# Shear bond and rebond strengths of four composite systems

Hussain A Obaidi (BDS, MSc) *
Raid Kh Mustafa (BDS, MSc) **

## Abstract:

The orthodontic composite bonding material is available in various systems which are chemically–cured composite such as Two–past and No–mix systems in which the composite set by chemical reaction; Light–cured composite system, in which composite set by light exposure; and Dual–cured composite system, by which the composite cured by chemical reaction and light exposure. Thus it is necessary to investigate and compare the commonly used composite bonding systems.

This study was aimed to determine and compare the shear bond and rebond strength of: Two–past composite system (Concise, 3M, Unitek USA), No–mix composite system (Right–On, TP Orthodontics UK), Light–cured composite system (Transbond XT, 3M Unitek USA), and Dual–cured composite system (Sono–Cem ESPE, Germany).

Fifty six upper premolars were divided into four groups of fourteen, each group, mesh–backed metal advant edge brackets were bonded to the buccal surface of the teeth using one of the composite system according to the instruction of manufacturer. Then bonded samples were thermocycled in an attempt to simulate oral circumstances.

The samples were subjected to shear force using the universal compression machine apparatus, then the results were recorded in Megapascal (Mpa). The remaining composite on the buccal surface of the tooth was removed by hand scaler and polished, a new bracket was bonded to the buccal surface of the tooth using the same type of composite system. The rebonded samples were tested under shear strength using the universal compression machine apparatus and the results were again recorded in Mpa.

The data were statistically analyzed using descriptive analysis, ANOVA test, Duncan's Multiple Range Test and Student's t–test at $p \leq 0.01$.

The results showed that the Concise had no significant higher bond shear strength than the Transbond and Sono–Cem composite systems, and there was significant increase bond strength of the Concise than the Right–On composite systems. Furthermore, there were no significant differences in bond shear strength among the Right–On, Transbond and Sono–Cem composite systems.

The shear rebond strength of composite systems was decreased, and there were no significant differences in bond and rebond shear strength of each composite system.

Conclusions of this study are that Concise has the higher shear bond strength but has highest regression in its rebond shear strength.

## Keywords:

Composite systems, shear bond strength, shear rebond strength.

## Introduction:

Since the introduction of the acid etch technique to orthodontic bonding by Fried and Newman,[1] many different bonding systems and techniques had evolved. The most common diacrylate resin (composite resin matrix material) is

*Assistant Professor in the Department of Pedodontics, Orthodontics and Preventive Dentistry. College of Dentistry. University of Mosul.
** Specialist Dentist. Hashimi Kingdom of Jordan.

usually bisphenol A glycidyl dimethacrylate (Bis–GMA). The curing of the composite is carried out either chemically with tertiary amino–benzoyl peroxide or by using ultraviolet light.[2] In composite composition a maximum amount of inorganic filler had been added to a minimum amount of a binder consisting of a cross–linking polymerizable organic resin[3].

The composite systems can be divided into: Chemically–cured and Light–cured composite systems. Chemically–cured composite system set rapidly when activated, severely limiting the working time;[4] Chemically–cured composite is available in Two–past system and No–mix system.

The Two–past system has stronger bond strength and was recommended in bonding the attachments of posterior teeth.[5] No–mix system is easy to handle, not need to mix, and less chair time.[1] It was suggested that No–mix system is to be used in bonding the attachment of anterior teeth [5].

Light–cured composite system offers a number of significant advantages as stated by Sonis[6] and Hamula,[7] which are: 1) Unlimited working time; 2) Brackets can be fixed in place with a short exposure before final curing; 3) Less patient discomfort because of the accelerated setting time; 4) Significant less chair time; 5) Bracket placement and flash removal are much easier, and 6) Easier clean up and less waste of adhesive and promote better hygiene and easier debonding.

Dual–cured composite system is composed of composite resins. These resins are both light–activated and chemically–cured. Thus, they can be cured completely by using light source and by the catalyst and base reaction of the material.[8] It was stated that the use of the dual–cured composite system for orthodontic bonding would offer the advantage of extending working time. It was postulated that using a dual–cured composite to bond the orthodontic brackets could result comparable bond strength to those of chemically–activated and higher than those for light–activated composites.

The bond strength of the composite bonding system influenced by the various factors, such as:

Acid Concentration: It was found that there were no significant differences in bond strength of the resin to enamel surface etched with 10–50% phosphoric acid concentration.[9] Furthermore, no significant differences in bond strength between 5% and 37% $H_3PO_4$ as etchant [10,11].

Phosphoric Acid Etching Time: It was observed that there was no significant difference in bond strength whether it was etched for 15 or 60 seconds [12–15]. Furthermore, no significant differences in bond strength when etching times were 15, 30, 60 and 90 seconds, but etching time 120 seconds had significantly decrease the bond strength [13].

Phosphoric Acid Etching Depth: Both 50% and 10% phosphoric acid produced etch more than 5 μm and less than 25 μm.[16] Matching findings, researchers observed that 37% phosphoric acid produced 21.5 μm [17].

Resin Tags: The conditioned enamel with phosphoric acid produces preferential etching the enamel surface. This establishes interfacial contact between the adhesive and the etched enamel, which achieved by resin tags which will bond the resin mechanically to the enamel; thus increasing the bond strength [18, 19].

Sealants: The sealants are used for two reasons: Either to facilitate the wetting of the enamel surface,[2] and to provide chemical union between the composite and the sealant.[2, 20] Satisfactory bonding can be achieved without using the sealant.[2] It was found that there was no significant increase in bond strength with use of sealant.[21, 22]

Adhesive Layer Thickness: Thick layer of the composite gives weaker bond strength than thin one,[23, 24] because a thick layer is more likely to become deformed and thus will fracture and has more shrinkage during polymerization. In addition to that swelling of the adhesive due to the absorption of the fluid during use is increased.[23]

The aims of this study were to determine and compare the shear bond strength of Two–past, No–mix Light–cured and Dual–cured composite systems; to determine and compare shear rebond strength when a new metal bracket was used for rebonding to the prepared previously bonded tooth using the same composite systems; and to compare the shear bond and rebond strengths of the composite systems.

## Materials and methods:

***Materials:***

The sample was fifty six sound, upper extracted premolars, which had been extracted for orthodontic treatment. The teeth were grouped into four groups of fourteen. the teeth were stored in 70% ethyl alcohol.[??]

The supplies used in this research were:

1. Brackets (upper premolars): Metal mesh–bracket advant–edge (TP Orthodontics, USA); each bracket has a surface area of 0.105 $cm^2$.
2. Bonding materials:

a. Two–past (Concise) orthodontic adhesive (3M Unitek, USA).

b. No–mix (Right–On) (TP Orthodontics, USA).

c. Light–cured (Transbond XT) (3M Unitek, USA).

d. Dual–cured (Sono–Cem) (ESPE, Germany).

3. Surveyor (Quayle Dental Co., England).
4. Universal compression machine (Soil Test Co. Inc., USA).

***Methods:***

Mounting the Tooth:

The tooth was fixed on the glass slide. The middle third of the labial surface was oriented to be parallel with analyzing rod of the surveyor. The tooth mounted by cold cured acrylic resin within polyvinyl plastic ring; then re–surveying the specimen was made to ensure the parallelism of the labial surface of crown was not changed.

Bonding and Rebonding of the Bracket to the Tooth Surface:

The bonding and rebonding procedures were achieved according to the manufacturers' instructions of the bonding materials. In addition to put all the brackets under constant pressure (200 gm); then the specimens were allowed to bench cure for 10 minutes. The samples were then thermocycled (100 cycles) from 4 °C to 56 °C ± 5 °C in an attempt to simulate oral circumstances.

Bond Strength Test:

The specimens were tested in shear using the universal compression machine, tested at a cross–head of 0.5 mm/minute.

Statistical Analysis:

The results were subjected to the descriptive analysis, one way analysis of variance (ANOVA), Duncan's Multiple Range Test and Student's t–test at $p \leq 0.01$.

## Results:

Shear Bond Strength:

The mean shear bond strengths of Concise, Right–On, Transbond and Sono–Cem were shown in Table (1).

**Table (1):** Shear bond strengths

| Type of the Adhesive | No. of Specimens | Mean Bond Strength (Mpa) | ± Standard Deviation (Mpa) |
|---|---|---|---|
| Concise | 14 | 15.87 | 3.82 |
| Sono–Cem | 14 | 13.56 | 3.14 |
| Transbond | 14 | 12.61 | 4.01 |
| Right–On | 14 | 11.27 | 2.76 |

The mean shear bond strength of the Concise was the highest (15.87 ± 3.82 Mpa), while the Right–On had the lowest shear bond strength (11.27 ± 2.76 Mpa).Analysis of variance at $p \leq 0.01$ level of significance revealed that there was a significant difference in the shear bond strength of the investigated composite systems as presented in Table (2).

**Table (2):** Comparison of the shear bond strengths among the adhesives

| One Way ANOVA | | | Duncan's Test | | | Adhesive |
|---|---|---|---|---|---|---|
| No. | F–value | PR>F | Mean (Mpa) | Letter of Adhesive | No. | |
| 56 | 4.36 | 0.01 | 15.87 | A | 14 | Concise |
| | | | 13.56 | AB | 14 | Sono–Cem |
| | | | 12.61 | AB | 14 | Transbond |
| | | | 11.27 | B | 14 | Right–On |

Significant differences among adhesives $p \leq 0.01$.
Adhesives with the same letter are not significantly different.

Duncan's Multiple Range Test at 1% level of significance showed that the Concise composite system had significantly higher shear bond strength than that of Right–On (Table 2), while there were no significant differences in shear strength of Concise, Sono–Cem and Transbond composite systems. Furthermore, there were no significant differences in shear bond strength of Sono–Cem, Transbond and Right–On composite systems.

Shear Rebond Strength:

The shear rebond strength of all the composite systems were presented in Table (3). The mean shear rebond strength of Concise was the highest (13.06 ± 2.63 Mpa), whereas Transbond had the lowest shear rebond strength (9.86 ± 1.23 Mpa).

**Table (3):** Shear rebond strengths

| Type of the Adhesive | No. of Specimens | Mean Rebond Strength (Mpa) | ± Standard Deviation (Mpa) |
|---|---|---|---|
| Concise | 14 | 13.06 | 2.63 |
| Sono–Cem | 14 | 11.96 | 3.44 |
| Transbond | 14 | 10.22 | 1.92 |
| Right–On | 14 | 9.86 | 1.23 |

Analysis of variance at $p \leq 0.01$ level of significance revealed that there was significant difference in shear rebond strength of the tested composite systems (Table 4).

**Table (4):** Comparison of the shear rebond strengths among the adhesives

| One Way ANOVA | | | Duncan's Test | | | Adhesive |
|---|---|---|---|---|---|---|
| No. | F–value | PR>F | Mean (Mpa) | Letter of Adhesive | No. | |
| 56 | 5.27 | 0.01 | 13.06 | A | 14 | Concise |
| | | | 11.96 | AB | 14 | Sono–Cem |
| | | | 10.22 | B | 14 | Transbond |
| | | | 9.86 | B | 14 | Right–On |

Significant differences among adhesives $p \leq 0.01$.
Adhesives with the same letter are not significantly different.

Duncan's Multiple Range Test at 1% level of significance (Table 4) showed that the shear rebond strength of Concise was significantly greater than that of Right–On and Transbond, while the shear rebond strength of Concise was not significantly greater than that of Sono–Cem. Furthermore, there were no significant differences in shear rebond strength among Sono–Cem, Right–On and Transbond composite systems.

Shear Bond and Rebond Strengths:

The mean shear bond strength was numerically higher than the mean shear rebond strength of all composite systems (Table 5).

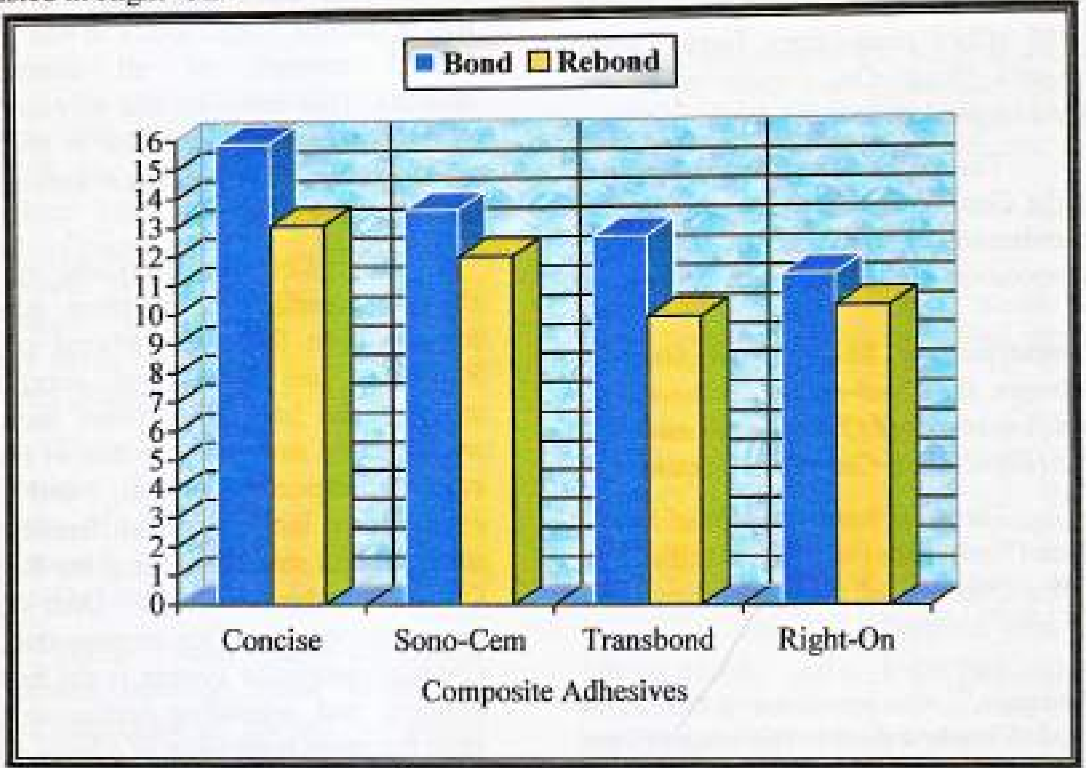
**Table (5):** Comparison of shear bond and rebond strengths for each adhesive by Student's t–test

| Adhesive | No. | Mean Bond Strength (Mpa) | Mean Rebond Strength (Mpa) | d.f* | t–value | PR | Significance |
|---|---|---|---|---|---|---|---|
| Concise | 14 | 15.87 | 13.06 | 26 | 2.78 | >0.05 | NS |
| Sono–Cem | 14 | 13.56 | 11.96 | 26 | 2.78 | >0.05 | NS |
| Transbond | 14 | 12.61 | 10.22 | 26 | 2.78 | >0.05 | NS |
| Right–On | 14 | 11.27 | 9.86 | 26 | 2.78 | >0.05 | NS |

*d.f: Degree of freedom; NS: No significant difference.

The Figure (1) shows the differences between the mean shear bond and rebond strengths of the investigated composite systems, the least regression in shear rebond strength was existed in Right–On.

By the application of Student's t–test at 1% level of significance, there was no significant difference between bond and rebond shear strengths of the studied adhesives as shown in Table (5).




**Figure(1):** Mean shear bond and rebond strengths of composite adhesives

## Discussion:

***Shear Bond Strength:***

The mean shear bond strengths of the Concise, Sono–Cem, Transbond and Right–On composite systems were higher than the clinically adequate shear bond strength (6–8 Mpa) as proposed by Reynolds.[2] This is in agreement with other studies.[8, 25–30]

***Comparison of Shear Bond Strength Between Two–past (Concise), and [Light–cured (Transbond), Dual–cured (Sono–Cem) and No–mix (Right–On)] Composite Systems:***

The shear bond strength of the Two–past composite system was insignificantly higher than the shear bond strength of Light–cured and Dual–cured composite adhesives. These results were in agreement with the findings of Smith and Shivapuja[8] concerning the Transbond and contrary with Alexander *et al.*,[30] who found that shear bond strength of the Dual–cured composite system was significantly higher than the shear bond strength of the Concise. This difference was due to use different Dual–cured composite system (Crysis) and could be to some variation in the investigation technique.

While the shear bond strength of

the Two–past composite system (Concise) showed significantly higher than of No–mix (Right–On) composite system. This result is in accordance with the findings of Pender *et al.*,[27] who advocated that the Concise composite system should be used for bonding orthodontic attachments to molars because it provided a bond strength that could afford masticatory forces, while No–mix (Right–On) composite system could be used on anterior teeth.

The higher shear bond strength of the Concise in this study may be due to existence of different filler types in composition of the composite systems.

***Comparison of Shear Bond Strength Between the Dual–cured (Sono–Cem), and [Light–cured (Transbond) and No–mix (Right–On)] Composite Systems:***

The shear bond strength of Dual–cured (Sono–Cem) was not significantly higher than that of the Light–cured and No–mix composite systems. This result was supported by Smith and Shivapuja,[8] who investigated the Dual–cured (Vivadent thick). The insignificant difference in shear bond strength of composite systems in this study could be due to that the existing of the fillers in composition of composite systems have no significant influence on bond strength of these composite systems.

***Comparison of Shear Bond Strength Between the Light–cured (Transbond) and No–mix (Right–On):***

The shear bond strength of the light cured (Transbond) was not significantly higher than that of the No–mix (Right–On) composite systems. This result was in agreement with other studies.[25, 29] The insignificantly difference in shear bond strength of these composite systems could be due to that fillers of the composite systems have same influence in shear bond strength.

***Shear Rebond Strength of Composite Systems:***

This study displayed that there was a decline (regression) in the shear rebond strength of all composite systems. This could be due to existence of the remnant of composite in enamel, which decreased the surface area to be etched before rebonding.

The Concise composite system showed significantly increase rebond strength than the shear rebond of the Right–On and Transbond composite systems and had insignificant increase shear rebond strength than that of Dual–cured composite system; and the existence of insignificant differences in shear rebond strength among the Right–On, Transbond and Dual–cured composite system. This express that the Concise composite system is the best in bonding and rebonding techniques; in spite the more regression in rebond shear strength, and this could be due to existence of type of fillers in its composition. Even that the shear rebond strength of the investigated composite systems was higher than that clinically adequate shear bond strength as stated by Reynolds.[2]

***Bond and Rebond Shear Strengths of the Composite Systems:***

This study showed that there was no significant difference between the shear bond and rebond strengths of Two–past (Concise), Light–cured (Transbond), No–mix (Right–On) and Dual–cured (Sono–Cem) composite systems. This result was matching the findings of other researchers,[21, 22] who investigated the Two–past (Concise) composite system. This insignificantly difference between shear bond and rebond strengths could be due to slight regression in shear rebond strength of these composite systems.

## C0nclusions:

Two–past (Concise) composite system had the highest shear bond strength, but insignificantly higher than the shear bond strength of the Light–cured (Transbond) and Dual–cured composite system. Also, the Concise composite system had significantly higher shear bond strength than that of No–mix (Right–On) composite system.

There were no significant differences among the shear bond strength of Dual–cured (Sono–Cem), Light–cured (Transbond) and No–mix (Right–On) composite systems.

There were no significant differences between shear bond and rebond strengths of the all composite systems.

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