Self-etching Bonding Systems: In-Vitro Micro-Leakage Evaluation

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Dr PD Brandt: NH Dip Elec Eng, Dip Aesth Dent, BChD (Stell), Division of Dental Materials, School of Dentistry, University of Pretoria
Dr FA de Wet: BChD, BChD(Hons); MDent, DTE, DSc(Odont)(Pret), Division of Dental Materials, School of Dentistry, University of Pretoria
Dr IC du Preez: BSc, BSc (Hons); MSc, DSc (UOF), BChD (Pret), MDS (MEDUNSA), Department of Operative Dentistry, School of Dentistry, University of Limpopo, MEDUNSA Campus

Corresponding Author:
Dr PD Brandt: Division of Dental Materials, School of Dentistry, University of Pretoria, PO Box 1266, Pretoria, 0001,Tel: (012) 319 2436, e-mail: pbrandt@medic.up.ac.za

SUMMARY

The purpose of this *in vitro* study was to compare dentine and enamel microleakage values of six self-etching bonding agents to that of a total etch dentine bonding agent (used as a control). Products evaluated were Scotchbond Multipurpose Plus (3M/ESPE), Xeno III (Dentsply), Clearfil SE Bond (Kuraray), ABF (Kuraray), Optibond Solo Self-Etch (Kerr), OneCoatSE Bond (Colténe Whaledent), and iBond (Heraeus-Kulzer). Using a medium sized Cerana bur (Nordiska Dental) a standard, cylindrical preparation was made at the cemento-enamel junction (CEJ) of human third molars. The teeth were randomly divided into 7 groups of ten teeth each. The bonding agents were applied and light cured strictly according to the manufacturer's instructions and the cavities then filled in two increments, using Z100 composite (3M/ESPE). The restored teeth were imbedded in acrylic resin and thermocycled between 5° – 60° C (± 2° C) for 250 cycles with a dwell time of 20 seconds. All seven groups were then placed in a 5% basic Fuchsin solution for 12 hours at 37°C.

The embedded teeth were removed from the basic Fuchsin, rinsed well, imbedded in acrylic and cut longitudinally through the centre of each restoration using an Accutom-2 cutting machine. Each tooth was then evaluated at the occlusal enamel margin and at the cervical dentine margin for micro-leakage using a light microscope at 50x magnification. The data obtained was analysed using the Kruskal-Wallis test, with Fisher's least significant difference method used for comparison of specific groups ($p<0.05$). When compared to the control (Scotchbond Multipurpose Plus), results for microleakage at the occlusal enamel margins as well as the cervical dentine margins indicated that only SE Bond and ABF (Protect Bond) showed values as low as the control.

It can be concluded that, as far as microleakage is concerned, Clearfil SE Bond and ABF (Protect Bond) self-etching bonding agents could be clinically acceptable alternatives to the clinically proven Scotchbond Multipurpose. The other products showed more microleakage.

INTRODUCTION

Marginal leakage that occurs at the interface between the restorative material and the tooth can lead to post-operative sensitivity, chronic hypersensitivity, recurrent caries and pulpal complications.[1, 2]

Despite all the modern improvements in bonding agents, composites and application techniques, post-operative sensitivity and micro-leakage due to polymerization shrinkage and shrinkage related shrinkage stress remains one of the biggest problems in modern clinical dentistry. Self-etching bonding systems are a relatively new development in the field of restorative dental materials. One of the factors determining clinical success will be its ability to bond the restoration to the exposed tooth structure effectively, thereby limiting micro-leakage. Various researchers have worked on micro-leakage associated with bonding agents and composite resin.[3-5] 'Traditional', fourth generation bonding agents, especially Scotchbond Multipurpose, have proven themselves in the clinical arena and are deemed to be worthy control products.

PURPOSE

The purpose of this study was to compare micro-leakage values for a selection of self-etching bonding systems to that of a control, being a fourth generation bonding agent.

MATERIALS AND METHODS

Seventy freshly extracted, intact, caries free human third molars were scaled, cleaned with a slurry of pumice and stored in a sodium azide solution at 5°C. In each tooth a standard, cylindrical preparation was made at the cemento-enamel junction (CEJ) using a size medium Cerana[a] bur (Fig. 1 & 2). The teeth were subsequently randomly divided into 7 groups of ten teeth each. Bonding agents were applied and light cured strictly according to the manufacturer's instructions. Bonding agents used in this study were Optibond Solo Plus Self-Etch[b], ABF (Protect Bond)[c], Clearfil SE Bond,[c] Xeno III[d], OneCoatSE Bond[e], iBond[f] and Scotchbond Multipurpose Plus[g] as a control.

The cavities were restored using two incremental layers of Z100[g] (A1) composite. Each layer was cured for 20 seconds using an Optolux 501[b] curing light. The cavities were slightly overfilled when placing the last layer. The restored teeth were then stored overnight for 12 hours in distilled water at 37°C. The restorations were subsequently finished and polished using Sof-Lex discs[g] and Enhance Polishing cups[d] and then imbedded in acrylic resin.

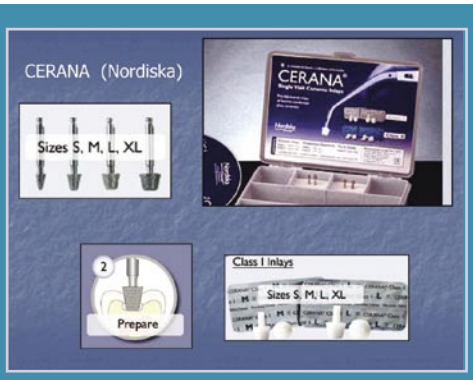

Figure 1 Cerana Bur kit from the Cerana Inlay System (Nordiska Dental)

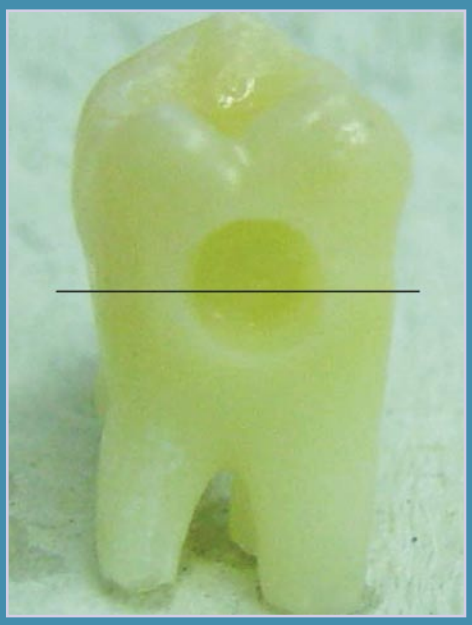

Figure 2 Prepared cavity at the Cemento-Enamel junction

Figure 3 Resin embedded tooth with restored cavity after basic Fuchsin treatment

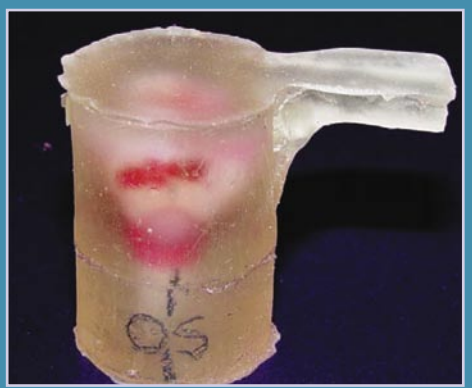

Figure 4 Re-imbedded tooth. Ready for longitudinal sectioning

The teeth were then thermocycled between 5 and 60° C (± 2° C) for 250 cycles with a dwell time of 20 seconds.[6]

All seven groups were then placed in a 5% basic Fuchsin[h] solution for 12 hours at 37° C (Fig. 3). The teeth were then removed from the basic Fuchsin, rinsed well, imbedded further in acrylic (Fig. 4) and cut longitudinally through the centre of each restoration using an Accutom-2[i] cutting machine (Fig. 5). Each tooth was then evaluated at the occlusal enamel margin and at the cervical dentine margin for microleakage using a light microscope at 50x magnification. Microleakage was evaluated by two independent evaluators and scores were allocated according to Table 1. The data obtained was analysed using the Kruskal-Wallis test, with Fisher's least significant difference method utilised for comparison of specific groups ($p<0.05$).

RESULTS

Incisal Enamel Margins (Table 2)

Results for microleakage at the INCISAL ENAMEL MARGINS indicated significantly different leakage values from the control, Optibond Solo Plus Self-Etch, Xeno III, OneCoatSE Bond and iBond. Enamel Margin microleakage values for SE Bond and ABF did not significantly differ from the control Scotchbond Multipurpose Plus. Enamel margin microleakage values for Xeno III, OneCoatSE Bond and iBond did not significantly differ from each other.

Apical Dentine Margins (Table 3)

Results for microleakage at the APICAL DENTINE MARGINS indicated significantly different leakage values compared to the control, for Optibond Solo Plus Self-Etch, Xeno III and OneCoatSE Bond. Dentine margin microleakage values for SE Bond, ABF and iBond did not significantly differ from the control, Scotchbond Multipurpose Plus.

Figure 5 Sectioned tooth. Ready for micro-leakage evaluation

DISCUSSION

An attempt was made to standardize the cavity size by using the Cerana inlay bur. Polymerization contraction generated by resin composite at the adhesive interface has been reported to increase as the C-factor increases.[7] Also applicable is the magnitude of the contraction stress that is dependant on the volume or thickness of the resin composite.[8, 9] In our study the cavity size and geometry resulted in high shrinkage forces and a high configuration factor, but since different bonding agents were compared with each other this fact should not have influenced the results and the final outcome of this study. Overall high leakage values could have been expected, as was indeed the case.

In the current study the prepared and subsequently restored cavities were allowed to mature overnight in distilled water before thermocycling. This maturing was done to ensure full maturation of the restoration before final immersion in dye. The time immediately following placement of the restoration is critical since enamel and dentine bonding must counteract composite shrinkage.[8] Even though bond strength values seem to be adequate, marginal leakage at dentine and enamel margins could not be prevented. The results, of this study seem to correlate well with similar studies reported in the literature.[10-12] It has also been indicated, and confirmed in our present study, that often there is a relationship between microleakage values and bond strength values, with higher microleakage often found in products with lower bond strength to enamel and dentine[13-15] (Table 4). The dentine bond strength values referred to in Table 4 were acquired through another study, by the same authors, on bond strength using self-etching dentine bonding agents, to be published soon.Because the bond to acid etched enamel is stronger than to dentin, an interfacial gap is likely to form (due to polymerization shrinkage of composite resin) at the gingival cementum (Api-

Table 1. Criteria for scoring micro-leakage

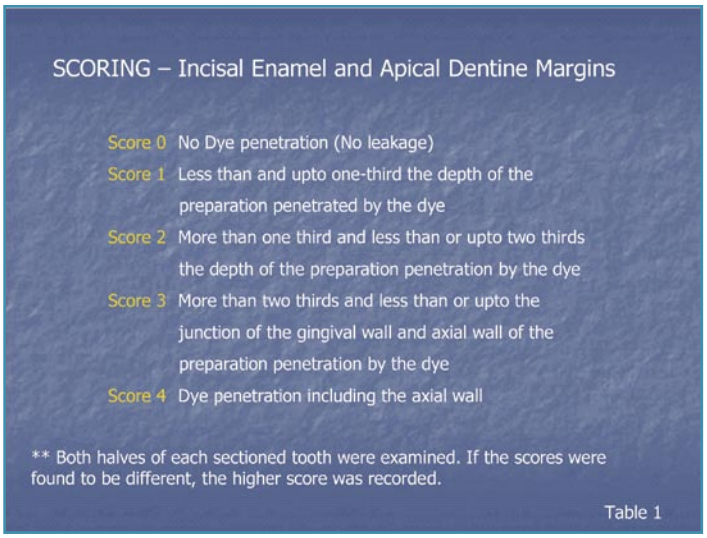

Table 2. Microleakage evaluation at the Incisal ENAMEL margins

Table 2: Microleakage: Incisal ENAMEL Margins

	0	1	2	3	4	Sum of Scores	Median Score
Scotchbond (Control)	4	5	1	-	-	7	1
SE Bond	3	3	4	-	-	11	1
ABF	5	2	3	-	-	8	0.5
OptibSoloSE	1	5	3	-	1	15	1*
OneCoatSE	-	3	6	-	1	19	2*
Xeno III	-	1	8	1	-	20	2*
iBond	-	4	5	-	1	18	2*

* Significantly different from Control at P<0.05

Table 3. Microleakage evaluation at the Apical DENTINE margins

Table 3: Microleakage: Apical DENTINE Margins

	0	1	2	3	4	Sum of Scores	Median Score
Scotchbond (Control)	4	3	-	2	1	13	1
SE Bond	6	1	-	2	1	11	0
ABF	7	-	-	1	2	11	0
OptibSoloSE	2	2	2	1	3	21	2*
OneCoatSE	1	4	1	-	4	22	2*
Xeno III	2	1	-	-	7	29	3*
iBond	4	3	1	-	2	13	1

* Significantly different from Control at P<0.05

Table 4. Enamel and Dentine Leakage Scores compared to Dentine Shear Bond Strength Evaluation*.

	Enamel Sum of Scores	Dentine Sum of Scores	Dentine MPa
Scotchbond (Control)	7	13	24.9
SE Bond	11	11	26.2
ABF	8	11	25.9
OptibSoloSE	15	21	21.9*
OneCoatSE	19	22	-
Xeno III	20	29	17.3*
iBond	18	13	-
	T: 98	T: 120	
	SE ave: 15.2	SE ave: 17.8	

Table 4

* These Dentine shear bond strength results will be reported on in a subsequent publication

cal Dentine) margins.[15] The bonding substrate at the gingival margins consists of an outer layer, 150-400μm thick, partially formed by cementum. This hypo-mineralized, hyper-organic substrate, even after etching, does not allow infiltration by adhesive materials.[16] The results of our study with self-etching systems do also seem to indicate better sealing at the enamel margins, both for the control and the self-etching systems as a group (Table 4).

CONCLUSION

Microleakage of some of the Self-etching bonding agents evaluated compared favourably to that of Scotchbond Multipurpose Plus, a well researched and proven fourth generation (total etch) dentine bonding agent. The results of this study compare well with research done by other workers in the field and private practitioners can be advised, that as far as marginal leakage is concerned, SE Bond and ABF (Protect Bond) self-etching bonding agents are viable alternatives for clinical use compared to clinically proven products such as Scotchbond Multipurpose Plus. More research needs to be done on enamel bond strength and sealing of enamel margins when using self-etching systems, as well as on the long term stability of self-etching bonds. Factors relating to sealing and bonding the 'difficult to etch' apical cementum/ dentin margin areas in class V restorations, using self-etching systems, also need to be investigated in more detail.

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2. Kidd, EA. Microleakage In Relation To Amalgam and Composite Restorations. A Laboratory Study. *Br Dent J* 1976; **141**(10): 305-310.
3. Ernsta, CP. Kotter, T. Victor, A. Canbek, K. Brandenbusch, M. Willershausen, B. Marginal Integrity Of Self- And Total-Etching Adhesives In Two Different Application Protocols. *J Adhes Dent* 2004; **6**(1): 25-32.

THE REST OF THIS ARTICLE'S REFERENCES (4-16) WILL BE PUBLISHED IN THE ONLINE SADJ. www.sadanet.co.za ~

FOOTNOTE

[a] Nordiska Dental, Ängelholm, Sweden
[b] Kerr Corporation, Orange, California, USA
[c] Kuraray, Osaka, Japan
[d] Dentsply, Konstanz, Germany
[e] Coltène Whaledent, Altstätten, Switzerland
[f] Hareaus Kulzer, Hanau, Germany
[g] 3M ESPE, St Paul, Minnesota, USA
[h] Sigma-Aldric, St Louis, Missouri, USA
[i] Struers, Ballerup, Denmark