Original Article

Comparison of Shear Bond Strength of Orthodontic Brackets Bonded with Core Max II and Transbond XT in Fluorosed Teeth and Evaluation of Enamel Damage after Debonding

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Abstract

Background and Aim: Orthodontic bracket bonding may encounter difficulties in fluorosed teeth. The aims of this study were to compare the shear bond strength (SBS) of brackets bonded to fluorosed teeth with Core Max II and Transbond XT and to assess the enamel damage after debonding.

Materials and Methods: In this *in-vitro* study, 60 fluorosed (TFI=4 and 5) and non-fluorosed teeth were divided into two subgroups. The standard edgewise metallic brackets were bonded to the teeth with Transbond XT in the first and third groups, and with Core Max II in the remaining groups. After bonding, the SBS of the brackets was tested with a universal testing machine.

The obtained data were analyzed by two-way ANOVA, post-hoc (LSD), Kruskal-Wallis, Wilcoxon, and paired samples tests.

Results: Fluorosis significantly reduced SBS (P=0.041). Core Max II significantly increased SBS (P=0.040). Teeth in group 4 (fluorosis and Transbond XT) had the lowest SBS (13.44±1.69 MPa); group 2 (fluorosis and Core Max II) showed the highest enamel damage.

Conclusion: Core Max II is a good adhesive for orthodontic bracket bonding in fluorosed teeth but conservative debonding methods should be necessarily applied to decrease enamel damage.

Key Words: Dental fluorosis , Enamel , Orthodontic adhesive , Shear bond strength

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Introduction

A common problem encountered during the orthodontic treatment of fluorosis patients is the presence of a superficial, hypermineralized, acid-resistant layer [1-3. Orthodontists frequently deal with bracket debonding in areas with high prevalence offluorosis. Rebonding is time consuming and has a negative impact on orthodontic treatment [4, 5]. The concentration of fluoride in the superficial enamel surface increases with increased severity of fluorosis [2, 3]. Regardless of the severity of fluorosis, the highest fluoride content is in the 200μ thickness of the superficial enamel [4]. Superficial enamel microabrasion in fluorosed teeth has been recommended for increasing the shear bond strength [5-10]. However, enamel microabrasion can also roughen the enamel surface adjacent to the bracket and lead to swallowing of the powder particles, facial trauma by the powder aerosols and allergy. Moreover, it takes time and imposes costs [11]. Increased the etching time has also been recommended for improving the shear bond strength [12-16]. However, it is difficult to estimate the etching time required for achieving a surface with adequate roughness [14].

Adhesion promoter has also been recommended for improving the shear bond strength in fluorosed teeth [11, 17, 18]. Although the adhesion promoter increases the shear bond strength to fluorosed teeth, it decreases the adhesive remnant index (ARI) and causes debonding at the enamel-adhesive interface [18]. Considering the high prevalence of fluorosis in Southern provinces of Iran [19], a material is required to improve the bonding of orthodontic brackets to fluorosed teeth.

Chemically cured composites have also been suggested for bracket bonding to fluorosed teeth [5, 7]. It has been claimed that hydroxy apatite (HA) and fluorohydroxyapatite (FHA) crystals tend to scatter the light radiated from the light curing unit. Thus, use of chemically cured composites has been suggested for fluorosed teeth [5].

Core Max II is a chemically cured adhesive. Studies on Core Max II are scarce [20-22]. Pakshir et al. showed that the shear bond strength of Core Max II was significantly greater than that of Transbond XT and its ARI following debonding was less that of Unite and Transbond XT [22].

Considering the controversial results of studies comparing different techniques for increasing the shear bond strength to fluorosed teeth and higher shear bond strength of Core Max II than Transbond XT, this study aimed to compare the shear bond strength of Core Max II and Transbond XT to fluorosed teeth.

Materials and Methods

This in-vitro case-control study was conducted on 30 human first and second premolar teeth with moderate fluorosis according to Thylstrup and Fejerskov Index (TFI) and 30 non-fluorosed teeth. To ensure accurate grading of the severity of fluorosis, each tooth was evaluated twice in two consecutive days (a total of 4 times) by two examiners. Only teeth with moderate degree of fluorosis (TFI=4-5) according to the opinion of both examiners were entered the study.

Sample selection and inclusion and exclusion criteria:

-The extracted teeth of patients in the age range of 13-18 years were evaluated. By increased age, the frequency of enamel cracks increases. In order to match the specimens, extracted teeth of patients in the mentioned age group were used.

-The teeth had to be extracted within the past 6 months

-No history of treatment with chemical agents such as hydrogen peroxide (H2O2) or acid etching

-Absence of continuous cracks in the crown (using direct dental unit light)

-Teeth had to be extracted for orthodontic purposes only

The bonding process:

Each group of teeth was randomly divided into 2 subgroups; and 4 subgroups of 15 each were created. Groups 1 and 2 included fluorosed teeth and groups 3 and 4 included healthy teeth. The extracted teeth were rinsed with water to eliminate tissue residues.

The teeth were stored in distilled water at 4°C until the experiment. In order to prevent bacterial growth, distilled water was refreshed weekly until bonding.Before bonding, specimens were polished with a rubber cup (Tizkavan, Iran) and non-fluoride pumice paste (Golchai, Iran) with a low speed handpiece (10,000-30,000 rpm) for 20s. In groups 1 and 3, specimens were etched with 37% phosphoric acid gel (3M, Unitek) for 30s followed by 20s of rinsing. A thin layer of Transbond XT primer was applied to the tooth surface by a microbrush. Transbond XT was also applied to the back of brackets.

Standard 0.022 edge-wise brackets (Dyna0Lock, 3M, USA) with a mean surface area of 12.09 mm^2 were placed at 4mm distance from the buccal cusp tip using a specific gauge (3M, Unitek). Complete adaptation of bracket to tooth surface was achieved by pressure applied by an explorer tip at the center. The excess adhesive around the bracket was removed by the explorer.

Light curing was done using LED light curing unit (Smartlife IQ2, Dentsply, Milford, USA) with 450nm wavelength for 10s from the incisal, 10s from the gingival, 10s from the mesial and 10s from the distal for a total of 40s at 3mm distance from brackets.

In groups 2 and 4, specimens were etched with Core Max Etching Agent (Sankin, Tokyo, Japan) for 30s according to the manufacturer's instructions followed by 20s of rinsing. One layer of Core Max II primer (Sankin, Tokyo, Japan) was applied by a microbrush to the tooth surface. The standard powder/liquid ratio recommended by the manufacturer was 130mg powder to one drop of Core Max II liquid. The mixture was applied to the back of the metal bracket and the remaining steps were performed as in previous groups; 15min time was allowed for complete setting of Core Max adhesive.

After bonding, all specimens in both groups were stored in distilled water for 48h prior to bond strength testing; 48h after bonding, the teeth were fixed on the surveyor jig (Jeleno Surveyor, USA) and placed into an acrylic mold. The shear load was applied parallel to the labial surface of teeth by an Instron machine (universal testing machine, Zwick Roell, Germany) at a crosshead speed of 0.5mm/min. The load was applied at the base-wing interface.

Assessment of length and number of cracks before bonding:

In order to achieve equal magnification in all specimens, the distance from the microscope lens to the buccal surface of teeth had to be equal. In order to do so, two laboratory plates and sculpture paste were used. The paste was placed in one of the plates and the specimen was fixed in the paste. By pressing the buccal surface of tooth with the second plate, tooth surface was aligned with the plate margin and parallel to the horizontal plane. To better observe the cracks, the teeth were rotated 360°around the center point while radiating the light; because if the crack and the light beam are in the same alignment, the crack will not be detected.

To assess the length and number of cracks, the microscope was attached to a digital camera and from there to a computer and the obtained microscopic image was assessed using Stereolith (version I) software.

The buccal surface texture, location, length, number and direction of enamel cracks were recorded on a piece of paper by the two observers. Each observer separately evaluated the cracks and interclass correlation coefficient was applied to assess the interobserver agreement. Each crack on each tooth was allocated a number in order to be evaluated again after debonding.

After debonding, excess composite was removed from the enamel surface using a low speed hand piece (30000 rpm) and tungsten-carbide bur (Dentaurum 00-603-123) with water coolant. All specimens were evaluated again by a stereomicroscope.

The differences in length and number of cracks at this step with the baseline values was calculated. A second observer also examined the specimens.

Statistical analysis:

Two-way ANOVA was applied to assess the effect of fluorosis, the adhesive used and their interaction on the shear bond strength. Tukey's post hoc test was used to compare the shear bond strength among the 4 study groups.

For normality testing, Kolmogorov-Smirnov test was used. Number of cracks did not follow a normal distribution. Thus, non-parametric Wilcoxon's Signed Rank test was used for intragroup assessment of difference in number of enamel cracks before and after debonding.

For intragroup assessment of difference in length of enamel cracks before and after debonding, repeated measures ANOVA was applied. Kruskal Wallis test was used to compare the number and length of enamel cracks after debonding among the 4 groups. For pairwise comparison of the number of enamel cracks after debonding, Dunn's test was applied.

Interclass correlation coefficient was used to assess the level of agreement between the two observers in terms of the accuracy of measurements.

Results

The results of two-way ANOVA revealed significant differences among the 4 groups in terms of type of material used and type of tooth. However, the interaction effect of the two variables was not significant (0.360) (Table 1). The P value for the effect of fluorosis and type of adhesive was 0.040 and 0.041, respectively. The mean and SD of the shear bond strength are shown in Table 2. The results of Tukey's post hoc test indicated significant differences between group 1 and other groups (Table 2).

Table 1: Comparison of shear bond strength based on the type of material used, type of tooth and the interaction of the two variables

Variable	Sum of squares	Mean of squares	F	Level of significance
Fluorosis	22/67	22/67	4/02	0/041*
Adhesive	25/06	25/06	4/42	0/040*
Fluorosis x adhesive	7/33	7/33	1/30	0/259
Error	316/008	56		
Total	371/078	59		

P<0.05: Significant
P<0.001: Very significant

Table 2: The mean and SD of shear bond strength of Core Max II and Transbond XT in fluorosed and non-fluorosed teeth

Groups	Mean	SD
Fluorosis and Transbond XT (group 1)	13/44 A	1/69
Fluorosis and Core Max II (group 2)	15/38 B	2/20
Non-fluorosed and Transbond XT (group 3)	15/44 B	2/83
Non-fluorosed and Core Max II (group 4)	15/97 B	2/63

No significant difference was observed in length or number of enamel cracks among the groups before bonding (P=0.980 for number of cracks and P=0.940 for length of enamel cracks). Intragroup comparison of length and number of enamel cracks after debonding using Wilcoxon Signed Rank test and repeated measures ANOVA in the 4 groups indicated a significant increase in number and length of enamel cracks after debonding (Table 3).
Comparison of the length of enamel cracks before and after debonding in the 4 groups using Kruskal Wallis test revealed no significant difference among the 4 groups in terms if increase in length of enamel cracks. However, the difference in number of enamel cracks among the 4 groups was statistically significant (Table 4). Dunn's test showed that increase in number of enamel cracks in group 2 (fluorosis and Core Max II) was significantly greater than in the remaining 3 groups (Table 4).
The results of intraclass correlation coefficient revealed an agreement between the two observers in terms of length of enamel cracks before debonding (P=0.000), number of enamel cracks before debonding (P=0.000), length of enamel cracks after debonding (P=0.000) and number of enamel cracks after debonding (P=0.000).

Table 3: The number (mean± SD) of enamel cracks before and after debonding in the 4 study groups

Groups	Number of enamel cracks	Mean± SD	P value (1)	Length of enamel cracks	Mean± SD	P value (2)
Group 1	Number of enamel cracks before bonding	1/47±0/92	0/000**	Number of enamel cracks before bonding	4/06±2/70	0/000**
	Number of enamel cracks after debonding	3/33±0/90		Number of enamel cracks after debonding	11/61±4/70	
Group 2	Number of enamel cracks before bonding	1/33±1/05	0/000**	Number of enamel cracks before bonding	4/28±2/91	0/000**
	Number of enamel cracks after debonding	4/33±0/98		Number of enamel cracks after debonding	12/09±1/90	
Group 3	Number of enamel cracks before bonding	1/40±0/92	0/001*	Number of enamel cracks before bonding	3/70±2/52	0/004*
	Number of enamel cracks after debonding	2/67±0/99		Number of enamel cracks after debonding	10/47±2/25	
Group 4	Number of enamel cracks before bonding	1/47±0/83	0/005*	Number of enamel cracks before bonding	4/13±1/96	0/001**
	Number of enamel cracks after debonding	2/93±1/16		Number of enamel cracks after debonding	11/16±2/14	

1. Wilcoxan signed rank tests
2. Repeated measure ANOVA

Table 4: Comparison of mean and SD of difference in number and length of enamel cracks after debonding in the 4 groups

Number and length of enamel cracks	Groups	Mean± SD	P value
Difference in number of enamel cracks before bonding and after debonding	1	1/87±1/95 (A)	0/010*
	2	2/87±1/41 (B)	
	3	1/47±1/06 (A)	
	4	1/57±1/55 (A)	
Difference in length of enamel cracks before and after deboning	1	7/29±5/56	0/871
	2	7/82±3/62	
	3	6/79±3/592	
	4	7/40±3/02	

Discussion

Direct bonding of orthodontic brackets is a common technique in orthodontic treatments. Several variables can affect the bonding such as the concentration and type of acid used, etching time, type of adhesive and type of bracket [7]. Several studies have reported the negative effect of prismless enamel on the bonding of orthodontic brackets [9].

Presence of a superficial, hypermineralized enamel layer in fluorosed teeth complicates the process of bracket bonding [3]. Our results also showed that fluorosis significantly decreased the shear bond strength of orthodontic brackets to enamel. Our results were in accord with some previous studies [4, 18] while some others did not find a significant difference in the shear bond strength of fluorosed and non-fluorosed teeth [7].

Most previous studies have assessed the shear bond strength of fluorosed teeth following changes in the enamel preparation process such as increasing the etching time and enamel abrasion [5-10, 12-16]. Fewer studies have evaluated the effect of adhesive type on the shear bond strength of fluorosed teeth [11, 18]. Miler suggested the use of self-cure adhesives like Concise in fluorosed teeth. He stated that HA and FHA crystals tend to scatter the light irradiated by the light curing unit during the process of bonding [5]. Ng'aga'aPM et al, in 1992 reported that Concise composite was suitable for use in fluorosed teeth [7]. Our results demonstrated that Core Max II, which is a self-cure adhesive, significantly increased the shear bond strength of orthodontic brackets to fluorosed teeth compared to Transbond XT (P=0.040).

In a study by Pakshir et al, in 2004 on the use of Core Max II for bonding of brackets, the shear bond strength of Core Max II was found to be greater than that of Transbond XT. Assessment of ARI in their study revealed that failures mostly occurred at the enamel-adhesive interface in the group bonded with Core Max II. However, in their study, no statistically significant difference was found between the two adhesives in the shear bond strength of orthodontic brackets to normal teeth [22].

Assessment of number and length of enamel cracks revealed an increase in number of enamel cracks in all 4 groups after debonding. Moreover, increase in enamel cracks was significantly greater in fluorosed teeth after using Core Max II. No significant difference was noted in number of cracks after debonding among the remaining 3 groups. Core Max II adhesive increased the number of cracks only in fluorosed teeth.

No significant difference was noted in length of enamel cracks among the 4 groups after debonding. It seems that although the fragile structure of hypoplastic enamel in fluorosed teeth has less resistance to cracks due to the strong bond of Core Max II, compact and fragile FHA crystals do not allow the extension of enamel cracks.

Pakshir et al. demonstrated that enamel damage following the use of Core Max II was not different from that following the use of Unite and Transbond XT adhesives in non-fluorosed teeth [22]. Similarly in our study, enamel damage in non-fluorosed teeth in Core Max II and Transbond XT groups was not significantly different.

Most studies on techniques to improve the bond strength of fluorosed teeth have only focused on the shear bond strength and only a few studies have evaluated the mode of failure (location of bond failure) [18]. No previous study on the shear bond strength to fluorosed teeth has evaluated enamel damage after debonding; whereas, enamel damage after debonding is irreversible. Although no direct association exists between the shear bond strength and failure mode (site of failure) [23], failure at the enamel-adhesive interface in materials with high shear bond strength can increase enamel damage [24]. Adanir et al. in 2009 showed that although the adhesion promoter (Enhance LC) increases the shear bond strength of orthodontic brackets to fluorosed teeth, it causes bond failure at an unfavorable location (enamel-adhesive interface) [18]. Core Max II can increase the shear bond strength to fluorosed teeth and number of enamel cracks as well.

Weersinghe et al. evaluated the effect of self etch primer on the shear bond strength to fluorosed teeth. They reported a reduction in shear bond strength following the use of self etch primer compared to 37% phosphoric acid. Moreover, stereological analysis in their study revealed that the highest enamel damage occurred following the use of 37% phosphoric acid for enamel preparation in teeth with moderate to severe fluorosis. In fluorosed teeth due to the presence of a hypoplastic structure, increased bond strength can damage the enamel structure.

Treatment in these patients should primarily aim to preserve the remaining tooth structure [4]. Core Max II provides favorable bond strength of orthodontic brackets to moderately fluorosed teeth. Use of materials with high bond strength is inevitable in fluorosed teeth. However, by using tensile forces during debonding we may be able to decrease enamel damage to some extent [25, 26].

Conclusion

-Fluorosis significantly decreases the shear bond strength of orthodontic brackets to teeth.

-Core Max II can increase the shear bond strength of orthodontic brackets to fluorosed teeth.

The greatest enamel damage was observed in fluorosed teeth following the use of Core Max II for bonding.

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