Does Immediate Dentine Sealing Improve Bonding Effectiveness of Glass Ceramic Restorations Compared to Delayed Dentine Sealing?

Keywords

Immediate Dentine Sealing
Dentine Bonding
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ABSTRACT

A systematic review of the literature was conducted to determine whether immediate dentine sealing (IDS) or delayed dentine sealing (DDS) would lead to a more effective bond between dentine and indirect glass ceramic restorations. Bonding effectiveness was determined by assessing bond strength or force to fracture from the selected studies. This report followed the PRISMA Statement. A total of 10 articles were subsequently identified for inclusion. In vitro studies evaluating bond strength or force to fracture of etchable glass ceramic restorations, following a bonding protocol that incorporates IDS and DDS were eligible to be selected. Analysis has shown IDS creates a more effective bond between dentine and glass ceramic restorations compared with DDS in 9 out of 10 of the studies assessed. Bond effectiveness was judged using three outcomes: microtensile bond strength (μTBS), shear bond strength (SBS) and force to fracture. IDS was shown to increase μTBS and force to fracture, in all seven studies that assessed these outcomes. IDS was also shown to positively affect the SBS in 3 of the 4 studies that assessed SBS. Further clinical trials are now required to understand the significance of IDS in a clinical environment.

INTRODUCTION

Effective bonding is the foundation of contemporary dentistry. The principle of dental bonding is based on an exchange process whereby minerals are substituted with resin monomers. The resultant process does not result in chemical bonding to the tooth surface, instead the subsequent polymerization of the monomers produces a micromechanical interlocking structure within the tooth surface[1] to which resin cements and restorations can adhere.

Dentine has always been considered a more unpredictable substrate for bonding when compared with enamel. Dentine is made up of hydroxyapatite deposited on a mesh of collagen fibres.[2] It is intimately connected with pulpal tissue which causes the dentine surface to be naturally moist and intrinsically hydrophilic. Consequently, dentine is resistant to monomer penetration prior to polymerization. This is partly overcome by using hydrophilic

monomers solvated in a carrier of volatile organic solvents. The solvent will often have a high vapour pressure resulting in further water removal from the demineralized dentine.[3] This results in better monomer penetration and enables the creation of micromechanical interlocking resin tags within the dentine tubules. Following polymerization, this area is known as the hybrid layer.[4] The resultant micro-mechanical interlocking is a prerequisite to achieve good bonding. It must be noted however, that inadequate removal of the solvent may affect the longevity of the resin–dentine bonds,[3] this is commonly achieved by gentle air-drying.

Magne suggested that the optimum time to create a hybrid layer for dentine bonding would be immediately following tooth preparation.[5] Although immediate dentine sealing (IDS) was originally proposed as a concept to seal and protect the pulp,[6] it was later postulated that the same technique may result in additional benefits.[5] A recent review suggested that IDS use appears to achieve fewer gap formations, decreased bacterial microleakage and reduced post-cementation sensitivity.[7] Additional studies have demonstrated that bond strength between dentine and indirect composite resin restorations can be increased with the use of IDS versus delayed dentine sealing (DDS).[8-11] Despite this, the literature appears to be lacking a review assessing specific benefit of IDS with indirect ceramic restorations.

Ceramic onlays have gained popularity in recent years in part because the preparation has been shown to preserve a greater amount of tooth tissue compared with traditional ceramic crowns.[12] Despite the conservative preparation, dentine will form a substantial portion of the bonding surface. The effectiveness of the dentine bond can be assessed with *in vitro* analysis of shear bond strength or microtensile bond strength (μTBS). Fatigue testing such as cyclic tensile testing, cyclic fracture toughness testing, force to fracture are additional methods of evaluating bonding. Bonding is known to increase the fracture resistance of ceramic restorations[13] and consequently it has been suggested that fatigue testing could be a better predictor of *in vivo* performance of dental adhesives[14] compared to traditional bond strength analysis.

A standardised IDS clinical protocol does not exist. Variance primarily exists based on the bonding system used as well as the optional application of a flowable resin layer. The study design from a recent Randomized Controlled Trial (RCT) that looked at IDS,[15] involved a two stage Primer/Adhesive applied to the freshly prepared tooth surface in accordance with the manufacturer's instructions. A thin layer of flowable composite resin was then added and photopolymerized. The enamel margins were then cleaned using a rubber point or bur before the definitive impression was made.

The aim of the present systematic review is to ascertain whether the use of immediate dentine sealing will increase the bond effectiveness of bonded ceramic restorations. Effectiveness will be assessed using bond strength and force to fracture. The null hypothesis is that the use of IDS will have no impact on the bond effectiveness.

METHODS

The present systematic review was conducted using the principles of the PRISMA statement[16] and asks the question, "Does immediate dentine sealing improve bonding effectiveness of glass ceramic restorations compared with delayed dentine sealing?"

SOURCES

The PICOS framework was used to structure the research question and develop literature search strategies for the present review. Table 1 details the PICOS strategy used for this study.

Table 1. PICOS table generated to detail and define the key aspects of the research question.

Population	Teeth from the permanent dentition Posterior teeth: premolars and molars Human teeth
Intervention	The use of immediate dentine sealing prior to the bonding of ceramic restorations to dentine
Comparator	The use of delayed dentine sealing (non-Immediate dentine sealing) prior to the bonding of ceramic restorations to dentine
Outcome	Shear bond strength or μTBS or force to failure / fracture
Study Design	All

A literature search was performed to 1st Aug 2020 comprised of both hand and electronic searches. The following databases were identified and used to search the literature; databases within WoS, Embase, Medline and the Cochrane central registry of controlled trials. An extensive hand-search was also performed encompassing the bibliographies of the included papers. The MeSH terms and keywords related to the search strategy are listed in Table 2.

Table 2. MeSH terms

1	immediate dentin* sealing OR IDS OR dentin* bonding OR resin coating technique OR "dual bonding"
2	ceram* OR porcelain* OR feldspathic* OR (lithium AND disilicate*) OR lithium-disilicate* OR e.max OR Empress OR Glass ceram*
3	1 and 2

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STUDY SELECTION

Both authors independently undertook an initial screening based on the title and abstract of all the studies identified from the literature search. Studies that clearly focused on immediate dentine sealing with ceramic bond were selected. Studies with insufficient information to judge suitability were also included for full assessment. Full copies of studies considered potentially relevant to this review were assessed. Studies in which bond strength was a secondary outcome were also included. The full-text papers were again assessed with only papers that fulfilled all the eligibility criteria (as seen in Table 3) were included. Where there were any disagreements on study eligibility or interpretation of the characteristics presented, these were discussed between the two authors and resolved.

Table 3. Inclusion and exclusion criteria

Inclusions	Exclusion
In vitro	Animal, non-human
Permanent molar / premolar teeth	Zirconia, composite resin, or metal restoration
Glass ceramic restoration	Root Filled teeth as whole population
Must compare IDS versus DDS	No case studies or reviews
Outcome observed: a measurable bond strength or a measurable fatigue test	Original study results
English language	Unpublished studies
Within each study, all groups to use the same ceramic	

ASSESSMENT OF RISK OF BIAS

Risk of bias assessment was undertaken for all included studies using the following parameters: blinding of the operator, randomization of teeth to different groups, description of sample size calculation, use of teeth with similar dimensions, evaluation of failure mode, description of coefficient of variation, teeth free from dental caries and the use of a control group. This method of assessing bias has been used in similar systematic reviews that investigated bond strength through *in vitro* studies.[17,18] If the authors of the studies reported the parameter, the article received a "yes" on that specific parameter; if it was not possible to find the information, the article received an "No". Articles that reported one to three items were classified as having a high risk of bias, four or five items as medium risk of bias and six or seven items as low risk of bias.[17]

RESULTS

SEARCH STRATEGY

A total of 1433 potentially relevant articles were identified following a comprehensive search of the four databases used. Endnote online (Clarivate Analytics, Philadelphia, USA) was used to identify and remove duplicate studies. Figure 1 shows a flow diagram based on the PRISMA statements showing the articles identified from the searches and the following screening, assessment and inclusion.

EXCLUDED ARTICLES

Of the 37 studies that underwent full article assessment, ten papers were found to meet the inclusion criteria and were included in the present review. 27 articles were excluded from this review and the reasons can be seen in Table 4.

ASSESSMENT OF RISK OF BIAS

Of the ten studies included in this review, eight were assessed to have a medium risk of bias, one study showed a high risk of bias and one study was found to have a low risk of bias. The results of the quality assessment are described in Table 5. The studies scored particularly poorly on the following items: sample size calculation, description of coefficient of variation and blinding of the examiner. Most studies in this review did not report on the sequence generation which may impact the risk of bias and overall confidence of the reported results.[19] Two articles cited previous study sample sizes to guide their own sample sizes.[20,21]

DATA EXTRACTION

Data was extracted from the ten studies and summarised *(Table 6)*. Data collected included demographic data (year, country), sample size, group distribution, IDS bonding agent used, cement and ceramic, description of the provisionalization and impression phase and finally the outcome results. Data related to the bond strength and force to fracture was also extracted and collated into charts for each cohort *(Figures 2-4)*.

DISCUSSION

The aim of the present systematic review is to ascertain whether the use of IDS will increase the bonding effectiveness between dentine and ceramic restorations. Effectiveness was determined by using bond strength and force to fracture. Ten studies were identified following a systematic search. Six studies assessed the impact of IDS on the bond strength between the tooth and ceramic and four articles examined the impact of IDS on force to fracture of the ceramic restoration. A meta-analysis was not undertaken for these results as although the comparison of bond strengths within one study is reasonable, comparison of different laboratories findings is not possible due to the different methods used by each study.[22] Therefore, a narrative assessment was undertaken.

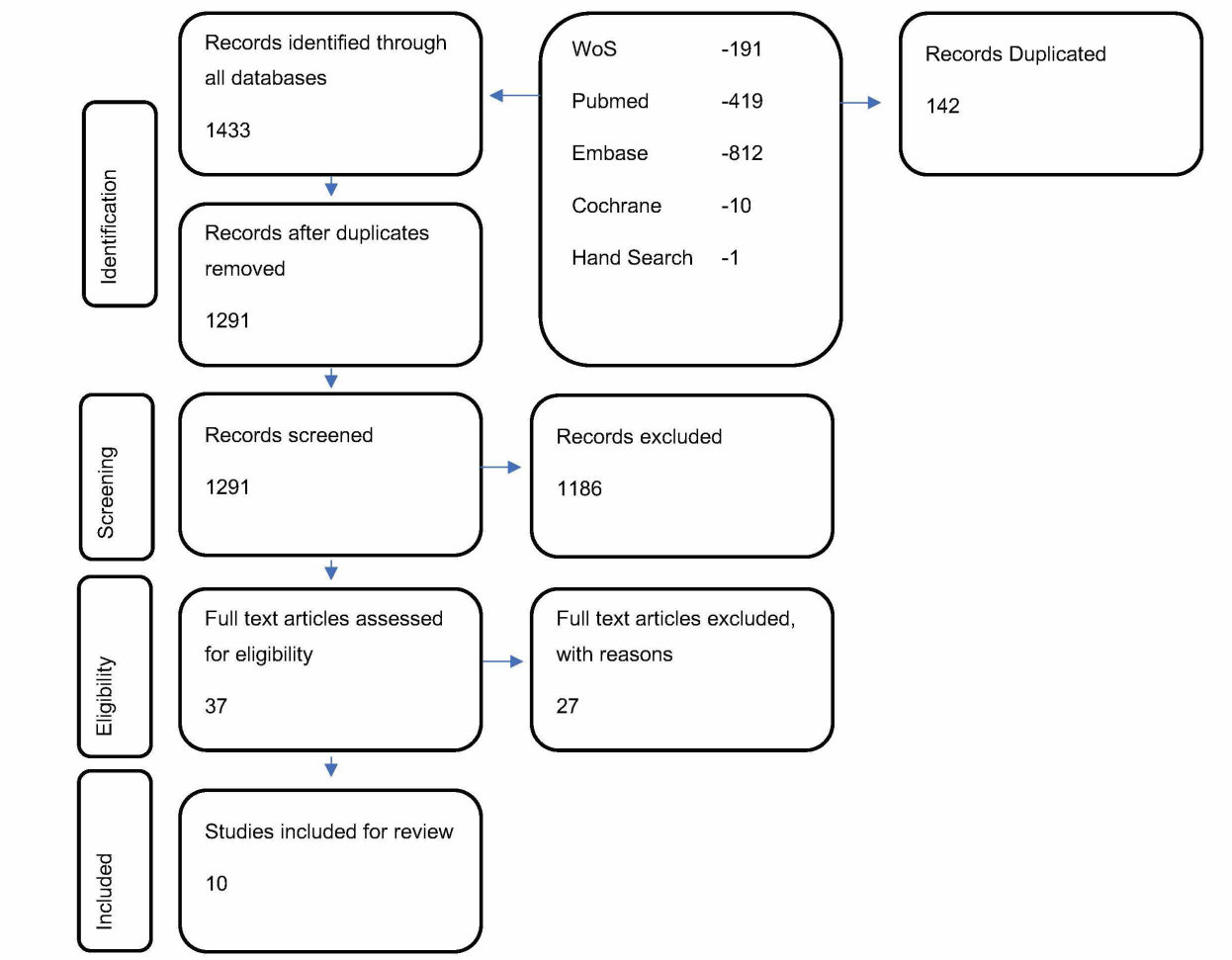

Figure 1: PRISMA flow diagram

Table 4. Studies excluded from the present study together with the reason for their exclusion.

Number of articles	Justification for exclusion
10	Studies used either a direct composite or indirect composite restoration material and not ceramic.
1	Studies used a ceramic restoration for the control group only
6	Studies did not investigate a form of bond strength as either the primary or secondary outcome
4	Studies used IDS for all the groups
3	Studies did not use IDS at all.
3	Studies used teeth that did not meet the inclusion exclusion criteria
1	Article not published

Three studies assessed shear bond strength with and without IDS. Graph 2 shows a summary of shear bond strength values from these studies. Two of these studies demonstrated that the use of IDS increased the shear bond strength[23,24] between the ceramic restoration and dentine substrate. One study however, found the opposite to be true in that delayed dentine sealing resulted in an increased shear bond strength.[20] This study also assessed the influence of different conditioning methods with IDS and versus DDS. The authors introduce a conditioning stage following tooth preparation and before IDS application. It is possible this stage reduced the potential benefit of the IDS process, but this is not addressed within their narrative.

Three studies detailed the method used for to determine shear strength,[20,23,24] however no single study produced a fully comprehensive account of all the parameters used. Three studies specified the exact testing equipment that was used as well as the method used to calculate the bond strength. One paper details the position and angulation of the force applied in relation to the bond surface,[24] and two papers recorded the crosshead speed used.[20,23] Further detail would be required from all three studies if their methodology were to be replicated including details of the method used to apply load during the testing. These variations in shear test design have been shown to influence the bond strengths' results and increase the scatter of the data.[25]

Analysis of μTBS has been a recognised laboratory testing method for well over two decades.[26] Three studies assessed the μTBS, and all three studies showed an increased μTBS following immediate dentine sealing[27-29] *(Figure 2)*. The

Table 5. Assessment of risk of bias

Study	Blinding of the examiner	Teeth randomization	Sample size calculation	Samples with similar dimensions	Evaluation of failure mode	Description of coefficient of variation	Teeth free of caries	Control group	Risk of bias
Choi, Y. S.[23]	No	Yes	No	Yes	Yes	No	Yes	Yes	Medium
Spohr, A. M.[31]	No	Yes	No	Yes	Yes	No	Yes	Yes	Medium
Falkensammer, F.[20]	No	No	Yes	Yes	Yes	No	Yes	Yes	Medium
Van den Breemer, C. R. G.[32]	No	Yes	No	Yes	Yes	No	Yes	Yes	Medium
Yazigi, C.[33]	No	Yes	No	Yes	No	No	No	Yes	High
Murata, T.[27]	No	No	No	Yes	Yes	No	Yes	Yes	Medium
Reboul, T.[24]	No	Yes	No	Yes	Yes	No	Yes	Yes	Medium
Hayashi, K.[28]	No	No	No	Yes	Yes	No	Yes	Yes	Medium
Hofsteenge, J. W.[21]	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Low
Ozturk, N.[29]	No	Yes	No	Yes	Yes	No	Yes	Yes	Medium

three studies assessing μTBS, all included a description of the methodology used[27-29] including the testing apparatus and the crosshead speed rate used. Two of the three studies used the same specimen shape for testing either 'beam'[27] or 'I-shape'.[29] The remaining study specified a 'dumbbell' shape.[28] This dumbbell has been shown to lead to higher bond strength recordings[30] however this study exhibited the lowest value μTBS in this review.

If an all-ceramic crown is fitted using a bonding technique instead of a luting technique, it has been shown to increase the force required to induce failure of the restoration.[13] Four studies assessed the force required to lead to failure of the ceramic restoration. All four of these studies demonstrated an increase in the force required to fracture when IDS was utilized.[21,31-33] Figure 4 shows the results from the included studies that assessed force to fracture as an outcome.

Failure analysis was undertaken in nine of the ten studies. Methodology for all studies relied on visual observation of the samples, seven studies detailing the magnification of light microscope that was used for their analysis. Magnification ranged from 22x to 200x. Variation existed in the method of classification of the observed fracture. Most studies devised a classification based on the location of the fractures that occurred. A consensus from these studies concluded that the use of IDS did not impact upon the mode of fracture. One study reported a higher number of non-repairable fractures (fracture observed extending below the cementoenamel junction (CEJ) into the root) in the IDS group.[21] Three studies assessed the percentage of the resin which was left adhered to the tooth surface after the fracture test. All three demonstrated that a greater proportion of resin was retained on the tooth surface in the IDS groups compared with the DDS cohort.[23,31,32]

The early rationalization for the use of IDS was that freshly cut dentine offers a better bonding substrate compared to dentine which has been contaminated by the oral environment.[5] By undertaking IDS before the impression and subsequent temporization phase, the hybrid layer is protected from contamination and degradation. Several of the articles within the present review have made attempts to reproduce aspects of the clinical environment to which an equivalent in vivo study may be subjected. Five studies used traditional impression materials. Four studies utilised digital techniques and one study did not discuss any impression technique. Magne *et al.* suggested that the use of IDS could affect the polymerisation of vinyl polysiloxane (VPS) impression materials.[34] The same study also speculated that VPS may alter the bond between the IDS resin coating and the luting agent.[34] Three of the five studies that used a traditional impression material used a VPS impression material. Coincidentally one of these studies found a greater bond strength existed when a delayed dentine sealing procedure was performed.[20] Although the potential interaction

Table 6. The characteristics of the included studies.

First author Year Country	Sample size	IDS Bonding agent	Cement used	Ceramic restoration	Impression and provisionalisation phase	Results
Choi, Y. S.[23] **2010** **Korea**	40 Molar teeth 4 groups (n=10) Group 1: Control Group 2: IDS, self-etching bond. Group 3: IDS, total etch Group 4: DDS	Self-etching protocol- Clearfil™ SE Bond Total etch then primer bond protocol- Adapter™ Single Bond 2	Variolink® II	Super Porcelain EX-3	No impression taken No provisional restoration used Thermo-cycled 500 times for 30 seconds in 5 - 55°C condition	Primary Outcome: Shear bond strength
Spohr, A. M.[31] **2013** **Brazil**	60 maxillary premolars 3 Groups (n=30) Group 1: Control, without the IDS technique Group 2: IDS with self-etch technique Group 3: IDS with self-etch technique and Protect Liner F	Self-etching protocol - Clearfil™ SE Bond	Panavia F	IPS empress 2	Impression using polyvinyl siloxane impression material. Provisional restorations made using acrylic resin crowns cemented with non-eugenol provisional cement Tooth specimens with provisional restorations were stored in distilled water at 37°C for 2 months	Primary Outcome: Thickness of IDS material on crown prepared teeth. Secondary Outcome: Force to Fracture
Falkensammer, F.[20] **2014** **Austria**	96 premolars 2 main groups each with 4 sub-groups utilising different conditioning methods, n=11 Group 1: IDS Group 2: DDS	Self-Etch protocol- AdheSE	Variolink II	Vitablocs Mark II	Impression using polyvinyl siloxane impression material. Provisional restorations made using Protemp 4 and cemented with eugenol-free interim cement Tooth specimens with provisional restorations were stored in a saline solution at 37°C for 1 week	Primary Outcome: Shear bond strength Secondary Outcome: Assessment of surface configuration following different surface conditioning methods.
Van den Breemer, C. R. G.[32] **2017** **Netherlands**	40 molars 4 groups (n=10) Group 1: IDS and ceramic restoration Group 2: Non IDS and ceramic restoration Group 3: IDS and resin composite restoration Group 4: Non IDS and resin composite restoration	Self-etching protocol - Clearfil™ SE Bond with Tetric Evoflow flowable composite	Adhese Universal	IPS e.max Press	Digital impression taken Provisional restoration Protemp 4 cemented using Durelon. Tooth specimens with provisional restorations were stored in distilled water at 37°C for 3 weeks.	Primary Outcome: Force to Fracture

Table 6 continued overleaf

Table 6. The characteristics of the included studies continued.

First author Year Country	Sample size	IDS Bonding agent	Cement used	Ceramic restoration	Impression and provisionalisation phase	Results
Yazigi, C.[33] **2017** **Germany**	96 max premolars 3 groups (n=32) Each group had two subgroups using either total or selective etch for the pre cementation. Group 1: No IDS Group 2: IDS using total etch Group 3: IDS using selective etch	Selective etch then bond protocol- Adhese Universal Total etch then bond protocol- Adhese Universal	Variolink Esthetic DC	IPS e.max CAD	Impression using polyvinyl-siloxane impression materials. No Provisional restoration discussed in article No storage method discussed in article.	Primary Outcome: Force to Fracture
Murata, T.[27] **2018** **Japan**	32 maxillary first molars 4 groups (n=8) Group 1: no IDS Group 2: IDS with 30mg of flowable composite Group 3: IDS with 90mg of flowable composite Group 4: IDS with 180mg of flowable composite	Self-etching protocol - Scotchbond Universal Adhesive With Filtek Supreme Ultra Flowable Restorative	Panavia V5	VITABLOCS Mark II	Digital impression No Provisional discussed in article. Prepared teeth were stored in 37°C water for approximately 30 min	Primary Outcome: Micro-tensile bond strength
Reboul, T.[24] **2018** **India**	30 lower third molars 3 groups (n=10) Group 1: IDS with Panavia Group 2: DDS with Panavia Group 3: IDS with heated Composite	Etch then Prime then Bond protocol- OptiBond FL	Panavia V5	VITA Suprinity® PC	Digital Impression No provisional discussed in article. Prepared teeth were stored physiological saline solution for 3 days at room temperature.	Primary Outcome: Shear bond strength
Hayashi, K.[28] **2019** **Japan**	60 mandibular premolars 2 groups both with 2 sub-groups with and without provisional restoration (n=15) Group 1: IDS Group 2: Non IDS	Self-etching protocol - Clearfil Universal Bond Quick With Clearfil Majesty ES Flow	Panavia V5	VITABLOCS Mark II	Digital impression Provisional restoration made using Protemp 4 and cemented using Temp Bond NE. Sub group with provisional restorations were stored in water at 37°C for 1 week.	Primary Outcome: Micro-tensile bond strength

Table 6 continued overleaf

Table 6. The characteristics of the included studies continued.

First author Year Country	Sample size	IDS Bonding agent	Cement used	Ceramic restoration	Impression and provisionalisation phase	Results
Hofsteenge, J. W.[21] **2020** **Netherlands**	40 molars 4 Groups (n=10) Group 1: Inlay preparation and IDS Group 2: Inlay preparation and no IDS Group 3: Overlay preparation and IDS Group 4: Overlay preparation and no IDS	Etch then Prime then Bond protocol- OptiBond FL. With Tetric Flow	Enamel Plus HFO UD2	IPS e.max Press	Impression using Aquasil Ultra Extra light body and Heavy body Provisional restorations made using Protemp 4 and cemented using Durelon. Samples were stored in water (20 C) for another 3 week	Primary Outcome: Force to Fracture
Ozturk, N.[29] **2003** **Turkey**	120 teeth Two ceramic materials tested each with 3 groups. All teeth sections into three for testing. 360 total testing samples. Group 1: Immediate dentine bonding Group 2: Delayed dentine bonding Group 3: Control without dentine bonding	Self-etching protocol - Clearfil Liner Bond 2V	Panavia F	Ceramco II IPS Empress 2	Impression using Permagum. No provisional restoration reported. No detail on storage method discussed in article.	Primary Outcome: Micro-tensile bond strength

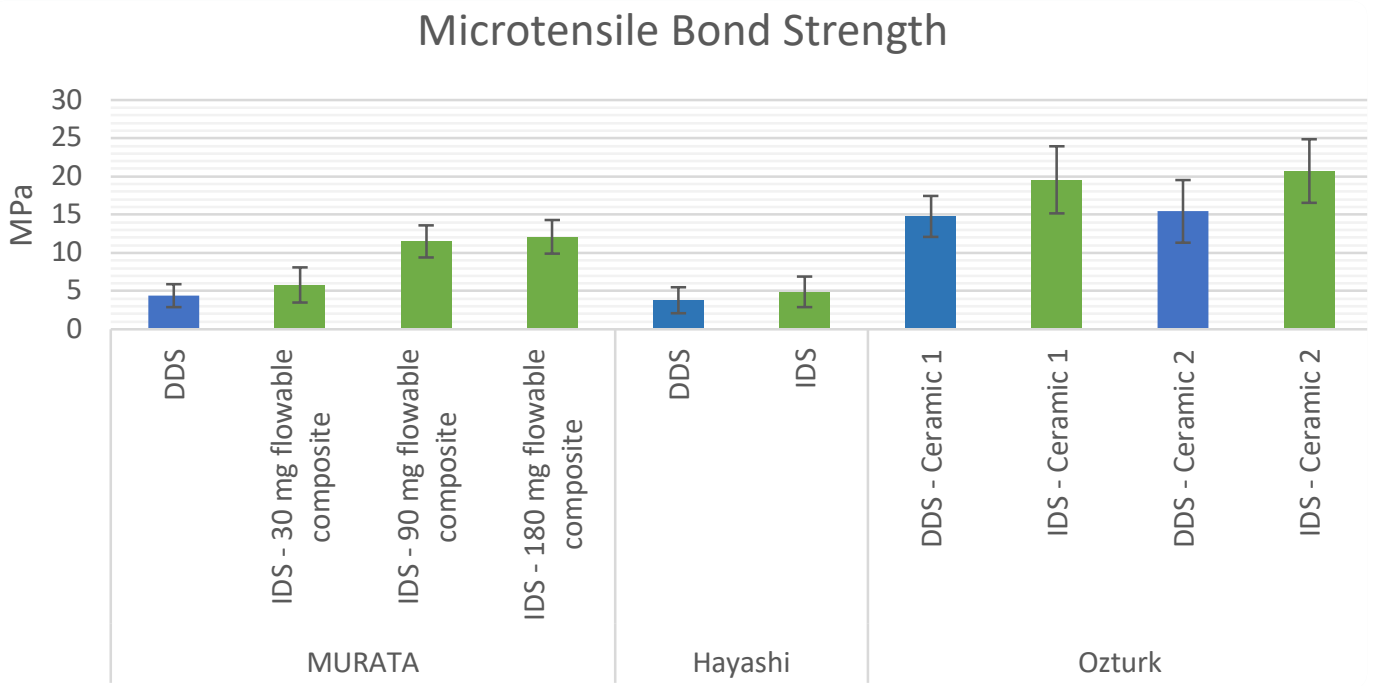

Figure 2: Graph representing the microtensile bond strength values from 3 studies,[27-29] with 6 groups utilising IDS (shown in green) and 4 using DDS (shown in blue). Standard deviation error bars are shown for each group.

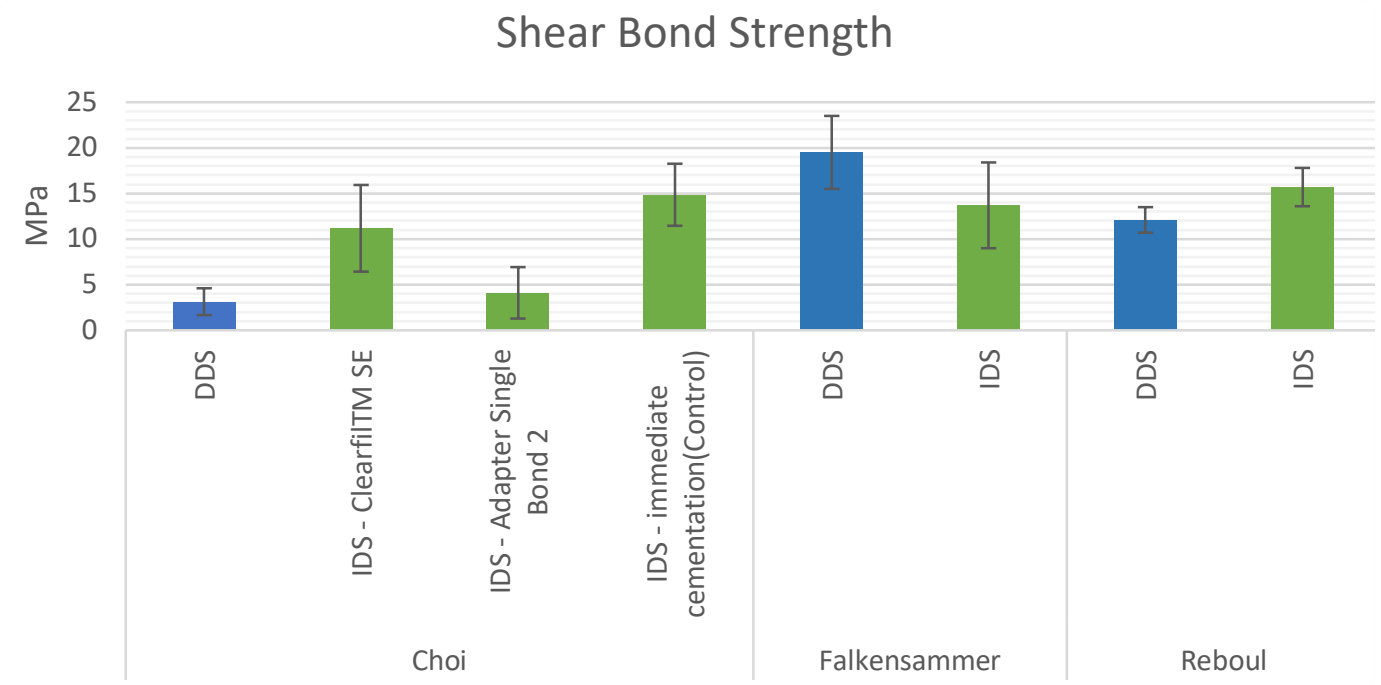

Figure 3: Graph representing the shear bond strength values from 3 studies,[20,23,24] with 5 groups utilising IDS (shown in green) and 3 using DDS (shown in blue). Standard deviation error bars are shown for each group.

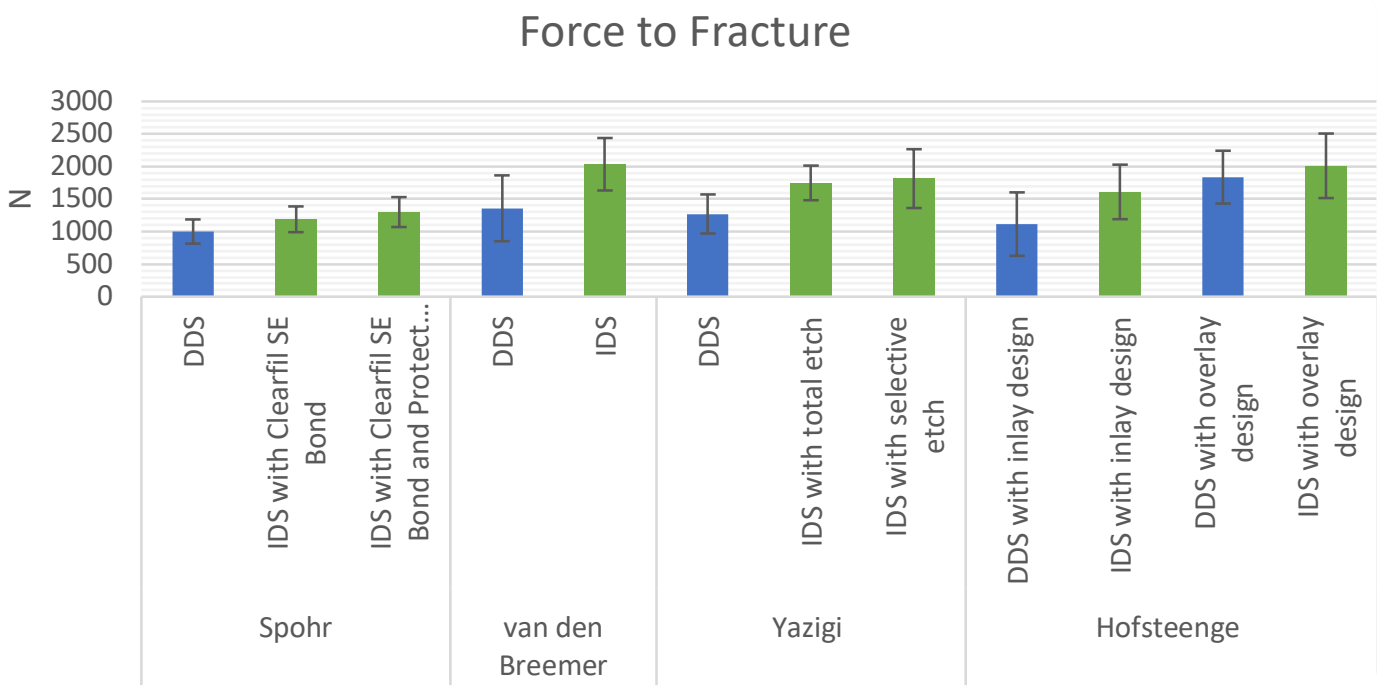

Figure 4: Graph representing the force to fracture values from 4 studies,[21,31-33] with 7 groups utilising IDS (shown in green) and 5 using DDS (shown in blue). Standard deviation error bars are shown for each group.

of the impression materials was mentioned in this study, the authors did not cite this as potential reason for the observed weaker bond following the use of the IDS technique.

Eight of the studies detailed the method used to simulate the time between the tooth preparation and final bond. The time interval varied considerably, ranging from 30 minutes to two months. Most studies stored the specimens in either water or saline at a constant temperature. One study subjected the specimens to a 500 thermocycles between 5 and 55°C.[23] This represents the greatest area of variation seen in the methodologies of the included studies. It must be recognised that temporization time in general dental practice would correlate with this range due to the increased popularity of onsite CAD/CAM fabrication process compared with more traditional laboratory timeframes.

A power calculation was not used by any of the included studies although two papers cited previous study samples sizes for justification.[20,21] Guidance offered by the Academy of Dental Materials on adhesive dentine μTBS testing suggest sample size should ideally be based upon a power calculation, with an absolute minimum of three teeth per experimental group.[35] All the included studies had more than three teeth in each group. However, the use of power calculations to determine their sample size would have further reduced the risk of bias from many of the studies.

Although nine of the ten studies assessed in this review, were rated as either medium or low risk of bias, it must be remembered that the inherent limitation of *in vitro* studies. The oral cavity will expose the restored tooth as well as the bond interface to environmental factors including masticatory stresses, pH and temperature variation that may all impact long term success. Although the resultant bond strength figures do not necessarily predict clinical performance,[22,36] the data should rather be interpreted as the potential of this technique. Clinical evidence will continue to be the only conclusive measure of adhesive performance. Clinically based, in vivo studies assessing the benefits of IDS in direct comparison with delayed dentine sealing are rare, a recent randomised clinical trial concluded no significant differences ($p = 0.32$) in survival rates after three years of function were found between IDS and DDS.[15] Further research is required to assess the long-term impact of IDS on longevity of indirect restorations.

Furthermore, the use of IDS in a clinical situation may impart benefits other than the increase in bond strength. The IDS may also protect the dentine from bacterial microleakage and post-operative sensitivity during the temporization period.[5]

The three reported outcomes examined by the articles in the present review, represent the common methods of *in vitro* bond analysis favoured by similar dental material research. The positive correlation demonstrated with these outcomes following the use of IDS has clearly been demonstrated. Consequently, the null hypothesis is rejected, as the use of IDS does have a positive impact on the bond effectiveness between glass ceramic restorations and dentine, in an *in vitro* setting.

CONCLUSIONS

The present review has concluded that within an *in vitro* setting, the use of an IDS technique can increase the effectiveness of the bond between glass ceramic restorations and dentine when compared with a DDS technique. Five out of six studies that assessed bond strength after IDS showed an increase in effectiveness of the bond. In addition, all four of the studies that assessed force to fracture also showed an increase in the effectiveness of the bond. IDS has been shown to be an advisable strategy for optimising the bonding strength and increasing the fracture resistance of glass ceramic restorations. The exact translation of these *in vitro* findings to a clinical significance is beyond the scope of this review and further clinical trials assessing longevity of restorations using IDS techniques are now required.

MANUFACTURERS' DETAILS

- Adapter™ Single Bond 2 (3M ESPE, Seefeld, Germany).
- AdheSE (Ivoclar Vivadent, Schaan, Liechtenstein).
- Adhese Universal (Ivoclar Vivadent, Schaan, Liechtenstein).
- Aquasil Ultra Extra light body and Heavy body (Dentsply, Konstanz, Germany).
- Ceramco II (Ceramco, Burlington, USA).
- Clearfil Liner Bond 2V (Kuraray Noritake Dental, Tokyo, Japan).
- Clearfil Majesty ES Flow (Kuraray Noritake Dental, Tokyo, Japan).
- Clearfil Universal Bond Quick (Kuraray Noritake Dental, Tokyo, Japan).
- Clearfil™ SE Bond (Kuraray Noritake Dental, Tokyo, Japan).
- Durelon (3M ESPE, Seefeld, Germany).
- Enamel Plus HFO UD2 (Micerium, Avegno, Italy).
- Filtek Supreme Ultra (3M ESPE, Seefeld, Germany).
- IPS e.max CAD (Ivoclar Vivadent, Schaan, Liechtenstein).
- IPS e.max Press (Ivoclar Vivadent, Schaan, Liechtenstein).
- IPS empress 2 (Ivoclar Vivadent, Schaan, Liechtenstein).
- OptiBond FL (Kerr, Salerno, Italy).
- Panavia F (Kuraray Noritake Dental, Tokyo, Japan).
- Panavia V5 (Kuraray Noritake Dental, Tokyo, Japan).
- Permagum (3M ESPE, Seefeld, Germany).
- Protect Liner F (Kuraray Noritake Dental, Tokyo, Japan).
- Protemp 4 (3M ESPE, Seefeld, Germany).
- Scotchbond Universal Adhesive (3M ESPE, Seefeld, Germany).
- Super Porcelain EX-3 (Kuraray Noritake Dental, Tokyo, Japan).
- Tetric Evoflow (Ivoclar Vivadent, Schaan, Liechtenstein).
- Variolink Esthetic DC (Ivoclar Vivadent, Schaan, Liechtenstein).
- Variolink® II (Ivoclar Vivadent, Schaan, Liechtenstein).
- VITA Suprinity® PC (Vita Zahnfabrik, Bad Säckingen, Germany).
- Vitablocs Mark II (Vita Zahnfabrik, Bad Säckingen, Germany).

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