Evaluation of Possibility of Using Core Max II in Bonding Orthodontic Brackets to Teeth

Pakshir HR [a] , Rostami R [b] , Alavi AA [c]

ABSTRACT

Background and aim: Different adhesives have been used for bonding orthodontic brackets to teeth. The aim of this study was to evaluate the possibility of using Core Max II in bracket bonding by comparing it's shear bond strength with the two commonly used orthodontic adhesives; Transbond XT and Unite.

Subjects and Methods: In this interventional study, 105 human premolars were divided into 3 groups of 35 each. After etching with 37% phosphoric acid, Dyna-Lock stainless steel brackets (3M Unitek, Monrovia, CA) with the average base surface area of 12.09 mm2 were bonded with three different adhesives; Core Max II (Sankin, Tokyo, Japan) Transbond XT (3M Unitek) and Unite (3M Unitek). The shear bond strength of 3 groups were measured by a universal testing machine (Instron 3401, Canton, Mass) with cross- head speed of 0.5 mm/min. Adhesive Remnant Index (ARI) was determined under 10× magnification. For data analysis, SPSS statistical package was used.

Results: Mean shear bond strength of Core Max II (17.24± 3.2 MPa) was significantly higher than Transbond XT (15.44 ± 2.2 MPa) (P=0.009) but had not statistically difference with Unite (17.16 ± 3.7 MPa) (P=0.93). Evaluation of ARI indicated that 83% of Core Max II samples had score 0 or 1 and 17% had score 2 or 3. These percentages were 66% and 34% for Transbond XT and 77% and 23% for Unite, respectively.

Conclusion: In this study, it was concluded that: 1) Core Max II had a shear bond strength higher that Transbond XT and equal to Unite. 2) ARI of Core Max II showed a higher frequency of score 0 and 1, which indicated that after debonding, most of the adhesive remains on the bracket base. 3) Core Max II has the potential of being a good orthodontic adhesive. (IJO 2006; 1: 42 - 47)

Key words: Shear bond strength, Core Max II, Transbond XT, Unite, Adhesive Remnant Index (ARI)
(Received: Dec.11,2005; Revised and accepted May.1,2006)

Introduction

Following the introduction of the acid etch bonding technique [1], the concept of bonding various resins to enamel has developed application in the bonding of orthodontic brackets. Modification of adhesive formulation over the past decades have led to current availability of 2 paste system [2], no-mix adhesive [3] glass ionomer cements[4] and light- activated direct bonding materials [5-6].

For years, self-cured resins were the unique choice for adhesives. Early self- polymerizing materials were two paste systems. One paste containing an activator and the other an initiator. The disadvantage of using these resins is limited working time for accurate bracket placement and also weakening of the bond strength from possible air incorporation or incomplete mixing of the pastes [7]. In 1977, Hocevar [8] initiated the use of concise restorative resin for bonding orthodontic brackets and then an orthodontic bonding system to decrease the necessity of adding liquid to the paste was developed by 3M in 1979 [9].

Buonocore first introduced the photosensitive light- cured

[a] DDS, MS Assoc. Prof. Dept. of Orthodontics, Dental School, Shiraz University of Medical Sciences, Shiraz- IRAN
[b] Orthodontist
[c] DDS, MS Assoc. Prof. Dept. of Restorative Dentistry, Dental School, Shiraz University of Medical Sciences, Shiraz- IRAN
Corresponding author: Dr. Hamidreza Pakshir
e-mail: hpakshir @ sums.ac.ir

resins in restorative dentistry as pit and fissure sealants and then became popular in orthodontics [10]. In 1979, light- cure adhesives with the ability to bond orthodontic attachments were introduced [11]. The greatest advantage of a light cured system is the increase in working time before polymerization. However one disadvantage is the time required to completely polymerize the adhesive. Fortunately, the clinical use of light- curing units has been recently described for orthodontic bonding purposes with a cure time of 2 seconds per brackets [12].

The bond strength of adhesive and attachment should be sufficient to withstand the forces of mastication and stresses exerted by the arch wire. At the same time, the bond strength should be at a level to allow bracket debonding without causing damage to the enamel surface [13]. Clinically, the clinician would prefer the failure to occur between the adhesive and the enamel at the time of debond because this would allow for easier resin removal from the enamel surface. On the other hand, maintaining a sound unblemished enamel surface after debonding orthodontic brackets is a primary concern to the clinician. As a result, bond failure at the bracket- adhesive interface or within the adhesive seems to be more desirable than at the adhesive- enamel interface [14].

Of additional importance is the question of the in-vivo bond strength requirements for orthodontic function. The adequate bond strength for clinical situation, suggested by various studies, ranges from 2.8 MPa to 10 MPa [15-18]. It has been demonstrated that enamel fractures on in vitro specimens may occure with bond strengths as low as 9.7 MPa [19].

In comparing the bond strength of self- cured resins to light-cured resins, Andreasen et al. found no significant difference in shear bond strength between the light- cured resin Heliosit with a 40 second light exposure and self- cured resin concise [20]. Other studies revealed that the shear bond strength of light-cured resins were weaker than that of self- cured ones [21-22]. Another study showed that the tensile bond strength of light- cured resin of Transbond was stronger that that of self-cured resin Concise but no statistical difference in bond facture interface distribution was found [23].

Many different adhesives exist for direct bonding and manufacturers are continuously introducing new restorative and adhesive systems to the dental profession that are more stronger and adhere better to enamel and dentin.

The purpose of this investigation was to determine whether CoreMax II (Sankin, Tokyo, Japan), an adhesive resin for core construction, could be used as a new adhesive in bonding orthodontic brackets by:

1. Comparing its shear bond strength with the two commonly used adhesives, Transbond XT and Unite.
2. Evaluating the debonding characteristics and site of bond failure of Core Max II and comparing the results with Transbond XT and Unite as control groups.

Materials and Methods

Teeth

One hundred and five sound upper and lower premolars that had been extracted for orthodontic purpose from patients between the age of 18 and 25 years were collected and stored in a solution of 0.1% (weigh/ volume) thymol to prevent dehydration and bacterial growth.

The criteria for tooth selection included intact buccal enamel with no carries and not subjected to any pretreatment chemical agent or root canal therapy. Teeth with hypoplastic areas, Cracks, or gross irregularities of the enamel structures were excluded.

After one week of storing in thymol solution, all teeth were transferred to distilled water for a maximum of 3 month before testing. Every week the distilled water was changed. The teeth were randomly divided into 3 equal groups with approximately equal numbers of first, second, upper and lower premolars in each groups (containing 35 teeth), to prevent bias caused by the possible difference in bond strength among tooth types.

The teeth were embedded in cold-curing, fast-setting acrylic (leocryl; leone, Sesto Fiorentina, Italy). The buccal surface of each tooth was cleaned with a pumice and water slurry and rubber prophylactic cups for 10 seconds. All teeth were thoroughly washed, and dried with oil-free compressed air before surface preparation.

Adhesives

Core Max II (Dentsply, Sankin K.K, Japan) is a composite resin which according to the manufacturer, is the only powder- liquid system which allows ideal consistency to be mixed to operator desire. It is fast setting and is used for core constriction by bonding to dentin. The powder is made of Silicon Dioxide with average particle size of 32 . Benzoic peroxide is included in the powder as catalyst. The liquid is Methacrylic acid (ester) and the total filler content of the mixture is 75%. The physical property of this resin is shown in table 1.

The two other adhesives used in this study were a light cured composite (Transbond XT, Unitek, 3M, St paul, Minn) and a chemical- cured composite (Unite, 3m Unitek, Monrovia, California, USA) both of which are well known orthodontic adhesives for bracket bonding.

Bracket used and bonding procedure

One hundred and five stainless steel 0.22 premolar brackets (Dyna-lock, 3M Unilek) with surface area of 12.9 mm2 were used for this study. The surface area was the average obtained from measuring 10 brackets. The teeth were etched with 37% by weight phosphoric acid gel for 30 seconds, washed for 20 seconds, and air- dried. Then the metal orthodontic brackets

Table 1. Physical property of Core Max II composite resin

Powder/ Liquid ratio (Standard)	1.8 g/ 0.5 ml (1 spoon level / 3 drops)
Setting time	3' 30"
Compression strength	328 MPa
Surface hardness	67 Hv
Bending strength	132 MPa
Tensile strength	60 MPa
Bonding strength	Human dentin 12 MPa
Coefficient of thermal expansion	29.5×10^{-6}

Table 2. Descriptive statistic of the shear bond strength for the three groups tested

Group	Adhesive	Mean N	Mean (SD) MPa	Min MPa	Max MPa
1	Core Max II	208.68	17.24±2.2	16.14	18.34
2	Transbond XT	187.22	15.44±3.2	14.67	16.22
3	Unite	207.45	17.16±3.7	15.87	18.45

were bonded to the teeth according to one of three protocols:

Group 1: Bonding with Core Max II adhesive system.

The bonding agent of Core Max II was placed on the etched enamel in a thin film and the powder- liquid mixture required to keep the brackets on the enamel surfaces and prevent them form sliding, was prepared according to manufacturer's instruction. The bracket were bonded with the adhesive by pressing on the tooth with 300 gm of force according to Bishara et al (24) and excess adhesive was removed with a sharp scaler.

Group II: Bonding with Transbond XT adhesive system.

Transbond XT primer was applied to the etched surface in a thin film. Transbond XT adhesive paste was applied to the bracket base and the bracket was positioned on the tooth and light cured with a halogen light for 20 seconds (XL 300; 3M Unitek). Before light curing the adhesive, the brackets were pressed on the tooth with 300 gm of force as for group 1 and the excess adhesive was removed.

Group III: Bonding with Unite adhesive system

Unite primer was applied to the etched surface in thin film. Unit adhesives paste was applied to the bracket base and brackets were bonded to the teeth as for group 1 and the excess adhesive was removed from around the bracket bases.

The bonded teeth were thermal cycled between 2 water baths containing distilled water at 55°C and 5°C. Seven hundred fifty cycles were preformed between these 2 temperatures, with dwell time of 30 seconds. Then all samples were stored in distilled water and room temperature for 24 hours and sub sequent test in a shear mode on a universal testing machine (Instron 4302, Conton, Mass).

Debonding procedure and evaluation of residual adhesive

For shear testing, the specimens were secured so that the bracket bases were parallel to the direction of the shear force. An occluso-gingival load was applied to the bracket, producing a shear force at the bracket- tooth interface. Shear bond strengths were measured at a cross head speed of 0.5 mm/ minute. The force required to dislodge the bracket was measured in Newton (N) and the shear bond strength (1MPa= 1 N/mm2) was then calculated by dividing the force values by the bracket base area (12.9 mm^2).

After bond failure, the brackets and teeth were examined by the same operator under a light stereomicroscope at 10 magnifications.

ARI scores were used as a method of defining bond failure site among the enamel, the adhesive, and the bracket base. The amount of adhesive remaining on the enamel sur-

Table 3. The adhesive remnant index score frequency for each group

Adhesive	Adhesive Remnant Index Score				Total
	0	1	2	3	
Core Max II	18 (51.4%)	11 (31.4%)	2 (5.7%)	4 (11.4%)	35 (100%)
Transbond XT	7 (20%)	16 (45.8%)	6 (17.1%)	6 (17.1%)	35 (100%)
Unite	3 (8.6%)	24 (68.6%)	3 (8.6%)	5 (14.3%)	35 (100%)

ARI Score 0= no adhesive left on the tooth; 1= less than half the adhesive left on the tooth; 2= more than half the adhesive left on the tooth; 3= adhesive covering the whole area of the bracket base.

face was coded using the criteria proposed in the adhesive remnant index (ARI) (25). ARI scores were scored as 0 to 3:

0= No adhesive remains on the tooth surface
1= Less than half the adhesive remains on the tooth surface
2= More than half the adhesive remains on the tooth surface
3= All the adhesive remains on the tooth surface with a distinct impression of the bracket base.

Statistical analysis

Descriptive statistics including the mean, standard deviation, minimum and maximum values were calculated for each of the three test groups. Differences in mean measurements among the groups were analyzed by two- way analysis of variance (ANOVA) and if a significant difference was present, Tukey's multiple comparison test were used to identify which of the means were significantly different from each other. The Chi-square test was used to determine significant difference in the ARI scores between the three test groups. Significance level for all statistical tests was predetermined at p 0.05.

Results

The results of shear bond strength (SBS) measurements (MPa) including the mean, standards deviation, minimum and maximum in 3 groups were presented in table 2. Two-way ANOVA showed significant differences in bond strength of the 3 test groups (p=0.029). The mean SBS for Core Max II was 17.24±3.2MPa, for Transbond XT 15.44±2.2 and for Unite was 17.16±3.7 MPa. The t-test comparisons revealed that there was significant difference between, the mean SBS of Core Max II and Transbond XT adhesives (p=0.009) but no significant difference in SBS was observed between Core Max II and Unite (p=0.43). The results also showed statistically significant difference between Unite and Transbond XT (p=0.026).

The failure mode of the three types of adhesives are presented in table 3. The ARI scores comparisons indicated that both Transbond XT and Unite had nearly similar failure mode and were not significantly different from each other (X2=4.3, p= 0.23). But, there was found to be significant difference between ARI scores of Core Max II with both Transbond XT (X2=8.16, p= 0.043) and Unite (X2=15.8, p= 0.001).

In Core Max II group, 83% of cases showed ARI scores of 0 and 1 and 17% had ARI scores of 2 and 3. These measurements were found to be 66% and 34% for Transbond XT and 77% and 23% for Unite, respectively. Table 4 shows the results of comparison of the shear bond strengths and adhesive remnant index for the three groups tested.

Discussion

In vitro investigation of bond strength plays an important role in evaluating the bonding efficiency of newly introduced orthodontic system.

The present study evaluated the use of Core Max II, a semi hybrid resin introduced for core construction, as an adhesive in orthodontic bonding by comparing its SBS with the 2 currently used adhesives, Transbond XT and Unite.

The direct bonding of orthodontic brackets has revolutionized and improved the clinical practice of orthodontics. Bond strength tests have shown wide variables [26]. These studies are difficult to compare and interpret due to many variables such as the adhesives used, the substrate, and the design of

Table 4. Result of comparison of the shear bond strength and Adhesive Remnant Index for the three groups tested.

Groups	SBS (MPa)	ARI
Core Max II Transbond XT	0.009 *	0.043
Core Max II Unite	0.93	0.001*
Transbond XT Unite	0.026 *	0.23

* Significant at p=0.05

the test. When a new bonding system is evaluated, its mean bond strength is compared with those values of bonding systems that have a clinical record of reliability.

Considerable research has been inducted in evaluating the bond strength of various orthodontic bracket-bonding systems. Orthodontic bonding systems have been evaluated by means of in vitro shear bond strength tests using a universal testing machine such as the Instron.

The bonding system used should be able to resist the forces present during orthodontic mechanotherapy and mastication. However, excessively high bond strength values are undesirable because of the increased debonding force needed, resulting in possible damage to enamel.

Numerous studies [27, 28, 29, 30, 31] have suggested bond strengths ranging from 2.8 Mpa to 10 Mpa as being adequate for clinical situations. The bond strength values recorded in the present study are greater than the range of values adequate for clinical situations.

The minimum in-vitro bond strength required for clinical reliability of orthodontic bonding procedures is still unknown and will vary, depending on the adhesive system used, bracket base design and area, enamel morphology, crosshead speed, appliance force system, and clinician technique [32].

This investigation found significant difference in shear bond strength between the newly introduced adhesive system, Core Max II with Transbond XT. While the mean shear bond strength of Core Max II (17.24 ± 3.2 MPa) was significantly higher than Transbond XT (15.44 ± 22 MPa), it had no significant difference with Unite (17.16 ± 3.7 MPa).

Also, there was statistical difference in the mean shear bond strength of the two commonly used orthodontic adhesive systems.

Williams et al. has found that the shear bond strength of Unite is less than Transbond XT (7.2 MPa and 8.4 MPa respectively) [32]. The difference in the result of the present study with Williams et al study might be due to the difference in direction of load application, cross head speed and bracket base area.

Comparison with other studies is difficult or somehow impossible due to the absence of study on Core Max II as an orthodontic bonding agent. Also, there is a lack of consensus on the materials and methods (storage time before debonding, thermocycling, bonding area, differences in the bracket mesh, etc) for orthodontic bond strength testing [34]. In this way, studies determining the bond strength are important mainly for their relative values and numerical comparisons are not possible.

The bond strengths of all the adhesives tested were greater than 5.9 to 7.8 MPa considered by Reynold [35] to be adequate for routine clinical use. Our observation was in favor of the idea that bond strengths of chemically cured composite resins are significantly higher than that of light cured composite resins.

Adhesive Remnant Index (ARI), developed by Artun and Berglund, has been used by investigators to help standardize the bond failure analysis. The ARI may oversimplify the very complex issues of bond failure analysis, but it does allow for statistical analysis and cross-study comparison. Review of the literature reveals that although many investigators use an ARI system, they often modify the criteria [36], the number system [37] or both for their projects. This makes cross- study comparisons more difficult. For the present study, the ARI scores follow the original criteria established by Artun and Berglund [25].

The site of failure also provides useful information about the bonding process. In orthodontics, an adequate bond that fails at enamel- cement interface is desirable because debonding and subsequent polishing procedures would become much easier [38]. The weak link of the bond may be at the tooth surface (adhesive failure at enamel surface; no cement on tooth), at the bracket (adhesive failure at bracket surface; cement on tooth, not on bracket), or within the adhesive cement (cohesive failure within the cement; cement on both tooth and bracket surfaces). Mixed failures are very common and can be characteristic of the stronger bond strength values.

Evaluation of the ARI scores indicated that there was a significantly higher frequency of bond failure at the enamel adhesive interface in the Core Max II group, whereas the Unite group showed a lower frequency of bond failure at this interface.

ARI scores of the Unite and Transbond XT did not show any significant difference (p=0.23, X^2=4.3). Whereas it was found that the ARI scores of the Core Max II group at 0 and 1 levels in %83 were statistically different with the two other orthodontic adhesives.

Conclusion

- Core Max II displayed significantly greater SBS than Transbond XT.
- There was no significant differences in mean SBS between Core Max II and Unite.
- The bond strength of all 3 adhesives was clinically acceptable.
- Core Max II tended to display adhesive failure at enamel/ adhesive interface while Transbond XT and Unite tended to display cohesive failure within the adhesive.
- Core Max II has the potential of being a good orthodontic adhesive.

References

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surface. J Dent Res 1955;34:849-853.
2. Gorelick I. Bording: The state of the art, a national survey. J Clin Orthod 1979;13:39-53.
3. Millett DT, Gordon PH: A 5-year clinical review of bond failure with a nomix adhesive (right-on). Eur J Orthod 1994;16:203-11.
4. Millett DT, McCabe JF: Orthodontic bonding with glass ionomer cements: a review. Eur J Orthod 1996;18:385-399.
5. Lovius BB, Pender N, Hewage S, O'Dowling I, Yomkins A: A clinical trial of a light- activated bonding material over on 18-month period. Br J Orthod 1987;16:11-20.
6. O'Brien KD, Read MJF, Sandison RJ, Robert CT: A visible light activated direct-bonding material: an in vivo comparative study. Am J Orthod Dentofacial Orthop 1989;95:348-351.
7. Pollack BF, Blitzer MH: The advantages of visible light curing resins. NY State Dent J 1982;48:228-230.
8. Hocevar RA: Direct bonding metal brackts with the concise. Enamel Bond system. J Clin Orthod 1977;11:473-482.
9. Hocevar RA: Direct bonding update. J Clin Orthod 1974;13:172-175.
10. Buonocore MG. Adhesive sealing of pits and fissures for caries prevention with use of ultraviolet light. JADA 1970;80:324-328.
11. Tavas MA, Watts DC: Bonding of orthodontic brackets by Transilluminations of a light activated composite. Br J Orthod 1979;6:207-208.
12. Cacciafesta V, Sfondrinin MF, Stondirini G. A xenon are light- curing unit for bonding and bleaching. J Clin Orthod 2000;34:94-96.
13. Knox J, Hubsuch P, Jones ML, Middleton J. The influence of bracket base design on the strength of the bracket- cement interface. Br J Orthod 2000;27:249-254.
14. Keizer S, Tencate JM, Arends J. Direct boding of orthodontic brackets. Am J Orthod Dentofacial Orthop 1976;69:318-327.
15. Lopez JI. Retentive shear strengths of various bonding attachments bases. Am J Orthod Dentofacial Orthop 1980;77:664-678.
16. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1985;2:171-178.
17. Buonocore MG. Principles of adhesive retention and adhesive restorative materials. J Am Dent Assoc 1963;67:382-391.
18. Miura F, Nakagawa K, Masahara E. A new direct bonding system for plastic brackets. Am J Orthod Dentofacial Orthop 1971;54:350-361.
19. Retief DM. Failure at the dental adhesive etched enamel interface. J Oral Rehab 1974;1:265-284.
20. Andreasen GF, Chan KC,Fahl JA: Shear strength comparison of autopolymerizing and light cured resins used for orthodontic bonding. Quintessence Int 1984;10:1081-1086.
21. King L, Smith RT, Wendt SL, Behrents RG. Bond strengths of light orthodontic brackets bonded with light- cured composite resin cured by Transillumination. Am J Orthod Dentofacial Orthop 1987;91:312-315.
22. Greenlaw R, Way DC, Galil KA. An in vitro evaluation of visible light- cured resin as an alternative to conventional resin bonding system. Am J Orthod Dentofacial Orthop 1980;96:214-220.
23. Wang WW, Meng CL: A study of bond strength between light- and self- cured orthodontic resin. Am J Orthod Dentofacial Orthop 1992;101:350-354.
24. Bishara SE, Von Wald L, Laftoon JF, Warren JJ. Effect of using new cyanoacrylate adhesive on the shear bond strength of orthodontic brackets. Angle Orthod 2001; 71: 466-469.
25. Artun J, Berglund S. Clinical trails with curstal growth conditioning as an alternative to acid-etch enamel pretreatment. Am J Orthod 1984; 85: 333-340.
26. Beech DR, Jalalay T. Clinical and laboratory evaluation of some orthodontic direct bonding system. J Dent Res 1981; 60: 972-978.
27. Mizrahi E, Smith DC. Direct cementation of orthodontic brackets to dental enamel. Br Dent J 1969; : 371-375.
28. Buonocore MG. a simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955; 34: 849-853.
29. Retief DH. Effect of conditioning the enamel surface with phosphoric acid. J Dent Res 1973; 52: 333-341.
30. Newman GV, Sharpe LH. On the wettability of tooth surfaces: preliminary investigation. J New Jersey Dent Soc 1966; 37: 289.
31. Pus MD, Way DC. Enamel loss due to orthodontic bonding with filled and unfilled resins using various clean-up techniques. Am J Orthod Dentofacial Orthop 1980; 77: 269-276.
32. Greenlaw R, Way DG, Khadry AG. An in vitro evaluation of a visible light-cured resin boding system. Am J Orthod Dentofacial Orthop 1989; 96: 214-220.
33. Willems G, Carles CH, Verbeket G. In-vitro shear/peel bond strength of orthodontic adhesives. J Dent 1997; 3: 263-270.
34. Fox NA, Mccabe JF, Gordon PH. Bond strengths of orthodontic bonding materials: an in-vitro study. Br J Orthod 1991; 18: 125-130.
35. Reynolds IR. A review of direct orthodontic bonding. Br J Orthod 1978; 2: 171-178.
36. Kent BE, Lewis GG, Wilson Ad. The bonding of glass inomer cements to metal and tooth substrates. Br Dent J 1977; 142: 41-47.
37. Bishara SE, Von Wald L, Olsen ME, Laffoon JF. Effect of time on the shear bond strength of glass inomer and composite orthodontic adhesive. Am J Orthod Dentofacial Orhtop 1999; 116: 616-620.
38. Owen SE Jr, Miller BH. A comparison of shear bond strength of three visible light-cured orthodontic adhesives. Angle Orthod 2000; 75: 352-356.