Original

The Effects of Different Black Mediators on the Shear Strength of Orthodontic Bracket to the Enamel Treated with Nd-YAG Laser

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Nd : YAG レーザー照射時の各種黒色塗布材による 牛のエナメル質表面の形態変化について

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要旨 : 本研究は, 各種黒色塗布材を併用して Nd-YAG レーザーによるエナメル質表層脱灰後の歯列矯正用ブラケットの接着性を検討することを目的に行われた。被験歯として72本の牛の歯が使用された。実験群としては, 対照群, 酸処理群, レーザー処理群の三つの群に分類した。レーザー装置として, ADL の300dl を用い, 20pps, 87. 5 mJ の照射条件でレーザーエッチングを行った。接着力 (shear strength) は Instion を使用して測定した。その結果, レーザー処理群よりも酸処理群の方が shear strength は強かった。なお, 酸処理群中では, phosphoric acid の方が maleic acid を用いた場合よりも強かった。黒色塗布材併合のレーザー処理群の中では, 黒と oil ink 併用群が最も shear strength が強く, ball pen と water ink の群は次に強い値を示した。transfer paper を用いた場合が最も弱い値を示した。

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Key words=Nd : YAG Laser : Black mediators : Shear strength : Bovine enamel : Acid etching

キーワード=Nd : YAG レーザー : 黒色塗布材 : 引っ張り強さ : 牛の歯エナメル質 : 酸エッチング

Introduction

The acid etching method can dissolve some part of enamel surface to produce the effect of enamel tags¹⁾. In orthodontics, these enamel tags will provide a very strong anchorage effect to hold the orthodontic brackets by bonding materials such as composite resins²⁾.

The laser can make a rough enamel surface,

and different energies of lasers have different effects on the enamel, such as ablation, crack, and crater³⁻⁶⁾. These effects are very similar to the effect of enamel tags produced by the acid etching method^{5,6)}. So the treatment of enamel surface by the dental laser was developed in orthodontic field recently⁷⁻¹⁰⁾.

The roughness of enamel surface was depended on the different laser energy levels

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which may be modified by the different black mediators¹¹⁾. This study was designed to understand the shear strengths of orthodontic brackets bonded to the different black mediators prepainted and laser radiated enamel surfaces. The effects of laser etching were compared with the effects of acid etching.

Materials and Methods

Labial enamels of 72 matured bovine teeth were grounded and polished with sand paper (from 320# to 600#) until the smooth surfaces appeared. The samples were then cut into a block size of 10mm×8mm, and afterwards embedded and divided into 3 main groups and 8 subgroups:

- 1) control group
- 2) acid etching group pretreated with acid solutions:
 - a) 37% phosphoric acid subgroup
 - b) 10% maleic acid subgroup
- 3) laser group pretreated with 5 different kinds of black mediators:
 - a) Chinese ink subgroup
 - b) black oil ink subgroup
 - c) black ball pen subgroup
 - d) black water ink subgroup
 - e) black transfer paper subgroup

Each subgroup contained 9 specimens.

The size of labial surfaces of bovine enamels for acid etching and black mediators painting was about 3.5mm×5.5mm.

There was no treatment on the labial surfaces of bovine enamel for control group.

The etching time for phosphoric acid and maleic acid was according to the manual of products as 1 minute and 15 seconds respectively. After the etching procedure, the samples were rinsed and dried.

Chinese ink and black oil ink were sticky and waterproof, black ball pen and black water ink were watery in character, and black transfer paper was easier to identify the size. After the above painting procedures, the samples were lased with Nd-YAG laser according to the method of previous study⁷⁾.

The laser machine used was the American

Dental Laser ADL model d Lase 300. Its wave length is 1064 nm, and its pulse width is 150. The spot size of its focus is 400 micron in diameter, and the fiber size is 320 microns. The distance between object and fiber tip is 0.16m m. The power is 20 pps, 87.5mJ. The reason why chose these conditions was because in a previous experiment⁷⁾ we had found such condition the best for laser treatment. Orthodontic brackets were bonded to the prepared tooth samples with composite resin (Ormco Co.) for testing shear strength. The shear strengths of enamel surfaces to the orthodontic brackets were measured by Instron 1125.

Results

The results of the shear strength experiments were shown in Table 1.

The control group did not show any significant bonding force between enamel and bracket. Acid etching enamels, either by phosphoric acid or maleic acid, had stronger shear strength than the laser lased enamels significantly. The phosphoric acid subgroup had stronger shear strength than the maleic acid subgroup. In the laser group, Chinese ink subgroup and oil ink subgroup had stronger shear strength than black ball pen subgroup and water ink subgroup significantly. The black transfer paper subgroup had the weakest shear strength in the laser group (Table 2).

There is not statistically significant difference

Table 1 Shear Strength of Orthodontic Brackets to Enamels Treated with Acid Etched or Laser Etched Methods

Control group	: 0 (kg)
Acid etching group:	
Phosphoric acid subgroup	: 19.97±2.77
Maleic acid subgroup	: 17.14±4.71
Laser group	
Chinese ink subgroup	: 6.35±2.21
Black oil ink subgroup	: 6.33±1.99
Black ball pen subgroup	: 4.41±1.09
Black water ink subgroup	: 5.08±2.59
Black transfer paper subgroup	: 3.34±3.14

Table 2 The t-test for the Shear Strength of Orthodontic Brackets to Enamels Treated with Acid Etched or Laser Etched Methods

	Ph	Ma	Ci	Bo	Bb	Bw	Bt
Ph	—	np	*	*	*	*	*
Ma	—	—	*	*	*	*	*
Ci	—	—	—	np	*	*	*
Bo	—	—	—	—	*	*	*
Bb	—	—	—	—	—	np	np
Bw	—	—	—	—	—	—	*
Bt	—	—	—	—	—	—	—

* : $P < 0.05$

Ph : Phosphoric acid Ma : Maleic acid

Ci : Chinese ink Bo : Black oil ink

Bb : Black ball pen Bw : Black water ink

Bt : Black transfer paper

in shear strengths either between the Chinese ink subgroup and oil ink subgroup or between the black ball pen subgroup and water ink subgroup (Table 2).

Discussion

Joffe¹²⁾ reported that enamel can be laser-etched to a depth comparable to that achieved with phosphoric acid etching. Myers^{13,14)} found that both the acid and laser energy penetrated the enamel to approximately the same depth from 20-40 microns, and that morphologic changes in enamel were very similar between the two techniques.

Abed¹⁵⁾ compared the adhesion power of orthodontic brackets to the 37% phosphoric acid and the Nd-YAG laser etched tooth enamels and reported that adhesion was greater with acid than with laser etching.

Huang¹⁶⁾ found that although the shear strength of orthodontic brackets to bovine enamel surfaces showed greater in phosphoric acid etched group than in laser etched group, but the strength produced by laser irradiation was still greater than the force needed for the orthodontic tooth body movement.

Hess⁴⁾ observed the coated enamel surface irradiated with 35mJ energy level of Nd-YAG

laser had melted and reconstructed with numerous small, bubble-like inclusions. The 75 mJ energy level showed individual impact craters with shallow centers and raised edges containing numerous pores and large bubble-like inclusions⁴⁾. So Hess⁴⁾ concluded that many bubble-like inclusions varying in size due to the different energy levels.

Morioka¹¹⁾ had mentioned about the pretreatment of different mediators would cause different levels of laser energy absorption at this surfaces, therefore different effects on the enamel surfaces could be observed.

We chose five different kinds of mediators for this experiment. The results of 5 laser subgroups can be divided into 3 groups. The first group was painted with waterproof and oil-like mediators including Chinese ink, and black oil ink, which are more sticky and have more particles in the suspension. These two subgroup showed the strongest shear strength in the laser group. The second group was consisted of black ball pen subgroup and black water ink subgroup which were characterized with watery content and less particles. They showed moderate shear strength in this experiment. The third group was painted with black transfer paper. Due to its homogenous character and easily to be identified in size, we included transfer paper as one subgroup in our experiment. This subgroup did not show enough shear strength to hold the orthodontic brackets.

The phosphoric acid solution is the most popular and well studied acid etching solution²⁾. Enamel surfaces etched with this solution had the strongest shear strength in the whole experiment. Our data was very similar to that of other researches^{8,15)}. Another one, maleic acid¹⁷⁾, has been used to prepare the hard tissue for bonding since 1987 and was lower consistency than the traditional phosphoric acid^{17,18)}. The maleic acid subgroup did not show similar strong shear strength as phosphoric acid subgroup, but was stronger than that of laser group.

So from the above data, although most of studies^{3-7,9,12-16)} agreed that phosphoric acid etching method produce stronger shear strength

between enamel surface and orthodontic brackets, and more retentive topographic change on the enamel surface than laser etched method, laser etched method still have enough shear strength to hold the brackets for orthodontic movement of teeth, and cause an uneven and complex surface change on the enamel surface. In addition, laser etched method has some benefits such as easily to identify the etching area, less procedures, less discomfortability for the patients, and more resistance to the caries which is always a big problem for young persons who have orthodontic brackets in their mouth^{15,16}. We suggest that the etching of Chinese ink prepainted enamel surface lased with Nd-YAG laser at 20 pps, 87.5mJ, has its practical benefits over traditional phosphoric acid etched method.

Conclusions

Seventy-two enamel surfaces of bovine lower anterior incisors were pretreated with phosphoric acid, maleic acid, or prepainted with 5 kinds of black mediators and lased with 20pps, 87.5mJ of Nd-YAG laser.

The acid etching group, either by phosphoric acid or maleic acid, has stronger shear strength than the laser group. In the laser group, the Chinese ink subgroup had stronger shear strength than other subgroups.

Although the acid etching group had stronger shear strength than the lased group, the Nd-YAG laser technique does have its advantages, such as an easier identification of the pretreated areas, shorter pretreatment duration, and less patient discomfort. The enamel surfaces painted with Chinese ink and lased by the Nd-YAG laser under the condition of 20 pps, 87.5mJ may be suitable for bonding orthodontic brackets in human orthodontic treatment.

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