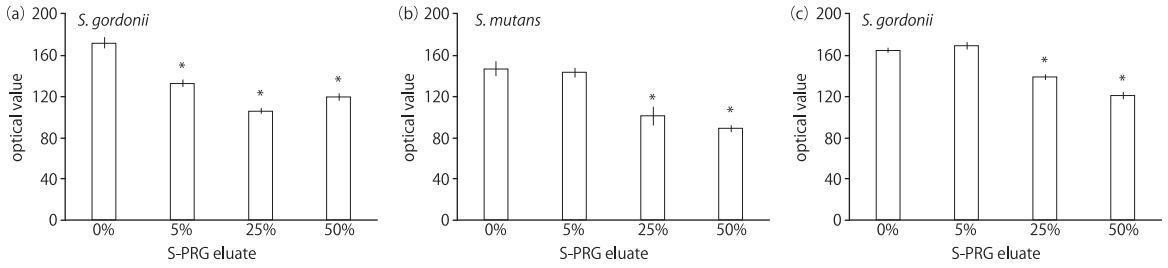

Fig. Effect of S-PRG eluate treatment on biofilm formation of various oral streptococci. Mean (n = 6) and SD of the optical values of CV-stained biofilms are indicated. The asterisk indicates that the optical values were significantly less than that of the control (0 % S-PRG eluate; P<0.001). The assays were performed using a *S. gordonii* DL1, b *S. mutans* MT8148, and c *S. oralis* 34.

Streptococcus gordonii, a bacterium involved in the initial colonization of tooth surfaces, contributes to dental biofilm formation and is an important cause of infective endocarditis. This study aimed to investigate the influence of surface reaction-type pre-reacted glass ionomer (S-PRG) filler on oral bacterial growth and aggregation of *S. gordonii*. The effect of various concentrations of S-PRG eluate on the growth and the biofilm formation of *S.gordonii* and other oral microorganisms (*Streptococcus mutans*, *Streptococcus oralis*, *Lactobacillus acidophilus*, and *Candida albicans*) was assessed. In addition, the effect of S-PRG eluate on coaggregation of *S. gordonii* with both *S. oralis* and *Fusobacterium nucleatum* was assessed. The effect of S-PRG eluate treatment on autoaggregation of *S. gordonii* was also evaluated. Our results indicate that S-PRG eluate treatment reduced both for the growth and for biofilm of all organisms in a dose-dependent manner. Coaggregation of *S. gordonii* with both *S. oralis* and *F. nucleatum* was inhibited by S-PRG eluate, whereas autoaggregation of *S. gordonii* increased at certain concentrations of S-PRG eluate. These results indicate that the S-PRG filler possesses antimicrobial activity that is mediated by inhibiting growth and biofilm of oral microorganisms, and by suppressing coaggregation of *S. gordonii*. In addition, these findings indicate that coaggregation of *S. gordonii* with other bacteria is inhibited by increased autoaggregation of *S. gordonii*.

Antibacterial Effects of an S-PRG Eluate on Polymicrobial Biofilms

Kuramochi E[1),4),5)], Tomiyama K[1),4),5)], Kumada H[3),5)], Shiiya T[1),4),5)], Iizuka J[1),4),5)], Hasegawa H[1),4),5)], Watanabe K[2),5)], Hamada N[2),5)], Teranaka T[1)], Mukai Y[1),4),5)]

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The Japanese Journal of Conservative Dentistry, 57(5), 414-420 (2014)

PURPOSE

The removal of oral biofilm to prevent dental diseases and systemic conditions has been investigated in recent years. In environments where oral cleaning is difficult, such as during a disaster, biofilm increases susceptibility to pneumonia and infections, requiring a simpler and more effective means of oral care. The present study used polymicrobial biofilms from saliva to investigate the antibacterial effects of surface pre-reacted glass-ionomer (S-PRG) filler eluate on biofilm. The eluate contained fluoride and the other ions (BO_3^{3-}, Na^+, Sr^{2+}, SiO_3^{2-}, and Al^{3+})

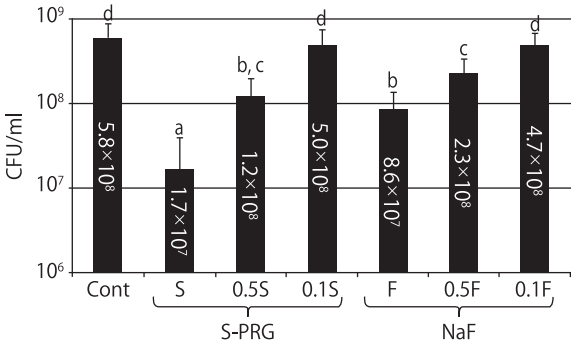

Fig. CFU counts at 48h

The same letter are not significantly different through the one-way ANOVA and Games-Howell test ($p>0.05$). N=12

METHODS

S-PRG filler was suspended in distilled water, and the clear supernatant was used as the S-PRG eluate (110.5ppmF). Buffered McBain 2005 culture medium prepared with this eluate was used for group S. Thereafter, buffered Mcbain 2005 was used to adjust 2-fold and 10-fold diluted culture containing S-PRG filler eluate(0.5S and 0.1S samples). For group F, NaF solutions with the same concentration of fluorides as that of S-PRG filler eluate, culture medium containig 2-fold and 10-fold diluted NaF (0.5F and 0.1F samples), were similarly created. These six solutions were used as test media. Buffered McBain 2005 medium was used as a standard medium for the control sample (Cont). A polymicrobial biofilm model was cultivated on glass plates in buffered McBain 2005 medium with stimulation saliva of one healthy subject and by continuous anaerobic culture for 24 h at 37℃. The media were refreshed at 10h. Thereafter, anaerobic culture was performed using the test media from 24 hours until 48 hours following commencement of the experiment, to investigate the impact of S-PRG eluates. These media were refreshed at 34 h. In each sample, pH values were measured after 24, 34, and 48 h. The CFU count of each group was measured after 48 h. The data of pH and CFU were statistically analyzed (One-way ANOVA, Games-Howell test, $p<0.05$).

RESULTS

The pH value of S after 34 h was 6.8, and that of 0.5S was 6.4. After 48 h, the pH of S was 6.8, a significantly higher value than those of the other samples. CFU counts (CFU/ml) after 48 h were: S: 1.7×10^7, 0.5S: 1.2×10^8, F: 8.6×10^7, and 0.5F: 2.3×10^8. These values were significantly lower than that of Cont (5.8×10^8). Group S showed significantly lower values compared to group F.

CONCLUSION

Various kinds of ion contained in the S-PRG eluate affect biofilm, including the possibility that they can reduce live bacterial counts.

Streptococcus mutans biofilm formation and release of fluoride from experimental resin-based composites depending on surface treatment and S-PRG filler particle fraction

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2)Institute of Experimental and Applied Physics, University of Regensburg
3)Department of Health Sciences, University of Milan

The Journal of Adhesive Dentistry. 16 (4), 313-321 (2014)

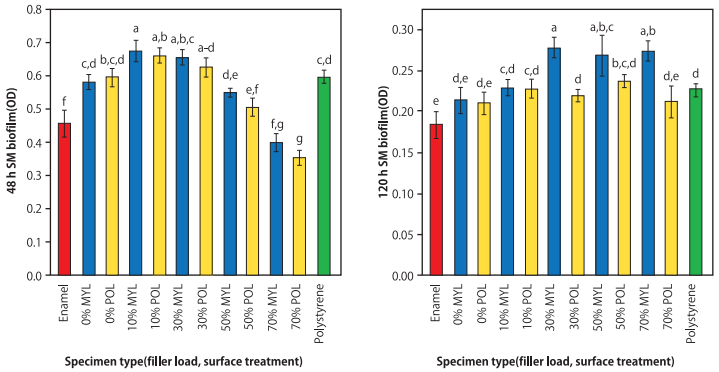

Fig. Viable biomass assessment after 48h (left) and 120h (right) of *S. mutans* biofilm formation. Data are displayed as mean ±1 standard error (SE). Identical lowercase letters indicate no statistical significance with α=0.05.

PURPOSE

To evaluate fluoride release and biofilm formation on resin-based composites (RBCs) including surface pre-reacted glass ionomer (S-PRG) filler particles.

MATERIALS AND METHODS

Specimens were prepared from experimental RBCs including different fractions of S-PRG fillers (0/10/30/50/70% w/v). RBCs were light cured against mylar strips (MYL), and 50% of the specimens were additionally polished to a high gloss (POL). Surface roughness (SR), surface free energy (SFE) and fluoride release were determined. *Streptococcus mutans* biofilm formation (SMBF) was simulated for 48 h and 120 h; adherent viable biomass was assessed using an MTT-based assay.

RESULTS

The highest SR was identified for POL specimens manufactured from the RBC with a filler fraction of 70%. For all specimens and surface treatments, polishing caused an increase in surface free energy. For both MYL and POL specimens, increasing the filler fraction coincided with an increased release of fluoride; a higher release of fluoride was identified for POL specimens with filler fractions of 50% and 70% in comparison to their MYL counterparts. Release of fluoride was lower after 120 h than after 48 h. No differences in SMBF were identified between MYL and POL specimens with identical filler fractions after 48 h of biofilm formation; with increasing filler fractions, a tendency towards decreasing SMBF was observed. After 120h, less SMBF was identified for POL specimens with filler fractions of 30%, 50% and 70% in comparison to corresponding MYL specimens.

CONCLUSION

The inclusion of S-PRG fillers and an effective surface treatment may reduce biofilm formation on RBCs.

Caries-Preventive Effect of Mouthguards Containing S-PRG Filler

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Japanese Academy of Sports Dentistry, 19 (1), 8-13 (2015)

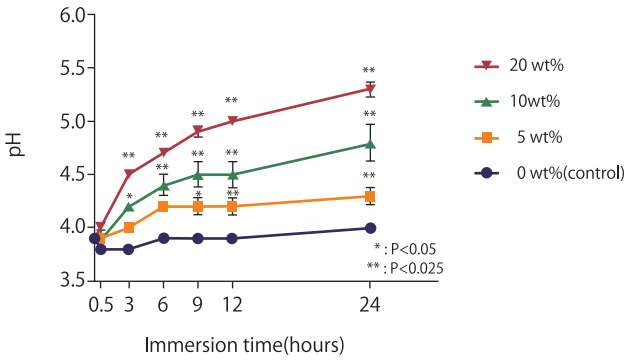

Fig. pH change of lactic acid solution

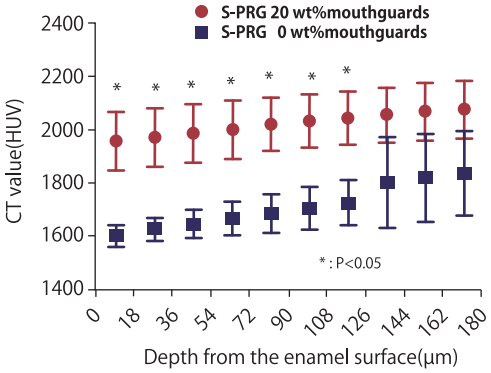

Fig. CT value of specimens

Although sporting mouthguards prevent orofacial injuries, they may also cause dental caries because they delay the contact of sugar in sports drinks to the surface of teeth. The aim of this study was to examine the cariespreventive effect of mouthguards containing an S-PRG filler, ethylene-vinyl acetate (EVA) copolymer. To evaluate the effect of these mouthguards on acid-neutralizing capacity, EVA plates with a different content of S-PRG filler (5, 10, 20 wt% ; control, 0 wt%) were prepared and pressed (1 t, 105℃, 3 min) to form disc specimens (diameter, 20 mm ; thickness, 2 mm). The specimens were stored in lactic acid solution (pH 3.9, 9.41 ml) in individual plastic containers (3rc, 24 h), and the time-dependent change in pH in the solutions was measured using a pH meter. To evaluate the effect of S-PRG filler containing EVA on decalcification, bovine tooth specimens were covered with EVA plates with different S-PRG content (20 wt% ; control, 0 wt%) and then stored in an artificial decalcification solution (37℃, 24 h). Micro CT (SkyScan117 4, Bruker) images of the teeth were obtained to determine the amount of decalcification. A Mann-Whitney U-test was used for two-group comparisons ; Kruskal-Wallis and Shirley-Williams tests were used for multiple group comparisons with $p<0.05$ considered statistically significant. Increases in pH observed in the lactic acid solutions containing the specimens were used to demonstrate their acid-neutralizing capacity. The magnitude of the pH increase varied according to the content of S-PRG filler, with higher content causing a sharper and greater increase in pH, whereas the control (content : 0 wt%) showed almost no change in pH. Significantly higher HUV was observed in specimens covered with the S-PRG filler containing 20 wt% EVA compared with the control (content : 0 wt%). These results indicate that S-PRG filler-containing EVA has an acid-neutralizing capacity and also prevents decalcification.

Effects of surface pre-reacted glass-ionomer fillers on mineral induction by phosphoprotein

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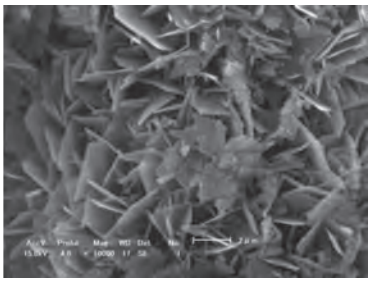
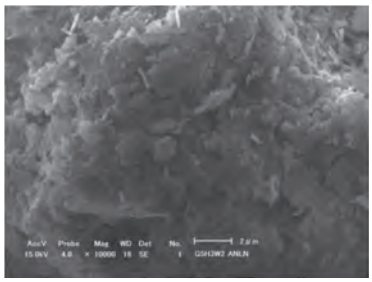
Division of Clinical Cariology and Endodontology, Department of Oral Rehabilitation, School of Dentistry, Health Sciences University of Hokkaido

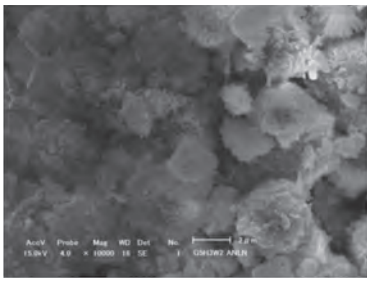
Journal of Dentistry, 39 (1), 72-79 (2011)



(a)



(b)



(c)

Fig. (a) Scanning electron micrographs of minerals formed on phosvitin cross-linked to agarose beads 24h after incubation in a control metastable solution alone, (b) in mineralizing solutions made with eluate from glass filler (c) in 100% eluate containing released ions from composite resin filled with S-PRG fillers.

OBJECTIVES

The aim of this study was to evaluate the mineralizing potential of ions released from surface pre-reacted glass-ionomer (S-PRG) fillers on mineral induction by phosphoprotein in vitro.

METHODS

Phosvitin was used as a model of dentin phosphoprotein in this study. Phosvitin was immobilized on agarose beads with divinyl sulfone. Five aliquots of phosvitin-immobilized agarose beads were incubated in control or experimental mineralizing solution. The experimental mineralizing solutions were made from eluates of resin filled with S-PRG fillers. The beads were incubated at 37℃ in a shaking water bath, and aliquots were taken at several time points during the incubation. Then the beads were analyzed for calcium by atomic absorption spectrometry.

RESULTS

Phosvitin-immobilized agarose beads induced mineral formation after incubation for 5.3h in the metastable solution without ions eluted from S-PRG fillers. Undiluted eluates significantly reduced mineral induction time. SEM observation and X-ray diffraction revealed larger apatite crystals on the beads incubated with eluates of S-PRG fillers than with the control.

CONCLUSIONS

S-PRG fillers may play a role in mineral induction.

Effects of S-PRG eluate on oral biofilm and oral malodor

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Archives of Oral Biology, 59 (4), 407-413 (2014)

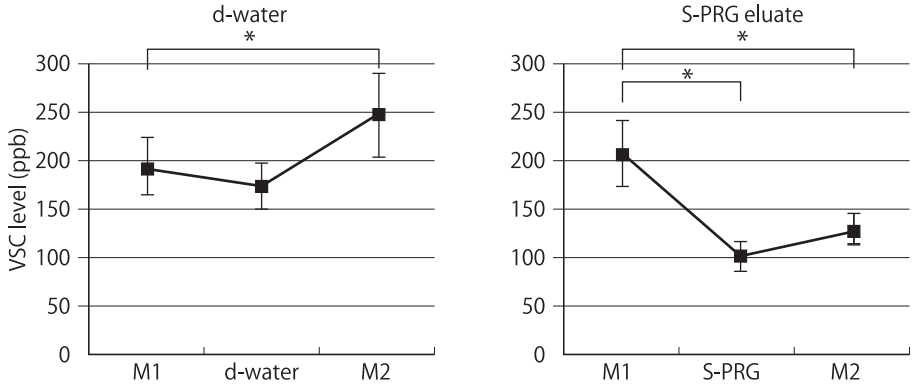

Fig. The effect of oral rinsing with S-PRG eluate on VSCs (n=5, mean±SD). *P<0.05 vs. M1. M1: VSC levels following the initial methionine rinse. Water or S-PRG: VSC levels following oral rinsing with distilled water or S-PRG eluate. M2: VSC levels following the second methionine rinse.

OBJECTIVES

This study evaluated the effects of a surface pre-reacted glass-ionomer (S-PRG) eluate on oral microbiota and dental biofilms in vitro, and on oral malodor and tongue bacterial loads clinically.

STUDY DESIGN

The effect of S-PRG eluate on the growth and survival of salivary bacteria was examined under both aerobic and anaerobic conditions; its ability to inhibit new biofilm formation and disrupt mature biofilms was also evaluated. The concentration of volatile sulfur compounds (VSCs) was measured using a portable sulfide monitor before and after rinsing with S-PRG eluate or distilled water. The number of bacteria on the tongue surface was calculated using a portable bacterial counter before and after tongue scraping with S-PRG eluate or distilled water.

RESULTS

No zone of inhibition was seen for S-PRG eluate against salivary microbiota under either aerobic or anaerobic conditions; however, treatment with ≥20% S-PRG eluate was sufficient to suppress biofilm formation relative to untreated controls. Mature biofilms were significantly disrupted following treatment with ≥60% S-PRG eluate relative to controls. Rinsing with S-PRG eluate significantly reduced the level of VSCs relative to baseline; this effect was not seen with distilled water alone. Waste fluids collected after oral rinsing with S-PRG eluate contained more bacteria than rinsing with distilled water alone. Finally, tongue scraping using S-PRG eluate was shown to significantly reduce the number of bacteria on the tongue surface.

CONCLUSIONS

S-PRG eluate inhibits biofilm formation and disrupts mature biofilms, although its antibacterial activity is limited. Oral rinsing and tongue cleaning with S-PRG eluate may reduce oral malodor by effectively removing oral bacteria from the oral cavity.

Fluoride Release and Recharge Capabilities of Orthodontic Resin Containing S-PRG Filler

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The Japanese Pediatric Dental Journal, 51(1), 1-7 (2013)

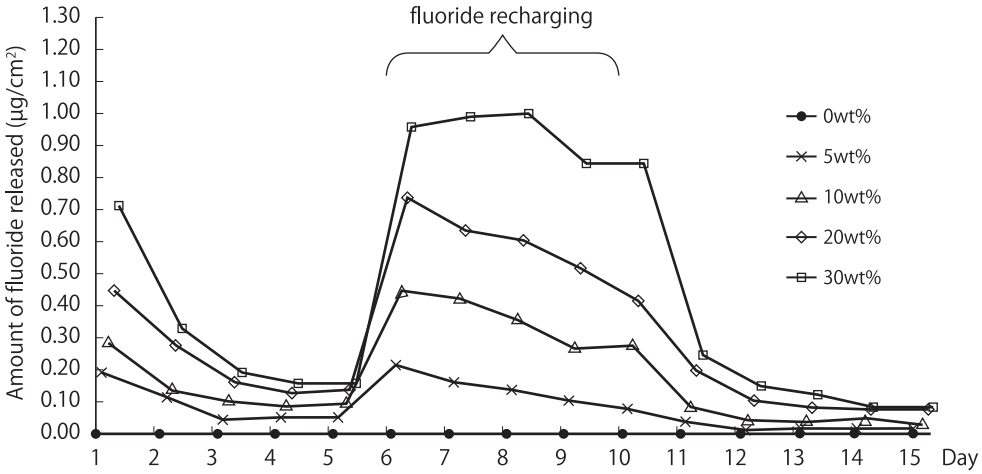

Fig. Fluoride release and recharge capabilities of orthodontic resin containing S-PRG filler.

We investigated fluoride release and recharge capabilities of orthodontic resin containing surface pre-reacted glass-ionomer (S-PRG) filler, using 5 sets of 7-resin samples containing S-PRG filler at 0, 5, 10, 20, or 30 wt%. Samples were immersed in distilled water from day 1 to 6. The water was changed every 24 hours and the amount of fluoride released was determined. From day 6 to 10, the samples were immersed in a fluoride solution (1,000 ppm) for 8 hours to recharge the fluoride and then in distilled water for 16 hours to determine the amount released. From day 11 to 15, the samples were again immersed in distilled water to estimate the fluoride release capabilities of the materials. Secondary electron images were obtained to assess the mixed state of the filler of a sample polymer containing 30 wt% S-PRG, while backscattered electron images were taken to observe the surface structure of the materials before and after the experiment. Our results revealed the following :

1. Regardless of fluoride recharging, the amount of fluoride released was increased with an increasing percentage of S-PRG, with significant differences seen between 5 wt% and 20 wt%, 5 wt% and 30 wt%, and 10 wt% and 30 wt%.
2. The amount of fluoride released appeared to decrease after repeated recharging. However, no significant reduction in the amount released was observed in samples containing 30 wt% S-PRG.
3. Backscattered electron images obtained before and after the experiment showed uniformly dispersed S-PRG filler with occasional aggregates in polymerized resin. No filler fallout or breakdown was observed on the surface of the resin samples.

Operative dentistry

EVIDENCE

Study on the Film Layer Produced from S-PRG Filler

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The Japanese Journal of Conservative Dentistry, 47(3), 391-402 (2004)

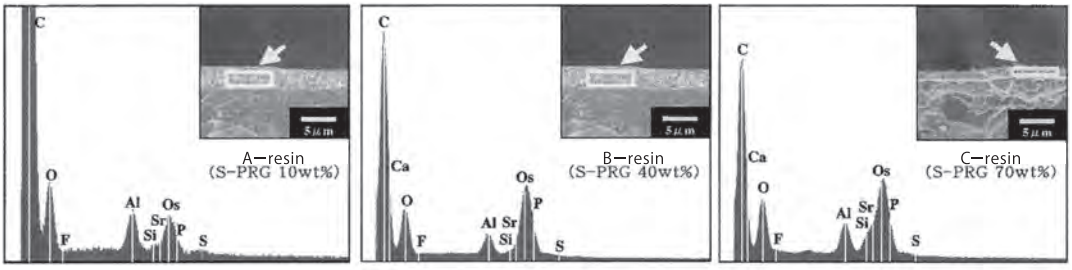

Fig. EDS observation of the film layer on the materials filled with S-PRG filler after 8-hour storage in human mouth. Spectral image was obtained from EDS observation in the boxed area indicated by an arrow.

OBJECTIVES

Recently a fluoride-releasing composite resin Beautifil (Shofu) in which S-PRG (Surface reaction type Pre-Reacted Glass Ionomer) filler was filled, has been developed and is in commercial use. In this study an initial colonizer onto various experimental composite resins filled with S-PRG filler was observed by scanning electron microscope (SEM) and X-ray energy-dispersive spectrometry (EDS).

METHODS

Composite resin blocks were set on the buccal side of the maxillary first molar. After 8, 12 and 24 hrs resin blocks were removed and then the condition of plaque accumulation on the resin surface was observed by SEM. The materials filled with S-PRG filler were also subjected to an in vitro adherence test using artificial saliva and human saliva and examined by SEM and EDS observation. *Streptococcus oralis*, which had been isolated from the composite resin surface, was used. Bacterial adhesion to the materials was tested by radioactivelabelled *S.oralis* and the viable count of bacteria was determined using the bacterial culture technique.

RESULTS

Plaque accumulation on three experimental composite resins filled with S-PRG filler was significantly inhibited and a thin layer-like interface substance was observed on these surfaces. EDS observation showed high levels of three elements (Al, Si, Sr) on this thin layer. On the thin layer no bacterial growth was observed and the growth of initial colonizers was localized in the restricted zone, which was the naked resin surface. As regards the artificial saliva immersion there was no thin layer on the surface. However, the human saliva immersion resin surface was found to have a thin layer.

CONCLUSIONS

These results suggested that the thin layer, which was mediated human saliva and is regarded to be an inorganic rich substance, interfered with the initial dental plaque formation. Therefore it is considered that S-PRG filler has a characteristic of anti-dental plaque restorative material, and so the film-like interface substance should be further investigated.

The Anti-dental Plaque Effect of Fluoride Releasing Light-cured Composite Resin Restorative Material

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Department of General and Operative Dentistry, Asahi University School of Dentistry

The Japanese Journal of Conservative Dentistry, 45(3), 459-468 (2002)

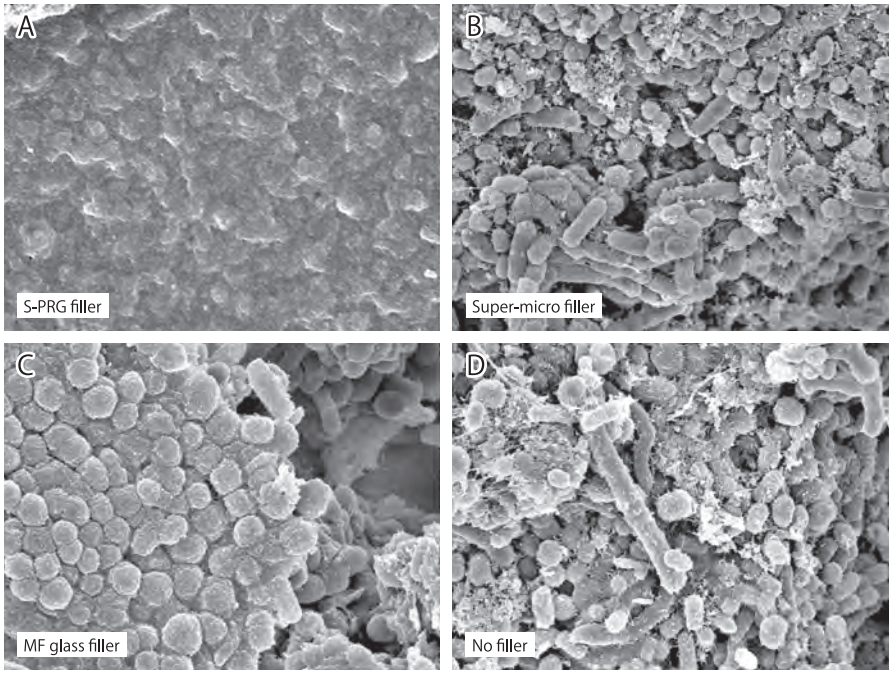

Fig. Anti-plaque effect of composite resin containing single filler which is applied for BEAUTIFIL.

A : S-RPG filler only resin B : Super-micro filler only resin
C : MF glass filler only resin D : No filler resin

Using a scanning electron microscope, we examined plaque accumulation on various commercial composite resins and experimental composite resin filled with S-PRG (Surface reaction type PreReacted Glass Ionomer) filler. Restorative materials used in this study were as follows: Light cured composite resins were Clearfil, Lite-Fill II, and Palfique; and polyacid-modified resin-based composites were S-PRG resin: Beautifil. Composite resin blocks were set on the buccal side of maxillary first molar. After 24 hrs, the plaque condition on resin surface was observed using a scanning electron microscope. *Streptococcus oralis (S. oralis)*, which had been isolated from composite resin surface, was used on bacterial adherent test in vitro. The numbers of adherence bacterial cells on resin blocks after 2 hrs immersion were counted using radio isotope ^{3}H.

S-PRG resin showed little adherence bacteria, and three types of fillers (S-PRG filler, alumina super-microfiller, and MF glassfiller) were detected on S-PRG resin surface. An experimental composite filler with S-PRG filler showed little matured plaque accumulation, while on the other hand, two experimental commercial composite resin filled alumina super-microfiller and MF glassfiller showed the matured plaque on their surface after 24 h. On an in vitro experiment (non saliva coating), no significantly different cell counts of bacteria *(S. oralis)* on various experimental resin surfaces were found. This may be expected saliva protein is associated with bacterial adherence on resin surface. These results indicate that fluoride released from S-PRG filler is connected with prevention of plaque accumulation on the surface, and S-PRG has potential for secondary caries prevention. Inhibition mechanism of fluoride at bacteria-resin surface interface and a role of saliva protein for bacterial adherence on resin surface should be investigated.

Antibacterial activity of composite resin with glass-ionomer filler particles

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Dental Materials Journal, 29(2), 193-198 (2010)

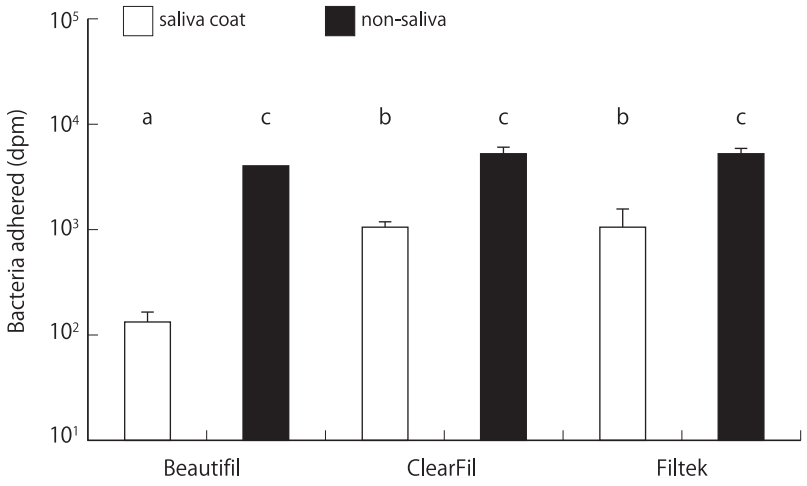

Fig. Amounts of adherent [3H]-thymidine labeled bacteria on the saliva-coated and non-coated surfaces of the three composite resins. Amount of bacteria adhered was expressed as disintegrations per minute (dpm). Error bars indicate standard deviations. Letters 'a', 'b', and 'c' indicate statistically significant differences ($p<0.05$) in values as tested with Bonferroni's test.

The purpose of this study was to examine the antibacterial activity of composite resin with glass-ionomer filler particles versus that of contemporary commercial composite resins. Three composite resins were used: Beautifil II (containing S-PRG filler), Clearfil AP-X, and Filtek Z250. Resin blocks were bonded to maxillary first molars, and plaque accumulation on the resin block surface was examined after 8 hours. For the antibacterial test, the number of *Streptococcus mutans* in contact with the composite resin blocks after incubation for 12 hours was determined, and adherence of radiolabeled bacteria was evaluated. Less dental plaque was formed on Beautifil II resin block as compared to the other two materials. Antibacterial test revealed that there were no significant differences in the number of *Streptococcus mutans* among the three composite resins. However, the adherence of radiolabeled bacteria to the saliva-treated resin surface was significantly ($p<0.01$) lower in Beautifil II than in the other two materials. These results suggested that Beautifil II could reduce dental plaque formation and bacterial adherence, leading to prevention of secondary caries.

Remineralization of Carious Dentin with Bio-active Restorative Materials

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The Japanese Journal of Conservative Dentistry, 52(6), 469-482 (2009)

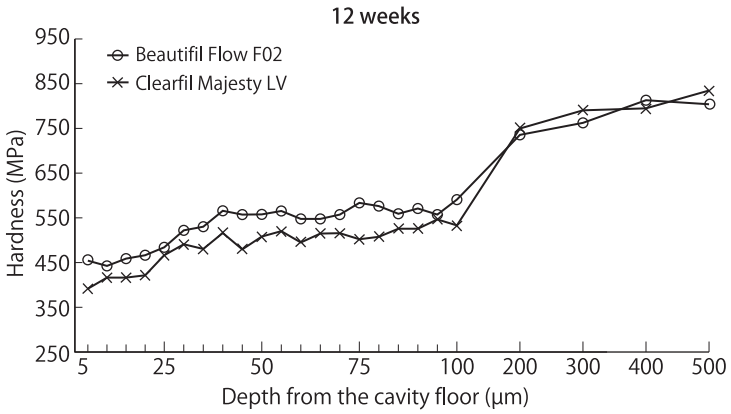

Fig. Nanohardness of carious dentin after 12 weeks from the Beautifil flow F02 and Clearfil Majesty LV restoration.

Caries detector differentiation of partially demineralized affected dentin: the action of organic acids of certain cariogenic bacteria-in vivo physiological remineralization occurs with time. Some reports suggest that certain bio-active adhesives may stimulate remineralization as well as provide long-term bonding durability. In this study, artificial lesions were restored with a bio-active ion-releasing agent and physiological remineralization of the resin-dentin interface below the in vitro carious lesions were measured for nano-hardness, compositional changes and SEM at 1 and 12 weeks.

Class I cavities were placed throughout the teeth of six extracted human third molars. Each cavity was subjected to lactic acid and cariogenic bacteria (*Streptococcus mutans*) . The in vitro caries was removed with a low speed round bur and the cavity was restored with one of two materials. Bio-active restorative materials Fluoro Bond Shake One and Beautifil Flow F02 including S-PRG(Surface reaction type Pre-Reacted Glass-ionomer) filler(SO) while Clearfil Mega Bond and Clearfil Majesty LV served as the ME-control. All materials were placed according to manufacturer's directions. After restoration, a hydrostatic Ringer's solution at a fluid pressure of 15 cm H_2O was maintained to the pulp chamber of each tooth and stored at 37℃ in 100% relative humidity for either 1 week (1w) or 12 weeks (12w). After storage, each specimen was cut perpendicular to the resin-dentin interface and each half surface was polished. The nano-hardness site of each resin-dentin interface was measured using a 1 mN load at each site at 5 μm pitch from the cavity floor to 100 μm and 100 μm pitch from 100 μm to 500 μm. Each site was determined at 10 points in a horizontal direction with 3 measurements for each specimen. Nano-hardness compared t-test and oneway ANOVA, Tukey's test (a =0.05). The other cut half was assayed for its compositional elements using energy dispersive X-ray (EDX) and FE-SEM ultrastructural analysis. Nano-hardness of the resin-dentin interface compared SO to ME-control at 12w, from the interface to the 100 μm, SO showed an increased hardness values against the ME-control. Additionally, we compared the SO resin-dentin interface at 1 w and 12w, from the interface to the 100 μm, 12w showed higher hardness values than 1w. EDX data indicates the rate of Ca and P of the ME-control was less than SO at 1w and 12w. Sr was found subjacent to the SO restorations, suggesting dentin remineralization of the in vitro lesion under the bio-active with S-PRG filler.

Evaluation of dentin bonding performance and acid-base resistance of the interface of two-step self-etching adhesive systems

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2) Faculty of Dentistry School for Dental Technology Tokyo Medical and Dental University
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4) Global Center of Excellence Program; International Research Center for Molecular Science in Tooth and Bone Diseases, Tokyo Medical and Dental University

Dental Materials Journal 28 (4), 493-500 (2009)

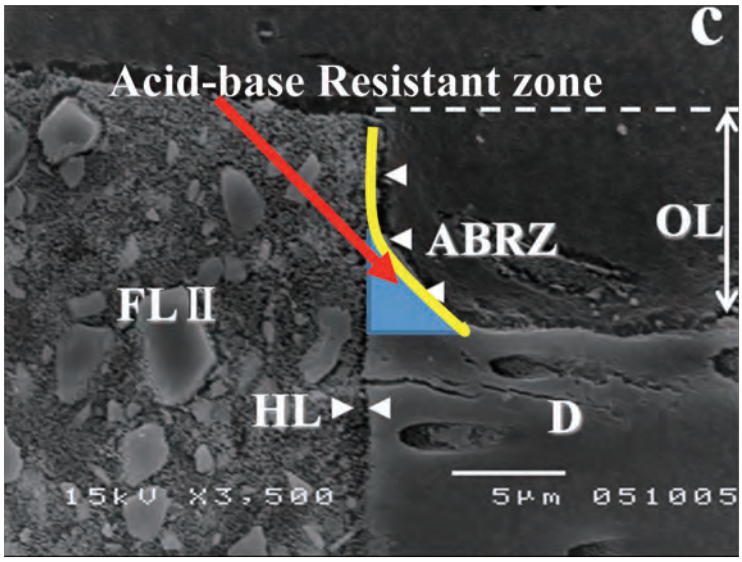

Fig. SEM observations of the adhesive-dentin interfaces after acid-base challenge (×3500). ABRZ: acid-base resistant zone, HA: hybrid layer distinguished with argon-ion-etching, D: dentin, OL: outer lesion.

The purpose of this study was to evaluate dentin bond strengths and to observe the adhesive-dentin interface after acid-base challenge using fluoride-free and fluoride-releasing self-etching adhesive systems; Clearfil SE Bond (SE), FL-Bond (FL) and FL-Bond II(FL II). Fifteen dentin surfaces from human molars were ground and bonded with one of three adhesive systems. The microtensile bond strength (μTBS) test was performed at a crosshead speed of 1 mm/min. The interface of the bonded specimens after acid-base challenge were also examined by a SEM. The μTBS of SE were significantly higher than those of FL and FL II ($p<0.05$), however, there were no significant differences between FL and FL II ($p>0.05$). An acid-base resistant zone (ABRZ) was observed in all the groups, however, formation of the ABRZ was material dependent. Fluoride-release from the adhesive is a key factor to create thick ABRZ.

An eighteen-month clinical evaluation of posterior restorations with fluoride releasing adhesive and composite systems

Akimoto N, Ohmori K, Hanabusa M, Momoi Y

Department of Operative Dentistry, Tsurumi University School of Dental Medicine

Dental Materials Journal, 30 (3), 411-418 (2011)

This study evaluated the clinical performance of a fluoride releasing restorative system (FL-Bond II & Beautifil II) in posterior restorations after 18-month placement. IRB forms were submitted with each patient approving by signing their acceptance. Seven Class I and 46 Class II restorations were placed by three clinicians in 38-patients. Each FL-Bond II & Beautifil II restoration was placed under rubber dam isolation according to manufacture's instruction. Clinical evaluation was assessed at baseline, 6 and 18-months using modified USPHS criteria. No post-operative sensitivity was reported in any restored tooth at each patient assessment. Only slight color change with some surface staining was noted. Slight marginal changes were observed in 12 of 53-restorations —seen as step irregularities when a sharp explorer was drawn across the tooth from the enamel toward the restoration interface. Utilizing USPHS evaluation criteria, the clinical performance of each (FL-Bond II & Beautifil II) posterior fluoride releasing system was clinically acceptable at 18-month.

Three-year clinical evaluation of posterior composite restorations placed with a single-step self-etch adhesive

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Journal of Oral Science, 57(2), 101-108 (2015)

Table Evaluation of clinival a single-step self-etch adhesive

		Recall period		
USPHS criteria	Baseline	6 months	18 months	3 years
Color match				
Alpha	60.4 (32/53)	58.5 (31/53)	45.7 (21/46)	45.2 (14/31)
Bravo	39.6	41.5	54.3	54.8
Anatomical form				
Occlusal cavities				
Alpha	100 (53/53)	100 (53/53)	100 (46/46)	90.3 (28/31)
Bravo				9.7
Approximal cavities				
Alpha	100 (42/42)	100 (42/42)	100 (37/37)	100 (26/26)
Surface roughness				
Occlusal cavities				
Alpha	100 (53/53)	100 (53/53)	69.6 (32/46)	58.1 (18/31)
Bravo			30.4	41.9
Approximal cavities				
Alpha	100 (42/42)	90.5 (38/42)	81.1 (30/37)	76.9 (18/27)
Bravo		9.5	18.9	23.1
Marginal adaptation				
Occlusal cavities				
Alpha	100 (53/53)	100 (53/53)	71.7 (33/46)	58.1 (18/31)
Bravo			28.3	41.9
Approximal cavities				
Alpha	100 (42/42)	100 (42/42)	100 (37/37)	76.9 (20/26)
Bravo				23.1
Marginal discoloration				
Occlusal cavities				
Alpha	100 (53/53)	100 (53/53)	100 (46/46)	83.9 (26/31)
Bravo				16.1
Approximal cavities				
Alpha	100 (42/42)	100 (42/42)	100 (37/37)	76.9 (20/26)
Bravo				23.1
Post-operative sensitivity				
Alpha	100 (53/53)	100 (53/53)	100 (46/46)	100 (31/31)
Secondary caries				
Alpha	100 (53/53)	100 (53/53)	100 (46/46)	100 (31/31)

Numbers in parentheses indicate scored teeth/evaluated teeth
USPHS, US Public Health Service

In this clinical study, we evaluated the 3-year clinical performance of a resin composite containing a surface-prereacted glass ionomer (S-PRG) filler (Beautifil II; Shofu Inc., Kyoto, Japan) placed with a single-step self-etch adhesive (BeautiBond; Shofu Inc.) in posterior restorations. Using modified US Public Health Service criteria, two experienced investigators performed clinical evaluations at the baseline, 6 months, 18 months, and 3 years. Color match, marginal adaptation, anatomical form, surface roughness, marginal discoloration, postoperative sensitivity, and secondary caries were evaluated. After 3 years, 26 patients attended the recall and 31 restorations were evaluated. No postoperative sensitivity or secondary caries was observed at any time point, and no restorations failed during the follow-up period. However, surface roughness, marginal adaptation, and marginal discoloration showed deterioration after 3 years. In conclusion, although some clinical changes were observed, resin composite containing S-PRG filler placed with self-etch adhesive exhibited acceptable clinical behavior in posterior restorations.

Two-year clinical evaluation of flowable composite resin containing pre-reacted glass-ionomer

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Pediatric Dental Journal, 19(1) 2009, 89–97(2009)

Flowable resin restoration is a useful technique for children with caries. However, when composite resin restoration is performed by an inexperienced clinician, improper placement technique can lead to such problems as poor adaptation, voids and secondary caries formation. In this study, we examined fluoride release from surface of pre-reacted glass-ionomer (S-PRG) fillers containing flowable resin, termed flowable giomer. Beautiful Flow F02 showed a higher amount of fluoride released during the experimental period as compared with the other flowable resins tested. We also used that flowable giomer for Class I, II, and III restoration procedures in 95 primary teeth and 85 permanent ones, and evaluated the results using USPHS/Ryge criteria. Beautiful Flow F02 showed good clinical properties equal to those of conventional resin restorations previously reported. Our results indicate that a flowable giomer is useful for primary and permanent teeth esthetic restoration, which is important for the prevention of secondary caries and adhesion of bacterial flora on resin surfaces.

An eighteen-month clinical evaluation of posterior restorations with fluoride releasing adhesive and composite systems

Akimoto N, Ohmori K, Hanabusa M, Momoi Y

Department of Operative Dentistry, Tsurumi University School of Dental Medicine

Dental Materials Journal, 30 (3), 411-418 (2011)

This study evaluated the clinical performance of a fluoride releasing restorative system (FL-Bond II & Beautifil II) in posterior restorations after 18-month placement. IRB forms were submitted with each patient approving by signing their acceptance. Seven Class I and 46 Class II restorations were placed by three clinicians in 38-patients. Each FL-Bond II & Beautifil II restoration was placed under rubber dam isolation according to manufacture's instruction. Clinical evaluation was assessed at baseline, 6 and 18-months using modified USPHS criteria. No post-operative sensitivity was reported in any restored tooth at each patient assessment. Only slight color change with some surface staining was noted. Slight marginal changes were observed in 12 of 53-restorations —seen as step irregularities when a sharp explorer was drawn across the tooth from the enamel toward the restoration interface. Utilizing USPHS evaluation criteria, the clinical performance of each (FL-Bond II & Beautifil II) posterior fluoride releasing system was clinically acceptable at 18-month.

A clinical evaluation of a giomer restorative system containing surface prereacted glass ionomer filler: results from a 13-year recall examination

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The Journal of the American Dental Association, 145(10), 1036–1043 (2014)

BACKGROUND

The authors' objective was to evaluate the long-term performance of a resin-based composite restorative material (Beautifil, Shofu, Kyoto, Japan) in combination with a self-etching primer (FL-Bond, Shofu) for posterior restorations.

METHODS

Two clinicians placed 61 restorations, 26 Class I and 35 Class II, in 31 patients. They placed restorations while using rubber dam isolation. Two other clinicians examined the restorations according to the modified U.S. Public Health Service (USPHS) criteria, observing color match, marginal adaptation, anatomy, surface roughness, marginal staining, interfacial staining, proximal and occlusal contacts, secondary caries, postoperative sensitivity and luster. Clinicians examined restorations at baseline as well as at one-, two-, four-, eight- and 13-year recall visits.

RESULTS

All restorations were examined at one year, 58 (95 percent) at two years, 39 (64 percent) at four years and 41 (67 percent) at eight years; at the 13-year recall examination, 41 (67 percent) either were examined or had a known outcome. Of the 41 restorations seen at the 13-year examination, 25 restorations (14 Class I and 11 Class II) were intact and acceptable, two had secondary caries and 14 either were not present or had failed (two were missing, 10 had received crowns and two had been replaced). No changes were observed in the modified USPHS criteria for 12 of the 25 restorations that were intact (48 percent). Areas of change observed in 13 of the 25 intact restorations included color match (12 percent), marginal adaptation at the occlusal (20 percent) and proximal surfaces (4 percent), marginal staining on occlusal (24 percent) and proximal surfaces (8 percent), and interfacial staining on occlusal (4 percent) and proximal surfaces (12 percent).

CONCLUSIONS

The study results showed that most of the restorations observed at the 13-year recall examination maintained acceptable clinical qualities.

PRACTICAL IMPLICATIONS

Beautifil restorative material demonstrated long-term successful results for restoration of posterior teeth.

Pediatric dentistry, Orthodontic dentistry, and Preventive dentistry

EVIDENCE

Application of a tooth-surface coating material containing pre-reacted glass-ionomer fillers for caries prevention

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Pediatric Dental Journal, 25(3), 72–78 (2015)

Table Results of clinical application of the tooth-surface coating material.

Group	Patient no.		Tooth no.		Plaque adhesion		Staining		Shedding		Dental caries		Change of hypoplastic tooth	
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
3 Months	14	7	74	40	0	0	8 (10.8%)	10 (25.0%)	0	1 (2.5%)	0	0	0	0
6 Months	13	7	68	34	0	0	0	10 (29.4%)	0	0	0	0	0	0
9 Months	5	4	28	18	0	0	0	8 (44.4%)	0	0	0	0	0	0
12 Months	5	4	28	18	0	0	0	8 (44.4%)	0	0	0	0	0	0

PURPOSE

Several methods have been used to prevent dental caries, including fluoride application to strengthen teeth and promote remineralization and the use of sealants to fill pits and fissures in pediatric dentistry. However, none of these methods alone can be considered a perfect preventive treatment. For caries prevention, we evaluated pre-reacted glass-ionomer (PRG) Barrier Coat (Shofu Inc., Kyoto, Japan), a tooth-surface coating material developed using PRG technology that contains high levels of controlled-release fluoride.

METHODS

The tooth-surface coating material was applied clinically as a new method of preventing dental caries. Its effect on plaque adhesion, along with its preventive effect on dental caries was investigated in actual cases treated in a pediatric dentistry department of a university hospital.

RESULTS

PRG Barrier Coat was shown to have suitable adhesive strength and to be a safe material that does not fracture the adherend. Actual ion release and acid buffering were confirmed, and when clinically applied, continuous fluoride release and recharge occurred, as did the release of the other ions. This suggests that this material promoted dentin remineralization, suppressed plaque adherence, and had a preventive effect on dental caries.

CONCLUSIONS

This material promoted enamel remineralization, suppressed plaque adherence, and had a preventive effect on dental caries. These results suggest that this coating material is appropriate for young children at high risk of dental caries.

Effects of a coating resin containing S-PRG filler to prevent demineralization of root surfaces.

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Dental Materials Journal, 31(6), 909–915 (2012)

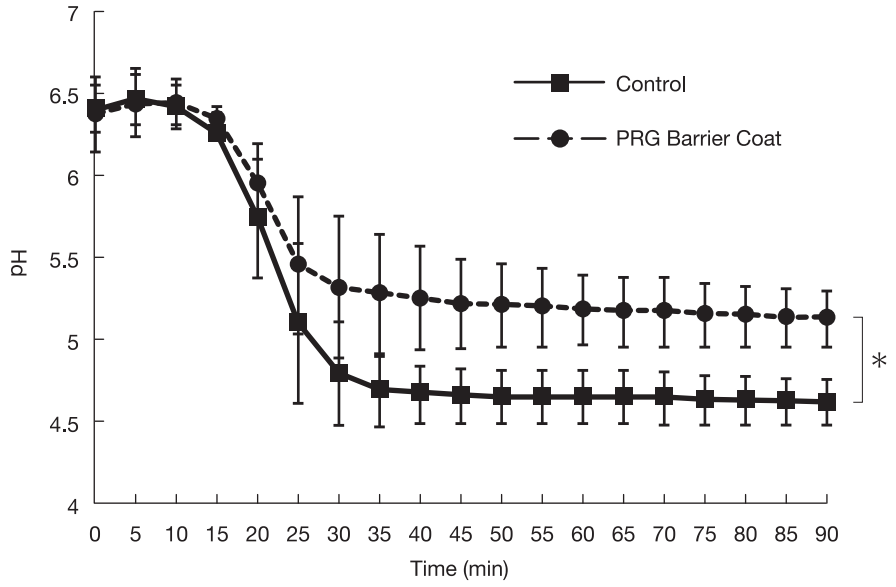

Fig. Time-related pH changes at the interface between *S. mutans* and the PRG Barrier Coat-coated PMMA plate (PRG Barrier Coat) or non-coated PMMA plate (Control) after addition of glucose to stimulate acid production. Data are mean ± standard deviation of three independent experiments. denotes a statistically significant ($p<0.01$, by Student's t-test) difference from the control at 90 min after glucose addition.

The purpose of this study was to evaluate the ability of a coating material containing the surface pre-reacted glass-ionomer (S-PRG) filler to protect the root from demineralization in vitro. The proprietary coating resin containing the S-PRG filler (PRG Barrier Coat) was applied to human root dentin and immersed in acid buffer at pH 4.5 for 3 d. Demineralization was evaluated by micro-CT scanning and the dentin-material interface observed by scanning electron microscopy. The ability of the coating resin to modify acid production by *Streptococcus mutans* was investigated by monitoring pH using an ion-sensitive field-effect transistor pH electrode. Application of PRG Barrier Coat produced a coating layer with the thickness of approximately 200 µm and completely inhibited demineralization. The bacteria-induced pH fall at the material surface was significantly inhibited. We conclude that S-PRG filler containing coating resin may be an effective material for protecting exposed root from both chemical and biological challenges.

Effects of immersion in solution of an experimental toothpaste containing S-PRG filler on like-remineralizing ability of etched enamel.

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Dental Materials Journal, 33(3), 430-6 (2014)

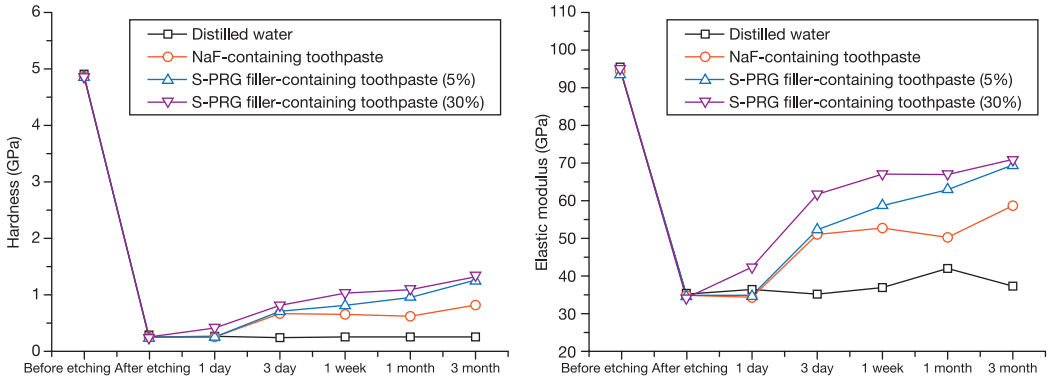

Fig. Mean hardness and elastic modulus values of the buccal enamel surface before etching, after etching and during a 3-month immersion period.

This study investigated the like-remineralizing ability of experimental toothpaste containing surface reaction-type pre-reacted glassionomer (S-PRG) filler on etched enamel. Human enamel blocks were etched with 35% phosphoric acid and immersed in 5-mL distilled water, fourfold diluted solution of NaF-containing toothpaste, or S-PRG filler-containing experimental toothpaste. Nanoindentation testing was carried out during immersion and the enamel surfaces were observed by scanning electron microscopy. Elemental analysis of the ions in each solution was performed using inductively coupled plasma atomic emission spectroscopy and fluoride electrode. After 1 month of immersion, the hardness and elastic modulus of the specimen immersed in S-PRG filler-containing toothpaste showed significantly greater values than those of the specimen immersed in NaF-containing toothpaste. Considerable amounts of Al, B, Na, Si, Sr, F ions were detected in the solution of S-PRG filler-containing toothpaste. Experimental S-PRG filler-containing toothpaste may enhance the like-remineralizing ability of etched enamel surfaces due to its ion-releasing ability.

Effects of ion-releasing tooth-coating material on demineralization of bovine tooth enamel

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Int J Dent. ID 463149. (2014).

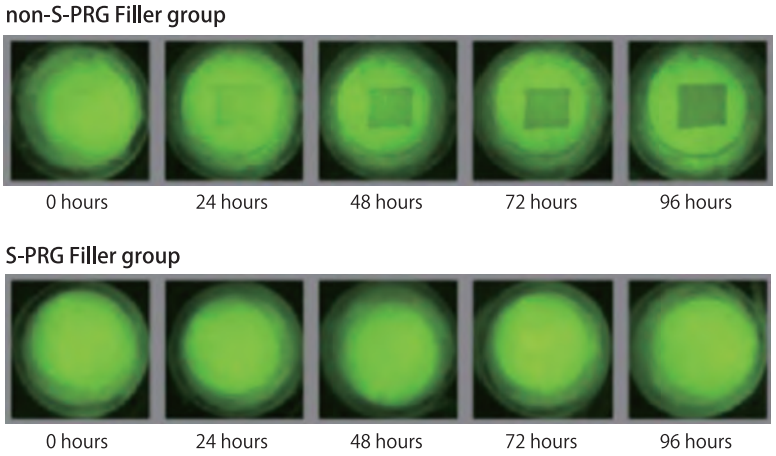

Fig. Digital images of QLF after the 96h demineralizing process.

We compared the effect of a novel ion-releasing tooth-coating material that contained S-PRG (surface-reaction type prereacted glass-ionomer) filler to that of non-S-PRG filler and nail varnish on the demineralization of bovine enamel subsurface lesions. The demineralization process of bovine enamel was examined using quantitative light-induced fluorescence (QLF) and electron probe microanalyzer (EPMA) measurement. Ion concentrations in demineralizing solution were measured using inductively coupled plasma atomic (ICP) emission spectrometry and an ion electrode. The nail varnish group and the non-S-PRG filler group showed linear demineralization. Although the nail varnish group and the non-S-PRG filler group showed linear demineralization, the S-PRG filler group did not. Further, plane-scanning by EPMA analysis in the S-PRG filler group showed no changes in Ca ion distribution, and F ions showed peak levels on the surface of enamel specimens. Most ions in the demineralizing solution were present at higher concentrations in the S-PRG filler group than in the other two groups. In conclusion, only the S-PRG filler-containing tooth-coating material released ions and inhibited demineralization around the coating.

Anti-demineralization effect of a novel fluoride-releasing varnish on dentin

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The American Journal of Dentistry. 25, 347-350 (2012)

PURPOSE:

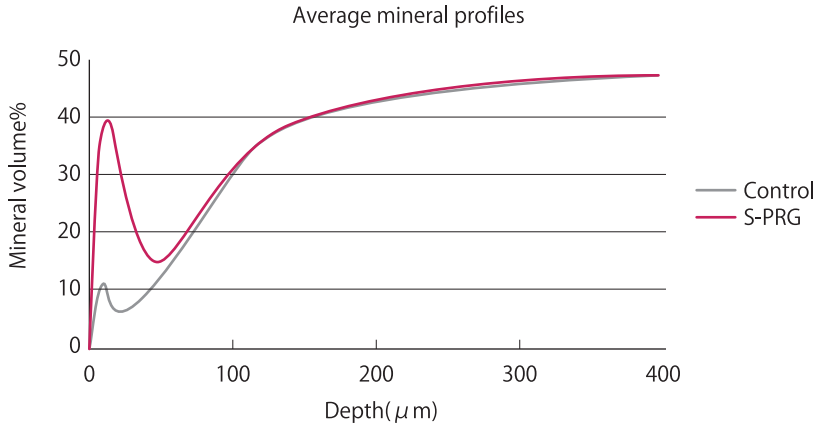
To investigate the laboratory anti-demineralization effect of a novel fluoride-releasing varnish containing surface reaction-type prereacted glass-ionomer (S-PRG) filler.

METHODS:

Paired specimens were cut from bovine root dentin. One of each pair was used for the S-PRG group, and the other served as a control (n = 6). A 1 x 3 mm test surface was made on each specimen with the fluoride-releasing varnish. The novel fluoride-releasing varnish is categorized as a two-bottle-type self-etch adhesive. These liquids were mixed, applied on the test surface, and light-cured for 10 seconds. As a control, an S-PRG filler-free varnish was applied in the same manner. Each specimen was immersed in 8% methylcellulose gel demineralization system (1.5 mM Ca, 0.9 mM PO_4, 0.1 M acetic acid, pH 5.0) for 7 days at 37℃. The mineral profiles and integrated mineral loss (IML) of the lesions were obtained by transversal microradiography and analytical software.

RESULTS:

The S-PRG group exhibited significantly thicker surface layer than the control group. Furthermore, the S-PRG group showed significantly lower IML (3,459 vol% x μm) than the control group (4,687 vol% x μm) ($P < 0.05$, Welch's two-sample t-test). The novel fluoride-releasing varnish increased acid resistance of root dentin in the vicinity of the coated surface.



Average mineral profiles formed in the control group and the S-PRG varnish group.
The S-PRG varnish group(S-PRG)(red line)showed a
remarkable surface layer compared with the control group (gray line).

Antibacterial activity of S-PRG filler

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Oral Studio Monthly Report, Extra Edition 03

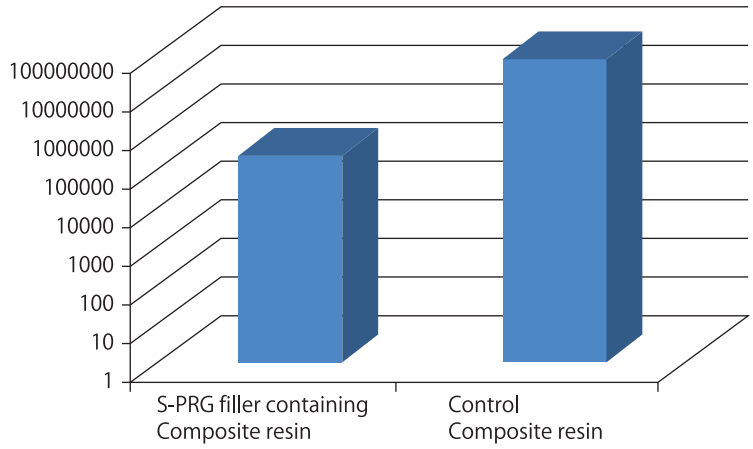

Fig. Concentration of bacteria on light-cured composite resin (CFU, *S. mutans* NCTC 10449, cultured for 18 hours)

As to an expression of additional functions by ions released from restorative materials, remineralization and tooth strengthening by fluoride ions from fluoride-added composite resin or glass ionomer cement are well-known for a long time. On the other hand, S-PRG filler, synthesized based on the reaction of a polyacrylic acid and a fluoro boroaluminosilicate glass, is a very unique material in terms of releasing not only fluoride ion but also other many ions. S-PRG filler releases aluminum, boron, sodium, and strontium ions. And boron, sodium and strontium ions are released at higher concentrations than fluoride ion. Especially, boron ion, released 10 times or more higher than fluoride ion, is one of ingredients of eye-drops or mouthwash added as antiseptic agent and expected to have an inhibitory effect on bacteria.

Fig. shows the results that we investigated the antibacterial properties of the prototype composite resin containing S-PRG filler in our laboratory. *Streptococcus mutans* suspension was inoculated on the surface of cured specimens and cultured for 18 hours. Significant inhibition of bacteria growth was observed on S-PRG filler containing composite resin in comparison with control (silica filler containing) composite resin; double digit difference in CFU (colony forming units). We expect that the release of high concentrations of boron may play a role in the development of antibacterial activity.

Meanwhile, we also tested acid production of *S. mutans* on "PRG Barrier Coat," commercially available tooth coating material, and confirmed clearly inhibition of acid production. We consider that various ions released from S-PRG filler showed inhibition of acid production ability of *S. mutans* as well as bringing an acid-buffering effect.

As described above, S-PRG filler indicates the possibility of caries prevention effect by releasing various ions. And the materials containing S-PRG filler are expected to be used as "Bio-Active" material which has antibacterial ability.

Inhibition of enamel demineralization by buffering effect of S-PRG filler-containing dental sealant

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Eur J Oral Sci. 122(1), 78-83 (2014)

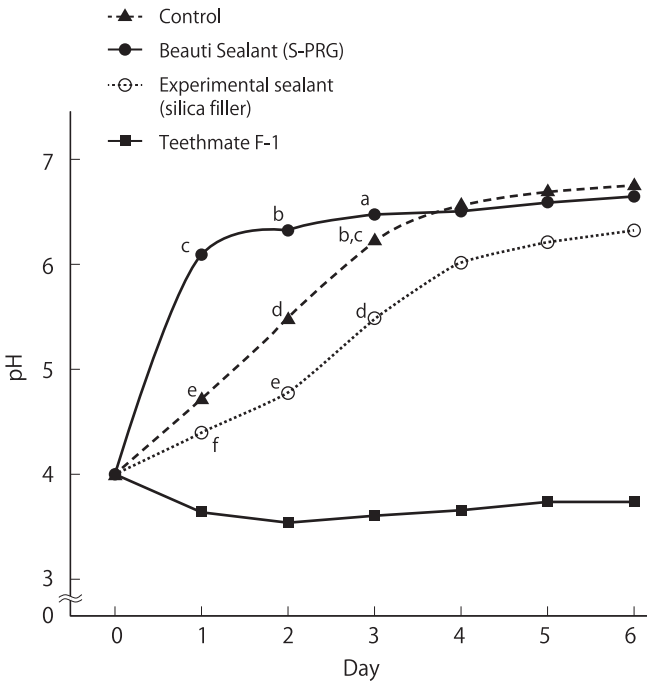

Fig. Changes in pH values in the different groups – enamel disk (control), enamel disk with BeautiSealant (S-PRG filler), enamel disk with experimental sealant (silica filler), and enamel disk with Teethmate F-1 – when incubated for 1-6 d in lactic acid solution (pH 4.0). Different letters denote a statistically significant difference compared with the other groups for days 1-3 ($P<0.05$, n=6). The pH in the Teethmate F-1 group was significantly lower than the pH in the other three groups on all days of measurement ($P<0.05$).

The buffering capacity and inhibitory effects on enamel demineralization of two commercially available dental sealants were evaluated in this study. The effects of filler particles were also examined. Disks of enamel and cured sealant materials of BeautiSealant (silica or S-PRG filler) or Teethmate F-1 were incubated in lactic acid solutions (pH 4.0) for 1-6 d. The pH changes and amounts of ions released in the solutions were assessed, and enamel surfaces were observed using a scanning electron microscope. The pH of the solution with BeautiSealant (S-PRG filler) was neutralized from pH 4.0 to pH 6.1 (after incubation for 1 d) and from pH 4.0 to pH 6.7 (after incubation for 6 d). In addition, no release of calcium ions was detected and the enamel surface was morphologically intact in scanning electron microscopy images. However, the pH of the solution with Teethmate F-1 remained below pH 4.0 during incubation from days 1 to 6. Calcium release was increased in solutions up to and after 6 d of incubation. Scanning electron microscopy images showed that the structures of hydroxyapatite rods were exposed at the specimen surfaces as a result of demineralization. Ions released from S-PRG filler-containing dental sealant rapidly buffered the lactic acid solution and inhibited enamel demineralization.

Caries-preventive effect of fissure sealant containing surface reaction-type pre-reacted glass ionomer filler and bonded by self-etching primer

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J Clin Pediatr Dent. 36(4), 343-7 (2012)

BACKGROUND

We aimed to evaluate the caries-preventive effect of a fissure sealant containing surface reaction-type pre-reacted glass ionomer (S-PRG) filler and bonded by self-etching primer versus those of 2 conventional resin-based sealants bonded by acid etching in terms of its impact on enamel demineralization and remineralization, enamel bond strength, and integrity of debonded enamel surfaces.

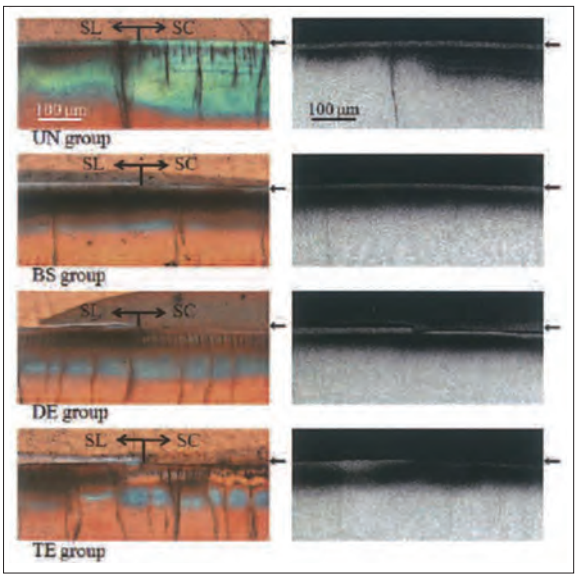

Fig. Post-treatment polarized light photomicrographs and microradiographs of the sealant groups. The enamel surface (arrow) is shown as an extension of the enamel subsurface lesion. SL, Enamel subsurface lesion area (control); SC, Sealant-coated area; UN, uncoated; BS, BeautiSealant; DE, Delton FS+; TE, Teethmate F-1$_{2.0}$.

MATERIALS AND METHODS

Demineralization, remineralization, and bond strength on untreated enamel and enamel subsurface lesions of bovine incisors were assessed among the sealants by polarizing microscopy and microradiography; debonded enamel surfaces were examined by scanning electron microscopy.

RESULTS

The conventional resin-based sealants bonded by acid etching caused surface defects on the enamel subsurface lesions and significantly increased the lesion depth (p=0.014), indicative of enamel demineralization. However the S-PRG filler-containing sealant bonded by self-etching primer maintained the enamel surface integrity and inhibited enamel demineralization. No difference in bond strength on both untreated enamel and enamel subsurface lesions was noted among the sealants.

CONCLUSIONS

An S-PRG filler-containing fissure sealant bonded by self-etching primer can prevent enamel demineralization, microleakage, and gaps without the tags created by acid etching regardless of the enamel condition. Such sealants are suitable for protecting the pits and fissures of immature permanent teeth.

Acid Resistance Induced by a New Orthodontic Bonding System in vitro

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Dental Materials Journal 27 (4), 590-597 (2008)

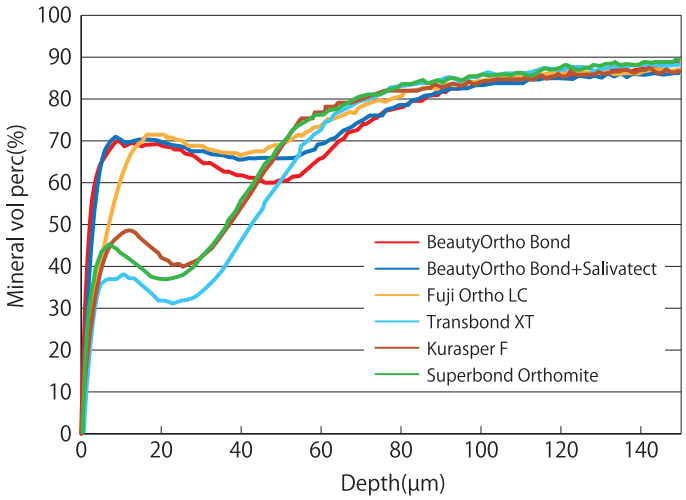

Fig. Averaged mineral profiles of all experimental groups.

The effect of fluoride-containing orthodontic resin bonding systems on acid resistance of adjacent enamel was evaluated using transversal microradiography.

Four fluoride-containing orthodontic resin bonding systems : BeautyOrtho Bond (BO), BeautyOrtho Bond+Salivatect (BOS), Kurasper F (KP), Transbond XT (TB) and a resin-modified glass-ionomer (Fuji Ortho LC (FO)) were used. Superbond Orthomite (SB) was used as a non-fluoride material. Rectangular bovine enamel specimens (10×6 mm) were prepared. After curing the materials, nail varnish was applied to the enamel surfaces, leaving a gap of 1 mm from the cured material's periphery. The specimens were demineralized with 8% Methocel MC gel and 0.1 M lactic acid. BO, BOS, and FO revealed shallow lesions and distinct surface layers. The mineral losses of BO, BOS, and FO were significantly lower than those of TB, KP, and SB ($p<0.05$). In conclusion, the new system induced superior acid resistance in enamel surrounding orthodontic brackets.

PRG Technology

Giomer

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