Review Article

Efficacy of prostheses bonding using silane incorporated to universal adhesives or applied separately: A systematic review

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Abstract

Currently, the long-term success of esthetic rehabilitation with ceramics is required. Hence, professional knowledge about the most indicated dental material for each clinical situation as well as its usage protocol is essential. The aim of this systematic review of clinical and laboratorial studies was to compare the bond strength of prostheses using silane incorporated to universal adhesives or applied separately. The literature search in databases "Cochrane Library," "MEDLINE," "Web of Science," "Scopus," "LILACS," "Scielo," and "Google Scholar" was based on the keywords "Silane;" "Silanes;" "Silane coupling agent;" "Universal adhesive;" and "Universal adhesives." A total of five articles were included in this review. In general, the studies showed better results for ceramic etching with hydrofluoric acid and application of silane separately to the universal adhesive. As a conclusion, the treatment with pure silane or as an additional pretreatment with universal adhesives improved the bond strength of glass ceramics. Hence, higher shear bond strength can be achieved, resulting in treatment longevity.

Keywords: Bond strength, silane, universal adhesives

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INTRODUCTION

Currently, the long-term success of esthetic rehabilitation with ceramics is required. Hence, professional knowledge about the most indicated dental material for each clinical situation as well as its protocol is essential. Assuming that manufacturers have simplified the materials protocols, an analysis of such products, postcementation is relevant to provide the longevity of ceramic rehabilitation.[1,2]

In this sense, the significant and versatile evolution of adhesive systems reduced the number of operative steps for clinicians such as the universal adhesives containing silane coupling agent.[1,3] This agent is essential for bonding of silica-based ceramics.[2] Hence, some studies have evaluated the bonding efficacy of such component when added to universal adhesives or applied separately.[1-3]

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The feldspathic, leucite-, and lithium disilicate-reinforced ceramics have a glass matrix with silica. Thus, silane has to be applied after etching with hydrofluoric acid to provide long-term chemical bonding between resin monomers of cement and silica crystals of ceramic. On the contrary, silane is optional or not required for zirconia-based ceramics.[2,3]

Assuming the relevance of adhesion for the longevity of indirect restorations and the effect of silane on bonding, the efficacy of such coupling agent when added to universal adhesives or not should be further evaluated. Hence, the aim of this systematic review was to compare the bond strength of prostheses when using silane incorporated into universal adhesives or applied separately. The question that this review proposes to answer is: Who is more effective in the adhesion of prostheses, the use of silane incorporated to adhesives, or when the silane is applied separately from the adhesive?

MATERIALS AND METHODS

This review followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-analyzes. A systematic review of all *in vitro* and *in vivo* laboratorial and clinical studies was done to evaluate the bonding efficacy of prostheses using silane incorporated to adhesives or applied separately. The inclusion criteria were clinical and *in vitro* and *in vivo* laboratorial studies evaluating bonding efficacy and stability when silane was added to the adhesive or applied separately, using protocols of bond strength test. Studies evaluating the bonding efficacy of prostheses using silane added to other materials or pretreatment of ceramic with any material sandblasting were excluded from the review. Studies with no control group were also eliminated.

The electronic search was done by three researchers (ISM, LAM, and EOA), independently, from January to March 2018. The search on databases Cochrane Library, MEDLINE, Web of Science, Scopus, LILACS, Scielo, and Google Scholar used the keywords "Silane;" "Silanes;" "Silane Coupling Agent;" "Universal Adhesive;" and "Universal Adhesives." The search strategies for each database are shown in Table 1.

After searching on databases, the titles and abstracts were organized in a standardized form. Then, the three researchers, using the same eligibility criteria, selected the studies that should be read and included in the review.

Data of those studies were extracted and recorded by the three authors (ISM, LAM, and EOA), independently and together. Data about sample and country, methods, details of bond strength test, and conclusions were recorded.

Table 1: Search strategies for each database

Base	Strategy
PubMed, Medline	(("Silane" OR "Silanes" OR "Silane coupling agent") AND ("Universal adhesive" OR "Universal adhesives"))
Web of science	TS=("Silane" OR "Silanes" OR "Silane coupling agent") AND TS=("Universal adhesive" OR "Universal adhesives")
Scopus	(TITLE-ABS-KEY ("Silane" OR "Silanes" OR "Silane coupling agent") AND TITLE-ABS-KEY ("Universal adhesive" OR "Universal adhesives"))
Cochrane	"Silane"OR "Silanes" OR "Silane coupling agent" and "Universal adhesive" OR "Universal adhesives"
Lilacs	"Silane" OR "Silanes"OR "Silanes coupling agent" [Words] and "Universal adhesive" OR "Universal adhesives" [Words]
Scielo	(("Silane" OR "Silanes" OR "Silane coupling agent") AND ("Universal adhesive" OR "universal adhesives"))
Google scholar	"Silane" + "Silanes" + "Silane coupling agent" + "Universal adhesive" +"Universal adhesives"

In case of disagreement, the authors consulted an additional author (ACFJ), and the group took a final decision by consensus. Finally, Cochrane risk of bias tool was used to evaluate sources of bias of the studies inserted in this review from the sequence generation, allocation concealment, masking/blinding of participants, personnel and outcome assessors, incomplete outcome data, selective outcome reporting, and other potential sources of bias. This tool was used to evaluate the quality of the studies included in this review, classifying them in studies with "low risk of bias," "unclear risk of bias," and "high risk of bias" [Table 2].

RESULTS

The manual and electronic search resulted in 75 titles and abstracts. Then, 18 articles were selected and read based on the inclusion and exclusion criteria. At the end, five studies were included in the review [Figure 1 and Table 3].

All studies included in this review performed *in vitro* analysis. The articles evaluated the prostheses bonding for universal adhesives containing silane in the same bottle, and also adhesives and silane applied separately. The studies conducted bond strength tests (i.e., shear and micro-shear bond strength) for prostheses and resin cements [Table 4]. In general, the studies showed better results for ceramic etching with hydrofluoric acid and application of silane separately to the universal adhesive.

For all the studies included in this review,[1,4-7] the type of study, the year of publication, the groups tested, and their results are presented in Table 4.

Table 2: Risk of biases of the articles selected for the systematic review

Study	Sequence generation	Allocation concealment	Masking/blinding of participants, personnel	Masking/blinding of outcome assessors	Incomplete outcome data	Selective outcome reporting	Other potential sources of bias	Study's classification
Cardenas *et al*.[4]	Low	Low	Low	Low	Low	Low	Low	Low
Moro *et al*.[1]	Low	Low	Low	Low	Low	Low	Low	Low
Yao *et al*.[5]	Low	Low	Low	Low	Low	Low	Low	Low
Kim *et al*.[6]	Low	Low	Low	Low	Low	Low	Low	Low
Alrahlah *et al*.[7]	Low	Low	Low	Low	Low	Low	Low	Low

Table 3: Studies excluded after reading and exclusion factor

Further surface treatment of ceramic with another material besides silane
Murillo-Gómez *et al*., 2017[8]
Garboza *et al*., 2016[9]
Zaghloul *et al*., 2014[10]
Amaral *et al*., 2014[11]
No investigated group (universal adhesive with silane and adhesive + silane in separate bottles)
Lee *et al*., 2017[12]
Yoshihara *et al*., 2016[3]
Xie *et al*., 2016[13]
Lee *et al*., 2015[14]
Passia *et al*., 2015[15]
Kalavacharla *et al*., 2015[16]
Isolan *et al*., 2014[17]
Murillo-Gomez and Goes 2017[18]
Siqueira *et al*., 2016[19]

DISCUSSION

The present systematic review of laboratorial and clinical studies compared the bond strength of prostheses using universal adhesives and silane in the same bottle or applied separately. All studies meeting the inclusion criteria were selected. A systematic review using randomized clinical trials with high scientific evidence was not possible since all researches comparing universal adhesives containing silane with those adhesives and silane applied separately are still in laboratorial phase. However, with regard to the quality of included studies, it can be seen that the proposed results have reliability, internal, and external validity since the studies have a low risk of bias.

The search results showed a low number of studies evaluating the efficacy of universal adhesives on prostheses bonding. No study in humans was found, which reveals a low level of scientific evidence for answering the study purpose.

In general, the review results indicated an unquestionable evolution of the universal adhesive systems to reduce the number of operative steps and time spent in clinical procedure.[1,4] However, the presence of different components in the same bottle (i.e., acid methacryloyloxydecyl dihydrogen phosphate (MDP), bisphenol-A glycidyl methacrylate (BisGMA), and silane) may influence the silane coupling agent function, making its molecule instable in solution.[5]

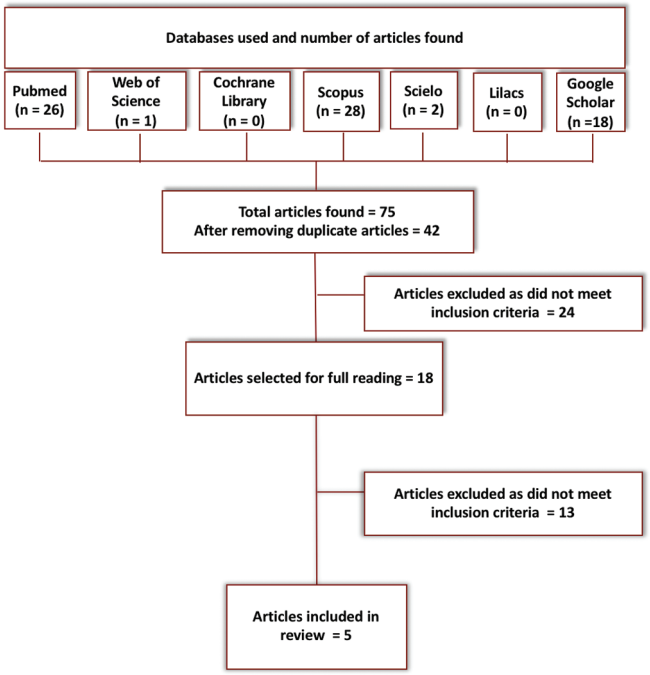

Figure 1: Flowchart of the studies

The bifunctional molecule of silane most used in Dentistry is 3-Metacriloxipropiltrimetoxisilane, prehydrolyzed and diluted in a solution of water and ethanol with optimum pH ranging from 4 to 5, adjusted with acetic acid.[1] Hence, assuming the higher acidity found in the bottle of universal adhesives as a consequence of MDP molecules, the optimum pH for silane is changed, causing an autocondensation reaction and early formation of its active form silanol. In addition, BisGMA avoids silane reaction with hydroxyl on ceramic surface, making it unstable.[5,14]

In the present study, all articles used in the review showed better prostheses bonding when silane and adhesive were applied separately. Hence, the pretreatment of ceramic with hydrofluoric acid followed by the application of universal adhesives containing silane is not as efficient as the application of only silane. Besides the influence of pH change on bonding between ceramic and resin cement, the high viscosity of universal adhesives may reduce the penetration of the coupling agent in the retentions created by the hydrofluoric acid.[5,14,19]

Table 4: Characteristics and summary of the results of the studies included in the review

Author and year	Purpose	Groups tested	Main results
Cardenas *et al*., 2017	Evaluate the effect of silane and adhesive, applied together or separately, on the bond strength of lithium disilicate-reinforced ceramics and resin cement using μSBS test	Group 1 - Application of only the cement enforce dentsply; Group 2 - Previous application of only the adhesive prime and bond elect and cement enforce dentsply; Group 3 - Previous application of only silane with no functional monomers (MBS) and cement enforce dentsply; Group 4 - Previous application of silane with no MBS and the adhesive prime and bond elect and cement enforce dentsply; Group 5 - Previous application of only silane with functional monomers- MDP (MB+) and cement enforce dentsply; Group 6 - Previous application of silane with MDP (MB+) and the adhesive prime and bond elect and cement enforce dentsply; Group 7 - Application of only the cement RelyX Ultimate; Group 8 - Previous application of only the adhesive Scotchbond Universal Adhesive (SBU) and cement RelyX Ultimate; Group 9 - Previous application of only silane with no MBS and cement RelyX Ultimate; Group 10 - Previous application of silane with MDP (MBS) and the adhesive Scotchbond Universal Adhesive and cement RelyX Ultimate; Group 11 - Previous application of only silane with MDP (MB+) and cement RelyX Ultimate; and Group 12 - Previous application of silane with MDP (MB+) and the adhesive Scotchbond Universal Adhesive and cement RelyX Ultimate	The application of cementation composites without adhesive showed the lowest mean μSBS in 1 year, while the application of adhesive prime and bond elect and MB+silane presented the highest mean μSBS in 1 year. RelyX Ultimate resulted in significantly higher μSBS in 24h when the SBU adhesive or MBS silane were used separately and when MB + was associated to SBU. Nevertheless, the association of MBS or MB+to SBU, as well as MB + with no adhesive, resulted in μSBS similar to the group with only cement. The PBE resulted in significantly higher μSBS in 24 h in all groups when compared to SBU. As a conclusion, a simplified cementation protocol using silane or universal adhesive is not recommended
Moro *et al*., 2017	Evaluate the effects of an additional application of silane, before using an universal adhesive, on bonding of lithium disilicate-reinforced ceramics and resin cylinders using shear bond strength test	Group 1 - Lithium disilicate blocks with application of silane and conventional adhesive (Adper Single Bond Plus); Group 2 - Lithium disilicate blocks with application of silane, conventional adhesive, and thermal cycling; Group 3 - Lithium disilicate blocks with application of silane and universal adhesive (adhesive Scotchbond Universal); Group 4 - Lithium disilicate blocks with application of silane, universal adhesive, and thermal cycling; Group 5 - Lithium disilicate blocks with application of only universal adhesive; Group 6 - Lithium disilicate blocks with application of universal adhesive and thermal cycling; Group 7 - Lithium disilicate blocks with application of silane and universal adhesive mixed with activator (Dual Cure Activator); Group 8 - Lithium disilicate blocks with application of silane, universal adhesive mixed with activator, and thermal cycling; Group 9 - Lithium disilicate blocks with application of only universal adhesive mixed with activator; and Group 10 - Lithium disilicate blocks with application of universal adhesive mixed with activator and thermal cycling	The groups with additional application of silane presented the six highest mean values of bond strength. Thermal cycling reduced the bond strength in all groups. Furthermore, the additional application of silane significantly improved the value of shear bond strength in the groups with universal adhesive and universal adhesive mixed with activator. As a conclusion, the performance of adhesive systems can be improved with an additional application of silane
Yao *et al*., 2017	Investigate the effect of pretreatment with silane previous to the application of universal adhesives on bond strength of lithium disilicate-reinforced ceramics and composite resins	Group 1 - Lithium disilicate blocks with previous application of only universal adhesive (All-Bond Universal); Group 2 - Lithium disilicate blocks with previous application of silane and universal adhesive (All-Bond Universal); Group 3 - Lithium disilicate blocks with previous application of only universal adhesive (Adhesive Universal); Group 4 - Lithium disilicate blocks with previous application of silane and universal adhesive (Adhesive Universal); Group 5 - Lithium disilicate blocks with previous application of only universal adhesive (Clearfil Universal Bond); Group 6 - Lithium disilicate blocks with previous application of silane and universal adhesive (Clearfil Universal Bond); Group 7 - Lithium disilicate blocks with previous application of only universal adhesive (Single Bond Universal); and Group 8 - Lithium disilicate blocks with previous application of silane and universal adhesive (Single Bond Universal)	For no additional pretreatment with silane, the shear bond strength was not significantly different between the adhesives Clearfil Universal Bond or Single Bond Universal (adhesives with silane) and the adhesives with no silane (All-Bond Universal and Adhese Universal). Furthermore, the highest shear bond strength was found for the adhesive single bond universal when the groups were pretreated with additional silane. For all universal adhesives, the groups pretreated with silane presented significantly higher shear bond strength than the groups with no pretreatment with silane

Contd...

Table 4: Contd...

Author and year	Purpose	Groups tested	Main results
Kim *et al*., 2015	Investigate the shear bond strength (μSBS) of universal adhesives applied on leucite-reinforced ceramic	Group 1 - Application of only resin cement (RelyX Ultimate) on ceramic blocks and no pretreatment with silane or universal adhesive; Group 2 - Application of only universal adhesive (Single Bond Universal; 3M ESPE) on ceramic blocks previous to resin cement; Group 3 - Application of only universal adhesive without silane (All-Bond) on ceramic blocks previous to resin cement; Group 4 - Application of silane and adhesive (Adper Scotchbond Multipurpose Adhesive) on ceramic blocks previous to resin cement	The μSBS reduced from Group 4>Group 2>Group 3>Group 1. However, all groups presented significant reduction in μSBS after thermal cycling. Hence, after thermal cycling, the highest and lowest μSBS was found in the Groups 4 and 1, respectively. No significant difference was found between the Groups 2 and 3. As a conclusion, conditioning of ceramic surface with silane and adhesive separately is better than a simplified procedure
Alrahlah *et al*., 2017	Evaluate the effect of different surface treatments on bond strength of lithium disilicate-reinforced ceramic and resin cement	Group 1 - Lithium disilicate blocks with previous application of hydrofluoric acid, silane, and universal adhesive; Group 2 - lithium disilicate blocks with previous application of hydrofluoric acid and universal adhesive; and Group 3 - Lithium disilicate blocks with previous application of self-adhesive ceramic primer and universal adhesive	The maximum and minimum shear bond strength was found in the Groups 3 and 2, respectively. The shear bond strength of the Groups 1 and 3 was significantly higher than Group 2. However, there was no significant difference between the Groups 1 and 3

MBS: Methacrylate-butadiene-styrene, μSBS: Micro-shear bond strength, MDP: Methacryloyloxydecyl dihydrogen phosphate

It's noteworthy that Yao *et al*., in 2017, found no significant difference in shear bond strength comparing adhesives containing silane or not when no additional pretreatment with silane was done.[5] It has been suggested that the amount of silane found in the universal adhesives may be not appropriate; hence, further studies evaluating the influence of silane amount on prostheses bonding are required.

Although most of the studies present different methods (i.e., different cement brands), all *in vitro* researches included in this review have demonstrated better performance for surface treatment of glass ceramics using hydrofluoric acid and silane in a separate bottle of the universal adhesive. Hence, the results suggest that an additional pretreatment with silane provides a regular and functional layer for bonding between the resin monomers of cement and glass ceramic. Then, assuming the limitations of laboratory studies compared to the real treatment in humans, clinical studies are required to confirm the results of the present study.

CONCLUSION

The results indicated that treatment with pure silane or as an additional pretreatment with universal adhesives could improve the bond strength of glass ceramics. Hence, higher shear bond strength can be achieved for the longevity of rehabilitation.

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Conflicts of interest
There are no conflicts of interest.

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