

Keywords
Cleaning Solutions, Shear Bond Strength(SBS), Zirconia

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Received:13-06-2026
Revised:19-07-2026
Accepted:24-07-2026
Doi:10.1922/ejprd.v34i3.1669

Evaluation and comparison of the shear bond strength of resin cement to zirconia after using two different cleaning solutions

Abstract

Aims & Background: Zirconia is widely used due to its strength and durability, but proper bonding is essential for long-term success. Contamination can reduce adhesion. While Ivoclean is well established, limited evidence exists for Finevo. This study evaluates and compares their effects on shear bond strength (SBS) of resin cement to zirconia.

Materials and Methods: Twenty-four CAD-CAM zirconia samples (10×6×2 mm) were divided into three groups (n=8): Group A (no cleaning after salivary contamination), Group B (cleaned with Ivoclean), and Group C (cleaned with the Finevo system). All samples underwent SBS testing, and results were analyzed using one-way ANOVA.

Results: A p-value <0.01 indicated a statistically significant difference among the groups.

Conclusion: Ivoclean demonstrated superior bond strength compared to Finevo.

Clinical Significance: Cleaning zirconia surfaces after contamination is critical for optimal bonding. Effective decontamination reduces debonding risk and supports the development of standardized clinical protocols for zirconia restorations.

INTRODUCTION

The CAD-CAM technology has revolutionised the field of restorative dentistry by allowing the production of high precision metal-free ceramics of excellent quality. The high mechanical strength, biocompatibility and attractive appearance of the zirconia has made it very acceptable in clinical use. Nevertheless, the effectiveness of bonding to the tooth structure is essential in the clinical longevity of zirconia restorations and this is still a significant issue during cementation procedures.[1]

A contaminated bond strength of zirconia and resin cement may occur as a result of saliva or blood that is added during the try-in phase. These contaminants and especially salivary phosphates remain on the surface of the zirconia even after rinsing or drying under air and disrupt the chemical bond between the resin cement and zirconia, in particular with MDP-based primers. [2]. This has led to several surface treatments such as mechanical abrasion and chemical cleaning agents which have been suggested to enhance resin to zirconia interface. Ivoclean is one of the existing chemical cleaning agents, which has demonstrated good outcomes in increasing the bond strength following contamination. [1]

Problem Statement and Research Gap

As much as Ivoclean has been researched on, very little information exists about the new systems like the Finevo cleaning system. Finevo is created to eliminate organic and inorganic polluting matter on a nanoscale and simplify the clean-up procedure during laboratory and clinical procedures [3]. Since no comparative research has been conducted to evaluate the performance of Finevo with the already-established cleaners such as Ivoclean, the research should be extended further.

Purpose of the Study

This study seeks to assess and compare the shear bond strength of resin cement to CAD-CAM zirconia following application of two cleaning protocols of Ivoclean and Finevo cleaning system and compare their results with that of the control group. The aim is to establish the best cleaning protocol with the highest bonding ability after being contaminated with saliva, hence informing clinicians about the best reliable surface cleaning method. The null hypothesis pins on the non-existence of a significant difference between the two cleaning systems with regard to their effect on shear bond strength.

Methods:

Subjects Recruitment

This in vitro experimental study was approved by the Institutional Ethical Committee. A total of 24 zirconia specimens were fabricated and randomly divided into three groups ($n = 8$) based on the cleaning protocol applied. Sample size estimation was based on expected bond strength values with a 90% confidence level and 10% relative precision, which determined a minimum of 8 specimens per group.

Specific Methods Used

1. Sample Preparation:

Zirconia specimens measuring $10 \times 6 \times 2$ mm were milled from Ceramill® Zolid HT+ (Amann Girrbach GmbH, Germany) using a Ceramill® Motion 2 CAD/CAM milling unit (Figure 1). Design was carried out in Ceramill Mind software, and samples were dry-milled from 14 mm blanks. Following milling, sintering was done in a Ceramill® furnace at a final temperature of 1450°C , with a ramp rate of $80^{\circ}\text{C}/\text{min}$ and a 2-hour hold at peak temperature over a 12-hour cycle.

The sintered specimens were embedded centrally in self-cure acrylic resin blocks using custom molds ($27 \times 10 \times 10$ mm). The blocks were then finished and polished with emery paper and rotary burs.

2. Surface Treatment and Grouping:

All specimens were sandblasted using $50\ \mu\text{m}$ aluminum oxide (Al_2O_3) particles at 2.5–3.0 bar pressure for 15–20 seconds from a 10 mm distance to increase surface energy and promote micromechanical retention [2].

After sandblasting, samples were contaminated with artificial saliva (E-saliva Plus) and randomly assigned to one of the three groups:

Group A (Control): After contamination with artificial saliva, no cleaning agents were used.

Group B (Ivoclean): Contaminated samples were cleaned with Ivoclean (Ivoclar Vivadent) for 20 seconds, followed by Monobond N application and resin cement placement. (Figure 2)

Group C (Finevo): Contaminated specimens were cleaned using the Finevo system (Bredent GmbH & Co. KG, Germany), which consists of three sequential ultrasonic baths:

Bath 1 which consists of an antibacterial solution containing chlorhexidine gluconate and cetrimide. Bath 2 which contains 80% ethyl alcohol and bath 3 which consists of medically pure water. Each cleaning stage was carried out at 35°C for 8 minutes in an ultrasonic cleaner. [3] (Figures 3,4).

For all groups, Monobond N (10-MDP containing ceramic primer) was applied prior to cementation to improve chemical adhesion between zirconia and resin cement by interacting with both phosphate groups on zirconia and methacrylate groups in the resin matrix [2]. A split Teflon mold was used to standardize the cement cylinder size (3 mm diameter $\times$ 3 mm height). Resin cement (RelyX™ U200 Automix, 3M ESPE, Germany) was injected into the mold and light-cured for 40 seconds. Excess cement was carefully removed with a scalpel.

Bond Strength Testing:

Shear bond strength (SBS) was measured using a Universal Testing Machine at a crosshead speed of 1 mm/min. Load was applied at the zirconia–cement interface until failure, and the peak debonding force was recorded in MPa. [1,2] (Figure 5).

Data Analysis

Descriptive statistics were used to summarise the data. One-way analysis of variance

(ANOVA) was performed to compare SBS values among the three groups. A p-value of <0.05 with a 95% confidence interval was considered statistically significant.

Statistical methodology was selected based on prior studies evaluating resin–zirconia bond strength under similar experimental setups [1,4].

Results:

Shear bond strength of resin cement to zirconia was measured in three groups namely Control (No cleaning), Ivoclean and Finevo. The statistical analysis has been done comparatively as presented in Table 1.

The control group (no cleaning) had the mean SBS of 15.7 Mpa, the median of 17.1

Mpa and the inter-quartile range (IQR) of 10.3 Mpa. Strengths of the bond were between 9.26 MPa and 21.7 MPa, which means that adhesion behaviour was low and inconsistent.

Ivoclean group registered the best bond strength with the mean of 26.5 MPa, median of 27.2 Mpa and Inter Quartile ranging between 6.46 Mpa. The values were 19.7 Mpa to 31.7 Mpa which indicates that the bonding was much better when decontaminated using Ivoclean.

The mean SBS in the Finevo group was 22.7 MPa and the median was 22.2 MPa and IQR was 5.3 MPa. The lowest and the highest values of bond strength were 18.4 Mpa and 26.9 Mpa respectively. Even though the mean was a little bit lower as compared to Ivoclean, Finevo had the most consistent results amongst all groups.

The SBS of the three groups was compared through one-way ANOVA. The experiment produced statistically significant difference (p less than 0.001), which validates the fact that the nature of the cleaning protocol has a significant impact on the shear bond strength of resin cement to zirconia (Graph 1).

Discussion:

The current research measured the shear bond strength (SBS) of resin cement to zirconia surfaces that were soiled in artificial saliva and then washed with Ivoclean or Finevo cleaning system. The findings revealed that specimens using Ivoclean had the best mean SBS (26.5 MPa), then Finevo (22.7 MPa) and the control group (Nothing cleansed with 15.7 Mpa). These observations imply that contamination substantially leads to a decrease in strength of the bond whereas cleaning agents are both effective in restoring the bond with Ivoclean being more effective. Improved performance of Ivoclean can be explained by the fact that the suspension of zirconium oxide particle has high affinity to phosphate contaminants, thus eliminating phosphate contaminants off the surface of zirconia, and enhancing the adhesion of resin cement. [1,5,6,7]. The effectiveness of Ivoclean as superior is supported by several studies carried out in the past. Both Hajjaj [1] and Atoche-Socola [8] were able to show that Ivoclean restored or enhanced bond strength on saliva contaminated zirconia surfaces. Blatz et al. [9] clarified Ivoclean works through the concept of the APC in which the air-particle abrasion, chemical cleaning (e.g., with Ivoclean), and application of phosphate monomer-based resin cement (e.g., 10-MDP) are synergistic in promoting bonding. Also, the protocol of air abrasion

followed by chemical cleaning offered by Özcan and Bock also helps to emphasise the significance of mechanical surface preparation. [2] Although other researchers had compared Ivoclean to other agents such as phosphoric acid, NaClO, and Zirclean, Finevo is not well tested. This paper presents useful information since it has Finevo as a direct competitor to Ivoclean.

An ultrasonic antibacterial cleaner made by Bredent, Finevo, has also been reported to be useful in cleaning abutments of the implants, particularly by the action of cavitation and vibration to remove both the biological and non-biological debris. [8,10,6] Not well documented though is its application on zirconia. In our research, Finevo was found to be of great help in improving SBS over the uncleaned control group, but it was a little less efficient than Ivoclean. This can be attributed to the fact that its action is not more specific to phosphate contaminants on zirconia, but its multi-stage cleaning effect (chlorhexidine, acetone, ethanol) is useful in a more global cleaning environment. [9] Such results suggest that Finevo can be an appropriate substitute to Ivoclean in the case when it is not available, but the use of zirconia might still need optimisation.

Although these are encouraging findings, this is a limitation of this in vitro study. It is not a simulation of the oral environment in its entirety, like saliva composition, temperature changes and mechanical loading were not modelled over the long-term. Moreover, the sample size is big enough to perform the preliminary evaluation, but it restricts with the generalizability. The efficacy of both systems of cleaning in vivo and their capacity to preserve bonding strength during functional loading and keeping of moisture necessitates larger and long-term clinical trials to ensure the efficacy of both systems in the efficacy of both systems in the efficacy of the two systems.

This study results have clinical implications to restorative dentistry. Since zirconia is gaining popularity due to its strength and esthetics, maintaining the best adhesion is of paramount importance to the success of fixed prostheses. It is important to adopt sound decontamination procedures as failures as a result of debonding are reported in ADA surveys [5]. The effectiveness of Ivoclean, and the future perspectives of Finevo prove their presence in clinical practise. This research can assist in directing the clinician towards making evidence-based choices on the surface treatment of zirconia prior to cementation, which in the end will lead to increased restoration longevity and patient satisfaction. [11, 12]

In the constraints of this in vitro research study, we can draw the following conclusions:

1. When no cleaning solution was used on saliva contaminated zirconia surfaces, the shear bond strength of resin cement was statistically significant reduced.
2. Utilisation of Ivoclean as a cleaning agent showed a significant enhancement in the shear bond strength between the resin cement and the zirconia.
3. The statistically significant increase in the shear bond strength of the Finevo cleaning system over the uncleaned control group was statistically significant.
4. Even though Ivoclean and Finevo are effective in terms of strengthening bond, Ivoclean provided

slightly better outcomes compared directly with Finevo.

Conclusion:

Within the limitations of this in vitro study, the following conclusions can be drawn:

1. The use of no cleaning solution on saliva-contaminated zirconia surfaces resulted in a statistically significant reduction in the shear bond strength of resin cement.
2. The application of Ivoclean as a cleaning agent significantly improved the shear bond strength between resin cement and zirconia.
3. The Finevo cleaning system demonstrated a statistically significant improvement in shear bond strength compared to the uncleaned control group.
4. Although both Ivoclean and Finevo were effective in enhancing bond strength, Ivoclean showed slightly superior results when compared directly to Finevo.

List of abbreviations:

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Figures and figure legends

Figure 1 –Blank of Zirconia (AmannGirbach Ceramill® CAD/CAM Material – Zolid HT+ 14mm).

Figure 2 – Ivoclean cleaning solution.

Figure 3 – Finevo solution in the ultrasonic bath. Figure 4 – Finevo solution ultrasonic cleaning bath. Figure 5 – Samples under UTM.

Tables and table legends



Figure 1 –Blank of Zirconia (AmannGirbach Ceramill® CAD/CAM Material – Zolid HT+ 14mm)



Figure 2 – Ivoclean cleaning solution



Figure 3 – Finevo solution in the ultrasonic bath



Figure 4 – Finevo solution ultrasonic cleaning bath

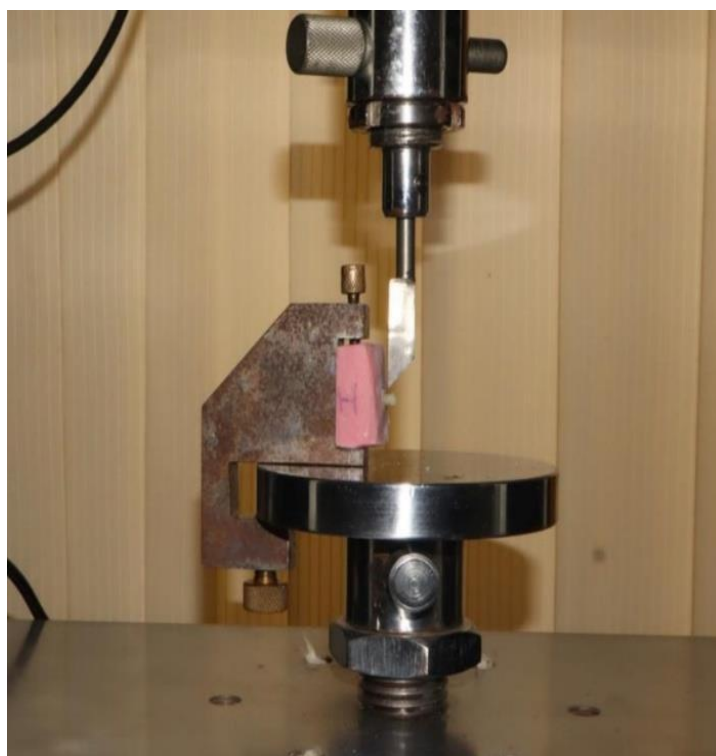


Figure 5 – Samples under UTM

TABLE 1: Shear Bond Strength comparison by different cleaning methods -Tested using One- way ANOVA test

Group	Mean	SD	95% Confidence Interval for Mean		Test statistic	p value
			Lower Bound	Upper Bound		
CONTROL	15.7475	5.349805737	11.27495048	20.22004952	11.836	<0.001
IVOCLEAN	26.48125	4.510446406	22.71042244	30.25207756		
FINEVO	22.6575	3.323860707	19.87868291	25.43631709		

GRAPH 1: Shear Bond Strength comparison by different cleaning methods

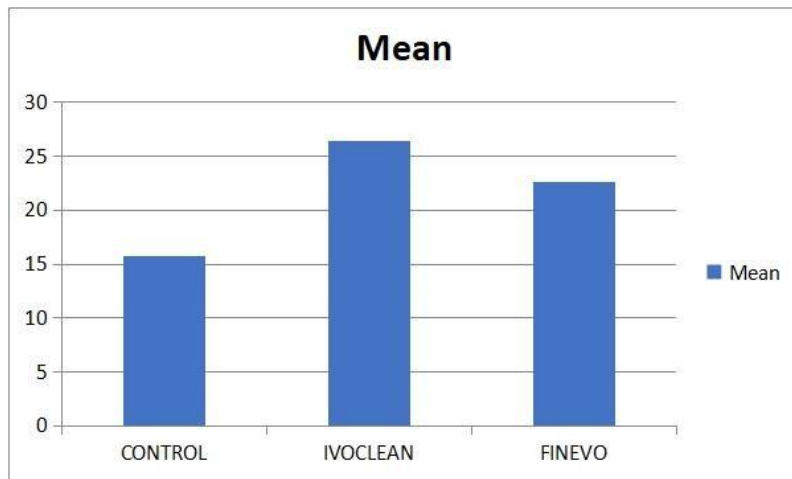


Figure 1: Zirconia Blank



Figure 2: Sample Fabrication



Figure 3: Resin Cement



Figure 4: Ivo Clean Liquid



Figure 5: Monobond



Figure 6: Finevo Cleaning Liquid

