



IMMEDIATE DENTIN SEALING SUPPORTS DELAYED RESTORATION PLACEMENT

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Statement of problem. Immediate dentin sealing (IDS) is a new approach in indirect restorations. Dentin is sealed immediately following tooth preparation, prior to impression making. It is not known whether it is still possible to obtain an efficient bond between the resin-coated dentin and the restoration after 2 to 4 months of placement of provisional restorations.

Purpose. The purpose of this study was to determine if there were differences in microtensile bond strength to human dentin using the IDS technique when comparing 2, 7, and 12 weeks of delay until restoration placement, using 2 different dentin bonding agents (DBAs). Previously published preliminary IDS data were included for comparison.

Material and methods. Fifty freshly extracted human molars were obtained and divided into 10 groups. A 3-step etch-and-rinse DBA (Optibond FL) and a 2-step self-etching DBA (SE Bond) were used. For each DBA, the control (C) specimens were prepared using a direct immediate bonding technique and composite restoration (Z100). Preparation of the other specimens used an indirect approach without dentin prebonding (delayed dentin sealing, DDS) or with immediate dentin sealing (IDS), immediately following preparation. IDS teeth had provisional restorations (Tempfil inlay) placed for 2 weeks (IDS-2W), 7 weeks (IDS-7W), or 12 weeks (IDS-12W) before restoration placement. All teeth were prepared for a nontrimming microtensile bond strength test (MTBS) 24 hours after definitive restoration with composite overlays (Z100). Ten to 11 beams (0.9 x 0.9 x 11 mm) from each tooth were selected for testing. MTBS data obtained from the 10 experimental groups were analyzed with a 2-way analysis of variance (ANOVA, dentin bonding system, and sequence of application) with each tooth (mean MTBS from the 10-11 beams) used as a single measurement. The Tukey HSD post hoc test was used to detect pairwise differences among experimental groups ($\alpha=.05$). Fractured beams were also analyzed under stereoscopic microscope (x 30) and SEM.

Results. For both adhesives, the mean microtensile bond strengths of C and all IDS groups were not significantly different and exceeded 45 MPa. DDS groups exhibited lower bond strength than all others sequences ($P<.001$) with SE Bond at 1.81 MPa significantly lower ($P=.026$) than Optibond FL at 11.58 MPa. The highest mean microtensile bond strength values were found with Optibond FL at 7 weeks (66.59 MPa) and 12 weeks (59.11 MPa). These were significantly higher than SE Bond in the same conditions with values of 51.96 MPa and 45.76 MPa ($P=.001$ and $P=.003$), respectively. Failures in DDS groups were all interfacial and purely adhesive. Both C and IDS-2W groups demonstrated interfacial failure that was typically mixed with both areas of failed adhesive resin and areas of cohesively failed dentin while IDS-7W and IDS-12W failed consistently between the existing resin coating (used during IDS) and the overlaying composite resin.

Conclusions. When preparing teeth for indirect bonded restorations, IDS with a 3-step etch-and-rinse or a 2-step self-etching DBA (prior to impression making) results in microtensile bond strength similar to that obtained with a freshly placed adhesive. The bond strength is not affected by up to 12 weeks of elapsed time prior to placement of the definitive restoration. (J Prosthet Dent 2007;98:166-174)

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CLINICAL IMPLICATIONS

The results of this *in vitro* study indicate that freshly cut dentin surfaces (inlay/onlay, veneer, and crown preparations) may be sealed with a dentin bonding agent immediately following tooth preparation, prior to impression making. Three-step etch-rinse or 2-step self-etching DBAs are recommended for this purpose, and the bond of the definitive restoration to the resin-coated dentin can still be obtained following extended placement of provisional restorations up to 12 weeks.

It is suggested that a dentin adhesive be applied to the freshly cut dentin according to the manufacturer's instructions¹⁻⁹ when a significant area of dentin has been exposed during tooth preparation for indirect restorations such as inlay/onlay, veneer, and crown preparations. Applying a dentin bonding agent (DBA) prior to definitive impression making, the so-called immediate dentin sealing (IDS) technique,^{4,8,10} or resin coating technique,^{6,7,9} provides significant advantages. At the time of preparation, the dentin is freshly cut and clean, which is ideal for dentin bonding (absence of contamination by the provisional cement).¹¹ IDS enables the prepolymerization of the DBA, resulting in improved bond strength.^{5,6,8,9,12} Delaying restoration placement allows the dentin bond to develop without stress during the provisional restoration stage.¹³ When used for traditional crown preparations and combined with glass ionomer or modified-resin cements, IDS can result in significantly increased retention, reduced marginal leakage, and improved bond strengths.¹⁴⁻¹⁶ IDS can, therefore, be useful for improving retention for short clinical crowns and excessively tapered preparations (Fig. 1). Beyond the aforementioned evidence-based principles, there are practical reasons to justify IDS^{1,10,17}: (1) the clinician can focus on the "wet bonding" to dentin (for total-etching situations), while dry enamel bonding can be performed separately at the stage of definitive restoration placement, (2) the sealed dentin is protected from infiltration and bacterial leakage during the provisional restoration stage,



1 A, Example of existing complete-coverage tooth preparation design enabled by IDS-optimized adhesive procedures. B, Close up view of resin-coated tooth preparations. C, Anticipated length of restorations (provisional restorations, laboratory work by Michel Magne, CDT, University of Southern California, Los Angeles, Calif).

thus, enhancing patient comfort (absence of sensitivity), (3) the potential risk for postcementation sensitivity is reduced, and (4) the cementation of the definitive restoration requires only limited or no anesthesia (the resin-coated dentin is pain-free), ultimately facilitating occlusal adjustment.

The success of this technique also relies on the bond between the existing resin coating placed at the time of tooth preparation and the new luting agent. During the provisional restoration stage, the potential exposure of the polymerized adhesive to oral fluids may permit water sorption,¹⁸ which may compromise the bond between the existing adhesive and the new restoration. Previously published data⁸ demonstrated that placement of a provisional restoration for a period of up to 2 weeks did not appear to affect the potential resin-to-resin bond, which may be explained by residual free radicals,^{19,20} van der Waals interactions (intermolecular forces), and micromechanical interlocking. Prior to restoration placement in the aforementioned studies, the existing adhesive layer was cleansed by using microairborne-particle abrasion. Complex inlay/onlay and veneer situations and, especially, prosthodontic patients, may require longer delays until the restoration is delivered by the laboratory. There are no data available regarding the dentin bond strength when bonding to the sealed dentin with an extended delay between definitive impression and restoration placement. The aim of this study was to evaluate the validity of IDS in situations of delayed restoration placement of up to 12 weeks and its influence on the dentin bond strength using the nontrimming microtensile bond test.^{21,22} A conventional 3-step etch-rinse adhesive and a 2-step self-etching adhesive were evaluated because of their proven reliability, bond strength,²³⁻²⁵ and suitability for the IDS technique.²⁶ Previously published data about the short-term use of IDS⁸ (using Optibond FL) by the same research group and generated in strictly

identical laboratory/testing conditions (same primary operator, same sample size) were included for comparison.

MATERIAL AND METHODS

Once approval was obtained from the University of Southern California Institutional Review Board, 50 freshly extracted, sound human molars stored in solution saturated with thymol were used. After removal of the occlusal half of the crown using a model trimmer (Orthodontic Model Trimmer; Gamberini srl, Bologna, Italy), flat, midcoronal dentin surfaces were created and finished with 600-grit SiC paper (Gatorgrit; Ali Industries, Fairborn, Ohio) under water to create a relatively smooth dentin surface. The surfaces were evaluated

for the presence of any remaining enamel, which was removed by additional trimming/finishing when observed. A 3-step etch-rinse adhesive system (Optibond FL; Kerr, Orange, Calif) and a 2-step self-etching adhesive system (SE Bond; Kuraray, Tokyo, Japan) were used, according to the manufacturers' instructions. Experimental groups varied according to the sequence and mode of application of the dentin adhesive (Table I).

Ten teeth (5 specimens per adhesive system), freshly cut, immediately bonded (adhesive polymerized), and restored, constituted the control (C) groups. The sample size of 5 was selected to be consistent with existing published data for comparison.⁸ Direct restorations consisted of 1.5-mm-thick increments of composite resin (Z100; 3M ESPE, St. Paul,

TABLE I. Experimental groups and sequence

Control Groups: Direct Restoration	DDS Groups: Indirect Restoration with Delayed Dentin Bonding	IDS Groups: Indirect Restoration with Immediate Dentin Sealing (IDS-2W, IDS-7W, IDS-14W)
Tooth preparation + Dentin bonding (etch/prime/adhesive), adhesive polymerized + Direct restoration	1. Tooth preparation	1. Tooth preparation + IDS=dentin bonding (etch and prime/adhesive), adhesive polymerized
	2. Provisional restoration (+ 2-week delay)	
	3. Provisional restoration removed Microairborne particle abrasion of dentin + Dentin bonding (etch and prime/adhesive), adhesive not polymerized + Restoration	2. Provisional restoration + 2-week delay (IDS-2W) or + 7-week delay (IDS-7W) or + 12-week delay (IDS-12W) 3. Provisional restoration removed Microairborne particle abrasion of adhesive + Adhesive resin only, adhesive not polymerized + Restoration

Minn), each layer was light polymerized (Demetron LC; Kerr) for 20 seconds at 600 mW/cm².

Ten teeth, first restored with a provisional restoration material (Tempfil-Inlay; Kerr), left in place for 2 weeks while immersed in saline solution, constituted the indirect restoration, delayed dentin sealing (DDS) groups. Following the 2-week delay, the provisional restoration was removed and dentin was cleaned by airborne-particle abrasion (Rondoflex; KaVo Dental Corp, Lake Zurich, Ill and Cojet; 3M ESPE), followed by the application of the dentin bonding agent. The adhesive resin was left unpolymerized until the application of the restorative material (Z100).

Thirty teeth (15 specimens per adhesive system), freshly cut and immediately bonded, constituted the indirect restoration with immediate dentin sealing (IDS) groups. Polymerization of the adhesive was followed by the application of an air-barrier (Lubricating Jelly; Medline Industries, Mundelein, Ill) and 10 seconds of additional light exposure with the same light unit to polymerize the oxygen-inhibition layer. The bonded surfaces were then isolated with petroleum gel. Teeth were restored with a provisional restoration material (Tempfil inlay; Kerr), left in place for 2 weeks (groups IDS-2W), 7 weeks (groups IDS-7W), or 12 weeks (groups IDS-12W), immersed in saline solution. Following these various time periods, the provisional restoration was removed and the sealed dentin was cleaned by airborne-particle abrasion (Rondoflex and Cojet). One coat of adhesive resin was then applied and left unpolymerized until the application of the restorative material (Z100).

After 24 hours of storage in distilled water at room temperature, each specimen was individually secured with sticky wax (Geo Cervical; Renfert, St. Charles, Ill) to a transparent plastic sectioning block. Multiple beams were prepared, with composite resin comprising half of the beam, and dentin comprising the other half using

the nontrimming technique developed by Shono et al.²¹ To accomplish this, specimens were vertically sectioned into 0.9-mm-thick slabs using a low-speed diamond saw (Isomet; Buehler Ltd, Lake Bluff, Ill) under water lubrication. Beams with a cross-sectional area of approximately 0.81-mm² were obtained by sectioning the slabs again. The specimens were attached to a table-top material tester (The Micro Tensile Tester; Bisco Inc, Schaumburg, Ill) using cyanoacrylate (Zapit; DVA, Corona, Calif) and subjected to microtensile testing at a crosshead speed of 5.4-kg-force per minute. Ten to 11 beams were prepared from each tooth. A stereoscopic microscope (x30) was used to determine the failure mode of each beam: (1) interfacial failure, if the fracture site was located entirely between the adhesive and dentin or if the fracture site continued from the adhesive into either the composite resin or dentin (mix type) or (2) substrate failure, if the fracture occurred exclusively within the composite resin or dentin. Bond strength data obtained from the 10 experimental groups were analyzed with a 2-way analysis of variance (ANOVA) (dentin bonding system and sequence of application) with each tooth (mean MTBS from the 10-11 beams) used as a single measurement. The Tukey HSD post hoc test was used to detect pairwise differences among experimental groups. All statistical testing was performed at a preset alpha of .05.

The dentin surface of 4 fractured beams (interfacial failure) from each group were air dried, sputter-coated with gold/palladium (Cressington 108; UK) and examined using a scanning electron microscope (Stereoscan 360; Cambridge Instruments, Cambridge, UK). Unused slabs (2 from each group) were also prepared for the SEM analysis of the intact dentin-resin interface. The sectioned surface of each slab was etched for 30 seconds with 35% phosphoric acid, rinsed, air dried, and sputter coated with gold/palladium.

RESULTS

The 2-way ANOVA (Table II) indicated a significant effect for both main factors (dentin bonding system, $P<.001$; application sequence, $P<.001$) but not their interaction term ($P=.085$). Table III lists the microtensile bond strengths of Optibond FL and SE Bond to dentin in the control (C) and experimental groups (preliminary data from Magne et al⁸ for Optibond FL groups Control, DDS, and IDS-2W). The mean microtensile bond strength varied from 2 to 67 MPa. For both adhesives, DDS exhibited lower bond strength than all other sequences ($P<.001$), with SE Bond producing microtensile bond strengths of only 1.81 MPa, which was significantly lower ($P=.026$) than Optibond FL values at 11.58 MPa. Both adhesives demonstrated that bond strength did not differ significantly from the control group when placing provisional restorations for 2, 7, or 12 weeks with IDS ($P>.07$). The highest mean microtensile bond strengths were found with Optibond FL at 7 weeks with 66.59 MPa and at 12 weeks with 59.11 MPa. These were significantly higher than SE Bond in the same conditions with 51.96 MPa and 45.76 MPa ($P=.001$ and $P=.003$), respectively.

Results of the failure modes determined by optical microscopic evaluation are shown in Table IV. Failures were either interfacial or cohesive in dentin for Optibond FL in the C and IDS groups, while most of the failures in the DDS group were interfacial. SE Bond showed a higher rate of interfacial failures in general. Stereoscopic microscope analysis of adhesively failed beams at 7W and 12W also revealed the consistent layer of adhesive resin still sealing the dentin side of the sample (Fig. 2).

While fractured beams for both the C and IDS-2W groups demonstrated interfacial failure that was typically mixed (areas of failed adhesive resin and areas of cohesively failed dentin), fractured beams for both IDS-

TABLE II. Two-way analysis of variance

Source	df	Type III Sum of Squares	Mean Square	F	P
Dentin bonding system	1	847.48	847.48	18.89	<.001
Application sequence	4	19562.81	4890.70	108.99	<.001
DB system x application	4	396.57	99.14	2.209	.085

P<.05 indicates significant difference

TABLE III. Mean (SD) microtensile bond strength (MPa) of Optibond FL/SE Bond

Dentin Bonding System	Control	DDS	IDS-2W	IDS-7W	IDS-12W
Optibond FL	55.06 ^{Aa} (6.69)	11.58 ^{Ab} (11.19)	58.25 ^{Aa} (3.29)	66.59 ^{Aa} (8.41)	59.11 ^{Aa} (3.44)
Clearfil SE Bond	54.75 ^{Aa} (7.69)	1.81 ^{Bb} (2.22)	55.14 ^{Aa} (4.78)	51.96 ^{Ba} (5.38)	45.76 ^{Ba} (8.35)

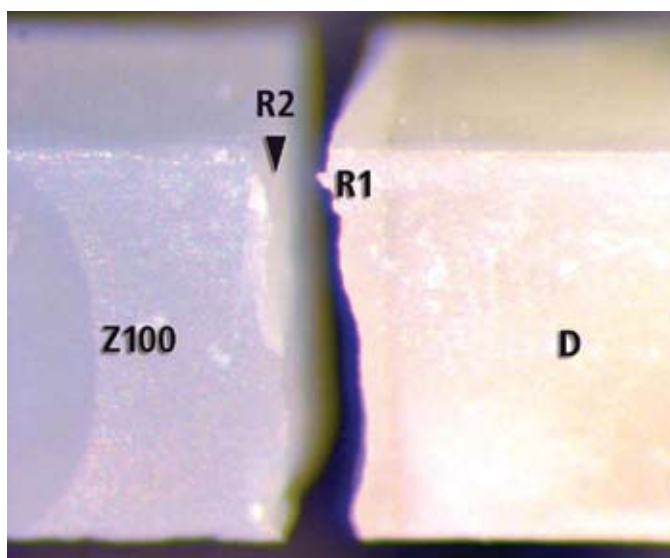
Values of groups having similar letters are not significantly different for *P*<.05
(Uppercase letters refer to columns; lowercase letters refer to rows)

TABLE IV. Distribution of failure modes as observed by optical microscopy

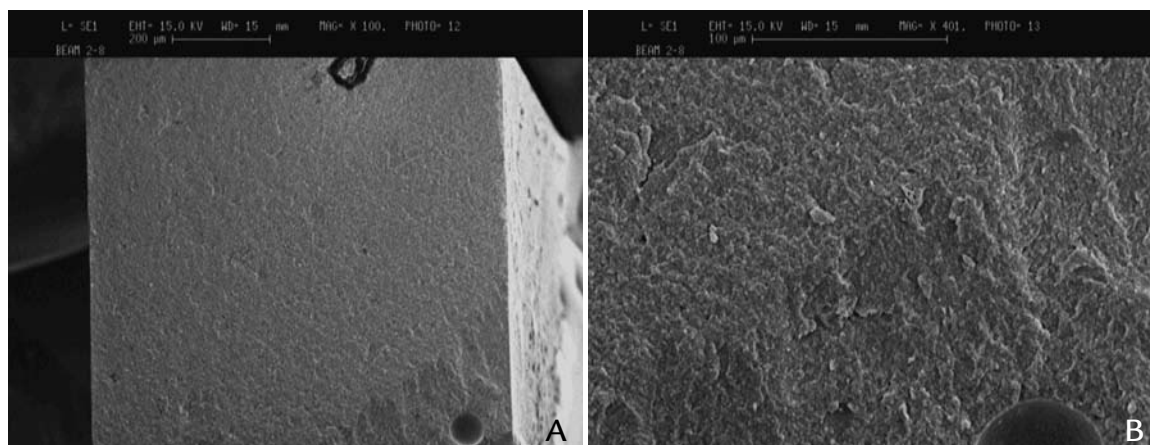
Dentin Bonding System	Control	DDS	IDS-2W	IDS-7W	IDS-12W
Optibond FL					
Interfacial (%)	62	98	49	66	84
Dentin substrate (%)	34	2	49	23	14
Composite substrate (%)	4	0	2	11	2
Clearfil SE Bond					
Interfacial (%)	73	100	74	89	88
Dentin substrate (%)	25	0	26	11	10
Composite substrate (%)	2	0	0	0	2

7W and IDS-12W failed consistently between the existing adhesive resin (used during IDS) and the overlaying composite resin itself (Figs. 3 and 4). One beam, which failed cohesively in dentin at 76.7 MPa (Optibond FL, IDS-7W), showed an unharmed interface despite the cumulative stress of testing and dehydration (Fig. 5).

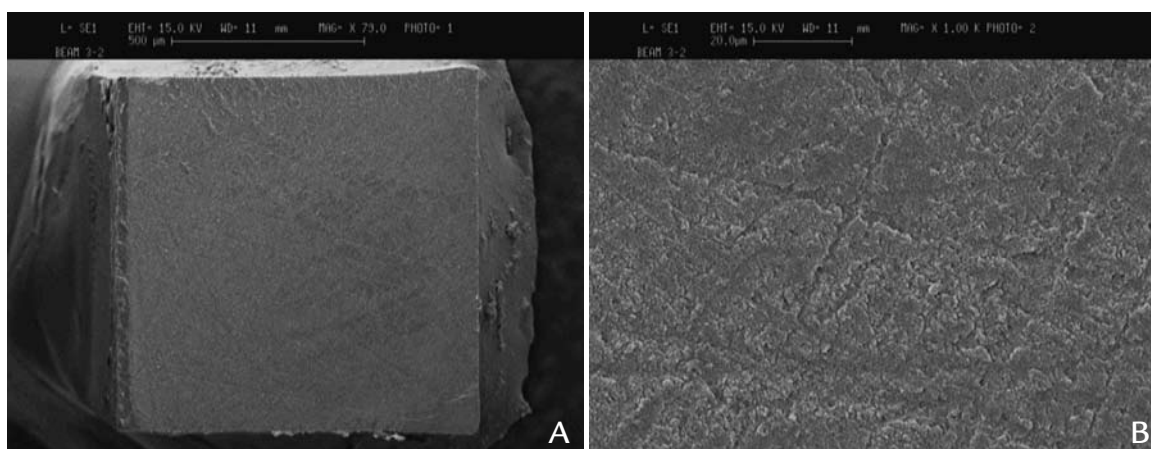
Intact slabs for all groups generated a well-organized hybrid layer and resin tags in continuity with the dentin underneath (Fig. 6). Even when cohesive failures within the composite resin or within dentin were found due to preparation and dehydration of the specimens, both the adhesive interface and the interface between the existing adhesive resin and the overlaying composite resin resisted this intense stress (Figs. 6 and 7).



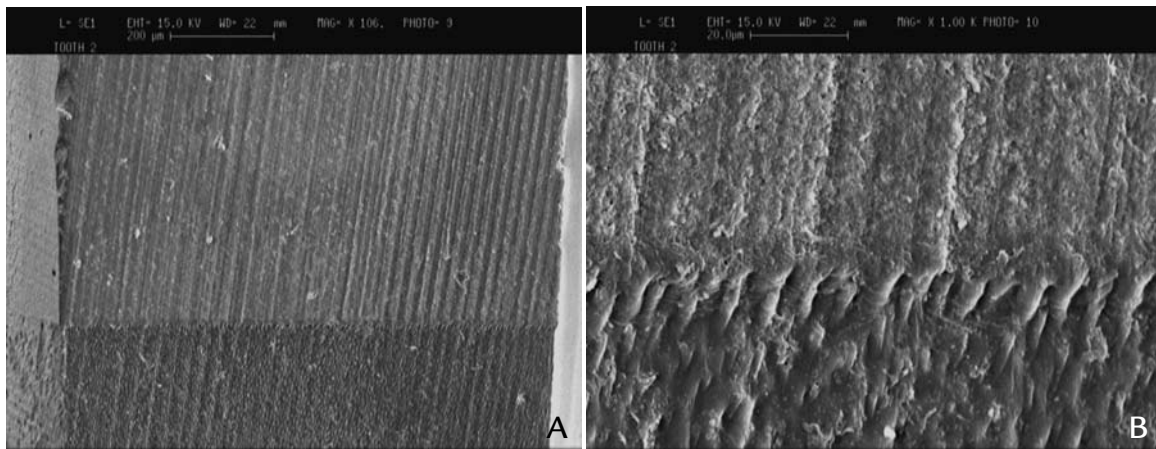
2 Stereoscopic microscope view of beam failed adhesively at 61.72 MPa (Optibond FL, IDS-12W). Consistent layer of adhesive resin (R1) is found at dentin side of specimen (D). Small fragment of adhesive resin (R2) found on composite side and can be distinguished from Z100 beam.



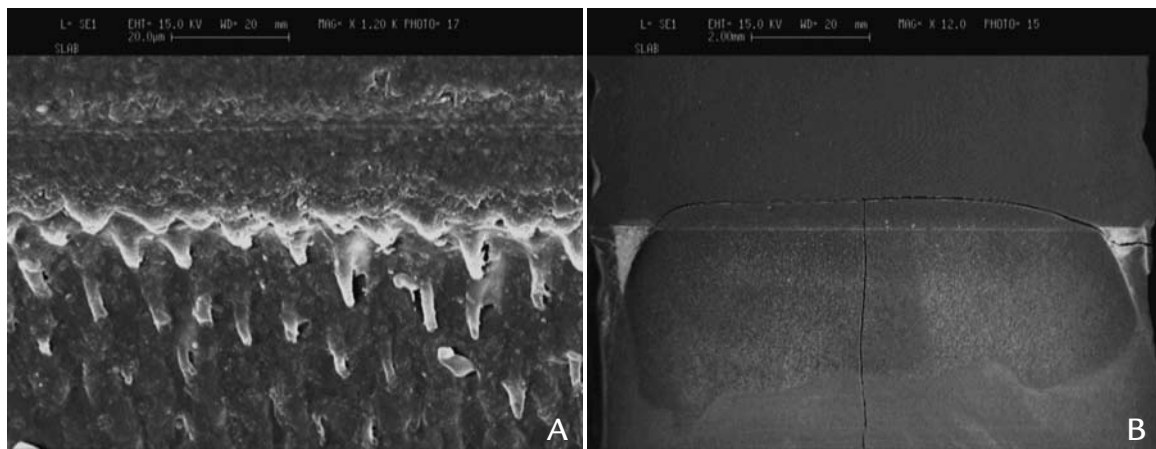
3 Typical SEM micrograph of dentin side of fractured beam from group IDS-7W (Optibond FL), which failed at 73.7 MPa. A, Note uniform resinous surface (original magnification $\times 100$). B, Higher magnification in center of specimen confirms that dentin is completely covered with adhesive resin (original magnification $\times 400$), suggesting failure between existing adhesive resin and composite resin.



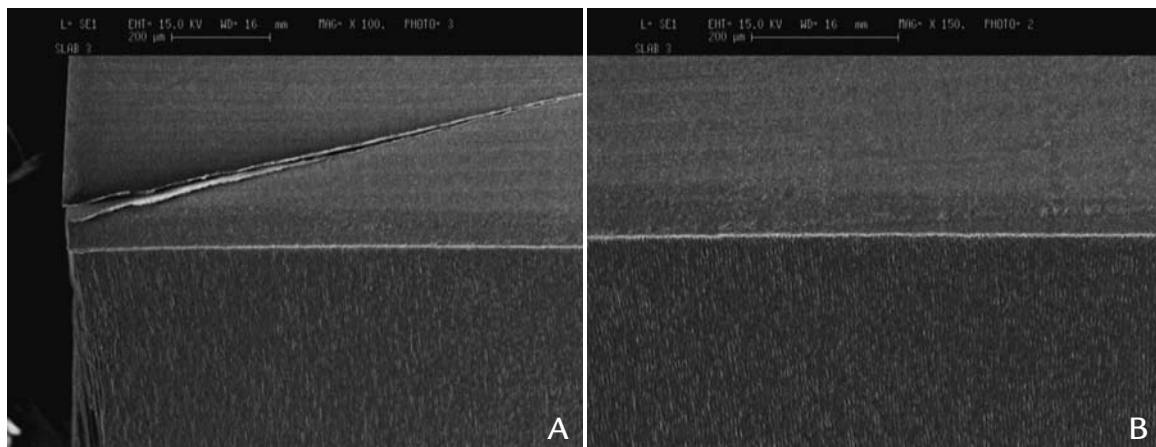
4 Typical SEM micrograph of dentin side of fractured beam from group IDS-12W (SE Bond), which failed at 53 MPa. Note uniform resinous surface. A, Original magnification $\times 173$. B, Higher magnification in center of specimen confirms that dentin is completely covered with adhesive resin (original magnification $\times 1000$), again suggesting failure between existing adhesive resin and composite resin.



5 SEM micrograph of beam in group IDS-7W (Optibond FL) which failed cohesively in dentin at 76.7 MPa. A, Demineralized specimen, original magnification $\times 100$. B, Higher magnification of intact interface demonstrates 5- to 6- μm -thick well-organized hybrid layer and resin tags; adhesive interface remains unharmed despite cumulative stress of testing and dehydration from specimen preparation (original magnification $\times 1000$).



6 SEM micrograph of unused intact slab for group IDS-7W (Optibond FL). Note cohesive failure within composite resin and dentin due to specimen dehydration. Adhesive interface remains intact despite intense stress generated by specimen preparation and dehydration. A, Demineralized specimen, original magnification $\times 12$. B, Higher magnification shows well-organized hybrid layer, long resin tags, and unharmed interface (original magnification $\times 1000$).



7 SEM micrograph of unused intact slab for group IDS-12W (SE Bond). Note cohesive failure within composite resin due to specimen dehydration. Adhesive interface remains intact despite intense stress generated by specimen preparation and dehydration. A, Demineralized specimen, original magnification $\times 100$. B, Adhesive resin for IDS (60- μm thickness) can be distinguished from overlaying composite resin but there is complete continuity between them (original magnification $\times 150$).

DISCUSSION

As reported in several studies, most simplified 1-step dentin adhesives are the least durable, while older 3-step etch-rinse and 2-step self-etching adhesives continue to show the best performance in terms of bond strength, aging, and stability of the bonded interface.²³⁻²⁵ Older adhesive systems are most appropriate for IDS because of their ability to form a more hydrophobic resin coating. As a consequence, none of the recent 1-step adhesives were included in this study. A key element in IDS is the development of an efficient resin-to-resin bond between the existing resin coating and the new luting composite resin. This situation is somewhat similar to a composite resin-composite resin repair. Contrary to the common perception, the oxygen-inhibited layer is not necessary for bonding additional layers of composite resin.^{19,20} As demonstrated by the MTBS results and SEM analysis of the IDS groups, bonding to the existing adhesive was efficient enough to generate cohesive failures in dentin and no gaps were observed between the existing resin coating and the new restoration. The current study confirms existing data showing that airborne-particle abrasion and the application of fresh adhesive resin can provide reliable bond to the existing composite resin.^{8,20} Other works have demonstrated that either pumice or roughening, using a coarse diamond rotary cutting instrument at low speed, can also be used to promote the bond to the sealed dentin.^{4,10} Until the present study, there was no data available to demonstrate that the aforementioned principles of IDS would be supported in situations when the restoration is placed over a 7-week- or 12-week-old resin coating, proving that free radicals within the resin seem to decay slowly and remain available for bonding even after 12 weeks.

Additional polymerization of the DBA through glycerin gel was used at the time of IDS to prevent the forma-

tion of the oxygen-inhibited layer. This is a step that, until proven otherwise, seems mandatory to maintain the DBA thickness and avoid potential exposure of dentin at later stages during cleaning of the adhesive interface with either airborne-particle abrasion or polishing.²⁶ Preventing the formation of the oxygen-inhibited layer is also recommended, as this unpolymerized tacky layer would interact with the impression material.

Considering the above, a filled adhesive system such as Optibond FL treated with airborne-particle abrasion seems to be more appropriate for IDS than an unfilled DBA because of its ability to produce a more uniform resin coating.²⁶ The filled adhesive was also visibly detectable, a fact that made the evaluation of the DBA during placement easier, as well as after surface cleaning prior to definitive cementation.

Polymerized DBA thicknesses can also vary significantly according to surface geometry, on average 60-80 μm on a smooth convex surface and up to 200-300 μm on concave surfaces such as chamfer finishing lines.^{1,4,26} Consequently, the omission of IDS and the application/polymerization of the DBA immediately before placement of the restoration may interfere with the complete seating of the restoration. From a practical point of view, it is recommended that the adhesive resin be kept unpolymerized before the restoration is fully seated, which was simulated by the DDS groups in the present study. In this situation, the pressure of the luting composite resin during the placement of the restoration may create a collapse of the hybrid layer^{3,4,6} and negatively affect the adhesive interface cohesiveness, which was verified for both products tested in the current study. Only 17% (Optibond FL) and 3% (SE Bond) of the maximum bond strength was obtained in the delayed dentin sealing group.

Because dentin bond strength develops progressively over time, the highest mean MTBS was obtained for

a 7-week-old resin coating (Optibond FL). One beam, which failed cohesively in dentin at 76.7 MPa, showed an unharmed interface despite the cumulative stress of testing and dehydration (Fig. 5). With such a high adhesive strength, it would be possible to suspend a 150-pound man using only a 3 $\times$ 3-mm bonded surface. In directly placed adhesive restorations, the weaker, early dentin bond is immediately challenged by the overlaying composite resin shrinkage and subsequent occlusal forces. However, when using IDS and indirect bonded restorations, because of the delayed placement of the restoration (intrinsic to indirect techniques) and postponed occlusal loading, the dentin bond can increase over time and residual stresses can dissipate,²⁷ resulting in significantly improved restoration adaptation.¹³ In the IDS-7W and IDS-12W groups, failure consistently left dentin covered with adhesive resin, suggesting that possible postoperative sensitivity is potentially prevented.

Provided that optimal adhesion is also achieved at the intaglio surface of the restorations, including techniques such as porcelain etching and silanization for inlays, onlays, and veneers, traditional principles of tooth preparation (retention and resistance form) can be omitted, allowing more conservative tooth preparations. In this regard, future studies are required to continue the work of Johnson et al¹⁴ and explore the interaction of IDS with the retention of traditional complete coverage restoration to update the classic data regarding the preparation retention/resistance form obtained by classic cementation prior to the introduction of IDS.

Practically speaking, caution must be applied during the provisional restoration stage because resin-coated dentin surfaces have the potential to bond to resin-based provisional materials and cements. As a result, retrieval and removal of direct provisional restorations can be difficult. Tooth preparations must be rigorously isolated with a separating medium such

as a thick layer of petroleum jelly during fabrication of the provisional restoration, and resin-based provisional cements must be avoided.

The results of the present study favor immediate dentin sealing using a 3-step etch-rinse or a 2-step self-etch adhesive. Although relatively early bond strengths were measured and no inference concerning the long-term durability of the bond in vivo can be made, there are several rational motives and other practical and technical reasons confirming the validity of sealing dentin immediately, prior to impression making. The results obtained when omitting IDS suggest that for both adhesives, the interphase simulated by the IDS groups could potentially better withstand long-term exposure to thermal and functional loads compared to the same adhesive being applied and polymerized together with the luting material (simulated by the DDS groups).

CONCLUSIONS

Within the limitations of this in vitro study, it can be concluded that IDS, when applied to tooth preparation for indirect restorations such as inlay/onlay, veneer, and crown preparations, has the potential to improve dentin bond strength. Freshly cut dentin surfaces should be sealed with a DBA immediately following tooth preparation. For this purpose, the 3-step etch-rinse or 2-step self-etching DBAs evaluated may be applied to the freshly cut dentin before making impressions. The bond of the definitive restoration to the resin-coated dentin can be obtained following extended provisional restoration phases up to 12 weeks. Omitting the IDS technique and applying the DBA during restoration placement without prepolymerizing the adhesive resin resulted in only 3 to 17% of the maximum bond strength (SE Bond and Optibond FL, respectively).

REFERENCES

- Pashley EL, Comer RW, Simpson MD, Horner JA, Pashley DH, Caughman WF. Dentin permeability: sealing the dentin in crown preparations. *Oper Dent* 1992;17:13-20.
- Paul SJ, Schaerer P. The dual bonding technique: a modified method to improve adhesive luting procedures. *Int J Periodontics Restorative Dent* 1997;17:536-45.
- Dietschi D, Herzfeld D. In vitro evaluation of marginal and internal adaptation of class II resin composite restorations after thermal and occlusal stressing. *Eur J Oral Sci* 1998;106:1033-42.
- Magne P, Douglas WH. Porcelain veneers: dentin bonding optimization and biomimetic recovery of the crown. *Int J Prosthodont* 1999;12:111-21.
- Ozturk N, Aykent F. Dentin bond strengths of two ceramic inlay systems after cementation with three different techniques and one bonding system. *J Prosthet Dent* 2003;89:275-81.
- Jayasooriya PR, Pereira PN, Nikaido T, Tagami J. Efficacy of a resin coating on bond strengths of resin cement to dentin. *J Esthet Restor Dent* 2003;15:105-13.
- Jayasooriya PR, Pereira PN, Nikaido T, Burrow MF, Tagami J. The effect of a "resin coating" on the interfacial adaptation of composite inlays. *Oper Dent* 2003;28:28-35.
- Magne P, Kim TH, Cascione D, Donovan TE. Immediate dentin sealing improves bond strength of indirect restorations. *J Prosthet Dent* 2005;94:511-9.
- Okuda M, Nikaido T, Maruoka R, Foxton RM, Tagami J. Microtensile bond strengths to cavity floor dentin in indirect composite restorations using resin coating. *J Esthet Restor Dent* 2007;19:38-46.
- Magne P. Immediate dentin sealing: a fundamental procedure for indirect bonded restoration. *J Esthet Restor Dent* 2005;17:144-55.
- Paul SJ, Scharer P. Effect of provisional cements on the bond strength of various adhesive bonding systems on dentine. *J Oral Rehabil* 1997;24:8-14.
- McCabe JF, Rusby S. Dentine bonding--the effect of pre-curing the bonding resin. *Br Dent J* 1994;176:333-6.
- Dietschi D, Monasevic M, Krejci I, Davidson C. Marginal and internal adaptation of class II restorations after immediate or delayed composite placement. *J Dent* 2002;30:259-69.
- Johnson GH, Hazelton LR, Bales DJ, Lepe X. The effect of a resin-based sealer on crown retention for three types of cement. *J Prosthet Dent* 2004;91:428-35.
- Kosaka S, Kajihara H, Kurashige H, Tanaka T. Effect of resin coating as a means of preventing marginal leakage beneath full cast crowns. *Dent Mater J* 2005;24:117-22.
- Islam MR, Takada T, Weerasinghe DS, Uzzaman MA, Foxton RM, Nikaido T, et al. Effect of resin coating on adhesion of composite crown restoration. *Dent Mater J* 2006;25:272-9.
- Cagidiaco MC, Ferrari M, Garberoglio R, Davidson CL. Dentin contamination protection after mechanical preparation for veneering. *Am J Dent* 1996;9:57-60.
- Ito S, Hashimoto M, Wadgaonkar B, Szevero N, Carvalho RM, Yiu C, et al. Effects of resin hydrophilicity on water sorption and changes in modulus of elasticity. *Biomaterials* 2005;26:6449-59.
- Suh BI. Oxygen-inhibited layer in adhesion dentistry. *J Esthet Restor Dent* 2004;16:316-23.
- Papacchini F, Dall'Oca S, Chieffi N, Goracci C, Sadek FT, Suh BI, et al. Composite-to-composite microtensile bond strength in the repair of a microfilled hybrid resin: effect of surface treatment and oxygen inhibition. *J Adhes Dent* 2007;9:25-31.
- Shono Y, Ogawa T, Terashita M, Carvalho RM, Pashley EL, Pashley DH. Regional measurement of resin-dentin bonding as an array. *J Dent Res* 1999;78:699-705.
- Tay FR, Carvalho R, Sano H, Pashley DH. Effect of smear layers on the bonding of a self-etching primer to dentin. *J Adhes Dent* 2000;2:99-116.
- Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Buonocore memorial lecture. Adhesion to enamel and dentin: current status and future challenges. *Oper Dent* 2003;28:215-35.
- De Munck J, Van Meerbeek B, Satoshi I, Vargas M, Yoshida Y, Armstrong S, et al. Microtensile bond strengths of one- and two-step self-etch adhesives to bur-cut enamel and dentin. *Am J Dent* 2003;16:414-20.
- Breschi L, Mazzoni A, Ruggeri A, Cadenaro M, Di Lenarda R, De Stefano Dorigo E. Dental adhesion review: Aging and stability of the bonded interface. *Dent Mater* 2007 Apr 16; [Epub ahead of print].
- Stavridakis MM, Krejci I, Magne P. Immediate dentin sealing of onlay preparations: thickness of pre-cured Dentin Bonding Agent and effect of surface cleaning. *Oper Dent* 2005;30:747-57.
- Park JW, Ferracane JL. Measuring the residual stress in dental composites using a ring slitting method. *Dent Mater* 2005;21:882-9.

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