Mestrado Integrado em Medicina Dentária

Faculdade de Medicina da Universidade de Coimbra

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Coimbra, julho 2020

‘’Courage is what it takes to stand up and speak. Courage is also what it takes to sit down and listen.’’

Winston Churchill

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Coimbra, Julho de 2020

Summary

Abstract

Introduction: Several methods are described to prepare dentin for adhesion, although most have few to no existing scientific data regarding their effect on dentin adhesion. Sandblasting with aluminium oxide particles consists in a mechanical treatment to introduce surface modifications and has been widely used as a dentin surface cleansing method prior to adhesive procedures. Air abrasion with bioactive glass used in an air-abrasion device has been advocated as an alternative technique that can create a bioactive smear-layer-covered surface for bonding procedures.

Methods: A review was performed to compare dentin pre-treatment with aluminium oxide and/or bioactive glass and pre-treatment only with adhesive systems. Studies were screened in 3 electronic databases. The selected reference lists were manually searched for additional original and reviewed papers. Common public general databases were used to search for grey literature.

Results: Eighteen articles were selected. The majority were comparative or evaluation studies. Very few clinical studies comparing both methods are available. Several methodological limitations are present on the collected literature and debated in this review.

Conclusions: Although available scientific evidence is scarce and at considerable risk of bias, it is still possible to conclude that the effect of alumina on resin–dentin bonding are still unclear and should be further researched. An apparent beneficial effect of bioactive glass is remineralization, but more data on its effect regarding dentinal bonding is still needed.

Keywords: dentin; air abrasion; aluminium oxide; bioactive glass; bond strength.

Introduction

The longevity of aesthetic restorations is directly linked to the effectiveness of adhesive systems, as the lack of bonding and inadequate marginal sealing may lead to restoration failure. [1]

Dentin adhesion represents a challenging step in dentistry. Lesser durability of resin-dentin bonding compared to resin-enamel bonding originates in these substrate's morphologic characteristics. While dentin bonding proves to be more complex due to a higher amount of organic content, fluid pressure from the dentinal tubules, presence of water and smear-layer, enamel bonding is simple and predictable because of its high mineral content. [2]

Traditionally resin-dentin bonding is predominantly micromechanical, via resin penetration and entanglement of exposed collagen fibrils in the partially or completely demineralized dentin. This is achieved by etching dentin with acid or acidic monomers derived from distinct hybridization techniques: etch-and-rinse or self-etch adhesives. [3]

The use of orthophosphoric acid as a conditioning step for enamel and dentin is the most common method for total removal of the smear-layer, and is associated to an etch-and-rinse technique but, with the evolution of adhesives, new forms of dentin surface treatment have emerged to battle the uncertainty of complete infiltration of resin monomers in the exposed collagen. [4]

Self-etch systems seem to avoid the formation of demineralization areas that may not be fully infiltrated with monomers and reduce the technique sensitivity by eliminating the acid etching step. [5]

Therefore, the main bonding mechanism is an exchange process involving substitution of inorganic tooth material by resin monomers that upon in situ setting become micromechanically interlocked in the created microporosities. Recently, more evidence has corroborated a possible additional bonding mechanism, chemical bonding between specific monomers and calcium in hydroxyapatite.[6]

Several methods are described to prepare or modify dentin for adhesion, which may result in distinct smear-layer features and make dentin surface receptive for bonding, although most have little to no existing scientific data regarding their effect on dentin adhesion. [6]

The characteristics of smear layer obtained with different dentin pre-treatments strongly influence the effectiveness of bonding strategies. [7] Therefore, dentin surface treatments for smear layer cleaning, such as its complete removal, dissolution, replacement or modification, should be considered as decisive steps previous to restorative bonding procedures.

Subsequently, within the same viewpoint, dentin surface cleaning may prove essential to obtain better bonding between the interfaces. Several cleaning methods, both mechanical and chemical, have been suggested. [2]

Sandblasting with aluminium oxide particles consists of a mechanical treatment to introduce surface modifications and has been widely used as a dentin surface cleansing method prior to adhesive procedures. As the particles collide with dentin, their kinetic energy is released, resulting in the fracture of microscopic fragments, thus creating a roughened surface. [8]

Air abrasion with bioglass - a calcium/sodium phosphate-phyllosilicate glass - used in an air-abrasion device (AquaCare, Velopex UK) has been advocated as an alternative technique that can allegedly create a bioactive smear-layer with therapeutic properties, which may potentially preserve and protect the bonding interface by its ion-releasing ability, favouring remineralization and creating a bioglass-rich smear layer available for conversion into apatite at the resin-dentin interface. [9]

The aim of this review was to answer the following question: ‘‘Does dentin pre-treatment with aluminium oxide and/or bioactive glass increase bond strength?’

Methods

This review was performed following the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P)*.

*Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ (Clinical Research Ed). 2015; 350: g7647.

1. **Selection Criteria**

To define the research question a PICO strategy was performed: ‘‘Does dentin pre-treatment with aluminium oxide and/or bioactive glass increase bond strength?’’. (Table.1)

Table.1 – PICO strategy

Population	Dentin
Intervention	Pre-treatment with aluminium oxide or bioactive glass
Comparison	Pre-treatment only with adhesive systems
Outcome	Bond strength

All study types were included. Regarding the type of intervention, studies were selected with sandblasting and/or air abrasion with bioactive glass, in vitro and/or in vivo, on human and/or animal dentin. Bond strength was the measured outcome. Specific inclusion and exclusion criteria are shown in (Table.2).

Table.2 – Inclusion and Exclusion criteria.

Inclusion Criteria	Exclusion Criteria
Full-text papers	Letters to the editor
English Language	Non-English
Permanent Teeth	Temporary Teeth
Dentin	Dental Implants, Ceramics, Orthodontic brackets

2. **Search Strategy**

PubMed (www.ncbi.nlm.nih.gov/pubmed) was used to identify Medical Subject Heading (MeSH) terms fitting this review. MeSH terms were used as often as possible, even though many papers do not comply with this controlled vocabulary thesaurus, thus making their sole use feeble and other terms were necessary. Subsequently, an electronic search was performed using Cochrane Library (www.cochranelibrary.com), Embase (www.embase.com) and PubMed (www.ncbi.nlm.nih.gov/pubmed) using various combinations of the key indexing terms shown in (Table.3).

Table.3 - Combination of terms for each database.

PubMed	(((((("aluminium oxide"[MeSH Terms] OR "aluminium oxide"[All Fields]) OR "aluminium oxide"[All Fields]) OR "air abrasion, dental"[MeSH Terms]) OR "air abrasion"[All Fields]) AND ("dentin"[MeSH Terms] OR "dentin"[All Fields])) AND ((((((((("bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields])) OR (((((("dentin"[MeSH Terms] OR "dentin"[All Fields]) OR "dentin"[All Fields]) OR "dentins"[All Fields]) OR "dentins"[All Fields]) OR "dentinal"[All Fields]) AND "bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields]))) OR ("microtensile"[All Fields] AND "bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields]))) OR ((((("shear"[All Fields] OR "sheared"[All Fields]) OR "shearing"[All Fields]) OR "shearings"[All Fields]) OR "shears"[All Fields]) AND "bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields]))) OR ("microshear"[All Fields] AND "bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields]))) OR (("tensil"[All Fields] OR "tensile"[All Fields]) AND

	"bond"[All Fields] AND ("strength"[All Fields] OR "strengths"[All Fields]))) OR (((((((("bonded"[All Fields] OR "bondings"[All Fields]) OR "bonds"[All Fields]) OR "object attachment"[MeSH Terms]) OR ("object"[All Fields] AND "attachment"[All Fields])) OR "object attachment"[All Fields]) OR "bonding"[All Fields]) AND ("agent"[All Fields] OR "agents"[All Fields]))) OR "dental bonding"[MeSH Terms]) OR "adhesive interface"[All Fields])) NOT ((((("ceramics"[MeSH Terms] OR (((((("ceram"[All Fields] OR "ceramics"[MeSH Terms]) OR "ceramics"[All Fields]) OR "ceramic"[All Fields]) OR "ceramization"[All Fields]) OR "cerammed"[All Fields]) OR "ceramming"[All Fields])) OR "dental implants"[MeSH Terms]) OR "dental implants"[All Fields]) OR "orthodontic brackets"[MeSH Terms]) OR "orthodontic brackets"[All Fields])
Cochrane Library	#1 MeSH descriptor: [Dentin] explode all trees #2 ("dentin"):ti,ab,kw (Word variations have been searched) #3 ("dentin"):ti,ab,kw (Word variations have been searched) #4 #1 OR #2 OR #3 #5 MeSH descriptor: [Aluminium Oxide] explode all trees #6 (aluminium oxide):ti,ab,kw (Word variations have been searched) #7 (aluminium oxide):ti,ab,kw (Word variations have been searched)

	#8 MeSH descriptor: [Air Abrasion, Dental] explode all trees #9 (air abrasion, dental):ti,ab,kw (Word variations have been searched) #10 #5 OR #6 OR #7 OR #8 OR #9 #11 (bond strength):ti,ab,kw (Word variations have been searched) #12 (dentin bond strength):ti,ab,kw (Word variations have been searched) #13 (microtensile bond strength):ti,ab,kw (Word variations have been searched) #14 (shear bond strength):ti,ab,kw (Word variations have been searched) #15 (microshear bond strength):ti,ab,kw (Word variations have been searched) #16 (tensile bond strength):ti,ab,kw (Word variations have been searched) #17 (bonding agents):ti,ab,kw (Word variations have been searched) #18 MeSH descriptor: [Dental Bonding] explode all trees #19 (adhesive interface):ti,ab,kw (Word variations have been searched) #20 #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 #21 MeSH descriptor: [Ceramics] explode all trees

	#22 MeSH descriptor: [Dental Implants] explode all trees #23 MeSH descriptor: [Orthodontic Brackets] explode all trees #24 (Orthodontic Brackets):ti,ab,kw (Word variations have been searched) #25 (dental implants):ti,ab,kw (Word variations have been searched) #26 (ceramics):ti,ab,kw (Word variations have been searched) #27 #21 OR #22 OR #23 OR #24 OR #25 OR #26 #28 #4 AND #10 AND #20 NOT #27
Embase	(air abrasion OR sandblasting) AND (aluminium oxide OR bioactive glass) AND dentin

MeSH terms used were: aluminium oxide; dentin; air abrasion, dental; dental bonding.

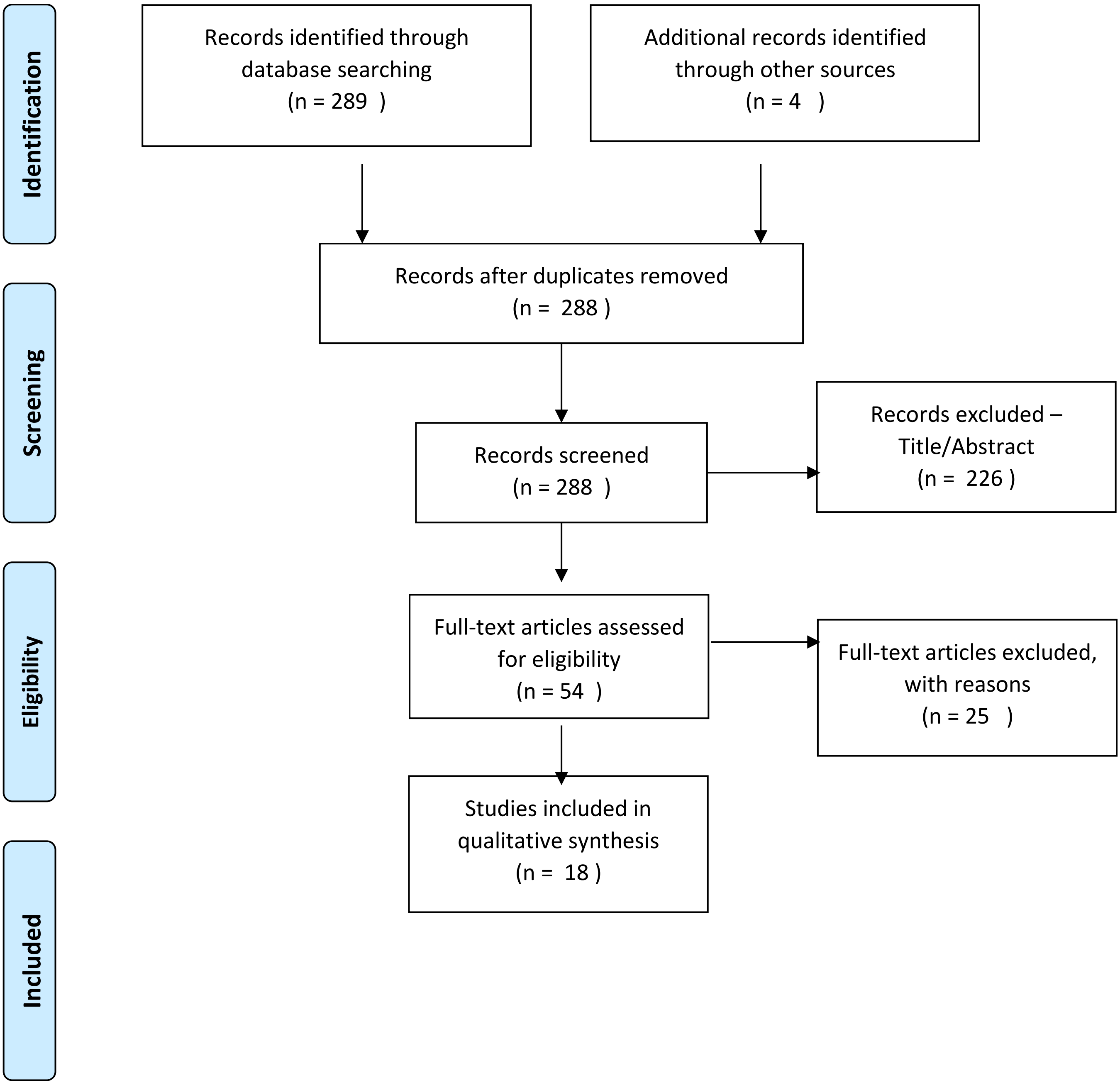
3. Data collection and Analysis

All titles and abstracts retrieved from the electronic search were independently and in duplicate screened by two reviewers. This was followed by a review to reject papers that did not meet inclusion criteria. Disagreement between reviewers was solved via debate and the opinion of a third reviewer was obtained when necessary.

The selected reference lists were manually searched for additional original and reviewed papers. Common public general databases, such as Google (www.google.com), were used to search for grey literature. Full-text copies of all papers found through this search methodology were obtained and scrutinized by each reviewer to decide which papers were eligible based on the inclusion and exclusion criteria. Any disagreement was solved in the same manner as previously described.

To determine the existence of published or unpublished studies that were not available on electronic databases, authors of relevant and possibly relevant studies were contacted. Authors were also contacted when missing data and/or any clarification was needed.

The literature search provided 289 titles and abstracts as shown in (Figure.1).



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

Figure.1 – Flowchart of study selection process.

Results

At the end of the selection process, 18 relevant studies whose characteristics can be found in Table.4, have been chosen for this review.

Table.4 – Study Characteristics of the articles selected for this review.

Study	Purpose	Sample	Bond Strength	Method	Results	Conclusion from the author
Amario,M.D *et al.*(2017).	Airborne particle abrasion (APA) pre-treatment on dentin and its effects on microtensile bond strength of four commercial total-etch adhesives.	Forty-three human molars.	Not abraded RB specimens showed significantly lower bond strength.	Treated with adhesive procedures VS abraded with aluminium oxide before treatment with adhesive. Adhesive systems applied were OptiBond FL, OptiBond Solo Plus, Prime & Bond and Riva Bond LC.	Two-way ANOVA showed that the adhesive system used and the pretreatment protocol significantly affected bond strength ($p<0.001$). Comparison showed significant increase in bond strength ($p < 0.001$) between abraded (32.51 ± 8.78 MPa) and non-abraded specimens (19.24 ±7.47 MPa), independently of adhesive brand.	Surface treatment by APA with Al_2O_3 particles can increase the bond strength of total-etch adhesives to dentin.
Coli, P. *et al.*(1999).	Define the morphology and roughness of dentin after various pre-	Thirty-eight extracted molars	The formation of interfacial contact between the adhesive resin and the mineralized or	Five pre-treatments were performed: A) 0.2% EDTA; B) abrasion with Al_2O_3 particles, 0.2% EDTA;	The hypothesis that the shear bond strength to dentin is independent of the formation of a hybrid layer was confirmed by the	Shear bond strength to dentin did not depend on a hybrid layer

	treatments to identify the effect of hybrid layer, resin tags, and mineralized dentin surface on shear bond strength.		partially mineralized dentin surface is the basic bonding mechanism.	C) 10% H3PO4 ; D) 10% H3PO4 and immersion in a collagenase solution; E) control: no treatment. Z100 composite resin cylinders were bonded to the specimens with All Bond 2 bonding system and tested for shear bond strength.	results. A second hypothesis tested was that the shear bond strength to dentin is dependent on the orientation of the dentinal tubules with respect to the dentin surface. This hypothesis appeared to be true depending on the kind of dentin pre-treatment.	formation, but on the direct contact of the adhesive with the mineralized dentinal surface and partly on the orientation of the dentinal tubules.
Anja, B. *et al.* (2015).	Microtensile bond strength of one-step self-etch adhesive to human dentin modified with air abrasion and sonic technique and morphological characteristics of the pretreated dentin surface.	Thirty-six human molar teeth	Surface roughness obtained with the air abrasion did not increase the adhesive bond strength, so this characteristic is not the only factor influencing bonding.	Control VS Air abrasion VS sonic preparation.	There was no statistically significant difference in bond strength between the three experimental groups (P > 0.05).	The use of air abrasion and sonic preparation with one-step self-etch adhesive does not appear to enhance or impair microtensile bond strength in dentin.

Carvalho,E.M. *et al.* (2015).	Microtensile bond strength (mTBS) of two resin cements bonded to dentin pre-treated with experimental niobophosphate bioactive glass (NBG).	Twenty human third molars.	Air-abrasion with bioglass did not change the microtensile values after 24h.	Air-abrasion with bioactive glass VS no pre-treatment. Two resin cements were used: Panavia F and RelyXU-100.	The two-way ANOVA did not detect statistically significant differences either for the interaction between Cements and NBG Pretreatment (p=0.349) or for the NBG Pretreatment (p=0.580), but only between the self-etching and self-adhesive cement (p=0.001).	Air-abrasion procedures performed with the use of a new bioactive glass containing niobium did not interfere with the immediate bonding performance of self-etching and self-adhesive resin cements.
Fornazari, I.A. *et al*. (2017).	The effect of surface treatment and universal adhesive on the microshear bond strength of nanoparticle composite repairs.	One hundred and forty-four specimens.	The surface treatment and chemical bonding between the new and existing (aged) composite must be maximized to ensure an effective repair.	Polished specimens (P) and polished and air-abraded specimens (A), were randomly divided according to the following treatments: hydrophobic adhesive only, silane and hydrophobic adhesive, MDP containing silane and	The variables ‘‘surface treatment’’ and ‘‘adhesive’’ showed statistically significant differences for p,0.05.	Air abrasion with Al2O3 particles increased the repair bond strength of the nanoparticle composite, the use of MDP-containing silane did not affect the results.

				hydrophobic adhesive, universal adhesive only, silane and universal adhesive, and MDP-containing silane and universal adhesive.		The application of a silane-containing universal adhesive alone was as effective as any of the silane and adhesive combinations tested.
França, F. *et al.* (2007).	Long-term storage and aluminium oxide air abrasion on the bond strength of self-etching adhesive systems.	Seventy-two human third molars.	Clearfil SE Bond and One-Up Bond F adhesive systems showed similar microtensile bond strength, regardless of aluminium oxide air abrasion treatment or storage time.	Clearfil SE Bond and One-Up Bond F were applied to dentin surfaces in accordance with manufacturer's instructions with or without previous aluminium oxide 50 µm air abrasion.	Air abrasion improved Clearfil SE Bond bond strength in the three month evaluation. No significant difference was found between the two adhesives systems, but bond strengths gradually decreased over time. Failure modes varied significantly among groups and were influenced by long-term storage and aluminium oxide air abrasion.	There were no statistically significant differences between bond strength means of the two adhesive systems used with and without aluminium oxide air abrasion at the different storage times.

Freeman, R. *et al.* (2012).	Air abrasion and thermocycling on the adaptation and shear bond strength of composite resin bonded to dentin using etch-and-rinse and self-etch resin adhesives.	Forty-eight extracted third molars.	Close adaptation of adhesive to dentin was compromised by air abrasion and thermocycling, with specimens showing separation of the hybrid layer from the underlying dentin.	Control VS thermocycled; Air abrasion VS Control; Self-etch VS Etch-and-rinse.	Air abrasion significantly increased resin tag length ($p<0.05$) for the etch-and-rinse adhesive and significantly increased the number ($p<0.001$), length ($p<0.001$) and thickness ($p<0.01$) of tags for the self-etch adhesive. However, air abrasion resulted in defect formation within the hybrid layer and thermocycling caused separation of the hybrid layer from adjacent dentin containing resin tags.	The clinical significance of enhanced resin tag formation in air abraded dentin for self-etch adhesive restorations remains to be determined.
G., Paolinelis *et al.* (2008).	Examine the removal rate of sound and carious dentin using bioactive glass air-abrasion and investigate abrasive particle retention of alumina and	60 dentin blocks were abraded.	The effect of alumina on resin–dentin bonding is unknown and should be further investigated. A beneficial effect of bioactive glass retained on the tooth surface is remineralization.	A total of 60 dentin blocks were abraded using Alumina or Bioactive glass in 12 groups of 5, using three different pressures and using wet or dry air-abrasion.	The amount of dentin removed using bioactive glass air-abrasion had a Somers' D coefficient of 0.65 for the Knoop hardness. Wet air-abrasion caused a significant (p 0.05) decrease in the amount of abrasive retained on the surface for Al air-abrasion at 138 and	Bioglass is potentially more selective instrument for clinical caries excavation.

	bioactive glass on abraded dentin.				413 kPa and BG air-abrasion at 413 and 689 kPa.	
Rafael, C. F. *et al.* (2016).	The ability of airborne-particle abrasion with aluminium oxide on dentin to remove the smear layer and the effects produced on the dentin microstructure.	Twenty human third molars.	Bulk size of the cracks observed suggests implications for dentin hardness and structural integrity. The debris might also influence the dentin bonding performance.	Phosphoric acid was used for comparison. Pre-treatment method used: phosphoric acid VS aluminium oxide. For dentin surface analysis, an environmental scanning electron microscope was used to observe dentin surfaces.	After pre-treatment with phosphoric acid, the images revealed dentin tubule orifices opened, enlarged and some erosive effects. After pre-treatment with aluminium oxide exposed tubule orifices without enlargement, but crack-like alterations were observed on the surfaces.	Abrasion with aluminium oxide was able to remove the smear layer. Further studies are necessary to evaluate the influence of the dentin roughness produced by this mechanical pretreatment method on dentin bonding.
S., Sauro. *et al.* (2018).	Load-cycle aging and/or 6 months artificial saliva (AS) storage on bond durability and interfacial	Caries-free molars from 20- to 40-yr-old human subjects.	The current study showed a slight, but non-significant increase of bond strength values along with	Specimens abraded using 320-grit SiC VS abraded using 320-grit SiC and conditioned with 10% PAA gel. The	RMGIC applied onto dentin air-abraded with BAG regardless PAA showed no significant µTBS reduction after 6 months of AS storage and/or load cycling ($p>0.05$).	Dentin pre-treatment using BAG air-abrasion might be a suitable strategy to enhance the

	ultramorphology of resin-modified glass ionomer cement (RMGIC) applied to air-abraded dentin using Bioglass 45S5 (BAG) with/without polyacrylic acid (PAA) conditioning.		reduction of interfacial nanoleakage, in those specimens created with application of the RMGIC on BAG air-abraded dentin.	restorative procedure was performed with RMGIC Ionolux; Voco GmbH, Cuxhaven, Germany.	RMGIC–dentin interface showed no sign of degradation/nanoleakage after both aging regimens. Conversely, interfaces created in PAA-conditioned SiC-abraded specimens showed significant reduction in µTBS ($p<0.05$) after 6 months of storage and/or load cycling with evident porosities within bonding interface.	bonding performance and durability of RMGIC applied to dentin.
S., Sauro. *et al.* (2012).	The microtensile bond strength (mTBS) of two ‘‘simplified’’ self-etching adhesives bonded to air-abraded dentin using experimental bioactive glass powders	Caries-free human molars.	Air-abrasion procedures performed using pure Bioglass or PAA-containing Bioglass do not interfere with the immediate bonding performance of self-etching all-in-one adhesive systems formulated with specific	Sound dentin specimens were air-abraded using a pure Bioglass 45S5 powder or two Bioglass powders containing different concentration of polyacrylic acid (PAA:15wt% or 40wt%). The bonding procedures were accomplished by the application of two self-	The CS3 adhesive system achieved higher mTBS than those attained in the specimens bonded with GB both after 24h and 6 months of PBS storage.	It is possible to affirm that air-abrasion procedures performed using pure Bioglass or Bioglass containing 15wt% PAA do not interfere with the immediate bonding performance of

	containing polyacrylic acid.		functional monomers such as 10-MDP or 4MET. Nevertheless, since the ability of PAA.	etching adhesives (CS3: Clearfil S3 Bond; or GB: G Bond).		self-etching adhesives. However, the durability of the bonded-dentin interfaces created subsequent to air-abrasion procedures using bioactive glasses will depend also upon the chemical composition of the self-etch adhesive systems.
S., Sauro. *et al.* (2012).	Microtensile bond strength, after 6 months of storage in PBS, of a resin-modified glass ionomer cement bonded to dentin	Caries-free molars from 20- to 40-yr-old human subjects.	The air-abrasion procedures performed using Bioglass and polyacrylic acid fluid may also enhance the bonding	In this study the dentin specimens were air-abraded with Bioglass using two different approaches: in combination with deionized H 2 O (air-	The null hypothesis was rejected because the different etching and Bioglass air-abrasion dentin pre-treatments influenced the ITBS and the interface ultramorphology	The abrasion procedures performed using Bioglass in combination with polyacrylic acid might be a suitable strategy

	pretreated with Bioglass 45S5 using various etching and air-abrasion techniques.		durability of the resin-modified glass ionomer cement-bonded dentin when used according to the manufacturer's instructions.	abrasion BAG control); and in combination with a 10% polyacrylic acid fluid. Restored with light-cured RMGIC/composite.	after storage in PBS for both 24h and 6 months.	to enhance the bonding durability and the healing ability of resin-modified glass ionomer cement bonded to dentin.
Motisuki,C*. et al.* (2006).	Influence of the abrasive technique on the microtensile bond strength of composite resin restorations.	Nine extracted and caries-free third molars.	Air-abrasive technique, using 27 µm aluminium oxide particles, demonstrated better results when compared to the conventional method of cavity preparation. In addition, the air abrasion system may increase restoration longevity.	Air abraded dentin with 27 µm aluminium oxide VS Air abraded dentin with 50 µm aluminium oxide VS Cut dentin with a diamond bur in high speed rotary instrument. Bonding procedures: Single Bond adhesive.	The Tukey test showed that µTBS was significantly higher for dentin treated with 27 µm aluminium oxide abrasive when compared to bur-cut dentin. However, no significant difference between 27 and 50 µm particles was detected. Air abrasion with 27 and 50 µm aluminium oxide particles created a dentin surface with similar characteristics.	The air-abraded dentin, using 27 µm alumina powder, demonstrated higher composite bond strength when compared to bur-cut dentin.

Sutil, B. G.da S. *et al.* (2017).	To evaluate the effects of dentin pre-treatment and temperature on the bond strength of a universal adhesive system to dentin.	Ninety-six extracted non-carious human third molars.	Treatment of dentin with sodium bicarbonate significantly increased bond strength of the two techniques. When the adhesive was used in ER mode, bond strength increased significantly when the dentin was abraded with aluminium oxide, and there were no differences in bond strength when SbU was used in SE mode.	Scotchbond Universal Adhesive (SbU) applied in self-etch (SE) and etch-and-rinse (ER) mode, adhesive temperature (20°C or 37°C) and sodium bicarbonate or aluminium oxide air abrasion.	Both dentin treatments showed higher bond strength for ER mode, regardless of adhesive temperature. When compared to control group, sodium bicarbonate increased bond strength of SbU in SE technique. Predominantly, adhesive failure was observed for all groups.	Dentin surface treatment with sodium bicarbonate air abrasion improves bond strength of SbU, irrespective of adhesive application mode.
Yazici, A.R. *et al.* (2009).	Shear bond strength of a one-step self-etch adhesive to dentin pretreated with phosphoric	Fifty-six extracted non-carious human mandibular molars.	Air abrasion pre-treatment did not affect the bond strength to dentin.	Surface Treatment: Acid VS Laser VS Air abrasion VS Control (no treatment).	No statistically significant differences were found in shear bond strength between surfaces treated with air abrasion and the control group ($p>0.05$).	Surfaces pretreated with acid and laser adversely affected the bond strength of

	acid, air abrasion, or laser.			One-step self-etch adhesive system was use: Futura Bond NR.	Surfaces pretreated with laser resulted in the lowest bond strength which was not statistically different from those pretreated with acid ($p>0.05$).	a one-step self-etch adhesive, Futura Bond NR, while pre-treatment with air abrasion had no effect on bond strength.
Mujdeci, A*. et al.* (2004).	The effect of airborne-particle abrasion on the shear bond strengths of 4 restorative materials to enamel and dentin.	One hundred twelve extracted human maxillary anterior teeth.	Shear bond strength of all restorative materials to enamel and dentin showed increase with airborne-particle abrasion compared to the control groups.	Flat enamel surface VS Flat dentin surface; Airborne-particle abraded VS Control; Composite VS Compomer VS Resin-modified glass ionomer cement VS conventional glass ionomer cement.	Airborne-particle–abraded specimens showed significantly higher shear bond strengths than control specimens. The 2-way interaction between tooth structure and restorative materials was significant.	The use of airborne-particle abrasion increased the shear bond strength of restorative materials tested to enamel and dentin.

Discussion

1. Dentin Adhesion

Dentin presents several intrinsic features that make adhesion a complex procedure: need to be wet, smear layer and organic content. [2]

Moreover, the tubular build-up of dentin and the resulting outward pulpal water current in vital teeth add to its complexity as a substrate. [6]

After tooth preparation, dentin is covered with an iatrogenically produced smear layer, a structure formed by the debris resultant from the cutting process, and may exhibit different compositions, thickness and morphology. This structure can obliterate the dentinal tubules entrance, reducing their permeability to the penetration of the adhesive system and therefore making the adhesion to dentin substrate dependent on the type of existing smear layer. [5]

Total-etch adhesives interaction is mainly micromechanical, requiring the substrate conditioning with phosphoric acid for smear layer removal. Acid etching is the traditional preparation method for adhesion of composite materials to dentin, but clinical manipulation involves drying, wetting and then drying again but leaving enough humidity to prevent the collagen network collapse, which can prove to be a truly challenging and sensitive step that may jeopardize the final outcome. [4]

Self-etch adhesives use a non-rinse acidic primer that leads to a smear layer dissolution and integration. This technique simultaneously demineralizes and impregnates dentin with a fluid resin, contributing to lower sensitivity levels and less chance of incomplete resin penetration into the collagen network. [1]

Currently, it is known that the quality of intertubular dentin might be the key for successful dentin bonding, so it should be preserved. [4]

2. Air Abrasion with aluminium oxide

Sandblasting is widely used as a dentin pre-treatment and aluminium oxide has been chosen for several reasons: its oxide is highly insoluble and unlike many other aluminium salts, it is nontoxic, resulting in excellent biocompatibility. [2]

According to Rafael *et al.*, air abrasion with aluminium oxide preserves intertubular dentin by maintaining the original tubule diameter, creating a rough dentin surface and enlarging the contact area for adhesion. They showed through ESEM images that large bulk size cracks may cause implications for hardness and structural integrity of dentin after sandblasting. Also, the presence of debris on dentin surface might influence the dentin bonding performance by creating a dense smear layer that causes a decreased adhesive system infiltration and, consequently hinders bond strength. [4]

Amario *et al.* [2] concluded that the water rinsing following acid etching could remove Al2O3 particles, leaving a positive effect on adhesive penetration in dentin, which could explain results with higher bond strength on abraded groups compared to control groups.

The increased adhesive strength registered in abraded specimens could have been obtained with the increase on micromechanical retention and wettability of the adhesive systems.

Also, Mujdeci *et al.* [10] concluded that all restorative materials tested showed increased bond strength after air abrasion. Several reasons could be offered for these findings: the increased surface area, the type of smear layer, and the increase in tooth structure wettability. Another reason for increased bond strength may be the combined effect between the application of a conditioning system and air-abrasion before applying restorative materials.

Air abrasion has been suggested to decrease resin bond strength to etched surfaces due to the increased capability of acid to over demineralise the dentin surface, causing collagen collapse and the deposition of calcium phosphate, which disrupts penetration of the adhesive. [5]

However, França *et al.* [1] concluded differently and stated that prior dentinal air abrasion with aluminium oxide did not influence the bond strength of self-etch adhesive systems at different evaluation times.

Yazici *et al.* [11] studied the different pre-treatment methods effects on dentin bond strength when using a one-step self-etch adhesive, stating that bond strength decreases with laser treatment, while air abrasion showed no effect on adhesive performance.

On the other hand, the same author also stated that the need for dentin pre-treatment prior to self-etch adhesive application is somewhat controversial and defeats the original purpose of these systems. [11]

In clinical practice, Al2O3 air abrasion requires some additional precautions. The isolation of the working field and an adequate suction of the formed aluminium powder cloud are both mandatory procedures to avoid inhalation of Al2O3 particles. Sandblasting standardization, such as maintaining pressure, angulation and distance, and ensuring that the procedure duration does not exceed the recommended time, represent a significant clinical challenge. [12]

3. Air abrasion with Bioactive Glass

Several methods are available to perform minimally invasive cavity preparation.

Air-abrasion with bioactive glass has been advocated as a technique that can be used for the preparation of a noise, vibration and pain-free cavity with rounded internal angles, while creating a bioactive smear-layer covered surface for bonding procedures. [13]

Moreover, Paolinelis *et al*. [8] showed that air-abrasion with Bioglass 45S5 can be used to prepare both sound and carious dentin and is potentially a more selective instrument for clinical caries removal than air abrasion with aluminium oxide.

Also Paolinelis *et al*. [8] showed that a beneficial effect of bioactive glass retained on the tooth surface is remineralization.

A biomimetic process characterized by silicic acid release, and a poly-condensation reaction with the presence of fluids analogous to saliva or body fluids (i.e. PBS) fortifies an immediate interchange between sodium ions and hydrogen cations, inducing a rapid release of calcium ions and phosphate. An increase in Ph seems to help the precipitation of calcium and phosphate from the particles and from PBS to form an amorphous calcium phosphate layer that is then hydrolyzed into hydroxyapatite as the reactions continue. Consequently, the activity of bioglass to promote hydroxyapatite precipitation by ion-release ability, and the inactivation of endogenous dentin proteases induced by remineralization processes seem to give such restorations a self-healing potential.[14]

Carvalho *et al*.[15] proposed that air abrasion with experimental bioactive glass is not a way to enforce bond strength, since this pre-treatment powder did not interfere with the performance of the restorative materials. It is rather presented as a promising technique to participate in the formation of a Bioglass-rich smear layer available for conversion into apatite at the resin-dentin interface.

Sauro *et al*.[14] also states that air-abrasion using Bioglass does not interfere with the immediate bonding performance of self-etching adhesives. However, the durability of the bonded dentin interfaces created subsequent to air-abrasion procedures using bioactive glasses seems to depend on the chemical composition of the self-etch adhesive systems.

Bioactive glass air abrasion techniques can possibly prevent the re-occurrence of secondary carious lesions, as well as the presence of a bioactive smear layer that can occlude dentinal tubules, protect the bonded interface and preserve the adhesion. [16]

The potential application of this dentin pre-treatment technology where caries may be surgically removed while at the same time remineralization of the remaining dentin is improved, would be particularly useful in Class V lesions where the prepared margin is often in dentin. [8]

Answering the research question ‘‘Does dentin pre-treatment with aluminium oxide and/or bioactive glass increase bond strength?’, discrepancies between studies and methodology’s make direct comparisons not always possible. Taking into account this heterogeneity, both of the dentin pre-treatments interfere with bond strength. The main disadvantage of air abrasion with aluminium oxide is creating a dense smear layer that would decrease the infiltration of the adhesive system and consequently decrease bond strength. On the other hand, air abrasion with bioactive glass seems to provide restorations with a self-healing potential, but further studies are necessary to confirm this observation and its influence on bond strength.

Conclusion

Based on reviewed literature findings and within the limitations of this review, it is suggested that the lack of *in vivo*, as well as *in vitro*, unbiased scientific evidence regarding these dentin pre-treatment techniques hinders their recommendation as evidence-based valid methods, thus making them controversial for clinical application without further research. Although the effects on resin–dentin bonding are still unclear and should be further investigated, an apparent beneficial effect of bioactive glass seems to be its remineralization potential, but more data on its effect regarding dentinal bonding is still needed.

Acknowledgements

Ao meu orientador, Professor Doutor Fernando Guerra, pelos conhecimentos transmitidos, pela oportunidade única de crescimento e pela ajuda, tanto a nível profissional como pessoal, ao longo destes 5 anos.

Ao meu co-orientador Doutor Rui Isidro Falacho, pelo apoio incondicional, pela paciência, por incutir em mim um espírito de profissionalismo, liderança e mais do que tudo por ver sempre o lado positivo da vida. Obrigada ainda pelos conselhos, pelas vivências, pela partilha de saber e pela amizade.

Aos meus pais, Alisa e Octavian, pela dedicação, pelo amor, pelos abraços nas horas certas, pela partilha de tudo aquilo que estes 5 anos significaram para mim. Obrigada pela compreensão e pelo exemplo de vida. São a força e a paixão que me acompanha diariamente, um exemplo que tentarei sempre seguir!

Aos meus avós, pelas memórias, pela paixão e por daqui ou do céu acompanharem o meu percurso.

Aos meus amigos, que agora são para sempre, por viverem comigo todos os dias aquilo que significa Coimbra.

E a ti, Coimbra!

O meu mais sincero bem-haja!

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