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Comparative evaluation and influence of new Optibond eXTRa self-etch Universal adhesive and conventional Transbond XT on shear bond strength of orthodontic brackets—An *in vitro* study

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Abstract

INTRODUCTION: The demand by dental practitioners for adhesives led to the innovation of newer self-etched universal adhesive systems. The objectives were to evaluate the shear bond strength (SBS) of metal brackets bonded with Optibond eXTRa Universal self-etch adhesive and Transbond XT primer and also to assess the adhesive remnant index (ARI).

MATERIALS AND METHODS: A total of 100 extracted human premolar tooth samples were divided into 2 groups ($n = 50$) according to the adhesive system employed: Transbond XT (3M Unitek) and Optibond eXTRa Universal (KaVo Kerr). In group A, Transbond XT primer was applied, and in group B, Optibond eXTRa was applied, and metal brackets (American Orthodontics) were bonded with the Transbond XT adhesive, followed by photopolymerization with LEDition. The samples were preserved in artificial saliva for 30 days. SBS was tested using a universal testing machine (DAK Series7200, India). The ARI was assessed at 10× magnification under a stereomicroscope (Meiji Techno, Japan). The SBS scores were subjected to independent sample t-test and ARI scores to Pearson's Chi-square test.

RESULTS: The mean SBS and standard deviation of Transbond XT is 12.11 ± 2.6 MPa and that of Optibond eXTRa Universal is 11.36 ± 2.8 MPa, revealing a statistically nonsignificant difference. Transbond XT displayed higher ARI scores and was statistically significant ($P = 0.001$).

CONCLUSION: The Optibond eXTRa Universal adhesive appears to be preferable for orthodontic bonding as it exhibited clinically acceptable SBS and performed better in terms of the ARI.

Keywords:

Adhesive remnant index, bond failure, Optibond eXTRa Universal, orthodontic adhesive, shear bond strength

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Introduction

Orthodontics, as a specialty in dentistry, has seen its share of growth and development. In due course of time, much attention has been paid to enhance bonding techniques which include acid etchants, primers, and adhesives. Since the advent of acid etching techniques by Buonocore[1] in the 1960s, the total etching technique by Kanca, and also the developments in

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adhesives by Saddler,[2] Newman,[3] Bowen,[4] Retief,[5] and Miura[6] further paved a way for it. However, bond failures still exist due to several reasons.

Nowadays, in orthodontics, total-etch multi-step adhesive systems are most often employed to bond brackets to the enamel surface. Orthophosphoric acid etching causes dissolution of the interprismatic enamel, which forms a rough pervious layer that ranges from 5 to 50 μm in depth for the formation of resin tags. This might harm the dental substrate, resulting in cracks and microfractures, discoloration, decreased modulus of elasticity, and enamel hardness.

The demand for usage of various adhesives by dental practitioners has led to the emergence of newer universal self-etch adhesive systems (USEASs).[7,8] It has a less invasive pH (1.5<pH<3) and bonding employed with acidic functional monomers glycerol dimethacrylate dihydrogen phosphate (GPDM) and 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), available in both self-etch and total-etch modes. When employed in a self-etch mode, USEASs may remarkably simplify the bonding procedure by decreasing the steps in bonding, number of eroded enamel rods, and eliminating the necessity for total acid etching.[9] USEASs may be applied to the substrate either after pre-etching or without etching, thanks to the presence of acidic functional monomers that have huge propinquity for the calcium ions of hydroxyapatite. The advantages of few bonding steps and reduced chair time should be weighed against the increasing cost of the self-etching universal adhesive system.

Optibond eXTRa Universal, a two-component universal new bonding agent from KaVo Kerr promoted unique smart pH technology, that is, acidity drop after photopolymerization, a patented formula enriched with the gold standard GPDM monomer and ternary solvent system for overall combined action, which includes enhanced etching, re-wetting ability, deep penetration, and a homogeneous adhesive layer.

Earlier, several universal adhesives were employed in orthodontic bonding to evaluate their performance, which include Scotchbond Universal,[10] Clearfil Universal Bond,[10] All-Bond Universal,[11] Ambar Universal,[11] etc. The current study was undertaken because there were no studies in the past to evaluate the shear bond strength (SBS) of the two-component self-etching universal adhesive (Optibond eXTRa Universal).

Materials and Methods

Inclusion and randomization

A total of 100 maxillary and mandibular premolar teeth were collected from patients undergoing therapeutic extractions for orthodontic purposes and were preserved in a 0.1% thymol solution. All premolars were selected on the basis of teeth that were non-carious and freshly extracted with an intact buccal surface. Teeth that were fluorosed, carious, restored, with anomalous morphology, and those having cracks were excluded from the study.

The extracted teeth were mounted vertically on acrylic resin blocks with only the crown portion exposed. Before bonding, the tooth surface was cleaned and polished with pumice and paste application using a rubber cup on a slow-speed handpiece, then rinsed with a splash of water, and dried with moisture-free airstream. MBT 0.022″ stainless-steel brackets (American Orthodontics, Sheboygan, USA) with a bracket base surface area of 9.806 mm^2 were used. All of the 100 samples were randomly assigned into two groups of 50 each: group A Transbond XT and group B Optibond eXTRa Universal.

Bonding procedure

In group A, all of the 50 samples were etched with 37% orthophosphoric acid gel (Neoetch gel, Orikam, India) for 15 seconds, rinsed with water, and air-dried. Transbond XT primer (3M Unitek, Monrovia, California, USA) was applied on the tooth surface and cured for 15 seconds. In group B, all of the 50 samples were etched with Optibond eXTRa Universal self-etching primer (KaVo Kerr, Brea, California, USA) for 20 seconds and air-dried for 5 seconds. Optibond eXTRa Universal self-etch adhesive (KaVo Kerr, Brea, California, USA) was applied on the tooth surface and cured for 15 seconds. In both the groups, brackets were bonded using the Transbond XT adhesive (3M Unitek, Monrovia, California, USA) [Table 1 and Figure 1]. All of the teeth were photo-polymerized on mesial and distal surfaces using a LEDition (Ivoclar Vivadent, 600 mW/cm^2) for

Figure 1: Bonding materials used in the study

30 seconds. The samples were then stored in artificial saliva for 30 days.

Shear bond strength: The long axis of each specimen was mounted perpendicular to the applied force onto a universal testing machine (DAK System Inc Series 7200, India) with a crosshead speed of 1 mm/min that was generated until the bracket debonded [Figure 2]. A looped wire made of 0.8 mm stainless steel was employed for shear-load testing directed from gingival to incisal as described by Oesterle *et al*.[12] The force values were noted initially in Newton (N) and then converted to megapascal (MPa = N/mm^2).

Adhesive remnant index: The enamel surface of each tooth was visually examined following debonding by applying articulating paper to contrast as described by Rachala *et al*.[13] Later, each tooth was observed under a stereomicroscope (Meiji Techno, Japan) at 10× magnification [Figure 3] for assessing the adhesive remnant index (ARI), as suggested by Artun and Bergland.[14]

Statistical analysis

All data were analyzed using IBM SPSS software (version 21). The *P* value at 5% was considered significant ($P < 0.05$). Levene's test was used to evaluate the normality of data. SBS values were subjected to the independent sample t-test for evaluating the statistically significant difference among the groups. The ARI scores were analyzed using Pearson's Chi-square test to evaluate the association between the kind of bond failure and bonding agents.

Results

The comparison of SBS between the groups revealed a slightly higher (4%) bond strength of Transbond XT than Optibond eXTRa Universal [Figure 4]. The mean and standard deviation value of group A was 12.11 ± 2.6 MPa and that of group B was 11.36 ± 2.8 MPa [Table 2, Figure 5]. The independent sample test showed that the variances between the two groups were homogeneous in nature ($P = 0.928$), and both groups were statistically insignificant with a *P* value of 0.170 (>0.05) [Table 3].

The comparison of ARI scores between the two groups showed a statistically significant difference ($P < 0.005$) [Figure 6 and Table 4]. Group A (Transbond XT) showed a higher distribution of ARI scores 1 and 2, suggesting failure mostly at the bracket–adhesive interface, whereas group B (universal

Figure 2: DAK System Inc Series 7200 Universal testing machine

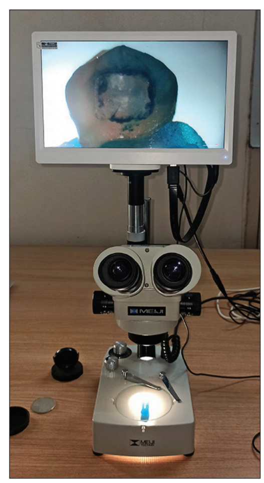

Figure 3: Assessment of the ARI using a stereomicroscope

Table 1: Bonding Materials used in the study

Groups	Bonding system (Lot No.)	Main components	Manufacturer
Group A	Etchant: Neoetch Gel Transbond XT (Primer: NC87164)	37% Phosphoric acid Bis-GMA, TEGDMA	Orikam, India. 3M Unitek, Monrovia, CA, USA
Group B	Optibond eXTRa Universal (Primer: 7247707) (Adhesive: 7246204)	Self-etch primer: GPDM, HEMA, acetone, ethyl alcohol Adhesive: GPDM, HEMA, glycerol dimethacrylate, ethyl alcohol, sodium hexafluorosilicate	KaVo Kerr, Brea, CA, USA
	Resin composite	**Main components**	**Manufacturer**
	Transbond XT Light Cure Adhesive (Lot No: NC90922)	Silane-treated quartz, Bis-GMA, dichlorodimethyl silane, silane-treated silica, diphenyliodonium hexafluorophosphate.	3M Unitek, Monrovia, CA, USA

Bis-GMA: bisphenol A-diglycidyl ether dimethacrylate; TEGDMA: triethyleneglycol dimethacrylate, GPDM: glycerol dimethacrylate dihydrogen phosphate, HEMA: 2-hydroxyethyl methacrylate

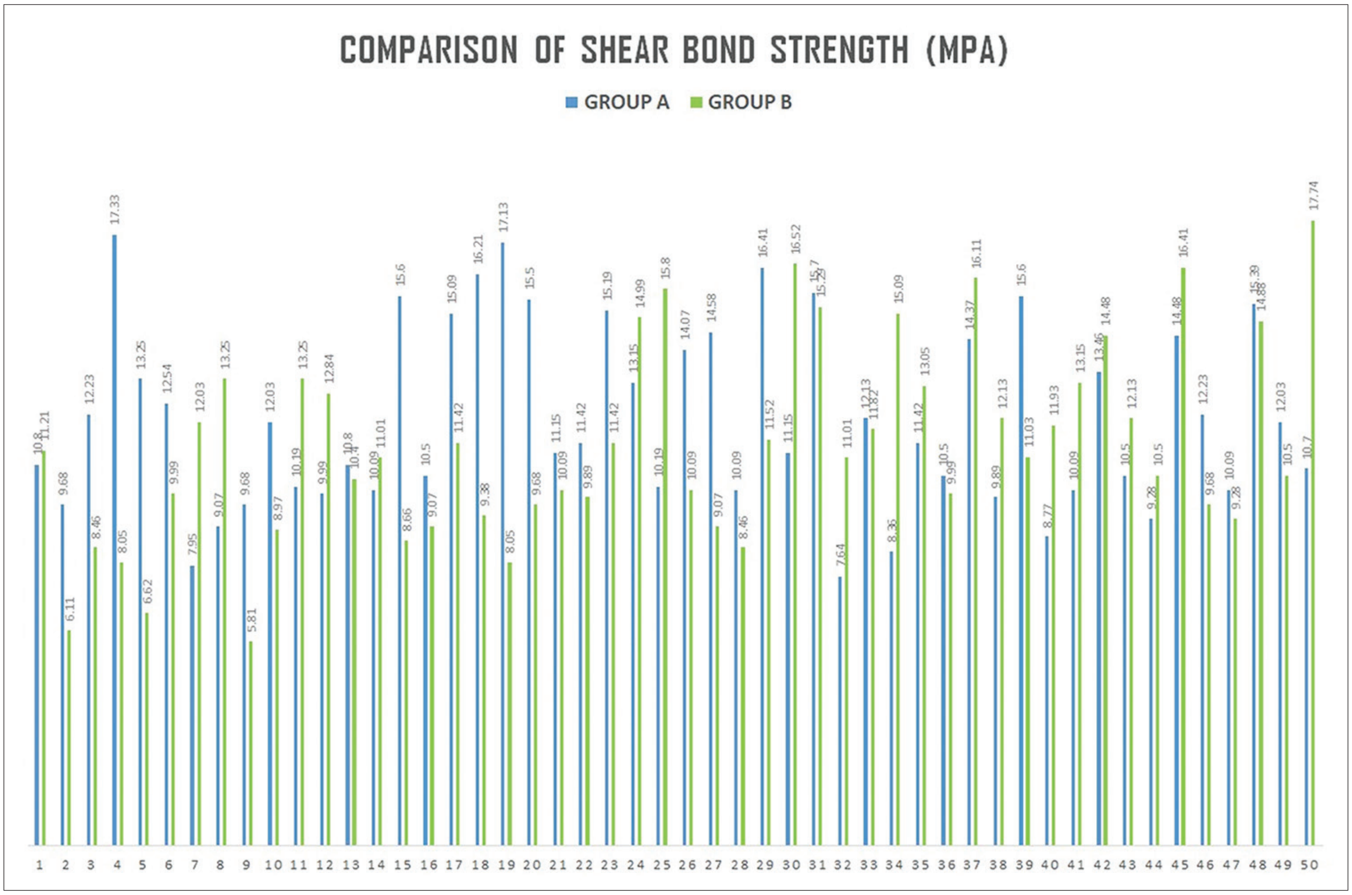

Figure 4: SBS (MPa) of Transbond XT and Optibond eXTRa Universal

Table 2: Both the groups showing the mean and standard deviation of SBS

	Minimum	Maximum	Mean	Standard deviation	Standard error	*P*
Group A	7.64 MPa	17.33 MPa	12.11 MPa	2.60057	0.36778	0.170
Group B	5.81 MPa	17.74 MPa	11.36 MPa	2.80753	0.39704	

Statistically insignificant (*P*>0.05)

Table 3: Independent sample *t*-test

	Levene's test for equality of variances		*t*-test for equality of means						
	F	Sig.	T	df	Sig. (2-tailed)	Mean difference	Standard error difference	95% CI of the difference	
								Lower	Upper
Equal variances assumed	0.008	0.928	1.381	0.98	0.170	0.7476	0.5412	–0.3264	1.8216
Equal variances not assumed			1.381	97.4	0.170	0.7476	0.5412	–0.3264	1.8216

Variances between two groups were homogeneous in nature (*P*=0.928)

self-etch adhesives) had a higher frequency of ARI scores 0 and 1, suggesting failure mostly at the enamel–adhesive interface [Figure 7].

Discussion

The adhesives utilized in orthodontics and clinical dentistry are improving day by day. However, there is still a need to enhance the current bonding techniques pertaining to orthodontics. The current study evaluated the SBS of the self-etching universal adhesive system and compared it with the conventional adhesive system for bracket bonding. The Transbond XT (conventional) adhesive system is most widely used and is well accepted as a standard control in several studies.

Universal adhesives contain the acidic functional phosphate ester monomer such as 10-MDP and GPDM that exhibit strong binding to hydroxyapatite.[15] The adhesion/decalcification concept ("AD concept") was put forward to elucidate the chemistry of acidic functional phosphate monomers with hydroxyapatite.[16] This

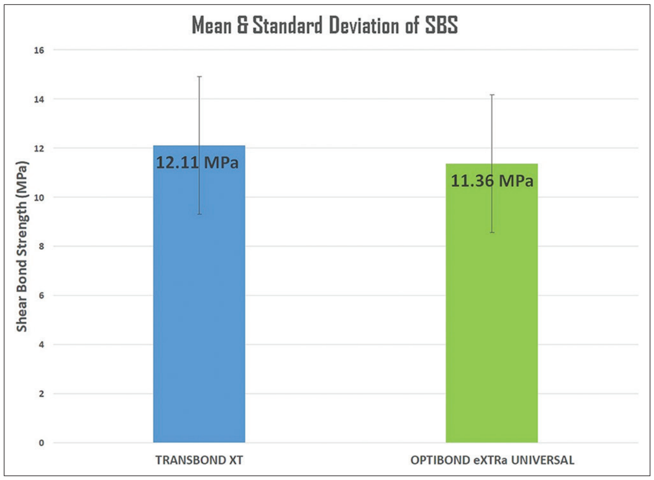

Figure 5: Mean and standard deviation of Transbond XT and Optibond eXTRa Universal

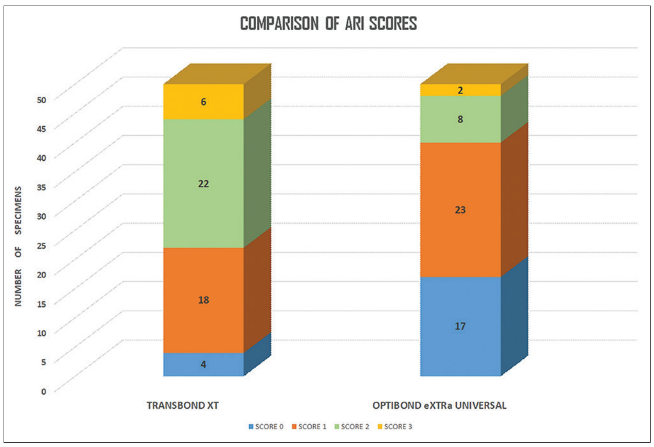

Figure 6: Frequency distribution of the ARI scores

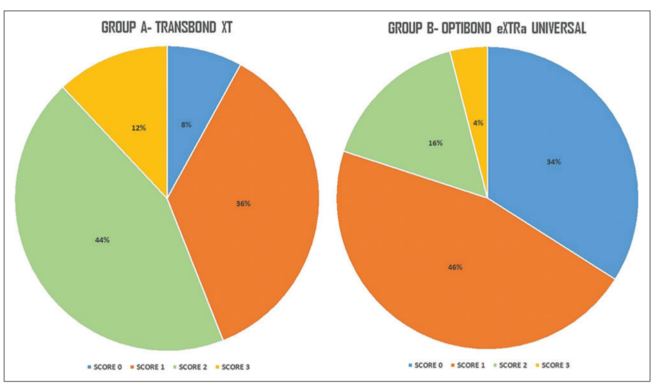

Figure 7: Percentages of Groups A and B ARI scores

AD concept indicates the interaction where all acidic monomers bond to the Ca ions of hydroxyapatite initially (phase 1), that is, within the midst of the release of phosphate (PO_4^{3-}) and hydroxide (OH^-) ions from hydroxyapatite to reach electron neutrality into its solution. Either the functional monomer will adhere (phase 2, adhesion route) or dissociate together with an abundant decalcification (phase 2, decalcification route) depending on the steadiness of the monomer–Ca salt formed. 10-MDP–calcium salt is slightly more stable than the GPDM–calcium salt; GPDM undergoes decalcification, and 10-MDP sticks to the adhesion route.[17]

Table 4: Frequency distribution for the ARI

	Total	Score 0	Score 1	Score 2	Score 3	P
Group A	50	4 (8%)	18 (36%)	22 (44%)	6 (12%)	0.001*
Group B	50	17 (34%)	23 (46%)	8 (16%)	2 (4%)	0.001*

*Statistically significant (*P*<0.05)

Reynolds *et al.*[18] suggested that the optimal SBS to withstand masticatory and orthodontic forces ranges from 5.9 to 7.8 MPa. The mean SBS of group A (Transbond XT) is 12.11 ± 2.6 MPa and that of group B (Optibond eXTRa universal system) is 11.36 ± 2.8 MPa. According to Bishara *et al.*,[19] a clinically acceptable SBS of 7.1 MPa was needed when a self-etched primer was employed. Therefore, SBS using the self-etched universal adhesive system was marginally lesser when compared to Transbond XT; however, it was within the range of ideal bond strength to hold brackets during orthodontic treatment.

The results were in agreement with previous studies conducted by Cal-Neto *et al.*,[20] Larmour *et al.*,[21] Arnold *et al.*,[22] Hellak *et al.*,[23] Zeynep *et al.*,[24] and Proenca *et al.*[11] who reported the SBS of self-etched primers and the universal bonding system that displayed similar SBS values to that of Transbond XT. The universal bonding system can be employed safely either in the etch or self-etch mode for orthodontic bracket bonding.[11] However, the results of studies related to self-etch adhesive systems are contradictory. Buyukyilmaz *et al.*[25] reported that self-etch adhesive systems had higher SBS than the conventional system—Transbond XT. Prakki *et al.*[10] in their study concluded that neither of the universal adhesives employed in the self-etch mode achieved SBS that was satisfactory for orthodontic therapy.

The ARI is most commonly used to assess the quantum of adhesion between the tooth, bonding agents, and bracket bases.[14] Lesser ARI scores are clinically advantageous because of the least adhesive remnant found on the substrate base, cleaning the tooth surfaces easier and quicker.[26] In our study, both groups showed significant differences in ARI scores. The group A conventional adhesive system showed a higher distribution of ARI scores 1 and 2, whereas the group B self-etched universal adhesive system had a higher frequency of ARI scores 0 and 1. A relatively USEAS performed best in terms of the ARI.

Al-Salehi *et al.*[27] claimed that there is a relationship between SBS and the failure mode as higher bond strengths correlate with greater mixed fractures. This relationship is seen during the present study when comparing the ARI scores of Transbond XT and Optibond eXTRa Universal; thus, we can reject our null hypothesis. Group A showed the highest SBS and also had a higher ARI score. The results are in accordance with the study conducted by Sharma *et al.*,[28] who concluded that the highest ARI scores were observed for the total-etch system.

Furthermore, variances in the mode of fracture between universal self-etch and total-etch adhesives are in accordance with the study of Schnebel *et al.*[29], which revealed that failure occurs mostly at the bracket–adhesive interface for total-etch adhesives, leaving the enamel surface intact, but more chair time is needed to eliminate the residual adhesive. Self-etched universal adhesives resulted in more failures at the enamel–adhesive interface. However, bracket failure occurs at the weakest link, indicating a weak bond with the enamel surface, leading to lower SBS values.

Conclusion

Both the bonding systems evaluated in the present study provide an adequate SBS for orthodontic purposes, and the self-etched universal adhesive system performed better in terms of the ARI. The self-etched universal adhesive system is advantageous over the conventional bonding system in terms of decreasing clinical chair-side time without compromising the bond strength and it reduces the amount of adhesive left, thus reducing the loss of enamel. Hence, a self-etched universal adhesive system is preferable for bonding brackets on the enamel surface.

Abbreviations

SBS = Shear bond strength

ARI = Adhesive remnant index.

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Conflicts of interest

There are no conflicts of interest.

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