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Journal of Prosthodontic Research

journal homepage: www.elsevier.com/locate/jpor

Review

Immediate dentin sealing for indirect bonded restorations

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ARTICLE INFO

Article history:
Received 27 October 2015
Received in revised form
27 March 2016
Accepted 3 April 2016
Available online 27 April 2016

Keywords:
Immediate dentin sealing
Resin coating technique
Pre-hybridization
Dentin adhesion
Dental coatings
Dentin bonding
Resin sealing

ABSTRACT

Purpose: The aim of this article is to review available literature on the clinical procedure of immediate dentine sealing for indirect bonded restorations.
Study selection: More than 40 articles reporting the technique, studies, outcomes, etc. were reviewed after PUBMED/MEDLINE search, most of them addressing the specific situation of dentin bonding for indirect restorations.
Results: It is known that tooth preparation for indirect bonded restorations can result in significant dentin exposures. Immediate application and polymerization of the dentin bonding agent to the freshly cut dentin, prior to impression making is therefore recommended by some authors. Literature indicates that this procedure, *immediate dentine sealing (IDS)*, appears to achieve improved bond strength, fewer gap formations, decreased bacterial leakage, and reduces post-cementation sensitivity. This rational approach to adhesion is also reported to have a positive influence on tooth structure preservation, patient comfort, and long term survival of indirect bonded restorations.
Conclusion: In the extensive literature regarding advantages of using IDS technique significant differences have been shown when compared to Delayed Dentine Sealing. Although more research is required in this field, presently there are NO scientific reasons not to recommend IDS in routine practice.

Contents

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http://dx.doi.org/10.1016/j.jpor.2016.04.001
1883-1958/

1. Introduction

Management of the dental tissues between the preparation and provisionalization phase of restorative treatment plays a pivotal role in the success of indirect bonded restorations. In the development of these restorations, the exposed vital dentin immediately after tooth preparation is susceptible to insult from bacterial infiltration and micro-leakage during the provisionalization phase. Bacterial and fluid penetration through the exposed dentinal tubules can result in colonization of microorganisms, post-operative sensitivity, and the potential for subsequent irritation of the pulp. To avoid these possible sequelae, whenever a substantial accessible area of dentin has been exposed during tooth preparation for indirect bonded restorations, local application of a dentin bonding agent (DBA) is recommended [1]. This immediate application of a DBA prior to provisionalization phase for indirect bonded restorations has been proposed since the early 1990s [1–5]. The so-called *immediate dentin sealing (IDS)* [1] has been extensively studied and significantly improved over the years with positive results with respect to bond strength, gap formations, bacterial leakage, and post-cementation hypersensitivity.

The principle of dentin bonding is to create an interphase, also called *the hybrid layer* [6,7] by the interpenetration of monomers into the hard tissues. Once the infiltrating resin is polymerized, it can generate a "*structural*" bond somewhat similar to the interphase formed at the dentinoenamel junction (DEJ) [8]. Some basic principles need to be followed during the clinical procedure of dentin–resin hybridization, the most important ones being related to the problems of (1) dentin contamination and (2) susceptibility of the hybrid layer to collapse until it is polymerized. These factors when viewed within the frame of indirect bonded restorations lead to the conclusion that dentin should be sealed immediately after tooth preparation.

The rationale behind IDS could be enumerated as [2]:

A. Freshly cut dentin is the ideal substrate for dentin bonding.

Dentin contamination owing to provisionalization can reduce the potential for dentin bonding. Various studies by Paul and colleagues [2,3,9] demonstrated significant reductions in bond strength owing to dentin contamination with various provisional cements. In practice, freshly cut dentin is present only at the time of tooth preparation (before impression making).

B. Pre-polymerization of the DBA leads to improved bond strength [10,11]

The unpolymerized dentin–resin hybrid layer collapses due to pressure during composite placement or seating of the restoration [12–14]. Pre-polymerization of DBA is absolutely compatible with direct composite restorations; however, it raises concerns when applied during the luting of indirect bonded restorations. Polymerized DBA thicknesses can vary significantly depending on both the type of DBA and the topography of the tooth preparation. Stavridakis et al. [15] recorded film thicknesses of DBA that ranged from 0 to 500 μm. Various other authors [13,16] have also demonstrated polymerized DBA thicknesses to range from 60 to 80 μm on a smooth convex surface and up to 200–300 μm on concave structures such as marginal chamfers, hence, interfering with the complete seating of the restoration. It is therefore recommended that the DBA be kept unpolymerized before the restoration is fully seated. This, in turn, generates two problems: (a) while the restoration is being inserted, the outwardly directed flow of dentinal fluid dilutes the bonding agent and blocks microporosities into which resin otherwise would have penetrated [17,18] and (b) the pressure of the luting resin during the seating of the restoration can create a collapse of demineralised dentin and subsequently affect adhesion. All these problems can be resolved with IDS after completion of tooth preparation, before final impression itself.

C. Immediate dentin sealing allows stress-free dentin bond development

Dentin bond develops progressively over time owing to the completion of the co-polymerization process. In directly placed adhesive restorations, the weaker early dentin bonding is challenged by the overlaying composite shrinkage and occlusal forces. On the other hand, when using IDS and

indirect bonded restorations, the delayed placement of the restoration and post-poned occlusal loading facilitate the dentin bond to develop without stress [19].

D. Immediate dentin sealing prevents bacterial leakage and sensitivity during provisionalization

2. Immediate dentin sealing technique [2]

2.1. Dentin identification

The first step towards IDS is the identification of exposed dentin surfaces. A simple method is to proceed to a short etching (2–3 s) followed by thorough drying of the prepared surfaces. Dentin can be easily recognized because of its glossy appearance while enamel is frosty. After this initial etch, the dentin surface must be re-prepared to expose a fresh layer of dentin and re-etched before the application of DBA.

2.2. Preparation depth

DBA thickness can reach several hundred micrometres when applied to concave areas. In case of porcelain veneers, the application and polymerization of DBA would significantly reduce the space left for ceramic build up which can negatively affect the stress distribution within porcelain. Hence, IDS is not indicated for very superficial dentin exposures.

2.3. Adhesive technique

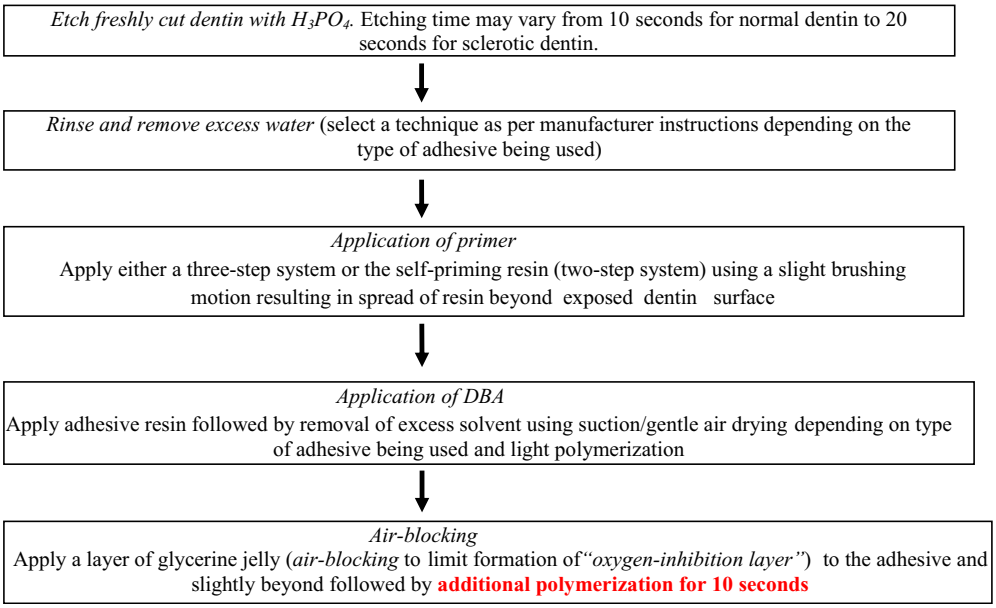
The technique described focuses on the use of total-etch technique (also called "etch and rinse"), as recommended by Magne [2], which may include either three-step (separate primer and resin) or two-step (self-priming resin) DBA.

3. Data resources

A search of English language peer-reviewed dental literature was designed to identify evidence supporting the efficacy of IDS for indirect bonded restorations. Keywords or phrases included immediate dentin sealing, resin coating technique, pre-hybridization, dentin adhesion, dental coatings, dentin bonding and resin sealing. PUBMED search was conducted focusing on evidence-based research articles published between 1990 and December 2014. A hand search of relevant dental journals was also completed.

Titles and/or abstracts of articles identified through the electronic searches were reviewed and evaluated for their appropriateness. Suitable articles were subjected to inclusion and exclusion criteria. Articles that did not focus exclusively on IDS for indirect bonded restorations were excluded from further evaluation.

The majority of studies are in vitro investigations [19–52]. They mainly concentrate on effect of IDS on the bond strength or adaptation of definitive restorations [3,5,15,19–25], interaction of IDS with impression materials [26–36] and post-cementation hypersensitivity [47–52]. Other factors evaluated with respect to the bond strength of definitive restoration included the type of bonding system used [20–22], film thickness of DBA [15,23,24], effects of provisional restorations [2,37], provisional cements [2,25,38–41], provisionalization period [32,46] and dentin conditioning agents [2,15,20,21,32,36,41–45].



4. Review

4.1. *Bond strength or adaptation of indirect restorations*

Successful dentin bonding is of paramount importance for dentin-bonded porcelain crowns and veneers because it determines the final strength of the tooth-restoration complex. Traditionally, Delayed Dentin Sealing (DDS) is performed with indirect restorations wherein dentin is sealed after the provisionalization phase at the final cementation appointment. But this chronology has been demonstrated to produce inferior bond strength as compared to IDS and also causes incomplete seating of the restoration [3,5,19].

4.1.1. *Type of bonding system*

Magne et al. [20], in their study, demonstrated that the mean Micro Tensile Bond Strength (MTBS) of a three-step etch-and-rinse dentin bonding agent for IDS group was five times that for DDS group. Duarte et al. [21] established that IDS resulted in high bond strengths for total-etch as well as self-etch dentin bonding agents; Sahin et al. [22] in their experiment tested etch-and-rinse and self-etch bonding agents for their ability to block the permeability of initially infused dentin wherein only the one-step self-etch bonding agent G-bond (GC Corp., Tokyo, Japan) and the two-step self-etch bonding agent Clearfil protect bond (Kuraray Medical Inc., Okayama, Japan) were more effective at sealing the dentin than original smear layer.

4.1.2. *Film thickness*

Lee and Park [23] demonstrated that the shear bond strength of indirect bonded restorations to dentin can be improved by application of DBA before impression making, thinning of DBA by gentle air drying and then light polymerization before cementation procedure. This erases any concerns about pooling of the bonding agent causing problems with restoration fit as it is applied and light activated prior to impression making. When DBA is not light-polymerized before cementation, particularly if the exposed dentin has not been sealed before making the impression, the exposed, decalcified collagen can collapse during the cementing procedure as a consequence of the pressure applied in the process. This can lead to a faulty hybrid layer and failure of an indirect restoration.

Stavridakis et al. [15] in their study demonstrated that a filled DBA (Optibond FL) presented a more uniform film thickness compared to an unfilled DBA. An additional advantage of using a filled adhesive would be lesser risk of re-exposing the dentin during cleaning of the preparation prior to final cementation. Dietschi et al. [24] studied various parameters influencing the marginal and internal seal of bonded restorations and specifically stressed on the important role that the adhesive configuration (enamel-dentin ration and bonding agent) plays in achieving same.

4.1.3. *Type of cement*

Though self-adhesive resin cements were designed to bond without any pre-treatment of dentin, pre-treatment such as resin sealing of dentin with priming/bonding solutions might influence the bonding quality of self adhesive resin cements. Sailer et al. [25] in their study demonstrated that resin sealing of dentin increased the bond strength of self-adhesive resin cement RelyX Unicem (3M ESPE, St. Paul, Minn) but had no significant effect on conventional resin cements Variolink II (Ivoclar Vivadent, Schaan, Lichenstein) and Panavia 21 (Kuraray, Tokyo, Japan).

4.2. *Interaction with impression materials*

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. The final impression of the resin-coated preparation surface poses a challenge since dentin bonding agents show a superficial oxygen-inhibition layer (OIL) when they are light polymerized [26–28]. 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 [28,29]. The OIL may in turn inhibit the polymerization of vinyl polysiloxane (VPS) impression materials, depending on the type of DBA [30].

The thickness of the OIL can be reduced by the application of a glycerine jelly (“air blocking”) to the sealed surface followed by additional 10 s of light polymerization [31] which is usually recommended in the IDS technique [2,13,20,32,33]. The thinner OIL will produce a thinner layer of inhibited impression material which will not affect the accurate fit of restorations because a die spacer is anyway used for indirect restorations.

Magne and Nielsen [33] demonstrated that the incompletely polymerized resin coating can inhibit the polymerization reaction of impression materials. Successful VPS impressions of resin coated surfaces can be obtained by air blocking and pumicing before making an impression whereas with polyether, air blocking/pumicing results in impression defects due to adhesion and subsequent tearing of impression material. The presence of HEMA (2-hydroxyethyl methacrylate), a well known hydrophilic monomer, in the adhesive resin of DBAs, as well as the high stiffness and low tear strength of polyethers, constitute potential causes for the development of these adhesions.

Another technique that has been suggested to reduce or eliminate the OIL is to wipe the sealed surface with a cotton pellet soaked in 70% ethyl alcohol for 10 s [34]. Ghiggi et al. [34] in 2014, evaluated the interaction between the resin materials [Clearfil SE Bond (Kuraray, Tokyo, Japan) and Protect Liner F (Kuraray, Tokyo, Japan)] used in immediate dentin sealing technique and impression materials (Express XT vs Impregum) with two different techniques (a) additional polymerization with glycerine jelly (b) cotton pellet soaked in alcohol, to eliminate the oxygen-inhibition between the resin materials and the impression materials. Different interaction types occurred between the resin materials and the impression materials. For vinyl polysiloxane, unpolymerized impression material remained over the resin materials due to reaction of the monomers in the OIL with the platinum salt. For the polyether, polymerized impression material remained joined to the resin materials due to reaction of the initiator agent of the polymerization reaction of polyether with the free radicals of the monomers from the resin materials on the surface.

This type of interaction renders the use of polyether impractical.

In cases where space permits, Bruzi et al. [35] advocated that covering the IDS layer with a liner (flowable/composite) resolves the issues of any interaction with impression materials. The type of liner and application technique seems to affect the bond strength of final restoration [36]. More studies are required to confirm the effect of liner application on bond strength of final restoration.

Since most of the techniques suggested by various authors only limit the formation of OIL and not eliminate it completely, it is therefore recommended that the resin-coated preparation surface be thoroughly cleaned using a diamond rotary cutting instrument at low speed or by air-borne-particle abrasion just prior to cementation [20,32,33].

4.3. *Interactions during provisionalization*

4.3.1. *Type of provisional restorative material*

Most provisional restorative materials have been proven to be incompatible with IDS [37]. It has been observed that direct bisacryl materials [e.g. Integrity (Dentsply, De Trey, Germany)] bond to the sealed surface inspite of the removal of oxygen inhibition layer. This results in cutting the restoration off the tooth and re-preparing it. Direct acrylic-based provisional restorations [e.g. Duraseal (Reliance Dental Manufacturing)] fail to seal the preparations adequately resulting in contamination of IDS surface and a tendency to lose retention in the weeks before cementation appointment especially with inlay and onlay preparations. Specifically with regards to inlay and onlay preparations proprietary materials (e.g. Telio CS inlay/onlay and Fermit; Ivoclar Vivadent) which are polymers of methacrylates are available for use with IDS technique. In case of porcelain laminate veneer preparations and partial or full veneer tooth preparations, Magne [2] suggests isolation of the sealed dentin with a separating medium like petroleum jelly during direct fabrication of the provisional restoration to prevent bonding of provisional materials to sealed dentin. Proprietary materials meant to achieve isolation of sealed dentin from provisional materials are available e.g. Pro-V Coat by BISCO. Pro-V Coat is a water-soluble separating agent manufactured solely for use with IDS technique. The IDS surface is lubricated with Pro-V Coat, gently air-dried from a distance of 8–10 cm from the preparation for 10–15 s to evaporate the solvent.

4.3.2. *Type of provisional cement*

Remnants of the provisional cements used to lute provisional restorations have been demonstrated to influence the bond strength of the final restoration. Cementation in case of inlays and onlays is not a concern as provisionalization technique for these restorations prohibits use of provisional cements [38]. Additionally, use of provisional cements is discouraged for veneer provisional restorations, therefore negating this as a factor for contaminating the sealed surface [39]. Magne [2] discourages the use of resin based provisional cements as they have the potential to bond to the sealed dentinal surface. Altinas et al. [40] advised the use of calcium hydroxide since the teeth that received calcium hydroxide provisional cement showed higher bond strength of final restoration compared to light polymerized provisional cement and eugenol-free cements. On the contrary, Fonseca et al. [41] reported higher bond strengths of final restoration to teeth that received zinc oxide eugenol and eugenol free cements than with calcium hydroxide. Sailer et al. [25] concluded from his study that eugenol-free provisional cement does not affect the bond strength of self-adhesive resin cement RelyX Unicem (3M ESPE, St. Paul, Minn) or conventional resin cement Variolink II (Ivoclar Vivadent, Schaan, Lichenstein) but reduces the strength of Panavia 21 (Kuraray, Tokyo, Japan).

4.3.3. *Conditioning methods*

Regardless of the use of a conventional or resin cement, proper cleaning of the abutment teeth is critical to avoid impairment of the etching quality of the tooth surface, the infiltration of the adhesive system, inhibition of polymerization of the resinous monomers and hence the final bonding and marginal adaptation of the restoration [42].

Various authors have evaluated methods for removal of provisional cement in vitro. Reviewing these studies, it was found that the highest bond strength values were reported with soft-air abrasion [43], air borne particle abrasion with aluminium oxide [20,32,36,42] and fluoride-free pumice paste systems [2,21,44]. Falkensammer et al. [45] demonstrated that polishing and air borne particle abrasion with silicoated aluminium oxide or glycin are equally efficient methods of conditioning IDS surfaces.

Although a critical element regarding the conditioning of immediately sealed dentin for restoration delivery is to detect the possible re-exposure of dentin after cleaning the preparation. Stavridakis et al. demonstrated in their study that the danger of re-exposure of dentin due to conditioning methods may not be critical if a filled DBA (OptiBond FL) is used [15].

4.3.4. *Provisionalization period*

When dealing with a complex restoration, there may be an inevitable delay until the final restoration is delivered from the laboratory. Burtscher et al. [46] demonstrated that the extinction rate of free radicals that promote co-polymerization between sealed dentin and luting resin is highly product dependent, and therefore, a prolonged interim period may influence the interface (IDS layer-luting resin) quality and stability. However according to Magne [32], optimal bond strength can be achieved between the definitive restoration and the sealed dentinal surface even up to an extended provisionalization phase of 12 weeks, proving that free radicals within the resin seem to decay slowly and remain available for bonding up to 12 weeks. This aspect needs to be substantiated with further studies.

4.4. *Placement of final restoration*

Just before the cementation of definitive restoration, it is recommended to roughen the existing adhesive resin using a coarse diamond bur at low speed or by micro-sandblasting. Surfaces sealed with an unfilled dentin bonding agent should be cleansed gently with a soft brush and pumice only [2]. The entire tooth preparation surface can then be etched with H_3PO_4, rinsed, dried and coated with bonding agent. At this stage pre-polymerization of bonding agent is not indicated as

it would prevent the complete seating of the restoration. For the final cementation, zinc phosphate cement should be avoided as the bonding agent alone fills in the tiny scratches on the external surface of the preparation thus drastically reducing any available mechanical retention. Resin cement would be the cement of choice for final cementation since it will bond chemically to the IDS treated substrate. Further, the resin cements exhibit low solubility leading to less leakage over time.

4.5. *Post-cementation sensitivity*

Post-cementation hypersensitivity is a symptom characterized by a short, sharp pain when introducing thermal and chemical stimuli to the vital abutment teeth after a newly cemented crown or fixed partial denture is placed [47]. This type of hypersensitivity would be self-healing in most cases, but it may also last for a long time. In general, the perceived sensitivity will disappear 24 months after cementation [48]. The treatment strategy for dentinal hypersensitivity is based on either interfering with the sensitivity of the mechanoreceptors or occluding the dentinal tubules .A large number of products and methods have been developed to cure dentinal hypersensitivity. Immediate dentin sealing is a new approach to seal the dentin before impression making with which patients experience improved comfort during provisional restoration stage, limited need for anaesthesia during insertion of definitive restoration, and reduced post-operative sensitivity. Jun hu et al. [49] in their study showed that preventive treatment with Prime & Bond (5th gen dentin bonding agent that combines primer and bond component in single bottle) using the IDS technique could significantly reduce post-cementation hypersensitivity. The choice of the bonding system to be used in IDS procedure is also critical with regard to dentin sensitivity. The self-etch systems are less technique sensitive and have higher qualitative and quantitative capacity of penetration than conventional system pointing out a tendency towards minimizing post-operative sensitivity [50]. There is inadequate literature available at present on a consolidated protocol and clinical effectiveness of IDS procedure to minimize hypersensitivity [51]. Hence further studies are necessary. Besides dentinal sealing, film thickness of the luting resin also appears to influence the incidence of post-cementation sensitivity. Feilzer et al. [52] in their study established that the film thickness of the luting resin governs the wall-to-wall contraction of the same which in turn affects the stability of the adhesive interface. Therefore, authors recommend that to decrease post-cementation sensitivity manufacturer recommendations for film thickness of luting resin be followed.

A summary of studies evaluating various factors influencing IDS technique is illustrated in Table 1.

5. Discussion

The immediate dentin sealing protocol has been proposed as an effective technique of sealing the dentinal tubules in order to prevent or reduce bacterial contamination and tooth sensitivity during the provisionalization phase while also enhancing the bond strength of the final restoration [2]. The principal concern regarding this technique would be how the intervening layer of DBA applied at the preparation appointment would influence the retention and placement of the final restoration. The study by Magne et al. [20] strongly suggests that the IDS technique provided improved the bond strength of the final restoration. This increased bond strength has been demonstrated with both total-etch and self-etch dentin bonding agents [20–22].

In addition to bond strength, many other factors require consideration one of which relates to the film thickness of the bonding agent and its influence on the fit of the final restoration. Studies [13,15,16] have shown that DBA thickness can reach several hundred micrometres when applied to concave areas. Stavridakis et al. [15] demonstrated that the filled DBA presented a more uniform film thickness compared to the unfilled one. Considering that DBA being used for IDS is applied and polymerized prior to impression making, concerns regarding its thickness influencing the seating of the restoration are redundant. Just before placement of the final restoration a single layer of DBA is applied onto the tooth surface following which the restoration carrying the luting agent is seated onto the prepared tooth and the unpolymerized layer of bonding agent and luting cement are polymerized together.

Considering the preceding discussion about polymerization of DBA it is important to discuss the unfavourable interaction of OIL with certain elastomeric impression materials especially polyether rendering its use impractical [33]. There is enough evidence in literature to suggest that use of glycerine gel with additional polymerization for 10 s (*Air-blocking*) has been used as part of IDS protocol to address the occurrence of OIL [2,13,20,32,33]. Another alternative to use of glycerine in IDS technique involves swabbing the sealed dentinal surface with a cotton pellet pre-soaked in 70% ethyl alcohol for 10 s [34] or covering the IDS surface with a liner (flowable composite) if space permits [35]. Although removal of OIL using alcohol swabbing needs to be performed with caution as it may result in significant thinning of the adhesive layer which may in turn result in dentin exposure during pre-cementation cleaning of the tooth preparation.

In addition to impression making, the provisional restoration stage also demands caution while using IDS technique because sealed dentin surfaces have the potential to bond to resin based provisional materials and cements making retrieval and removal of provisional restorations extremely difficult. Therefore, tooth preparation must be isolated with a separating medium like petroleum jelly or PRO-V COAT (Bisco) during direct fabrication of provisional restorations and resin based provisional cements must be avoided [20]. Regardless of the use of a conventional or resin cement, proper cleaning of the abutment teeth prior to final cementation is critical to the final bonding of the restoration. Reviewing the literature it was found that soft-air abrasion [43], air borne particle abrasion with aluminium oxide [20,32,42], fluoride-free pumice paste systems [2,21,44], silicoated aluminium oxide and glycin [45] and use of rotary cutting instruments at low speed [20] are some of the efficient methods of cleaning the IDS surface. Dillenburg et al. [42] found that additional etching with H_3PO_4

Table 1 – Studies evaluating various factors influencing IDS technique.

Author	Study design	Study outcome
Type of bonding system		
Magne et al. [20]	Evaluated the differences in micro tensile bond strength (MTBS) to human dentin using IDS technique compared to delayed dentin sealing (DDS).	MTBS improved.
Duarte et al. [21]	Determined effectiveness of IDS using total-etch (adper single bond) or self-etch dentin adhesives (adper prompt-L pop) on MTBS.	High bond strength for both adhesives.
Sahin et al. [22]	Tested etch-and-rinse and self-etch bonding agents for their ability to block the permeability of previously infused dentin.	Only one-step self-etch bonding agent (G-Bond, GC) and two-step self-etch bonding agent (Clearfil protect bond, Kuraray) were more effective than original smear layer.
Film thickness		
Stavridakis et al. [15]	Evaluated the thickness of pre-polymerized DBA used for IDS of onlay preparations.	Filled DBA (OptiBond FL) presented a more uniform film thickness than unfilled one (Syntac classic).
Lee et al. [23]	Evaluated the effect of three variables on the shear bond strength (SBS) of indirect bonded restorations: IDS, thinning of dentin adhesive by air bowing before cementation and light polymerization of the dentin adhesive before cementation.	SBS improved.
Dietschi et al. [24]	Studied four variables: rigidity of the restoration substrate set up, cement thickness, adhesive configuration (enamel-dentin ratio and bonding agent) and luting agent influencing marginal and internal seal of bonded restorations.	Adhesive configuration plays an important role.
Type of cement		
Sailer et al. [25]	Evaluated the efficacy of dentin desensitizing or sealing methods on the SBS of self-adhesive resin cements (RelyX Unicem, 3M) and conventional resin cements (Variolink II and Panavia21).	Beneficial effect on bond strength of self-adhesive resin cement.
Interaction with impression materials		
Magne and Nielsen [33]	Assessed possible interactions between two impression materials (Extrude-PVS, Impregum Soft-PE) and resin coated tooth surfaces using two DBAs (Optibond FL & Clearfil SE Bond).	Air-blocking using glycerine jelly prevents interaction of PVS with sealed dentin. PE is not recommended in combination with IDS.
Ghiggi et al. [34]	Evaluated interaction between the resin (CSE & PLF) used in IDS techniques and impression materials (Express XT-PVS, Impregum-PE) using two different techniques to eliminate OIL (Glycerine Jelly, Alcohol Swabbing).	Glycerine Jelly and alcohol are equally efficient in preventing interaction with impression materials.
Bruzi et al. [35]	Evaluated the interaction between adhesive resins/liners (Optibond FL, Scotch bond universal, Optibond XTR & Filtek LS) and impression materials (Express STD-PVS & Imregum F-PE) when using IDS.	Liner resolved issues of any interaction with impression materials.
Magne et al. [36]	Evaluated the dentin bond strength using different methods of application of opaque resin to mask dentin discoloration.	Bond strength decreased.
Type of provisional cement		
Altinas et al. [40]	Evaluated the effect of three provisional cements: Eugenol-free provisional cement (Cavex), calcium hydroxide (Dycal) and light-polymerized provisional cement (Tempbond clear) and two cleansing techniques: dental explorer and air water spray or a cleaning bur (opticlean) on shear bond strength of porcelain laminate veneers.	Calcium hydroxide provisional cement and cleaning with a dental explorer are advisable.
Fonseca et al. [41]	Evaluated the effect of provisional cements: calcium hydroxide (Dycal), ZOE containing cement (Provy), zinc oxide eugenol-free cement (Tempbond NE) and cleaning techniques: hand scaler for 10 s, pumice–water slurry for 10 s, aluminium oxide sandblasting for 10 s on MTBS of final restoration.	Calcium hydroxide provisional cement demonstrated lowest bond strength values of final restoration.
Sailer et al. [25]	Tested the effect of provisional cement on the bond strength of dentin luted with self-adhesive (RelyX Unicem, 3M) and conventional resin cements (Variolink II & Panavia 21).	Contamination of dentin with provisional cement has no influence on the bond strength of self-adhesive resin cement.
Conditioning methods		
Dillenburg et al. [42]	Evaluated the effect of surface treatments (aluminium oxide, 37% phosphoric acid or combination of two) of the pre-polymerized adhesive layer in the IDS technique on MTBS of two-step etch-and-rinse adhesive systems.	Aluminium oxide alone or associated with 37% phosphoric acid gave high MTBS.

Table 1 (*Continued*)

Author	Study design	Study outcome
Rocca et al. [43]	Evaluated the influence of different surface treatments (soft air abrasions vs sandblasting) on marginal and internal adaptation of class II indirect composite restorations after simulated occlusal loading.	Soft air abrasion represents a potential alternative to airborne particle abrasion for treating cavities before cementation.
Falkensammer et al. [45]	Evaluated the bond strength and surface configuration of immediate and delayed dentin sealing surface after applying different conditioning methods: polishing with fluoride-free pumice paste, air borne particle abrasion with silicoated aluminium oxide, glycin and calcium carbonate.	Polishing and air borne particles abrasion with aluminium oxide and glycin are efficient methods.
Provisionalization period		
Magne et al. [32]	Determined difference in MTBS to immediately sealed dentin when comparing 2, 7 & 12 weeks delay until restoration placement.	Optimal bond strength can be achieved even up to an extended provisionalization phase of 12 weeks.
Post-cementation sensitivity		
Hu et al. [49]	Investigated the effect of prime and bond adhesive on preventing post-cementation sensitivity of immediately sealed vital abutment teeth.	Preventive treatment with prime and bond using IDS technique significantly reduces post-cementation sensitivity.

MTBS = micro tensile bond strength; IDS = immediate dentin sealing; DDS = delayed dentin sealing; DBA = dentin bonding agent; SBS = shear bond strength; PVS = poly vinyl siloxane; PE = polyether; OIL = oxygen inhibition layer; CSE = clearfil bond SE; PLF = Protect liner F; ZOE = zinc oxide eugenol.

was effective in conditioning of IDS surface and helps to remove all kinds of contaminants.

Upon reviewing the literature on aforementioned factors it is evident that IDS though beneficial may pose some clinical dilemmas. The major hurdle in direct extrapolation of results of most of the studies is that randomized controlled trials on IDS are lacking. The efficient execution of all steps of the IDS protocol in a clinical scenario involves techniques that do not have adequate literature backing. The prominent techniques that suffer from this shortcoming are discussed below.

Techniques that are recommended to remove OIL or for cleaning the abutment prior to final cementation include the use of pumice or rotary cutting instruments at low speed. It is interesting to note that there are no guidelines provided for the kind of subjective techniques mentioned above. The measures to verify that the sealed dentin is not removed in the process are also unavailable. Other concerns include the interaction between the OIL and the elastomeric impression materials. OIL related errors in elastomeric impressions cannot be detected by routine visual examination. Thus, the presence or extent of OIL related impression flaws may go unnoticed leading to compromised restorations. Lastly, the IDS protocol assumes that the procedure/technique is followed under complete isolation, although achieving the same may not be possible in every clinical situation.

Despite these shortcomings studies [3,5,19–25] have demonstrated that IDS might provide a better long term bonding to the dentin than that provided by the resin cement alone. These studies have shown better results with IDS technique despite employing procedures that raise concerns. In the extensive literature regarding advantages of using IDS technique significant differences have been shown when compared to delayed dentin sealing. Although more research is required in this field, presently there are NO scientific reasons not to recommend IDS in routine practice.

6. Conclusion

A thorough review of literature suggests the need for a revised protocol for dentin bonding when placing indirect bonded restorations. Immediate application and polymerization of the dentin bonding agent to the freshly cut dentin prior to impression making is recommended. The IDS technique helps achieve improved bond strength, fewer gap formations, decreased bacterial leakage and reduced dentin sensitivity. This concept should stimulate both the researchers and clinicians in the study and development of new protocols for the rationalization and standardization of adhesive techniques and materials leading to maximum tooth structure preservation, improved patient comfort, and long term survival of indirect bonded restorations.

Conflict of interests

The subject matter of this article does not involve any conflict of interests.

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