EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

VOL. 71, 773:784, JANUARY, 2025

PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360

CONSERVATIVE DENTISTRY AND ENDODONTICS

Submit Date : 01-09-2024 • Accept Date : 07-10-2024 • Available online: 10-01-2025 • DOI : 10.21608/edj.2024.317446.3191

# THE IMPACT OF VARIOUS VINEGAR PRETREATMENTS ON MICRO-TENSILE DENTIN BOND STRENGTH AMONG DIFFERENT ADHESIVE MODES

Hadeel Farouk *, Hatem M Ibrahim ** *and* Sarah D Shaheen ***

## *ABSTRACT*

**Purpose**: To compare and evaluate the effectiveness of the two fruit vinegar pretreatments, apple vinegar, and grape vinegar, on micro-tensile dentin bond strength at different universal adhesive modes.

**Material and Methods**: Sixty premolars were divided into two groups according to universal adhesive modes (30 teeth for self-etch and 30 teeth for etch and rinse groups). Three subgroups of ten teeth each were created from each group: no pretreatment of the dentin, pretreatment with apple vinegar, and pretreatment with grape vinegar. Mid-coronal dentin was exposed using an automated diamond saw with copious water coolant. Vinegar was applied for 60 seconds, followed by 10 seconds of rinsing, and adhesive layers were applied according to manufacturer instructions. After resin composite build-up, teeth were sectioned to obtain 0.9±0.1 mm rods. Micro-tensile bond strength and mode of failure were measured. ANOVA and the Mann-Whitney U test were used to analyze the data statistically.

**Results**: No significant difference was found between etch and rinse and self-etch modes in no pretreatment subgroup. For apple and grape vinegar, self-etch recorded significantly higher values than etch rinse mode. Regarding the mode of failure, the predominant failure in both pretreated vinegar etch and rinse modes was adhesive failure. The majority mode of failure in the pretreated vinegar self-etch mode was a cohesive and mixed failure.

**Conclusion**: Apple and grape vinegar pretreatment positively impacts dentin micro-tensile bond strength, specifically with self-etch universal adhesive mode. Cohesive failure was more represented in both types of vinegar pretreatment.

**KEYWORDS**: Apple vinegar, Grape vinegar, Universal adhesive, micro tensile bond strength, Mode of failure

* Associate Professor of Conservative Dentistry, Al-Ryada University for Science and Technology, Sadat City, Menoufia, Egypt
** Lecturer of Dental Biomaterials, Collage of Oral and Dental Surgery, Misr University for Science and Technology, Giza, Egypt
*** Lecturer of Conservative Dentistry, Collage of Oral and Dental Surgery, Misr University for Science and Technology, Giza, Egypt

## INTRODUCTION

The quality and durability of the adhesive interfaces in enamel and dentin are critical to the long-term clinical success of composite resin restorations[1].

The reduced endurance of the resin-dentin bond is largely caused by excessive residual water on the dentin surface. Unprotected dentin collagen fibrils can be broken down by endogenous matrix metalloproteinase (MMPs) and cysteine cathepsins when exposed to water. These enzymes prevent adequate resin bonding impregnation into dentin, reducing the bond strength of the resin composite to dentin. Reduced adhesive durability can lead to marginal caries, leakage, loss of restoration, and tooth structure over time[2-3].

Additionally, moisture affects phase separation in adhesion, resulting in hydrolytic breakdown of the adhesive resin. Consequently, researchers have proposed various approaches to address these challenges and enhance the limited durability of the resin-dentin bond[4].

One proposal to solve this problem is to treat the dentin with conditioning material with an antibacterial mechanism, cross-linking ability, and remineralizing effect to improve the strength of the collagen fibers of the dentin and enhance the bond strength[5,6].

For hundreds of years, vinegar has been utilized as a natural food preservative. It has many health benefits, such as antibacterial and antiseptic characteristics, and is thus used to heal infected wounds. Furthermore, it contains a variety of bioactive components that differ depending on the raw material, such as grape and apple vinegars[6].

Apple vinegar, which includes acetic and maleic acids, has been shown to lower the number of Enterococcus faecalis cells by around 30%[7].

Grape vinegar is an extremely biocompatible solution that is low-cost and easily accessible. It has produced attention and was studied for application as an auxiliary solution for biomechanically cleaning dentin surfaces to improve the demineralization of dentin owing to its mildness; however, there is a lack of evidence on the effect of vinegar on bond strength[7].

Numerous studies have used apple vinegar and gape vinegar as irrigant solutions due to their biocompatibility and antimicrobial activity; however, the irrigation solution in contact with coronal dentin may alter the structure of the dentin, affecting the sealing of the restoration after endodontic treatment. No study has yet examined the effect of fruit vinegar on resin composite bond strength to the coronal dentin[7-10].

Further demineralization may also be performed in some conditions, such as sclerotic dentin, where minerals obliterate dentinal tubules and bacteria can be found on top of the mineralized layer. Sclerotic dentin is more resistant to acid demineralization than normal dentin due to the presence of hyper-mineralized layer[11]. Fruit vinegar, with its chelating, antioxidant, and antibacterial properties, might be quite beneficial in this condition.

Therefore, this study compares the effectiveness of apple vinegar and grape vinegar as pretreatment on dentin micro-tensile bond strength in different adhesive modes. The null hypothesis was that no difference exists regarding the dentin bond strength of universal adhesive in different adhesive modes with and without pretreatment with two fruit vinegars.

The question in this study was addressed in terms of the PICO question, which involves four elements:

Problem (P), Intervention (I), Comparison (C), and Outcome (O) as follows:

P. Micro tensile bond strength.

I. Using a universal bonding system with different adhesive modes.

C. Using natural pretreatment (apple vinegar, grape vinegar).

O. Change in bond strength.

## MATERIAL AND METHOD

### Outcome Measures

### Primary outcome:

Micro tensile bond strength was measured with different adhesive modes after the application of two various fruit vinegars.

### Secondary outcome:

After applying two fruit vinegars, the failure mode was measured in different adhesive modes.

## MATERIAL AND METHODS

### Study design

Sixty premolars were divided into two main groups of 30 teeth each: Group 1 (30 teeth subjected to universal adhesives in self-etch mode) and Group 2 (30 teeth subjected to the universal adhesive in etch and rinse mode), and then each main group was subdivided into three sub-groups: A-control group; no pretreatment was done (10 Teeth), B-apple vinegar treatment (10 Teeth) and C-grape vinegar treatment (10 Teeth)

### Sample size calculation

The G Power statistical power calculation program (version 3.1.9.4) was used to calculate the sample size. The sample size (n = 60; 30 in each group and 10 in each subgroup) was sufficient to detect a significant difference (d) = 0.74, with an actual power (1-β error) of 0.8 (80%) and a threshold of significance (α error) of 0.05 (5%) for two-sided hypothesis testing[12,13].

### Specimen preparation

Extracted human premolar teeth were utilized in this study. The institutional review board of the Faculty of Oral & Dental Medicine, Ahram Canadian University, evaluated and approved the study protocol in accordance with research ethics (protocol number: IRB00012891#127). Every procedure was carried out in compliance with all applicable guidelines and regulations. For orthodontic purposes, sixty freshly erupted premolar teeth were extracted at the pedodontic department as part of a treatment plan.

TABLE (1) The material used in this study with its manufacture name, composition, and batch number

| Material | Composition | Manufacture name and Batch number |
|---|---|---|
| **Filtek Z350 XT Nanohybrid composite resin** | BisGMA, Bis-EMA, UDMA, and TEGDMA<br>Filler size of 5–20 nm<br>Filler loading is 78.5% by weight or 58.5% by volume | 3M ESPE, St. Paul, MN, USA<br>N179865 |
| **Scotch Bond Universal Adhesive** | MDP phosphate monomer, dimethacrylate resins, HEMA, methacrylate modified polyalkenoic acid copolymer, filler, ethanol, water, initiators, saline | 3M ESPE, St. Paul, MN, USA<br>D-82229 |
| **Gel etchant** | 37% orthophosphoric acid, synthetic amorphous silica, polyethylene glycol | Kerr, Orange, CA, USA<br>3213200 |
| **Gran Sapore Apple Vinegar - 500 ml** | Water, acetic acid, malic, citric, formic, lactic, succinic acids carbohydrates, Na, potassium, probiotics, polyphenols, zinc 1%, 0.04 mg and calcium (1%, 1.7 mg) | Sapore, vervllo, SA, Italy<br>AW3/052 |
| **Gran Sapore grape Vinegar - 500 ml** | Acetic acid, citric acid, succinic acid, and malic acid, Mg, k and Antioxidant: Potassium metabisulfite | Sapore, vervllo, SA, Italy<br>B0C2JKY6JX |

The teeth were scaled to remove calculus, and periodontal ligament residuals were carefully cleaned under running water to get rid of blood and mucus. The teeth were polished using soft rubber cups and fine pumice. With a magnifying lens, the teeth were checked for the absence of cracks. Every tooth showing evidence of microcracks, cavities, or any other damaged structure was discarded according to the International Caries Detection and Assessment System (ICDAS)[2,3].

Every sample was kept in deionized (DI) water containing 0.02% thymol just after extraction and utilized in this investigation within one month of extraction.

**The specimen mounting**

Each tooth was prepared by removing the root under the cementoenamel junction with an automated diamond saw (Isomet Linear Precision Saw, Buehler, USA) and water coolant. The remaining coronal tooth structure was vertically impeded into self-curing acrylic resin blocks (Acrostone Dental Factor, England). Acrylic blocks were made for tooth retention using a specially made Teflon mold that was cylinder-shaped (4 cm vertically and 4 cm horizontally).

**Teeth preparation**

Each tooth was marked 3 mm from the mesiolingual cusp tip to the middle surface with a marker from the whole tooth circumference to ensure the height of the cutting surfaces. Mid coronal dentin was exposed using (Isomet Linear Precision Saw, Buehler, USA). Occlusal enamel was removed perpendicular to their long axis, exposing a uniform layer of mid-coronal dentin[12].

**Pretreatment of dentin**

***Apple vinegar pretreatment***

5% apple vinegar (Gran Sapore- Italy) was applied for 60 seconds with manual gentle rubbing pressure[12,14], followed by 10 seconds of rinsing with water and 5 seconds of gentle drying with oil-free compressed air. In group 1 (self-etch), the apple vinegar acid was applied before applying the universal bonding agent. However, in group 2 (total-etch), the apple vinegar acid was applied after the phosphoric acid etch.

***Grape pretreatment***

6% grape vinegar (Gran Sapore-Italy) was applied for 60 seconds with manual gentle rubbing pressure[12,14], followed by 10 seconds of rinsing with water and 5 seconds of gentle drying with oil-free compressed air. In group 1 (self-etch), grape vinegar was applied before the universal bonding agent, whereas in group 2 (etch and rinse), the grape vinegar acid was applied after the phosphoric acid.

***Bonding procedures and resin composite application***

The adhesive system (3M™ Scotch bond™ Universal Adhesive SBU) has been applied in group 1 (self-etch) and group 2 (etch and rinse) modes.

Group 1: One drop of universal bonding agent has been applied using a micro brush on the dentin surface with the active application technique for 20 seconds (manual slight rubbing pressure)[15]. Gentle solvent evaporation was done for 10 seconds with oil-free compressed air to produce a uniform thin layer[16]. This procedure was repeated for three successive adhesive layers in compliance with the manufacturer's guidelines. The curing system (Elipar™ Deep Cure-S LED Curing Light. Light output: 1200mW/cm$^2$) has been applied for 10 seconds[8].

Group 2: Thirty-five percent of phosphoric acid was administered to the dentin surface for 15 seconds, rinsed with water for 10 seconds, and the blot technique was made with a clean, dry, and high-quality micro brush for removing water residue from the dentin surface[5]. Then, the pretreatment of dentin was done with different kinds of vinegar and washed, as mentioned before.

A single drop of the universal adhesive agent was added to a dentin surface with an active adhesive application technique for 20 seconds (manual slight rubbing pressure)[14]. The bonding procedure was done in the same manner as mentioned before.

A specifically designed flat two-half split Teflon ring mold with an internal rectangular dimension of (6x6mm in diameter and 4mm height) was used to fabricate resin composite blocks on the dentin substrate, and the occlusal surface was filled with the resin composite A3; Filtek bulk-fill posterior (3M ESPE, St. Paul, USA). Above the filled mold was a polyester matrix strip. The composite was built to a minimum thickness of 4 mm, which acted as support and connection to the jig[16].

A rectangular glass slab was placed against the upper polyester matrix strip to extrude the extra composite resin and create a smooth surface. Subsequently, the material was light-cured upward using an LED light curing unit (Elipar™ Deep Cure-S LED Curing Light, light output 1200mW/ $cm^2$) for forty seconds.

Specimens were polished with fine, superfine (24 µm), and suprafine (8 µm) aluminum oxide polishing disks (Sof-lex, 3M ESPE, St Paul, MN, USA) using a slow-speed handpiece in a dry environment.

### Micro tensile bond strength test

The tooth/composite specimen was placed in an automated diamond saw (Isomet Linear Precision Saw, Buehler, USA) and serially sectioned using a 0.3-mm thick diamond coated disc (Buehler, IL, USA) at 2050 rpm and an 8.8 mm/min feeding rate while receiving copious amounts of coolant. A 90°clockwise rotation and a mesiodistal sectioning direction followed the buccolingual direction of serial sectioning. The resultant beam has a thickness of 0.9±0.1 mm. Four center sticks were selected from each specimen, and a caliper was used to measure each stick's thickness.

Each tooth was sectioned to obtain an average of 4 specimens per tooth. Hence, each sub-grouping examined forty sticks for micro-tensile bond strength. Each group consisted of 120 rods for each bonding agent (Group 1 = 120 rods; Group 2 = 120 rods). The ends of the adhesive-dentin bonded beams were attached to a jig through cyanoacrylate adhesive and tested under tension using a universal testing machine (Model 2519-104; Instron®, US).

The force in Newton (N) required to displace the restoration was measured. The micro tensile bond strength ($\mu$TBS) was calculated by dividing the load at failure (N) by the cross-sectional bonding area (1 $mm^2$). The readings are expressed in mega Pascal (MPa)[11].

### Failure mode analysis:

After undergoing micro-tensile testing, the debonded specimens' fracture patterns were examined using a stereomicroscope at a magnification of 40x. Four groups were created based on the nature and location of the failure modes:

Mode 1: Adhesive fracture between adhesive agent and dentin (adhesive failure AF)

Mode 2: Partial cohesive fracture in the dentin or composite restoration along with adhesive fracture between the dentin and adhesive material (mixed fracture MF)

Mode 3: Cohesive failure in dentin (CD)

Mode 4: Cohesive failure in the composite restoration (CC).

### Statistical analysis

Commercial software (SPSS Chicago, IL, USA) was used for statistical analysis. Depending on whether the data is normal, the terms mean and standard deviation or median and range have been used to characterize numerical data. Depending on the degree of normalcy, the Mann-Whitney U test or an independent t-test were used to compare the data.

## RESULTS

### I-Micro tensile bond strength

The data in Table (2) and Figure (1) showed a comparison between the main groups. For the Control group, total-etch was recorded (34.72±2.2), while self-etch was recorded (35.58±2.44), with no significant difference between groups (p=0.417). For apple vinegar, self-etch recorded a significantly higher value (39.25±1.43) in comparison to total-etch (36.67±2.72) (p=0.019). For grape vinegar: Self etch recorded a significantly higher value (40.30±1.63), in comparison to total-etch (36.71±2.19), (p=0.001).

The data in Table (3) and Fig. (2) presented a comparison between the subgroups. For the total-etch, Control recorded (34.72±2.2), while with apple vinegar recorded (36.67±2.72), and with grape vinegar recorded (36.71±2.19). The difference between subgroups was not statistically significant (p=0.122). For Self-etch: Control recorded (35.58±2.44), while apple vinegar recorded (39.25±1.43) and grape vinegar recorded (40.30±1.63). ANOVA and post hoc tests revealed a significantly lower value in control (p=0.000). Apple vinegar and grape vinegar were not significantly different.

### II- Mode of failure

The data presented in Table (4) and Fig (3,4) showed that in the control group, in total-etch, mode of failure one was noted at 30%, mode two at 50%, mode three at 10%, and mode four at 10%, in comparison to 20%, 20%, 50%, and 10%, respectively, in the self-etch group. However, there was no statistically significant difference between the groups (p=0.246).

With apple vinegar: In total-etch, mode of failure one was noted at 50%, mode two at 30%, mode three at 20%, and mode four at 0%; in comparison to 20%, 40%, 10%, and 30% respectively in self-etch group. However, there was not a statistically significant difference between the groups. (p=0.19)

With grape vinegar: In total-etch, mode of failure one was noted at 50%, mode two at 30%, mode three at 20%, and mode four at 0%; in comparison to 40%, 30%, 10%, and 20% respectively in the self-etch group. However, there was not a statistically significant difference between the groups. (p=0.485)

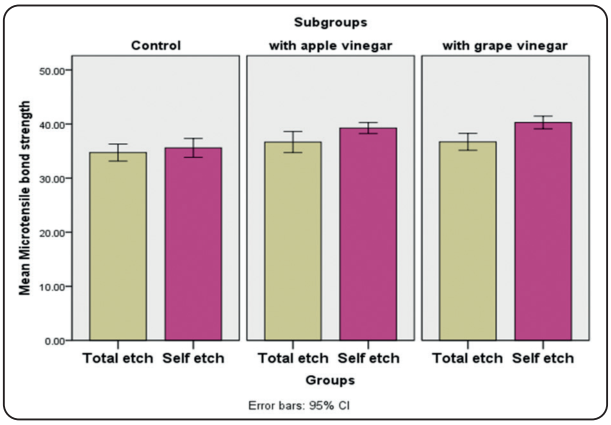


Fig. (1) Bar graph displaying the average Strength of micro tensile bonds in various groups

TABLE (2) Mean and standard deviation of microtensile bond strength and group comparison (independent t-test).

| | Groups | Mean | Std. Dev | Difference | | | | T | P value |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | Std. Dev | C.I. lower | C.I. upper | | |
| Control | Total etch | 34.72 | 2.20 | -0.86 | 1.04 | -3.05 | 1.32 | -0.83 | 0.417 ns |
| | Self-etch | 35.58 | 2.44 | | | | | | |
| With apple vinegar | Total etch | 36.67 | 2.72 | -2.58 | 0.97 | -4.67 | -0.49 | -2.66 | 0.019* |
| | Self-etch | 39.25 | 1.43 | | | | | | |
| With grape vinegar | Total etch | 36.71 | 2.19 | -3.59 | 0.87 | -5.41 | -1.77 | -4.15 | 0.001* |
| | Self-etch | 40.30 | 1.63 | | | | | | |

***Significance level p≤0.05, * significant, ns=non-significant, C.I. =95% confidence interval***

TABLE (3) Mean and standard deviation of micro tensile bond strength along with subgroup comparison (ANOVA test)

| Groups | | Mean | Std. Dev | 95% Confidence Interval for Mean | | Min | Max | P value (within the same group) | P value (for all six subgroups) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound | | | | |
| Total etch | Control | 34.72 [b] | 2.20 | 33.14 | 36.29 | 32.44 | 38.69 | 0.122 ns | 0.000* |
| | With apple vinegar | 36.67 [b] | 2.72 | 34.73 | 38.61 | 32.44 | 39.13 | | |
| | With grape vinegar | 36.71 [b] | 2.19 | 35.14 | 38.28 | 32.12 | 39.69 | | |
| | Total | 36.03 | 2.49 | 35.10 | 36.96 | 32.12 | 39.69 | | |
| Self-etch | Control | 35.58 [b] | 2.44 | 33.84 | 37.33 | 32.44 | 39.13 | 0.000* | |
| | With apple vinegar | 39.25 [a] | 1.43 | 38.23 | 40.27 | 37.15 | 42.14 | | |
| | With grape vinegar | 40.30 [a] | 1.63 | 39.13 | 41.47 | 37.87 | 43.34 | | |
| | Total | 38.38 | 2.75 | 37.35 | 39.40 | 32.44 | 43.34 | | |

***Significance level p≤0.05, * significant, ns=non-significant***
***Post hoc test: indicates that there are no significant differences between groups with the same superscript letter.***

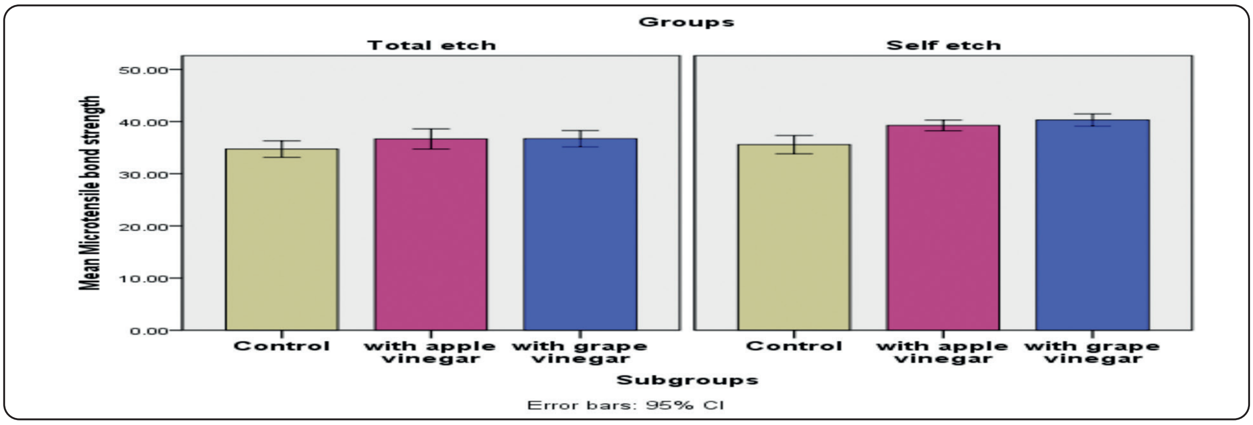


Fig. (2) Bar graph displaying the average Strength of micro tensile bonds in various subgroups

TABLE (4) Comparison of the mode of failure between groups (Chi-square test)

| Mode of failure | Control | | With apple vinegar | | With grape vinegar | |
|---|---|---|---|---|---|---|
| | Total etch | Self-etch | Total etch | Self-etch | Total etch | Self-etch |
| 1 | 12 (30%) | 8 (20%) | 20 (50%) | 8 (20%) | 20 (50%) | 16 (40%) |
| 2 | 20 (50%) | 8 (20%) | 12 (30%) | 16 (40%) | 12 (30%) | 12 (30%) |
| 3 | 4 (10%) | 20 (50%) | 8 (20%) | 4 (10%) | 8 (20%) | 4 (10%) |
| 4 | 4 (10%) | 4 (10%) | 0 | 12 (30%) | 0 | 8 (20%) |
| $X^2$ | 4.15 | | 4.76 | | 2.44 | |
| P value | 0.246 ns | | 0.19 ns | | 0.485 ns | |

***Significance level p≤0.05, ns=non-significant***

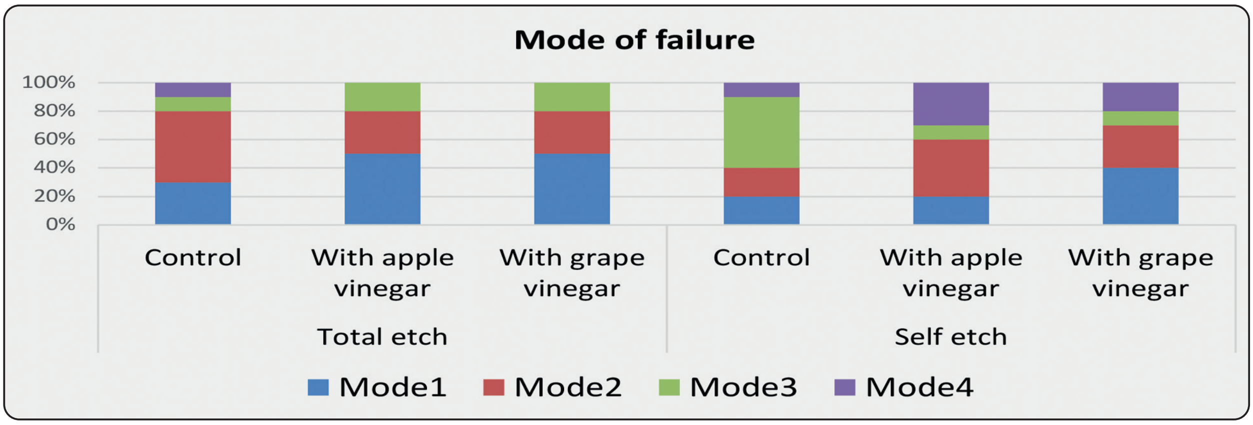


Fig. (3) Bar chart illustrating the mode of failure in different group

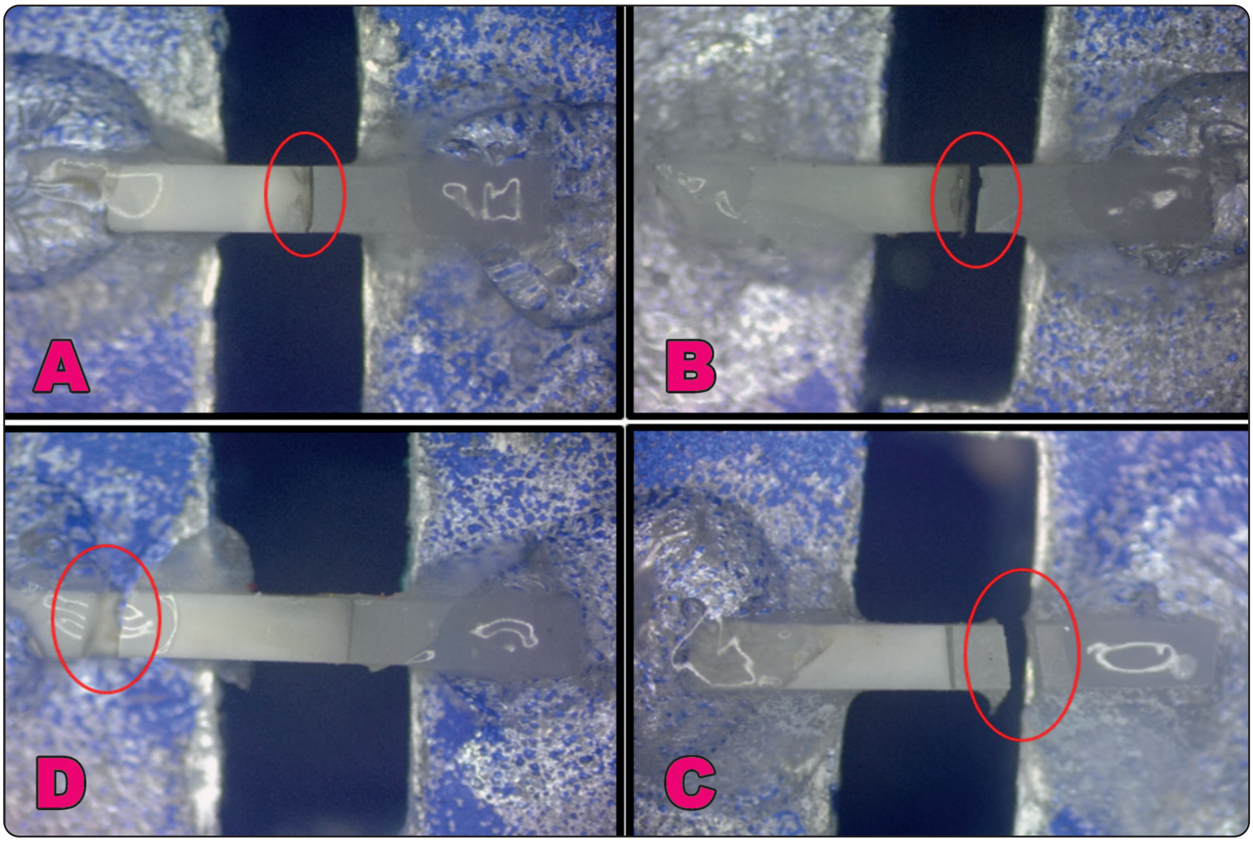


Fig. (4) Representative images for the failure mode analysis A: Mode 1 (Adhesive Failure), B: Mode 2 (Mixed Failure), C: Mode 3 (Cohesive failure in dentin) & D: Mode 4 (Cohesive failure in the composite restoration)

## DISCUSSION

A long-term objective of the dentistry profession has been to create a strong, durable bond between tooth structure and restorative materials. Various pretreatment materials were applied to improve the behavior of the dentin. Nowadays, the trend is to focus on natural products due to their biocompatibility. Fruit vinegars have been used in endodontic treatment in many experiments as irrigants due to their antibacterial activity; however, their impact on bond strength is still unclear[7-9].

Our present study compared the micro tensile bond strengths of the different adhesive systems with and without dentin surface pretreatment with apple and grape vinegar.

The universal adhesive system was chosen for our investigation because it may be utilized in all application modes, including self-etch and etch-and-rinse. The universal bonding system has a high bonding strength because it contains phosphoric acid groups such as 10-methacryloyloxydecyl dihydrogen phosphate (MDP) that cannot rinsed off, forming a chemical bond to the tooth structure[12].

The application time of apple vinegar and grape vinegar was chosen to be 1 minute based on a previous study that compared different application times (1, 3, or 5 minutes) of grape vinegar on smear layer structure and erosion and discovered that there is no difference in removal of smear layer and microhardness between 1 and 3 minutes, but 5 minutes decreased microhardness[14].

The present investigation found that apple vinegar was more effective than untreated dentin at improving micro tensile bond strength when used with self-etch and total-etch adhesives.

Apple vinegar is derived from apple fruit and comprises acetic (the major component), malic, citric, formic, lactic, and succinic acids. Apple vinegar's acidic pH (2.71) may have an impact on its chelating activity[13,14].

Maleic acid has been identified to be an essential component of apple vinegar, with anti-fungal and antimicrobial properties[17].

Numerous mineral components found in apple vinegar, including potassium, phosphorus, fluoride, calcium, sulfur, silicon, and magnesium, have been shown to have significant therapeutic properties[17].

Other components of apple vinegar, including pectin, beta-carotene, amino acids, and enzymes, have been discovered to alter the immune system by attacking the free radicals to improve the strength of collagen of dentin and act as cross-linking agents[13].

The 5% acidity represents the concentration of acetic acid by weight (or weight percent) in the vinegar, and the pH should be about 2.4. The mild acid can partially demineralize the smear layer, which has an insignificant impact on dentin microhardness[14].

Moreover, apple vinegar contains zinc (1%, 0.04 mg) and calcium (1%, 1.7 mg) in its composition, which may be one of the reasons it enhances bond strength by suppressing MMPs and strengthening the collagen fibers[16-20].

According to previous studies conducted apple and grape vinegar increase surface roughness, which may have an important value in improving bond strength to resin composite[21-23].

Furthermore, the current results revealed that grape vinegar has the highest micro tensile bond strength in universal adhesives in self-etch and etch and rinse modes. There are several explanations for this result. First, grape vinegar contains a weak acid and approximately 74-78% proanthocyanidin (PA). The occurrence might be attributed to the high PA concentration in grape vinegar. In addition, PAs have been demonstrated to improve biomechanical dentin properties by reducing collagen fiber biodegradation and breakdown while also decreasing enzymatic degradation and MMP enzyme activity[23-26].

The current result was in accordance with Kamh et al. (2023)[12] who found that proanthocyanidin acts as a dentin modifier, improving the microtensile bond strength of treated dentin.

Second, dentin's chemical and mechanical characteristics are greatly altered by removing the smear layer. Although both manufactured and organic chelators reduce the microhardness of dentin, organic chelators appear to be less effective than manufactured chelators in decreasing dentin microhardness[27-28].

The present study's findings were in accordance with Adel et al., 2022[7] and Abdelghany et al., 2022[6]. They stated that fruit vinegar has a mild acidity, which can partially remove the smear layer and demineralize the surface without decreasing its microhardness. This finding may explain the increased bond strength in pretreated teeth with fruit vinegar.

Also, the micro tensile strength in the etch and rinse groups was lower than in the self-etch groups in the treated subgroups, which could be attributed to the combination of different acids: phosphoric acid, apple vinegar, and grape vinegar, which may reduce dentin strength and increase hydrolytic activity.

Another factor contributing to improved bonding in universal adhesives' self-etch mode is the solvent evaporation period after 10 seconds of application to dentin. As a result, the leftover water may be removed, and hydrolytic destruction of polymers and collagen is unlikely to occur. Furthermore, the active application technique used with universal adhesives may improve monomer penetration into the dentin and bond strength[28,29].

In terms of failure mode, a perfect adhesive system occurs in a cohesive failure, which means that the adhesive has a stronger grip on the surface than itself, indicating a high surface adhesion. However, adhesive failure occurs when the whole adhesive is preferentially kept on one substrate, resulting in inadequate adherence to dentin[16].

The predominant failure mode in the pretreated vinegar etch and rinse mode universal adhesive was adhesive failures, likely caused by the bonding agent's inability to fully penetrate the exposed collagen dentin and the dentin's diminished mechanical characteristics. However, the difference between the control and the pretreated vinegar was not significantly different.

The majority failure mode in the pretreated vinegar self-etch mode universal adhesive was a cohesive and mixed failure, which was indicated by the strong bond strength. The mode of failure results did not contradict the micro tensile bond strength results. Thus, the null hypothesis was rejected since there was a significant difference in micro tensile bond strength between the tested groups.

## CONCLUSION

Under the circumstances of this study, apple vinegar and grape vinegar dentin pretreatment positively impact microtensile bond strength, specifically with self-etch universal adhesive mode. Moreover, cohesive failure was more represented in both types of vinegar pretreatment.

### The limitation of this study

However, the study evaluates the bond strength and the failure mode in extracted teeth; it cannot mimic the natural oral environment.

### Recommendation

More research is needed to assess the hybrid layer under a scanning electron microscope following pretreatment with fruit vinegar for dentin.

### Financial support and sponsorship

Authors provide their auto support

### Conflicts of Interest

There were no conflicts of interest.

## REFERENCES


1. Carvalho M, Manso P, Geraldeli S, Tay R, Pashley H. Durability of bonds and clinical success of adhesive restorations. Dent Mater. 2012; 28:72–86.

2. Spencer P, Ye Q, Park J, Topp EM, Misra A, Marangos O, Wang Y, Bohaty BS, Singh V, Sene F, Eslick J, Camarda K, Katz JL. Adhesive/Dentin interface: the weak link in the composite restoration. Ann Biomed Eng. 2010;38:1989–2003.

3. Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, De Munck J. Relationship between bond-strength tests and clinical outcomes. Dent Mater. 2010; 26:100–121.

4. Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater. 2011;27:17–28.

5. Heintze D, Thunpithayakul C, Armstrong R, Rousson V. Correlation between micro tensile bond strength data and clinical outcome of Class V restorations. Dent Mater. 2011;27:114–25.

6. Abdelghany M, Kamel W, Bastawy H. Efficacy of Apple Vinegar as Final Irrigating Solution in Removing Smear Layer Using XP-Endo Finisher. ADJ-for Girls.2022; 95–103.

7. Adel A, Sherif R, Aboelseoud M. A comparative study of the effect of apple cider vinegar and Ethylenediaminetetraacetic acid chelating solutions on root dentin microhardness .adj. 2022; 27:17–28.

8. Baruwa A, Martins J, Maravic T, Mazzitelli C, Mazzoni A, Ginjeira A. Effect of Endodontic Irrigating Solutions on Radicular Dentine Structure and Matrix Metalloproteinases— A Comprehensive Review. Dent. J. 2022; 10: 219–222.

9. Sudhakar S, Gupta N, Ghambir N, Singh R, Singh D. Comparative Evaluation of Intracanal Smear Layer Removal by Different Root Canal Irrigants: A Scanning Electron Microscope Study. Int J Clin Pediatr Dent. 2023; 16:633-638.

10. Elsheikh H, Rabie M, Soliman E, Sharman M. Evaluation of the antimicrobial action and cleaning ability of different naturally based vinegar used as endodontic irrigants (in-vitro study). 2024; 5: 117–129.

11. Kwansirikul A, Sae-Lee D, Angwaravong O, Angwarawong T. Effect of different surface treatments of human occlusal sclerotic dentin on micro-tensile bond strength to resin composite core material. Eur J Oral Sci. 2020; 128: 263-273.

12. Kamh R, Niazy M, El Yasky M. The effect of two nano proanthocyanidin-based dentin biomodifiers on micro tensile bond strength of dentin treated with two adhesive modes. EDJ. 2023; 69: 3035-3043.

13. Uttley J. Power Analysis, Sample Size, and Assessment of Statistical Assumptions—Improving the Evidential Value of Lighting Research, LEUKOS, 2019; 15: 143–162.

14. Kalçay M, Tinaz AC. Effects of different concentrations of phytic acid on smear layer removal and erosion. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi. 2018; 28:341–347.

15. Schulz-Kornas E, Tittel M, Schneider H, Pellino N, MeissneStrumpski M, Haak R., et al., Tooth-composite bond failure with a universal and an etch-and-rinse adhesive depending on mode and frequency of application, Dent Mats J. 2024;40: 359–369.

16. Rengifo F, Presas C, Andía R, Huamaní E, Chávez P, Ganoza L, Rojas C, Microtensile Bond Strength and Failure Mode of Different Universal Adhesives on Human Dentin, Int Den J. 2024;23: 59-69.

17. Melkis, K.; Jakubczyk, K. The Chemical Profiles and Antioxidant Properties of Live Fruit or Vegetable Vinegars Available on the Polish Food Market. Foods J 2024; 13:1855-1860.

18. Jäggi M, Karlin S, Zitzmann NU, Rohr N. Shear bond strength of universal adhesives to human enamel and dentin. J Esthet Restor Dent. 2024; 36:804-812.

19. Tezvergil-Mutluay A, Agee A, Hoshika T, Carrilho M, Breschi L, Tjäderhane L, et al., The requirement of zinc and calcium ions for functional MMP activity in demineralized dentin matrices. Dent Mater. 2010 26:1059-67.

20. Oh S, Jung S, Kim J, Jang H, Kim S, Choi K, Kim Y. Effect of zinc on the collagen degradation in acid-etched dentin. J Dent Sci. 2018 13; 97–102.

21. Budak H, Aykin E, Seydim C, Greene K, Guzel-Seydim B. Functional properties of vinegar. J Food Sci. 2014; 79:757–764.

22. Safwat H, Nour El-Deen M, Bastawy H. Evaluation of Smear Layer Removal and Calcium Ions Concentration in Intraradicular Dentin Treated with Apple Vinegar (SEM Study) ADJ-for Girls. 2017; 4:279-287.

23. Zandim L, Corrêa O, Sampaio E, Rossa Júnior C. The influence of vinegars on exposure of dentinal tubules: A SEM evaluation. Braz Oral Res. 2004; 18:63–68.

24. Aalaa M, Bastawy H. Evaluation of Intraradicular Surface Roughness Following Final Irrigation by Apple Vinegar and its Correlation with Resin Sealer Bond Strength. ADJ-for Girls. 2020; 7:79-88.

25. Green B, Yao X, Ganguly A, Xu C, Dusevich V, Walker P, et al. Grape seed proanthocyanidins increase collagen biodegradation resistance in the dentin/adhesive interface when included in an adhesive. J Dent. 2010; 38:908–915.

26. Balalaie A, Rezvani B, Basir M. Dual function of proanthocyanidins as both MMP inhibitor and crosslinker in dentin biomodification: A literature review. Dent Mater J. 2018; 37:173–182.

27. Margono A, Angellina A, Suprastiwi E. The effect of grape seed extraction irrigation solution on the cleanliness of the smear layer on the apical third of the root canal wall. J Int Dent Med Res. 2017; 10:244–247.

28. Fawzy A, Amer M, El-Askary S. Sodium hypochlorite as dentin pretreatment for etch-and-rinse single-bottle and two-step self-etching adhesives: atomic force microscope and tensile bond strength evaluation. J Adhes Dent. 2008; 10:135-144.

29. Bahrololoomi Z, Mehravar F. Comparison of Different Adhesive Systems on Bond Strength of Resin Composite Posts Placed in Primary Teeth. Int J Dent.2022; 2:1-6.