Effect of Fluoride-releasing Adhesives on Dentin

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Abstract: Fluoride-releasing materials can be expected to inhibit secondary caries and enhance remineralization of decalcified dentin underneath restorations. The aim of this study was to evaluate the inhibitory effect on secondary caries and remineralization of decalcified dentin by fluoride-releasing adhesives. Two commercial fluoride-releasing adhesives, Reactmer bond (RB, Shofu) and One-up bond F (OB, Tokuyama), and a commercial adhesive without fluoride release, Mac-bond II (MB, Tokuyama), were used in this study. For examination of the inhibitory effect, class V cavities were prepared on extracted human premolars and restored with a restorative material following the application of each adhesive. The restored teeth were incubated in bacterial medium for 14 days after storage for 14 days at 37℃, 100% humidity. For examination of remineralization of decalcified dentin, decalcified dentin was promoted by using a bacterial caries induction system at the cavity wall. The cavities were then restored with resin composite after application of each adhesive and incubated for 4 weeks at 37℃, 100% humidity. Microradiographs in the inhibitory test showed an acid-resistant layer adjacent to the restoration in the caries-like lesions. The acid-resistant layers in the RB and OB groups with fluoride release were thicker than that in the MB group. Microradiographs in remineralization tests showed that the radiopacities of the decalcified dentin layers in the RB and OB groups were significantly higher than that in the MB group without fluoride release. These results indicated that fluoride-releasing adhesives are effective in inhibiting wall lesions and in enhancing the remineralization of decalcified dentin.

Key words: fluoride, adhesive, dentin, remineralization

Introduction

It is well known that the causes of secondary caries are poor adhesion to the tooth substance or remnant decalcified dentin underneath the restoration [1]. In the former, numerous adhesive systems promoting good adhesion to dentin have been developed and the bond strength to the dentin is improved [2]. However, it is doubtful that adhesion between the dentin and the restoration can be maintained for long term in the severe oral environment. In the latter, the complete removal of decalcified dentin is difficult because complete caries removal may result in dental pulp exposure. Therefore, some decalcified dentin is frequently left in the cavity, with the associated danger of occurrence of the secondary caries even when good adhesives have been used.

It has been reported that fluoride ions are effective for secondary caries inhibition and can enhance remineralization of decalcified dentin in vitro [3,4]. Recently, many fluoride-releasing adhesives have been developed. These adhesive systems can be expected to prevent secondary caries around a restoration due to their fluoride release [5]. As fluoride-releasing adhesives directly contact the cavity wall, fluoride ions released from them easily penetrate and diffuse into the cavity wall dentin. Therefore, the fluoride-releasing adhesives may be beneficial for the inhibition and prevention of secondary caries. The aim of this study was to evaluate the inhibitory effect of secondary caries and the remineralization of decalcified dentin by fluoride-releasing adhesives.

Materials and methods

Two commercial fluoride-releasing adhesives, Reactmer bond (RB, Shofu, Kyoto, Japan) and One-up bond F (OB, Tokuyama, Tokyo, Japan), and a commercial adhesive without fluoride release, Mac-bond II (MB, Tokuyama), were used. Reactmer paste (RP, Shofu), Lite-fil II A (LF, Shofu), Estelite (EL, Tokuyama) and AP-X (AP, Kuraray, Osaka, Japan) was used as the restorative material in this study.

We measured the fluoride release from specimens coated with adhesives and specimens made by adhesives only. For the former, specimens coated with the adhesive except for the top surface were prepared. For the latter, specimens made with adhesive only were prepared. After 24 h, these specimens were individually immersed in distilled water and stored at 37℃. The amount of fluoride release from the specimens was measured every week for 10 weeks.

Extracted upper premolars without caries and other defects were used for inhibitory test. Class V cavities were prepared on the buccal and palatal surfaces of each tooth. Cavities were treated with each adhesive and restored with a restorative material followed by light irradiation for 40s. The specimens were mounted individually on plastic tubes and stored for 14 days at 37℃ in 100% relative humidity. Hanks' balanced salt solution was poured into each tube. After storage, specimens were incubated in BHI broth containing 1% sucrose inoculated with *Streptococuss mutans* at 37℃ for 14 days. After incubation, the specimens were cut through the restorations and axial sections were prepared. Contact microradiographs were taken with a soft x-ray source and the artificial secondary carious lesions at the gingival margin in each root were observed with a microscope. For evaluation of the inhibitory effect of artificial secondary caries, the thickness of the acid-resistant layer in the root was measured at a depth of 250 μm under the surface of the restoration, and the depth of the outer lesion in the root was measured at a distance of 100 μm from the restoration margin using a microscope attached to a micrometer.

For remineralization test class V cavities were prepared and the teeth were mounted individually on plastic tubes. Decalcified dentin was then promoted by a caries inducing system at the cavity wall. Cavities were treated with adhesive systems and restored

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with a resin composite, AP-X, followed by light irradiation for 40 s. The specimens were stored for 4 weeks at 37℃ in 100% relative humidity. The specimens without restoration and storage for 4 weeks were used as a control. After storage, axial sections of the specimens were prepared and contact microradiographs were taken. For the evaluation of remineralization of decalcified dentin, the density of decalcified dentin underneath each restoration was analyzed. The density of the decalcified dentin and sound dentin underneath the decalcified dentin layer were analyzed using the same specimen. The ratio of the radiopacity of decalcified dentin/ sound dentin was used as the degree of remineralization of decalcified dentin in this study.

Results

Among the specimens coated with adhesives, the RB/RP and RB/LF groups showed higher amounts of fluoride release than the OB/EL group at all test periods. No fluoride release was detected in the MB/EL group. However, among the specimens made by adhesive only, the amount of fluoride release from the OB group was larger than that of the RB group. In the MB group, no fluoride release was detected at any time.

In all specimens, there were outer lesions on the exposed tooth surface but no wall lesions were observed in the root. Moreover, acid-resistant layers were observed in the lesions adjacent to the restorations. In the RB/RP, RB/LF and OB/EL groups, acid-resistant layers were observed clearly in the lesions, but these were not clear in the MB/EL group. The layers in the RB/RP, RB/LF and MB/EL groups were significantly thicker than in the MB/EL group. There was no significant difference among the RB/RP, RB/LF and OB/EL groups. The outer lesions in the RB/RP group were significantly the shallowest of all groups. There was no significant difference among RB/LF, OB/EL and MB/EL groups in the depth of the outer lesion.

In the RB/AP group and OB/AP group, the radiopacity of the layer was higher than that in the MB/AP or control groups. The means of the ratio of radiopacity in the RB/AP and OB/AP groups were significantly higher than those in the MB/AP or control groups. There were no significant differences between the RB/AP and OB/AP groups, and MB/AP and control groups.

Discussion and Conclusion

In this study, fluoride-releasing adhesives inhibited the formation of wall lesions. It was reported that poor adhesion allows marginal leakage to create a wall lesion [6,7]. Therefore, the absence of wall lesions shows that the fluoride-releasing adhesive systems produced good adhesion to the cavity wall dentin. Moreover, thicker acid-resistant layers were recognized adjacent to the restorations at the cavity wall dentin in the RB/RP, RB/LF, and OB/EL groups. Hsu *et al.* [8] reported that an inhibition area along the cavity wall was observed in fluoride-releasing restorative materials. This layer was formed by the fluoride ions released from the RB or OB, and resisted acid-attack during artificial caries formation. Therefore, a fluoride-releasing adhesive is desirable for inhibition of wall lesions because of the reinforcement of the wall dentin by fluoride release.

On the other hand, outer lesions were formed on the exposed tooth surface around the restoration in all specimens. The formation of outer lesions is caused by *S.mutans* in the medium [9]. Inhibition of outer lesions was recognized in the RB/RP group only. The inhibition of outer lesions is caused by the uptake of fluoride to the root surface [10]. A high concentration of fluoride around the restoration is thus required for the inhibition of outer lesions. The RB/RP group was restored with RP, a fluoride-releasing restorative material, which was exposed directly to the medium and probably supplied a high concentration of fluoride ion at the root surface.

In the experiment of remineralization of decalcified dentin, the RB/AP and OB/AP groups with fluoride release exhibited higher radiopacity than the MB/AP or control groups. The high radiopacities of microradiographs on the decalcified dentin layers suggest remineralization of the decalcified dentin by fluoride ions released from the adhesive resin. This suggestion may be supported by the previous finding that fluoride ions enhanced remineralization of carious dentin [4]. In addition, a radio-opaque layer was observed in the decalcified dentin layer in RB/AP group. This radio-opaque layer may be produced by the deposition of inorganic components as aluminum or strontium released from the RB containing glassionomer filler. The deposition of these components would occur at the decalcified dentin layer in the RB/AP group. Therefore, this radio-opaque layer may contribute the inhibition of the progress of secondary caries underneath the restoration.

In conclusion, it was found that the use of fluoride-releasing adhesive systems was effective in inhibiting wall lesions and enhancing the remineralization of decalcified dentin.

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