



INTERACTIONS BETWEEN IMPRESSION MATERIALS AND IMMEDIATE DENTIN SEALING

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Statement of problem. Immediate dentin sealing is a new strategy in which a dentin bonding agent is applied to freshly cut dentin and polymerized before making an impression. Interactions are suspected between the resin coating and the impression material.

Purpose. The purpose of this study was to identify possible interactions between 2 impression materials and resin-coated tooth surfaces using 2 different dentin bonding agents.

Material and methods. Extracted molars (n=6) with flat midcoronal preparations underwent 1 of 4 procedures: control group, unsealed tooth surface/impression; IDS group, immediate dentin sealing (Optibond FL or Clearfil SE Bond)/impression; IDS/AB group, immediate dentin sealing/air blocking/impression; IDS/AB-P group, immediate dentin sealing/air blocking/pumicing/impression. All specimens underwent impressions (Impregum Soft or Extrude). Optical microscopy was used to detect unpolymerized and residual impression material on the bonded tooth surface.

Results. A substantial layer of unpolymerized resin (oxygen-inhibited layer) was found in the IDS group, which resulted in 100% faulty impressions (unpolymerized impression material) for both adhesives and impression materials. Air blocking the resin coating (IDS/AB group) did not completely eliminate the oxygen-inhibited layer of Optibond FL and slightly altered the surface of SE Bond (wrinkles). Only SE Bond along with Extrude generated ideal impressions in group IDS/AB, while all other combinations of adhesive/impression material resulted in faulty impressions (unpolymerized impression material or adhesions). The IDS/AB-P group yielded ideal Extrude impressions but generated faulty Impregum impressions (adhesions) in more than 50% of the specimens.

Conclusions. Immediate dentin sealing should be followed by air blocking and pumicing to generate ideal impressions with Extrude. Impregum is not recommended in combination with immediate dentin sealing. (J Prosthet Dent 2009;102:298-305)

CLINICAL IMPLICATIONS

The results of this qualitative evaluation indicate that clinicians must be cautious when using immediate dentin sealing. The incompletely polymerized resin coating can inhibit the polymerization reaction of impression materials. Successful Extrude impressions of resin-coated surfaces can be obtained by air blocking and pumicing before making an impression. With Impregum, air blocking/pumicing results in impression defects due to adhesion and subsequent tearing of impression material.

The immediate application of a dentin bonding agent (DBA) prior to making an impression for indirect composite resin and porcelain restorations has been proposed since the early 1990s.¹⁻⁵ Immediate dentin sealing (IDS) has been significantly re-

financed and extensively studied over the years with positive results regarding bond strength, as well marginal/internal adaptation of indirect restorations, when compared to traditional delivery techniques.⁵⁻¹⁴ It is now an accepted approach,¹⁵ with advantages

such as immediate protection against bacterial leakage and sensitivity, patient comfort, and tissue conservation.

A problematic step in the procedure is the final impression of the resin-coated preparation surface, since

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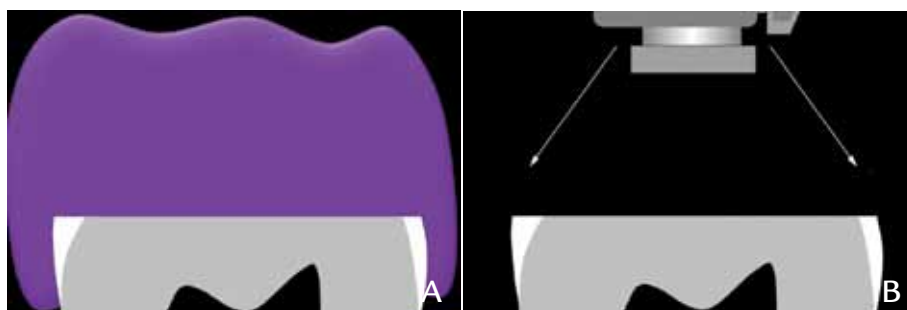
dentin bonding agents show a superficial oxygen-inhibition layer (OIL) when they are light polymerized.¹⁶⁻¹⁸ The OIL has a thickness of up to 40 μm and is due to an increasingly low conversion rate of the resin because of the oxygen inhibition of the radicals that normally induce the polymerization reaction.^{18,19} The OIL may in turn inhibit the polymerization of vinyl polysiloxane (VPS) impression materials, depending on the type of DBA.²⁰ It has been reported that the formation of the OIL can be prevented by the application of a glycerin jelly during polymerization ("air blocking"),²¹

which is usually recommended in the IDS technique.^{5,6,10,12,22} Yet there are anecdotal reports and findings that popular DBAs and impression materials still display inhibition phenomena or adhesion and tearing. In addition, the absence of existing data about these phenomena prompted the present work. This study is a qualitative evaluation with the objective of (1) identifying possible interactions between 2 popular impression materials and IDS-treated tooth surfaces using 2 different DBAs, and (2) proposing an optimized clinical protocol. A conventional 3-step etch-and-rinse adhe-

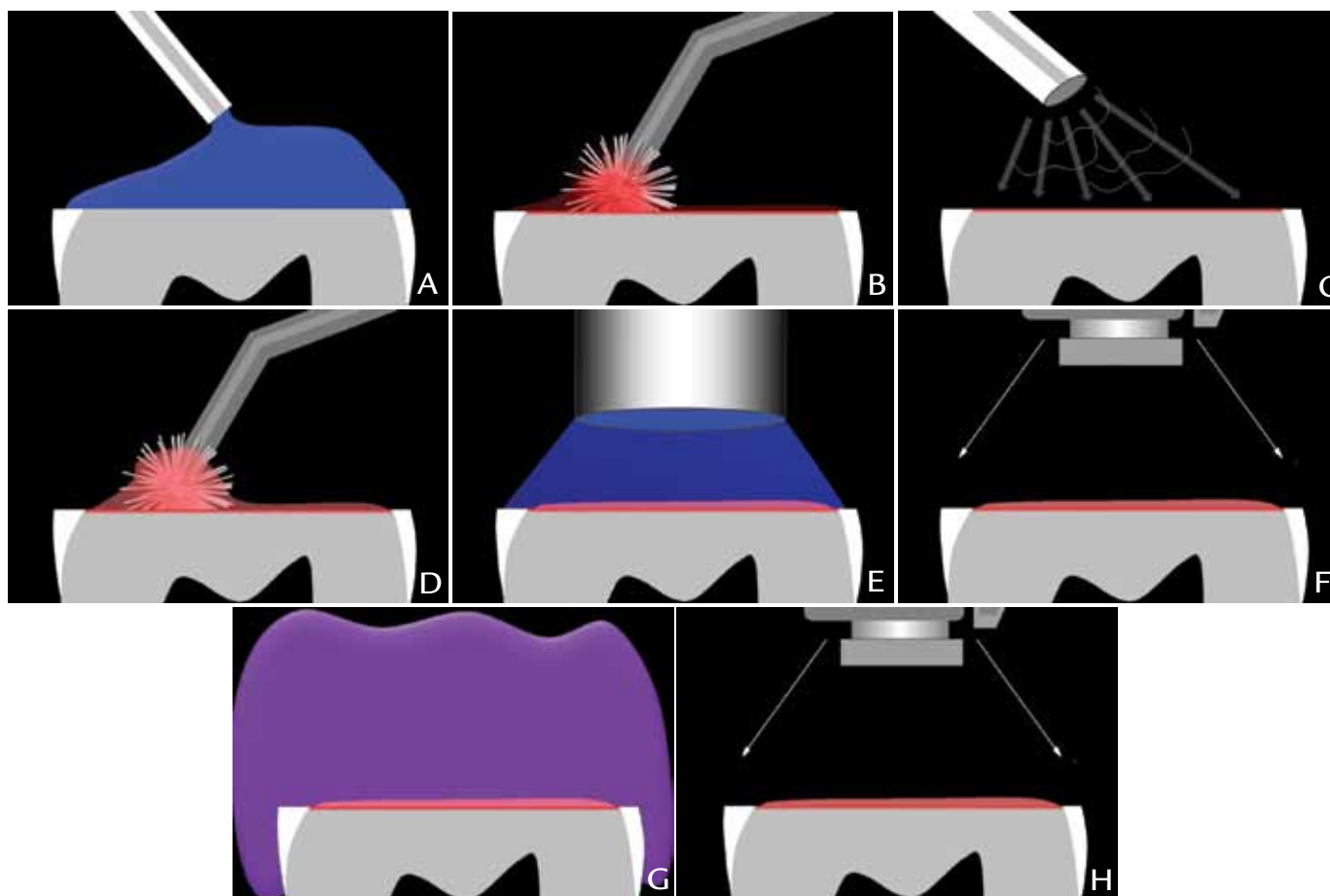
sive and a 2-step self-etching adhesive were evaluated because of their proven reliability, bond strength,²³⁻²⁵ and suitability for the IDS technique.²²

MATERIAL AND METHODS

Once approval was obtained from the University of Southern California Institutional Review Board, 6 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,



1 Control group. A, Impression of unsealed tooth surface. B, Evaluation.



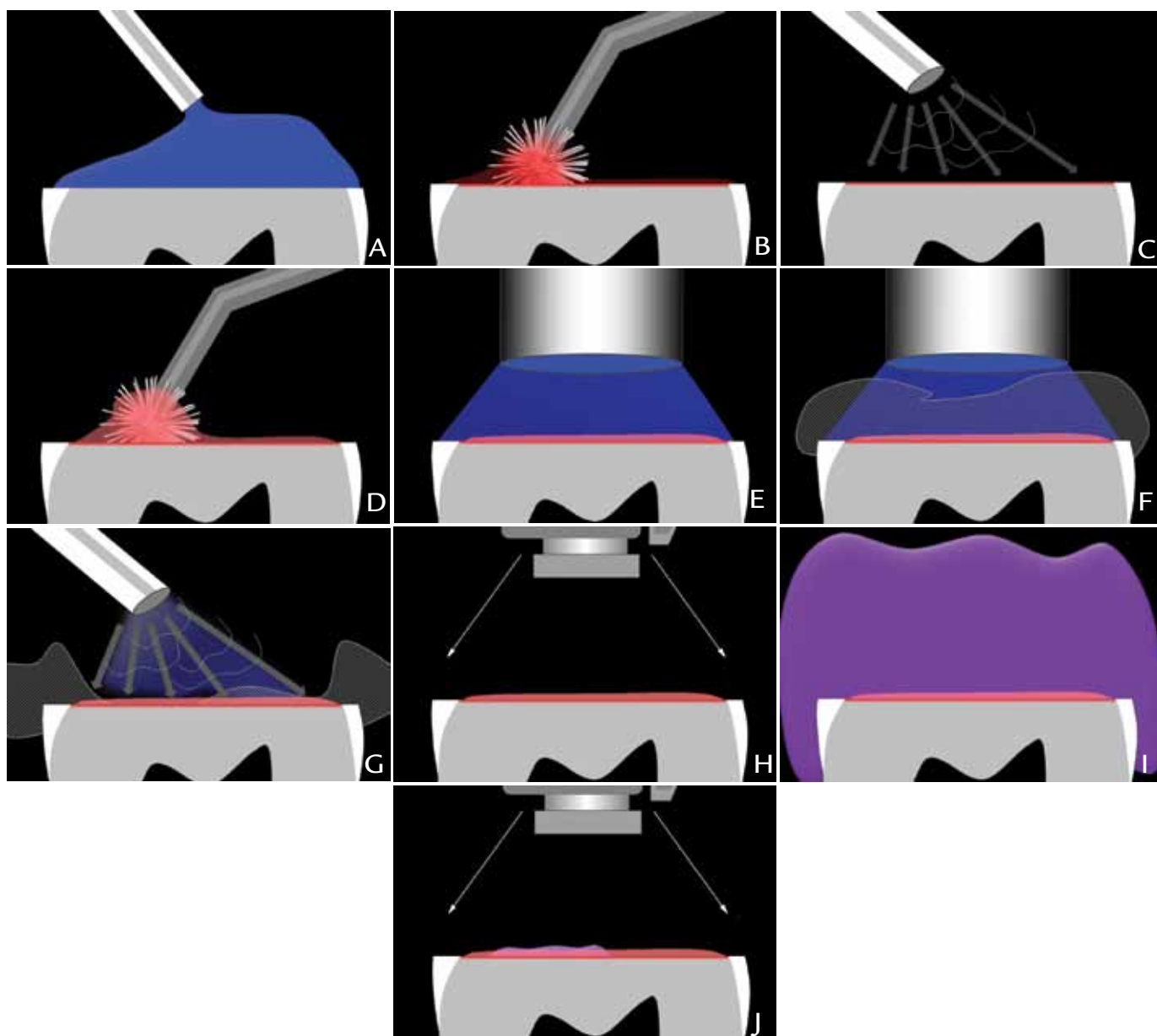
2 IDS group. A, Etching (not required with SE Bond). B, Priming. C, Gentle air drying. D, Application of adhesive resin. E, Light polymerization. F, Evaluation. G, Impression. H, Evaluation.

Italy), flat midcoronal dentin surfaces were created and finished with 600-grit SiC paper (GatorGrit; Ali Industries, Fairborn, Ohio) under water until a smooth dentin surface was obtained. The surfaces were evaluated for the presence of any remaining enamel, which was removed by additional trimming/finishing when observed. For easier handling, teeth were mounted in an acrylic resin base (Palapress Vario; Heraeus Kulzer, Armonk, NY), embedding the root up to 3.0 mm below the cemento-enamel junction (CEJ). The prepared surface of each tooth was assessed following 1 of 4 treatments: control group

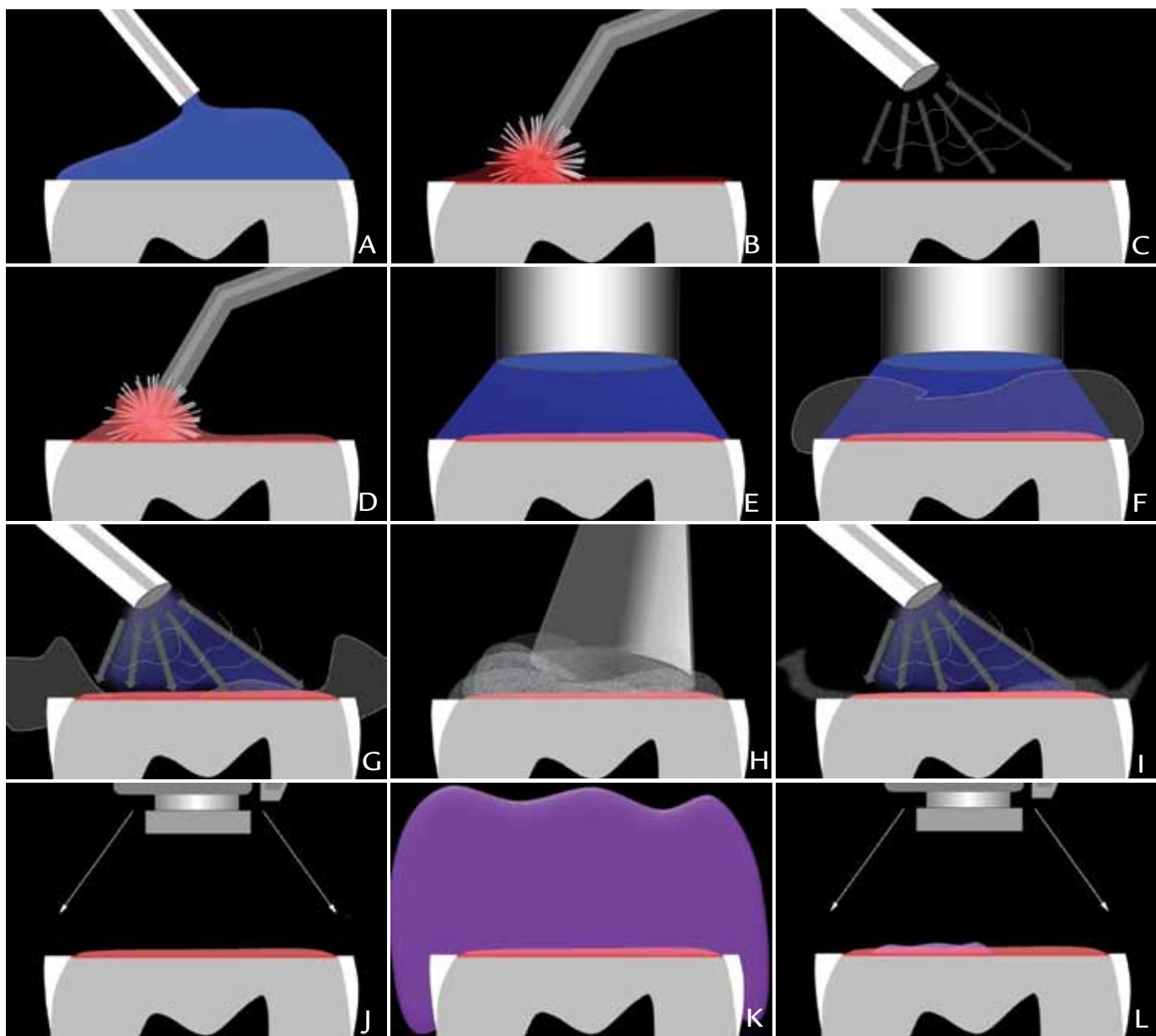
(Fig. 1): the unsealed tooth surface underwent impression; IDS group (Fig. 2): IDS was used and followed by impression making; IDS/AB group (Fig. 3): IDS was followed by air blocking and impression. Air blocking was accomplished by applying a 7-mm-thick layer of glycerin jelly (K-Y Jelly; Personal Products Co, Skillman, NJ) to the sealed surface and beyond with an additional 10 seconds of light polymerization at 800 mW/cm² and a 3-mm tip-to-specimen distance (Rembrandt Allegro LED Curing Light; Den-Mat, Santa Maria, Calif) to eliminate the air-inhibited layer of the resin. The glycerin jelly was then

easily removed by rinsing with water. In the IDS/AB-P group (Fig. 4), IDS was followed by air blocking, pumicing, and impression. Pumicing was accomplished by gentle application of a pumice-water mix with a soft rubber prophyl cup and a slow-speed handpiece at 500 rpm.

Each trial was repeated using the same teeth (following nondestructive removal of the adhesive with a blade and refinishing of the dentin surface with 600-grit SiC paper) with 4 different combinations of DBA and impression materials. A 3-step etch-and-rinse system (Optibond FL; Kerr Corp, Orange, Calif) and a 2-step



3 IDS/AB group. A, Etching (not required with SE Bond). B, Priming. C, Gentle air drying. D, Application of adhesive resin. E, Light polymerization. F, Air blocking. G, Rinsing/drying. H, Evaluation. I, Impression. J, Evaluation.



4 IDS/AB-P group. A, Etching (not required with SE Bond). B, Priming. C, Gentle air drying. D, Application of adhesive resin. E, Light polymerization. F, Air blocking. G, Rinsing/drying. H, Pumicing with soft rubber cup. I, Rinsing/drying. J, Evaluation. K, Impression. L, Evaluation.

self-etching system (Clearfil SE Bond; Kuraray Medical, Tokyo, Japan) were evaluated (both were used according to the manufacturer's instructions) in combination with 2 impression materials, a 2-phase VPS (Extrude Extra and Extrude Wash; Kerr Corp), and a monophasic polyether (Impregum Soft Medium Body; 3M ESPE, St. Paul, Minn) ($n=6$). Optical light microscopy of up to $\times 10$ magnification was used to examine the surface of the adhesive resin before and after air blocking and pumicing, as well as to examine the presence of unpolymerized and residual impression material

left on the treated tooth surface.

RESULTS

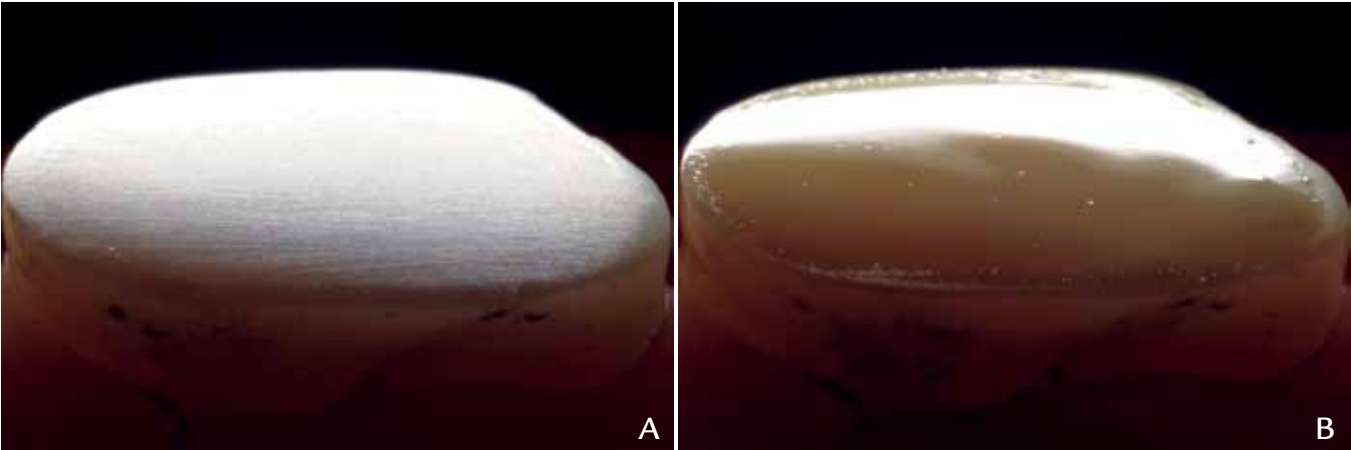
All results are presented in Table I. There were no specific observations for the control group. In the IDS group, unpolymerized impression material was found at the surface of all specimens, generally covering the entire preparation surface (Figs. 5 and 6), regardless of the type of adhesive or impression material used. Large amounts of unpolymerized Impregum Soft were found at the enamel margins (Fig. 6, B) when using Optibond

FL for IDS.

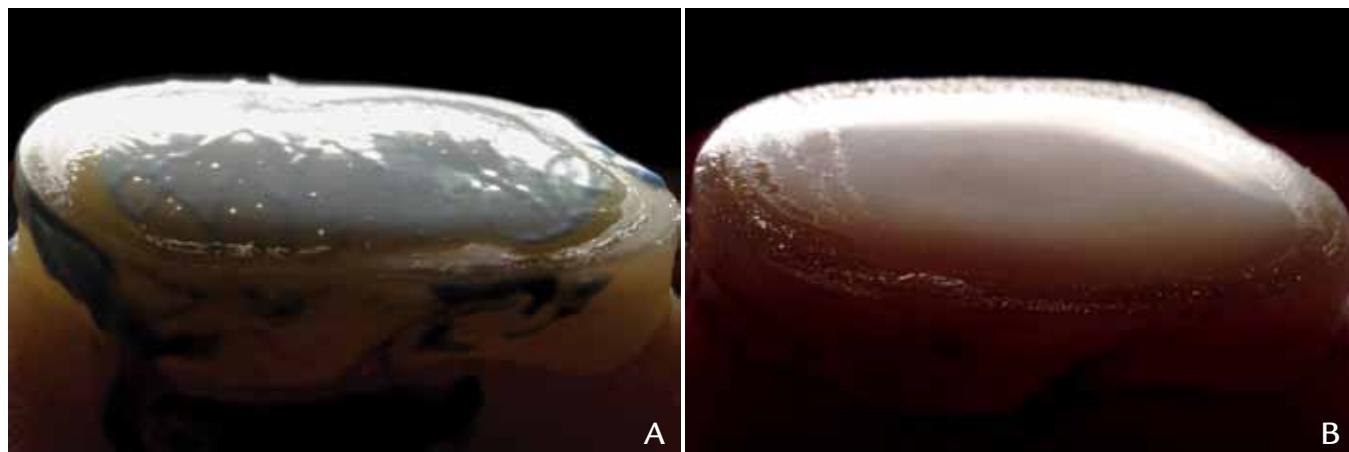
In the IDS/AB group, the effect of air blocking was markedly different between Optibond FL and Clearfil SE Bond. While air blocking Optibond FL left a smooth resin coating (Fig. 7, A), SE Bond was characterized by more surface irregularities (Fig. 7, B). Different results were also observed following the impression-making procedure. Optibond FL in combination with Extrude showed a result similar to the IDS group (unpolymerized impression material on all specimens), but displayed a much thinner unpolymerized residue (Fig. 8, A). Howev-

TABLE I. Results

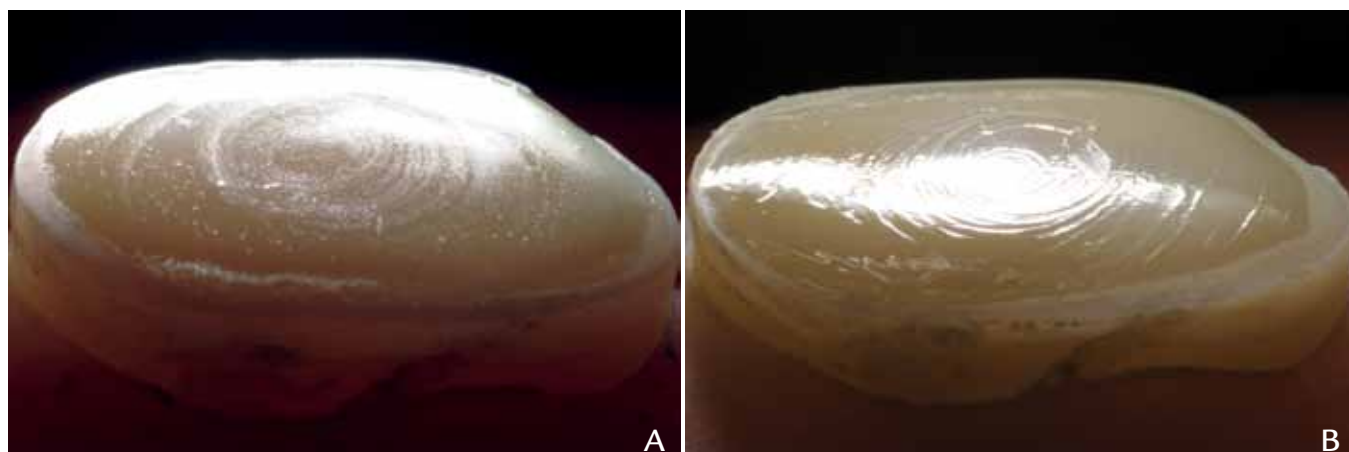
			Extrude		Impregum Soft	
			Optibond FL (N=6)	SE Bond (N=6)	Optibond FL (N=6)	SE Bond (N=6)
Control group	No IDS (Control)	after impression	Impressions without defects, 100%			
IDS group	IDS	before impression	Adhesive smooth, 100%			
		after impression	Unpolymerized impression material on tooth surface, 100%			
IDS/AB group	IDS + air blocking	before impression	Adhesive smooth, 100%	Adhesive rough, 100%	Adhesive smooth, 100%	Adhesive rough, 100%
		after impression	Unpolymerized impression material on tooth surface, 100% (all over surface)	Impressions without defects, 100%	Impressions without defects, 66.6%	Unpolymerized impression material on tooth surface, 66.6%
					Impressions with adherences, 33.3%	Impressions with adherences, 33.3%
IDS/AB-P group	IDS + air blocking + pumicing	before impression	Adhesive smooth, 100%	Adhesive rough, 100%	Adhesive smooth, 100%	Adhesive rough, 100%
		after impression	Impressions without defects, 100%		Impressions without defects, 33.3%	Impressions without defects, 50%
					Impressions with adherences, 66.6%	Impressions with adherences, 50%



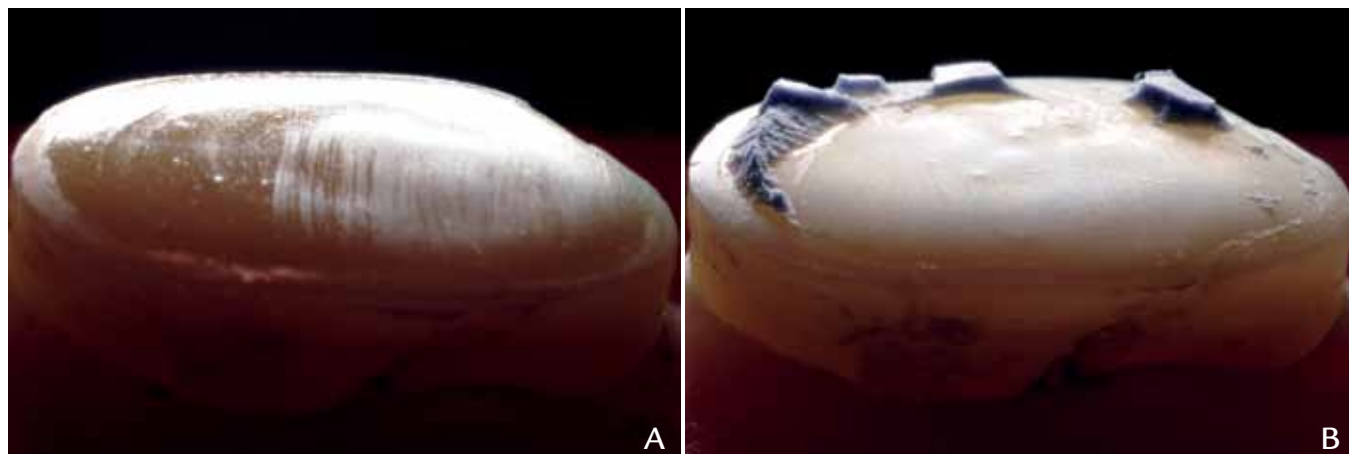
5 A, Specimen before, and B, after immediate dentin sealing (including light polymerization) with Optibond FL.



6 A, Unpolymerized impression material in IDS group, SE Bond with Extrude, and B, Optibond FL with Impregum Soft.



7 A, Specimens after IDS and air blocking (before impression) of Optibond FL, and B, SE Bond.



8 A, Optibond FL specimen after IDS and air blocking, following impression with Extrude. Note thin layer of unpolymerized impression material (swabbed off on right half of tooth surface). B, Following pumicing (IDS/AB-P group) and impression with Impregum Soft, adherences could be found in majority of Optibond FL specimens.

er, air-blocked SE Bond with Extrude generated defect-free impressions. Following impressions made with Impregum Soft, both air-blocked adhesives displayed some adhesion and tearing of impression material.

In the IDS/AB-P group, the ad-

ditional step of pumicing slightly smoothed the surface of the air-blocked SE Bond and further softened the surface of Optibond FL. Both pumiced surfaces generated ideal impressions with Extrude. By contrast, both adhesives displayed

a high frequency of torn adhesions when pumiced before impression making with Impregum Soft (Fig. 8, B). Such adhesions were not found following impression making with Extrude.

DISCUSSION



The immediate dentin sealing (IDS) concept was originally suggested as a protection for the pulp¹ and was later shown to provide optimized bond strength and marginal and internal adaptation.²⁻⁵ The idea of having an additional resin coating placed on the preparation raised concerns about the thickness of this coating and possible interferences with complete seating of the restoration. This dilemma was resolved by proper sequencing of the procedure and placement of the DBA before impression making.⁶

Impression materials have their own catalyst; therefore, no interferences with DBAs were expected, in theory.²⁰ However, IDS-group impressions in the present study were faulty. It is clear that, unless it is removed, the OIL will inhibit the polymerization of both VPS and polyether materials. The use of glycerin and air blocking (IDS/AB group) significantly reduced the thickness of the OIL, but close examination revealed that a thin OIL was still present with Optibond FL even following air blocking and additional light polymerization. As a result, the resin-coated surface was still slightly tacky. This could explain the residual inhibition of Extrude in group IDS/AB (Fig. 8, A), which appeared more discrete than in the IDS group. There may be a “concentration effect,” the thinner OIL with air blocking producing a thinner layer of inhibited impression material. Because the use of die spacer is necessary for indirect restorations, this may not affect the accurate fit of restorations. The contamination of the resin coating by the impression material, however, remains an issue, as it may alter the bond between the existing resin coating and the luting agent. Therefore, it is recommended that the resin-coated preparation surface be thoroughly cleaned using a diamond rotary cutting instrument at low speed or by airborne-particle abrasion just prior to cementation.^{5,10,12} The residual inhibition phenomenon was not observed

using SE Bond with air blocking and Extrude (all impressions were without defect), probably because it created a thinner adhesive layer than Optibond FL and air blocking was, therefore, more effective. Air blocking seemed to slightly affect the surface of SE Bond, which was more irregular than Optibond FL (compare Figs. 7, A and B). SE Bond is significantly less viscous than Optibond FL because of its reduced filler content and can be more easily displaced and “wrinkled” when applying the glycerin jelly. Impregum Soft generated 100% faulty impressions with air-blocked SE Bond adhesion and tearing of both air-blocked DBAs in 33% of the specimens. This interaction may be explained by the polarity (ionic polymerization) and hydrophilicity of the material. No such phenomenon was observed with Extrude. The presence of HEMA (2-hydroxyethyl methacrylate), a well known hydrophilic monomer, in the adhesive resin of both DBAs, as well as the high stiffness and low tear strength of polyethers,²⁶ constitute potential causes for the development of these adhesions.

While additional pumicing of the resin coating (IDS/AB-P group) was not successful to smooth the wrinkled air-blocked SE Bond surface, it generated smooth surfaces of the Optibond FL resin coatings and was shown to be the ideal surface treatment for impressions with Extrude (100% defect-free regardless of the type of DBA). Pumicing the DBA surface increased the risk of development of adhesions and tearing (up to 50% to 67% of impressions) with Impregum Soft. It may be hypothesized that pumicing produced a rougher surface and promoted chemical interaction, while a weak tear strength will produce the adhesions.

Limitations of this study include the small sample size and the in vitro nature of this experiment. Further studies are needed to elucidate the exact mechanism of these interactions and allow the optimization of DBAs or the development of surface condi-

tioners for the application of IDS in combination with polyether impression materials.

CONCLUSIONS

Within the limitations of this in vitro qualitative evaluation, it can be concluded that both air blocking and pumicing the existing resin coatings are necessary to obtain defect-free Extrude impressions, regardless of the type of DBA. At this time, Impregum Soft cannot be recommended with IDS because of a high incidence of faulty impressions (unpolymerized impression material, adhesion, and tearing).

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NOTEWORTHY ABSTRACTS OF THE CURRENT LITERATURE

Impact of thermal misfit on shear strength of veneering ceramic/zirconia composites

Fischer J, Stawarczyk B, Trottmann A, Hämmerle CH.
Dent Mater 2009;25:419-23. Epub 2008 Nov 6.

Objectives: Thermal misfit is discussed as one reason for chipping of veneered zirconia restorations. The aim of the investigation was to assess the effect of thermal misfit on the shear strength of zirconia/veneering ceramic composites.

Methods: Shear strengths of 12 different veneering ceramic/zirconia composites were measured ($n=10$). The veneering ceramics were fired onto polished Y-TZP. In order to create a strong thermal mismatch, one of the veneering ceramics was intended for use on alumina and one for the metal-ceramic technique. The glass transition temperatures of the veneering ceramics and the coefficients of thermal expansion of all ceramics were measured ($n=6$). Statistical analysis was performed with one-way ANOVA and a post hoc Bonferroni test ($p<0.05$).

Results: Shear strength ranged from 21.9 ± 6.2 to 31.0 ± 7.1 MPa. The ceramic for the metal-ceramic technique showed spontaneous debonding. The differences in the coefficients of thermal expansion of core and veneer ($\Delta\alpha$) were calculated. In addition the differences between glass transition temperatures of the veneering ceramics and room temperature (ΔT) as the effective temperature range for stress formation were calculated. Highest shear strength was observed when $\Delta\alpha\Delta T \approx 1000 \times 10^{-6}$.

Conclusions: Thermal expansion and glass transition temperature of the veneering ceramic have an impact on the shear strength of veneer/zirconia composites.

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