

Orthodontic bonding to porcelain *A systematic review*

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ABSTRACT

Objective: To use a systematic review to determine which materials and technique/protocol present the highest success rate in bonding brackets to porcelain surfaces.

Materials and Methods: Different databases were searched without limitations up to July 2013. Additionally, the bibliographies of the finally selected articles were hand searched to identify any relevant publications that were not identified earlier. In vitro and in vivo articles were included.

Results: No in vivo articles were found that fulfilled the inclusion criteria. A total of 45 in vitro articles met all inclusion criteria. They were published between 2000 to July 2013.

Conclusions: The best protocol described in this review is the etching of 9.6% hydrofluoric acid for 1 minute, rinsed for 30 seconds, and then air-dried. The etching of hydrofluoric acid should be followed by an application of silane. Considering the harmful effects of etching with hydrofluoric acid, another appropriate suggestion is mechanical roughening with sandblasting followed by an application of silane. (*Angle Orthod.* 2014;84:555–560.)

KEY WORDS: Bond; Brackets; Orthodontics; Porcelain

INTRODUCTION

The number of adult patients seeking orthodontic treatment is increasing.^{1,2} This has encouraged orthodontists to test several different protocols with respect to bonding brackets to different dental restorations (specifically porcelain/ceramic restorations). Bonding orthodontic brackets to porcelain/ceramic surfaces presents a higher degree of failure when compared to bonding to enamel. Many times this is granted to the porcelain type and surface conditioning, bracket material (base design, retention mode), properties of the bonding adhesive, and the light-curing source, as well as the skill of the clinician.^{2,3} Also, adequate bond

strength is desired with easy removal to avoid damage of the restored teeth.^{4,5}

Several techniques have been used to bond brackets to porcelain surfaces and these differ in surface preparation and bonding agent applied. Some examples of these have been reported with the use of phosphoric acid⁶ or hydrofluoric acid.⁷ Other studies tested the use of silane coupling^{6,8} and other present discrepancies in terms of roughening of the porcelain surface or not.^{8,9}

With the advancement of science and technology, dental materials are being improved at a very fast pace.¹⁰ The purpose of the present systematic review is to determine which materials and technique/protocol present the highest success rate in bonding brackets to porcelain surfaces.

MATERIALS AND METHODS

Terms used in the literature search consisted of bond, porcelain, orthodontics, and their respective abbreviations according to the search engine used. Inclusion criteria applied to the initial selection of the appropriate articles from the published abstracts consisted of:

- orthodontic bonding on porcelain crowns or veneers;
- in vitro and in vivo studies;
- no case reports; and
- studies published from 2000 to present.

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Table 1. Search Results From Different Databases

Database	Keywords	Results	Selected	% of Total Selected Abstracts ^a
PubMed	(1) Bond*; (2) orthodontic*; (3) porcelain*; (4) 1 and 2 and 3	158	36	83.7
Medline	(1) "Bond*"; (2) "orthodontic*"; (3) "porcelain*"; (4) 1 and 2 and 3	144	36	83.7
Embase	(1) "Bond*"; (2) "orthodontic*"; (3) "porcelain*"; (4) 1 and 2 and 3	156	33	76.7
All EBM reviews (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE, and CCTR)	(1) "Bond*"; (2) "orthodontic*"; (3) "porcelain*"; (4) 1 and 2 and 3	18	1	2.3
Lilacs	(1) Bond; (2) porcelain; (3) orthodontic; (4) 1 and 2 and 3	25	2	4.7
Web of science	(1) Ceramic*; (2) porcelain*; (3) bond*; (4) orthodont*; (5) 2 or 1; (6) 5 and 4 and 3; (7) 5 and 4 and 3 refined publication years 2000–2012	143	35	81.4

* Used to truncate word to have search engine search word with different endings.

^a Percentages do not add up to 100% because the same reference could be found in several databases.

A computerized search was conducted using Medline (from 2000 to July 2013), Lilacs (from 2000 to July 2013), PubMed (2000 to July 2013), Embase (from 2000 to July 2013), and all evidence-based medicine review (Cochrane Database of Systematic Reviews, ASP Journal Club, DARE, Web of Science, and CCTR) (from 2000 to July 2013) databases for orthodontic bonding to porcelain.

Eligibility of the articles identified by each search engine was determined by reading their respective title and abstract. Two researchers selected the articles to be collected. Articles from abstracts in which not enough relevant information was stated were also obtained.

The researchers reading the complete articles independently completed the final selection, and their results were compared until final consensus was achieved. Reference lists of the selected articles were hand-searched for additional relevant publications that may have been missed by the search engines.

RESULTS

The search results and the initial number of abstracts selected according to the selection criteria from the various databases are provided in Table 1. From the 51 studies collected from all of the databases based on their title and abstract, only 45 studies actually fulfilled the selection criteria after the two reviewers examined each study. Two of the trials were rejected because the articles proved to be a review based on the topic rather than on an experimental study.^{11,12} One of the articles was rejected because it was an unpublished thesis. Three trials were rejected because they proved to be irrelevant to the topic of determining the ideal protocol for bonding brackets to porcelain teeth.^{13–15} One trial was rejected because it failed to provide a protocol.⁴ The author was contacted, but we were not able to determine the extra information that was needed for this review. Another trial was

rejected because it was before the year 2000.⁸ The final selection of studies were all in vitro. Table 2 presents the flow of article selection in this systematic review. Although 45 articles satisfied the final selection criteria, methodologies were varied, making a meta-analysis not possible.

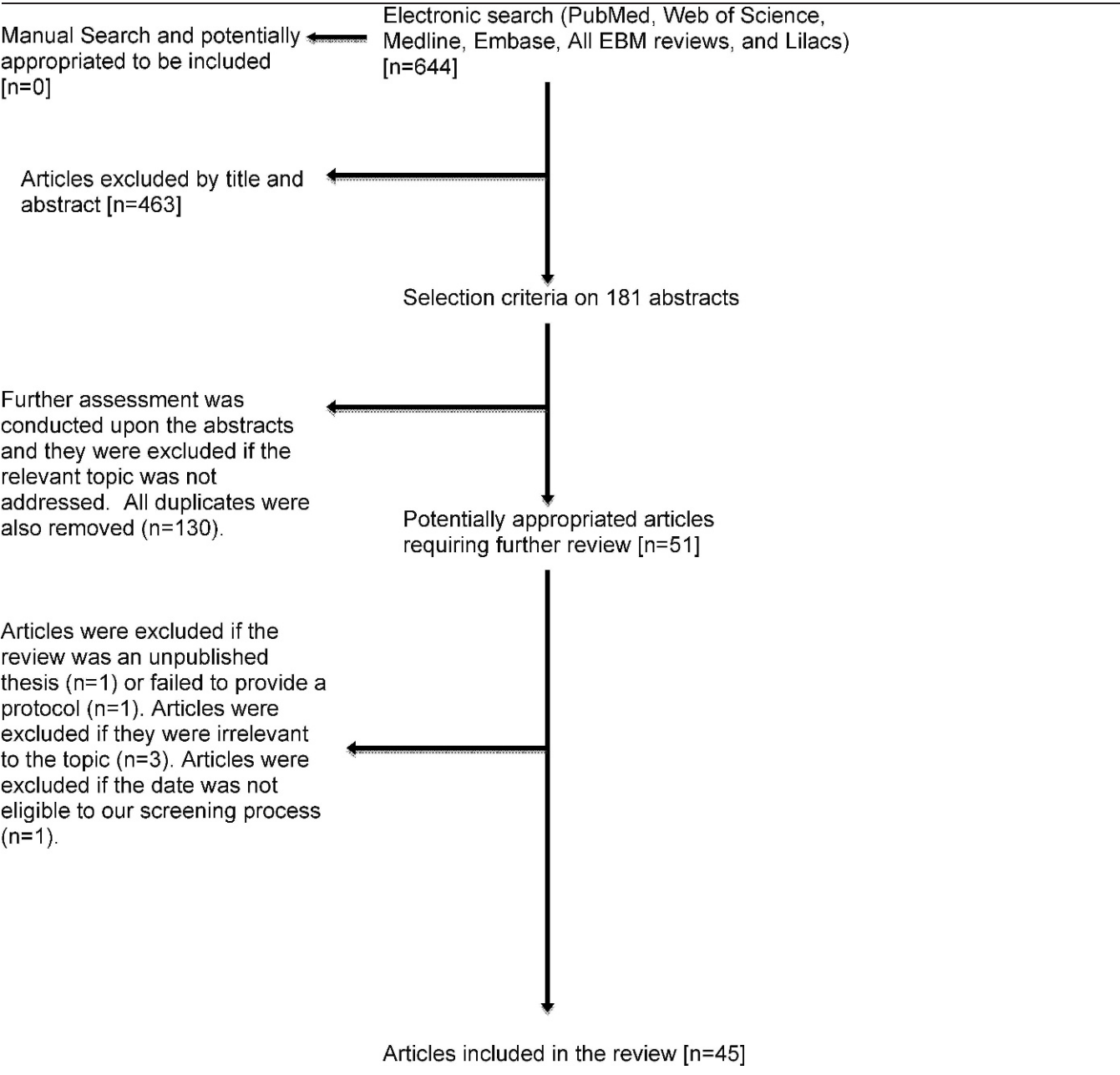
Treatment by Different Laser Techniques

Six studies involved laser techniques in bonding. Three of the studies focused on showing the effect of laser irradiation on the adhesion of the bracket to porcelain and compared it to conventional techniques.^{16–18} An and Sohn¹⁹ and Akova et al.²⁰ showed that the conventional technique of hydrofluoric acid (HFA) and silane, sandblasting and silane, orthophosphoric acid and silane, and hydrofluoric acid had higher bond strength than laser etch and silane. However, the bond strength of the laser group was significantly higher than the orthophosphoric acid, sandblasted, and control groups. The results prove that the 2W/20-second superpulse CO₂ laser irradiation provides acceptable bond strength of metal brackets to porcelain surfaces. Poosti et al.²¹ proved that laser irradiation by Nd:YAG laser is an acceptable substitute for hydrofluoric acid; however, the Er:YAG laser is not an acceptable option.

Elekdag-Turk et al.¹⁶ evaluated the effect of different light-emitting diode curing times on shear bond strength of the metal brackets to porcelain surfaces. There was no significant variance shown in the groups with the different curing times, and they proved LED use is reliable for a 3-second curing time because it presented adequate bond strength.

Goncalves et al.¹⁷ proved that there was no significant difference between the different light sources of XL2500 halogen light, UltraLume 5 LED, AccuCure 3000 argon laser, and Apollo 95E plasma arc in bond strength. Turkkahraman and Kucukesen¹⁸ determined the difference between using a LED

Table 2. Flow Diagram of the Literature Search



light and a halogen light. The LED curing technique yielded higher bond strength of the metal brackets than the halogen light.

Different Acid Concentrations

The study by Trakyalii et al.²² determined if there was an optimum acid concentration that would yield the highest bond strength of metal brackets to porcelain surfaces. The optimum concentration that increased bond strength was 9.6% hydrofluoric acid, but no significant difference was found between the groups etched with 9% and 5% hydrofluoric acid.

Different Brands of Silane

Results from the study by Trakyalii et al.²² and Costa et al.²³ proved that there is a difference between the bond strength that results from the various brands of silane. The conclusion proved that silanization with Reliance resulted in higher bond strengths than Pulpdent.

Different Etching Times

Two studies evaluated the bond strengths of metallic brackets to porcelain surfaces with different etching times.^{17,22} The results proved that the specimens that

were etched for 60 seconds showed significantly higher bond strengths than the specimens etched for 20 seconds.

Different Adhesives

Two of the studies focused on comparing the durability of the different adhesives tested on the bonding of the brackets to the porcelain surfaces.^{24,25} Rambhia et al.²⁴ used two different adhesives: Fuji Ortho LC and Ortho Bracket Adhesive. Kitayama et al.²⁵ used three adhesives: Concise as a chemically cured composite resin, Fuji Ortho as a chemically cured resin-modified glass ionomer cement, and Fuji Ortho LC as a light-cured resin-modified glass ionomer cement. Both studies concluded that there was no alteration among the different adhesives.

Various Base Designs

Two of the studies evaluated the difference between various base designs of brackets bonded to porcelain surfaces.^{26,27} Both studies concluded that beads base design statistically yielded the highest shear bond strength and was significantly higher than large round pits base, irregular bases, and metal mesh base designs.

Deglazed or Glazed

Barceló Santana et al.²⁸ conducted a study to display the highest bond strength to three different commercial ceramic brands and to determine whether deglazed or glazed, with or without silane treatment would distinguish a difference. This study proved that the greatest bond strength value was for Empress 2 deglazed with the silane application, followed by Finesse glazed with the silane application. This study concluded that a deglazed porcelain surface would yield the highest shear bond strength.

With or Without Silane Treatment

The studies concluded that using a silane application significantly increased the bond strength of the brackets to the ceramic materials.^{23,28,29} The studies compared different conditioning techniques and the techniques that included silane proved that it efficiently increased the shear bond strength.

Different Ceramic Surfaces

These studies tested how different ceramic surfaces or ceramic brands would affect the shear bond strength of metal brackets bonded to these surfaces.^{28,30-34} The experiments also incorporated other factors that could affect the shear bond strength such as the different conventional techniques. However,

there was a trend that the brand that represented the highest bond strength was Empress II and Finesse. The conclusion stated that ceramo-metal and In-Ceram had comparable shear bond strengths, and IPS Empress group showed the weakest bond strengths. The different conventional techniques that were shown to be most effective on the different ceramic surfaces were silica coating on feldspathic and lithia disilicate-based ceramic. The conventional technique that yielded the lowest shear bond strength for ceramic surfaces was sandblasting surfaces alone.

Different Conditioning Techniques

Throughout this review, it was concluded that a particular protocol resulted in the highest shear bond strength. There were many protocols that included various brands of adhesives, different etching times, optimum acid concentration, and a particular sandblasting technique. The protocol that resulted in the highest shear bond strength was etching the porcelain surface with 9.6% hydrofluoric acid and applying silane or a bonding agent. This procedure produced higher shear bond strength than groups that were etched with acidulated phosphate fluoride, silane, and sandblasting by diamond burs or aluminum oxide particles, or sandblasting and etching alone. It was also concluded that an ideal protocol was using air-particle abrasion at a pressure of 2.5 bars for 4 seconds and etching with hydrofluoric acid. This produced higher shear bond strength than using hydrofluoric acid alone.

DISCUSSION

The main objective of this review was to determine the most efficient and reliable method in obtaining bond strength of orthodontic brackets to porcelain crowns that can be applied to clinical practice. In the subsection of different conditioning methods, the results of whether hydrofluoric acid and roughening through sandblasting and diamond burs were proven to significantly increase the bond strength. Throughout the studies, it is apparent that the use of hydrofluoric acid greatly increases the bond strength. This is due to the acid's ability to react with the silica phase, which creates micromechanical retention through microchannels. Over time, the glassy matrix partially dissolves and increases the formation of retentive channels. The etching of HFA ultimately increases the surface area, which helps penetrate the resin cement into the microchannels created. Therefore, the longer etching time increases the bond strength as it allows the acid to react with the ceramic matrix and partially dissolve it. The studies that tested different acid concentrations concluded that the use of a strong acid to etch porcelain increases the bond strength because the

acid creates a series of pits on the surface by dissolution of the glass phase from the ceramic matrix.²² Since there was no significant difference between the 5% and 9.6% HFA groups, it is suggested that the use of 9.6% HFA is not necessary to achieve higher bond strength.

The studies that focused on analyzing porcelain surfaces treated with silane concluded that the bond strength of brackets to porcelain surfaces was improved by the application of silanes.^{23,28,29} The reason is that silane forms chemical bonds with inorganic and organic surfaces, which ultimately increase the bond strength. The studies also proved that another efficient conditioning method was roughening the surface by a diamond bur or sandblasting.

While testing various ceramic surfaces and brands, it is expected that different results will appear since the available brands of porcelain have dissimilar particle size and crystalline structure. The results seen in the reviewed studies are due to the fact that the porcelain surfaces contain structural differences that lead to higher or lower bond strength. Also, the base designs of the brackets have an effect on the bond strength. Irregular base designs and large, round pit base designs incorporate small glass particles fused to the polycrystalline alumina. These base designs allow for no undercut for mechanical interlocking of adhesive resin. On the contrary, the base surface consists of monocrystalline beads evenly distributed across the surface. This allows for the greatest bond strength since it has undercuts for mechanical interlocking of the adhesive resin. In the same effect, the different types of adhesive affect the shear bond strength of brackets on porcelain surface. In the study²⁵ testing different adhesives, Concise showed higher shear bond strength than Fuji Ortho and Fuji Ortho LC; however, no difference in tensile bond strength was seen. The destruction of porcelain surfaces is correlated with bond strengths. In the second study²⁴ between Fuji Ortho LC and Ortho Bracket Adhesive, similar shear bond strengths were produced, which indicates their ability to be equally effective. Also, different brands of silane were tested, and the results concluded that the higher bond strength achieved with Reliance could not be justified since the manufacturers do not disclose the exact chemical compositions.

This review contains many limitations, which makes it difficult to apply the results to clinical practice. Since the studies found were in vitro, the conclusions do not hold direct value, and to employ these methods on humans could be unsafe. The results cannot be universally accepted since many environmental factors could have influenced the determination of the most efficient method in bonding the brackets to porcelain surfaces.

CONCLUSIONS

- The best protocol described in this review is 9.6% hydrofluoric acid etched for 1 minute, rinsed for 30 seconds, and then air-dried. The etching of hydrofluoric acid should be followed by an application of silane.
- Considering the harmful effects of etching with HFA, another appropriate step is mechanical roughening with sandblasting followed by an application of silane.

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