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THE EFFECTS OF PRETREATMENT SOLUTION OF THE DIRECT BONDING SYSTEM ON THE ENAMEL SURFACE

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Direct Bonding System의 塗布液이 琺瑯質 表面에 주는 效果

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》國 文 抄 錄《

著者는 direct bonding system의 pretreatment液 處理後 Epoxy adhesive의 bonding strength의 變化를 測定하기 爲해서 拔去된 上顎 前齒 唇面 琺瑯質 表面에 pretreatment液으로서 65% phosphoric acid를 塗布한 實驗群과 塗布하지 않은 比較群을 比較硏究하고 臨床에 適用하여 다음과 같은 結果를 얻었다.

1. 琺瑯質 表面에 pumicing과 65% phosphoric acid를 塗布했을때 joint strength는 顯著히 上昇했다.
2. Epoxy adhesive의 bonding strength는 plastic attachment를 齒牙面에 接着維持시키기에 충분하며 臨床的으로 利用할 수 있다.
3. Joint area가 클 수록 bonding strength는 증가했다.

INTRODUCTION

The trend in orthodontics, as in other fields of dental practice is to try to simplify technical procedures so that the objective can be achieved with a minimum of effort. The initiation of preformed bands in fixed appliance therapy contributed greatly toward this end.

The placement of fixed appliances would be further simplified if the orthodontic attachments could be bonded directly to the teeth. The only known way to attach brackets directly to the enamel surfaces intraorally is by means of adhesives. Various methods of bonding orthodontic brackets directly to tooth surfaces have been reported by

Newman[1-6], Miura[7-8], Mitchell[9], Mizrahi and Smith[10-11], and Retief and associates[12]. These studies have concentrated largely on the mechanical properties of bonding materials, but very few orthodontic cases, completely treated by the use of direct bonding methods, have been presented. Perhaps this is due to the insufficient strength of the bonding materials under the extremely severe conditions of the mouth.

There are many factors within the mouth which act unfavorably on the adherends and adhesives.

An understanding of the oral environment in which the desired adhesive system must function is essential for the understanding of the problem of bonding plastic attachments to tooth structure.

Let us assume that we limit ourselves within bonding the upper anterior teeth for esthetic purposes. Since we are bonding upon the labial surfaces of the upper anterior teeth, the direct force of mastication is not transmitted to the adhesive joints, unless there is an anterior cross-bite or an undesirable impact force. Kydd and associates[13] found that lip forces exerted upon the upper incisors vary from 0.071 to 2.78 pounds per square inch. The adhesive joint is subjected to variations in temperature which range from that of ice cream at 35°F. to hot tea at 145°F. The pH of saliva varies intermittently, depending upon the liquids and foods ingested, from low-pH orange juice to high-pH bicarbonate of soda.

Coupled with these environmental variations are the effects of bacteria, enzymes, constant moisture, and humidity, all contributing to biologis and physical degradation of the properties of the materials composing the adhesive unit and attachment.

Topography of the enamel surface itself is highly variable and irregular[14]. As for its composition, it is unfortunately unhomogeneous.

On the average, enamel is 96% (by weight) inorganic, while the remainder consists of 1.7 per cent organic material and 2.3 per cent water[15].

As a result, an adhesive that would bond to the inorganic substance may not bond to the organic material and may thus cause localized sites of stress concentration which may eventually lead to fracture of the adhesive joint.

The inorganic portion of enamel consists mainly of a calcium-deficient form of hydroxy apatite$(Ca)_{10}(PO_4)_6(OH)_2$. Enamel behaves like a typical semipermeable membran e and is permeable to selective ions, such as calcium.

It is highly permeable to water. The effect upon the adhesive joint by the capillary movement of the internal enamel fluid to the enamel surface is an additional factor we are presently studying.

It has been theorized that the hydroxyl groups present on the enamel surface create a possible reaction to epoxy or other polymeric adhesive compounds. An adhesive may be able to bond tooth surface through two theoretical means: 1) physical (mechanical) adsorption, bonds that result from the attraction between molecules, so-called Van der Waal's forces, and 2) chemisoption, bonds resulting from ionic, covalent, or coordinate bondings.

Coefficient of thermal expansion is one of the most important physical properties of tooth enamel relative to bonding; adhesive experts agree that the coefficient of thermal expansion of tooth enamel, 5.3×10^{-6} in./in. /°F., should match that of the adhesive and attachment.

Most important is the knowledge of the surface energy of tooth structure and how it can be favorably altered. When the surface energy of tooth enamel is low, as it normally is, as shown by Newman and Sharpe[16], wetting of the tooth surface by a liquid resin adhesive, which also has low energy, is unsatisfactory. However, if tooth structure is converted into a high-energy surface by eliminating the layers of low surface energy absorbed on the tooth surface, then wettability is done by contact angles.

Generally, an adhesive which has relatively low contact angle compared the adherend's surface is said to have good wettability and is desirable for bonding. By pretreating the tooth surface with a surface-active agent, such as phosphoric acid, one can convert the normally hydrophobic, low-energy surface of tooth structure to more wettable, hydrophilic, high-energy surface ready to accept the low-energy adhesive resin. This slight etching of the outer enamel surface(5 to 15 microns) improves adhesion.

To ascertain the above characteristics in bonding materials, the author studied the relationship between the bonding strength and pretreatment solution, 65%-phosphoric acid.

MATERIAL and METHOD

Twenty teeth were selected from recently extracted upper incisors, stored in tap water at room-temperature with optimal humidity. The roots were cleaned of remnant tissues. The roots were then embedded in self-curing acrylic resin bases to facilitate handling of the testing apparatus.

They were divided into 2 groups. One is experimental group and the other, control group.

The tooth surfaces of the experimental group were prepared by wet-pumicing of the labial surface with a toothbrush, applying 65% phosphoric acid for 60 second, washingthe acid off, drying the tooth with an air syringe, and applying the adhesive to the tooth and attachment.

The surfaces of the control group were prepared by wet-pumicing of the labial surface with a toothbrush, drying the tooth with an air syringe, applying the adhesive to the tooth surface and attachment.

The unfilled polycarbonate was selected as the material for the plastic because of the following properties.

1. It is nontoxic.
2. It is relatively easy to fabricate into precision small parts, such as brackets.
3. It has shown good abrasion resistance.

4. It has high impact strength.
5. It has good optical clarity and colorability.
6. It has neither an undesirable odor nor a bad taste.
7. It is resistant to creep and deformation under load.

Since the epoxy resins are very stable in its physico-chemical properties, the professional kit containing polimer, monomer and primer, with an assortment of GAC plastic bracket, was utilized as dental adhesives and attahmcents.

Testing apparatus.

A device to calculate the joint strength was not available, so a home-made device was used.

Water is poured into a scaled jar which is pendant to the bracket, the volume of water is observed at the moment of attachment breakage.

The weight of the water can be easily calculated from its volume, consequently, this is the critical weight that the bracket can endure.

Clinical Trials

The procedure adopted in the clinical trials was as follows:

1. The enamel surfaces were polished with pumice.
2. The enamel surfaces were dried, conditioned with 65% phosphoric acid for 60 seconds, washed thoroughly, and dried with hot air.
3. Moisture from the saliva and gingival crevices was controlled.
4. The epoxy resin formulation was mixed and spread on the mixing slab, and the prepared attachments were placed in the resin.
5. The brackets with a thin layer of curing resin were placed in the correct position on the resin.
6. 15 minutes after placement of the brackets, the patient was allowed to rinse the mouth gently with warm air.
7. The archwires were placed after 7 days.

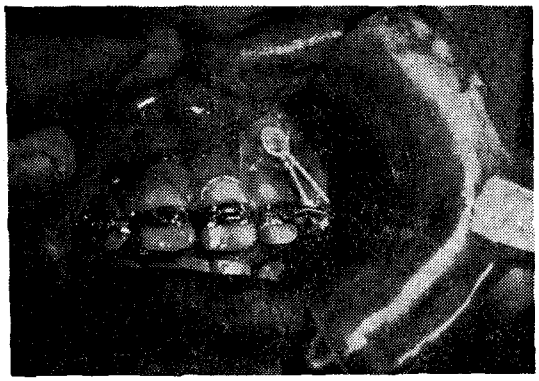

Fig. 1. A plastic bracket bonded on the impacted canine.

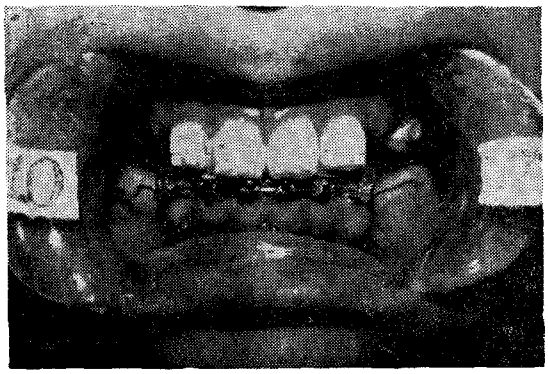

Fig. 2. Plastic brackets bonded on the teeth.

Fig. 3. Plastic bracketsbonded on the teeth.

Figure 1 illustrates treatment of an impacted upper left canine with a bonded plastic bracket. The direct bonding technique can be conveniently adapted for treatment of an impacted tooth on which the metal band could not be placed because of the surrounding gingival tissue.

As shown in Figure 1, the crown of the impacted canine was exposed surgically, after which a plastic bracket was bonded directly to the tooth surface.

This tooth was moved into its normal position by means of an elastic thread to main arch wire.

Figure 2 and figure 3 illustrate a Class II Divisionl malocclusion, which is treated by using conventional bands and plastic brackets. Extraction was indicated because of an associated arch length discrepancy. Conventional metal bands were cemented on the lower teeth, upper molars and second premolars, and plastic brakets were bonded on the upper six anterior teeth.

Table I

min.	UNCONDITIONED SURFACE	CONDITIONED SURFACE
3	4.20	29.40
4	5.10	42.10
5	4.20	43.20
6	5.90	50.05
7	5.90	42.10
8	3.40	33.70

(KG/CM²)

RESULTS

As shown in Table I and Figure 4, the bonding strengths obtained on unconditioned enamel surfaces were extremely poor and the bond strengths of the conditioned surfaces were very good.

These results show that it is necessary to condition the enamel surface to obtain

adequate adhesion with the epoxy resin formulation used.

DISCUSSION

1) *Strength of bonding to the enamel surface.*

As many investigations have pointed out, the primary hinderance against bonding to the enamel surface is the presence of water.

The bonding strength may be sufficient on an extracted tooth surface in the oral cavity. The adhesive breaks down after water immersion over a long period.

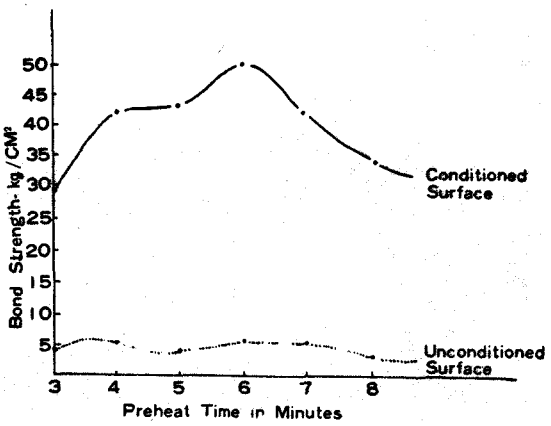

Fig. 4. Changes of the bonded strength ob tained on the conditioned and uncon ditioned enamel surfaces by the time.

2) *Secondary effect on the enamel surface.*

Since Buonocore[17] reported first that acid pretreatment improved the strength of bonding to the enamel, this subject had been discussed from various points of view by many authors.

Buonocore and colleagues demonstrated taglike projections of adhesive, approximately 10 to 25μ in length, into grooves formed on the enamel surface by pretreatment with phosphoric acid. Regarding the secondary effect of acid pretreatment on the enamel surface, Newman[3] conducted surface-replica studies by interferometer measurement and revealed a significant reduction in maximum peak-to-valley height due to acid pretreatment 3 to 6 months after removal of the bonded attachment.

3) *Advantage of bandless orthodontics.*

1. Contact points. In a high percentage of all cases to be treated orthodontically there is some degree of lack of space.

   This associated with crowding. Under these circumstances, it becomes imperative to seperate the tooth to permit the fitting and cementing of bands. When the attachments are bonded directly to the teeth, this procedure is unnecessary.

2. Soft-tissue irritation. Preformed bands have considerably reduced gingival trauma during the fitting of bands, but a certain degree of gingival trauma is still unavoidable when the bands are fitted for a full banded technique. In addition, the edges of the band material and the subsequent stagnation in this area tend to predispose to, if not cause, the gingivitis so frequently associated with a multi-banded technique.

3. Oral hygiene. Despite all the modern appliances for cleaning the mouth during orthodonic treatment, a number of our patients still present with soft debris on and around the bands. It has been our experience that the patients with bonded brackets have far cleaner mouths. The reduction of overhanging edges, especially in the interdental area, seems to reduce the cleaning problem

4. Space occupied by bands. The total space occupied by the bands and cement could amount to as much as 0.8 cm. There are times when this additional space is most welcome during the final stages of treatment. In most instances, however, the last stage of treatment has to be devoted to space closure after removal of the bands.

5. Attachments to partially erupted teeth. It is generally accepted that tooth repositioning is accomplished much more speedily during the eruptive phase. It would often be advantageous to be able to fix an attachment to a partially erupted tooth, particularly in cleft palate patients. The conventional banding is often extreamely difficult, or even impossible, in such cases. The epoxy resin adhesive can readily be used for these patients.

6. Danger of decalcification under detached bands. Preformed bands have reduced the percentage of bands which become loosened during treatment, allowing stagnation and decalcification under them.

   Some of these, to our subsequent embarassment, remain undetected and often lead to considerable decalcification. This problem is not encountered with epoxy-bonded attachments, for loosening of these attachments results in complete displacement. In addition, Buonocore and associates[17] have shown that the resistance of enamel to acid decalcification is increased after it has been coated with a dental resin which has then been dislodged. They suggest that the presence of a thin covering layer of adhesive and or penetration of the adhesive could produce enamel protection.

7. Increased esthetics.

8. This method needs less time than metal banding of the teeth.

SUMMARY and CONCLUSION

An epoxy resin developed for bonding orthodontic attachments directly to enamel surfaces has been subjected to laboratory and clinical trials.

Pretreating tooth surfaces by pumicing and by applying 65 percent phosphoric acid will enhance joint strength.

The larger the joint area, the larger the force required to break the joint. However, the larger the joint area, the smaller the force per unit area required to break the joint.

Some of the direct bonding of orthodontic attachments to teeth are demonstrated.

When various plastic brackets become available, this system of plastic bracket bonding will be a valuable aid in clinical orthodontic practice.

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