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Research Article

Impact of Simulated Gastric Acid on Tensile Bond Strength of Class II Inlay Indirect Restorations

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ABSTRACT: The current study aimed to determine the impact of using hydrochloric acid (HCl) on the tensile bond strength of four distinct restorative materials. By doing so, we sought to provide valuable insights into the durability and resilience of these materials in the face of gastric acid exposure. **Materials and Methods**: Eighty sound maxillary first premolars were included in this study; Teeth were randomly assigned into four groups (n=20) according to the restorative materials. The first group was restored using Filtek Bulk Fill Posterior Restorative (3MTM). The second group was restored with EverX Posterior Fiber Reinforced Dental Composite (GCTM). The third group was restored with multilayer high-strength cubeX zirconia (Dental Direkt TM), and the fourth group was restored with IPS e-max press (Ivoclar/VivadentTM). The samples in the four main categories were further classified into two subgroups (n = 10) based on their immersion in either artificial saliva or simulated gastric acid solution (SGAS). The specimens underwent a tensile bond strength assessment utilizing a universal testing apparatus. The data were examined utilizing Two-Way ANOVA and the Friedman test. The threshold for statistical significance was established at $p < 0.05$. **Results**: The impact of HCl was evident on all tested materials, with a significant difference observed between groups after immersion in HCl ($p<0.000$). The lithium disilicate group demonstrated the greatest tensile bond strength, whereas the cubeX zirconia group exhibited the least. All samples showed a notable decline in tensile bond strength following exposure to simulated gastric acid. However, the extent of tensile bond reduction differed throughout the tested groups. **Conclusion**: The simulated gastric acid, regardless of its type, significantly reduces the tensile bond strength of the tested materials. This underscores the need for further research and the development of more acid-resistant restorative materials.

Keywords: Bulimia nervosa; Gastric acid; GERD; Tensile bond strength.

INTRODUCTION

Dental erosion is defined as the loss of dental hard tissue resulting from chemical disintegration, independent of oral bacteria involvement. Acids and certain chemicals can deteriorate the surface of teeth and dental restorations, resulting in structural loss [(1)]. Gastric liquid may enter the oral cavity due to bulimia nervosa, gastroesophageal reflux disease (GERD), or extended acute nausea during pregnancy [(2)].

Gastroesophageal reflux disease (GERD) is a common medical illness characterized by the involuntary regurgitation of gastric acid into the oral cavity. The global prevalence rates in adults range from 21% to 56%, indicating a substantial problem. Fifteen percent of persons have heartburn weekly; seven to ten percent feel it daily; twenty-five to forty percent of Americans encounter symptomatic GERD at some stage; and forty-five to eighty-five percent of women experience GERD or heartburn during pregnancy [(3)].

Although saliva has a buffering capacity for acid neutralization, it is insufficient to completely prevent erosion caused by GERD completely, underscoring the need for alternative preventive strategies [(4)].

It is essential to recognize that certain restorative materials, such as various ceramic substances including lithium disilicate IPS e.max press, are susceptible to prolonged exposure to hydrochloric acid, which leads to the breakdown of lithium disilicate crystals. This highlights the significance of employing resilient materials in dental restorations [(5,6)].

Enamel demineralization occurs when the oral ambient pH falls to the crucial threshold of 5.5, facilitating erosion and caries formation. The pH of gastric acid varies from 1 to 1.5, far lower than the crucial pH of 5.5, at which dental enamel begins to erode [(7,8,9)].

Indirect composites mitigate specific drawbacks of direct composite resin restorations, including polymerization shrinkage and conversion degree. Dental material manipulation improves proximal contacts, morphology, and occlusal surface adjustments. The clinical rationale for indirect composite restorations depends on assessing the residual dental structure, intraoral conditions, and associated costs [(10)].
Ceramics are regarded as chemically inert biomaterials; yet, their chemical stability may be influenced by several factors, including composition, chemical properties, environmental conditions, and exposure to acidic solutions. The intake of acidic meals or beverages, regarded as a minor contributor, leads to the deterioration of enamel crystals, resulting in dental erosion. Individuals with gastroesophageal reflux disease (GERD), regarded as a key cause, may also experience dental erosion. Gastroesophageal reflux disease (GERD) is diagnosed when the esophageal pH falls

below 4.0 for a minimum of 60 minutes during the daytime, including at least 10 minutes below pH 1.0, before gradually returning to baseline levels [11,12].

Understanding the behavior of these materials under gastric acid exposure can assist dentists in selecting appropriate materials for patients with bulimia or GERD [13].

A few existing studies have examined gastric acid's effect on class II inlay tensile bond strength, and the results are controversial. Therefore, the purpose of the present study was to evaluate the impact of simulated gastric acid on the tensile bond strength of lab-processed restorations in class II inlay cavity preparation.

The null hypothesis proposed that the erosive impact caused by HCl would not result in distinct variations in the tensile bond strength properties of materials with differing compositions.

MATERIALS AND METHODS

A power analysis was conducted with the G*Power program (version 3.1.9.6, Düsseldorf, Germany) to ascertain the sample size for each group. The input parameters were defined with the following values: α = 0.05, power = 95%, and effect size f = 0.42. The study produced a non-centrality variable of 31, with a threshold F value of 1.68, and an optimal sample size of 10 research samples per group [14].

Eighty teeth were selected from a collection of freshly extracted, intact maxillary first premolars, acquired for orthodontic purposes with ethical approval from the University of Mosul, College of Dentistry (project reference number UoM.Dent.23/58). Teeth were scrutinized under magnification (X10) for indications of caries, obvious fractures, restorations, or attrition to be ruled out. To mitigate confounding variables, the chosen teeth exhibited comparable sizes, evaluated by measuring the buccolingual, mesiodistal, and occluso-cervical dimensions in millimeters with a digital vernier caliper. The allowable deviation within these parameters did not exceed 5% of the defined averages [15]. The teeth were then disinfected in a 0.1% thymol solution for 48 hours before being stored in distilled water at room temperature [16].

The root portion of each tooth was encased in an acrylic block at the cementoenamel junction using a preformed silicone mold. This was conducted to enhance the management of samples throughout experimental procedures [17].

A conventional class II inlay cavity (4mm width x 4mm depth x 2mm length) was created for each sample with a high-speed handpiece (NSK, Tochigi, Japan) connected to a modified dental surveyor with comprehensive water cooling. The employed burs (flat-ended diamond fissure bur, flat-ended diamond tapered fissure bur) (LUSTER DENT, Henan, China, LOT: 137399) were replaced after every four preparations to ensure optimal cutting efficiency. A calibrated periodontal probe was utilized to measure the dimensions of the generated cavity, which were subsequently verified with a dental vernier at multiple locations (18,15).

Teeth were randomly divided into four main groups (n=20) as follows:

Group A (n=20): Filtek Bulk Fill Posterior Restorative (3M/ ESPE, St. Paul, MN, USA Lot no. NC63367).

Group B (n=20): GC EverX posterior (GC, Tokyo, Japan Lot no.2305011).

Group C (n=20): DD cubeX²® ML – Super High Translucent (5Y-TZP) (Dental Direkt GmbH, Spenge, Germany, Lot no.1162217002).

Group D (n=20): lithium disilicate glass-ceramic IPS e.max press (Ivoclar Vivadent, Zurich, Switzerland, Lot no. Z02355).

The samples within each of the four primary groups were subdivided into two subgroups (n=10), based on immersion in either artificial saliva or simulated gastric acid solution (SGAS), as illustrated in Figure 1.

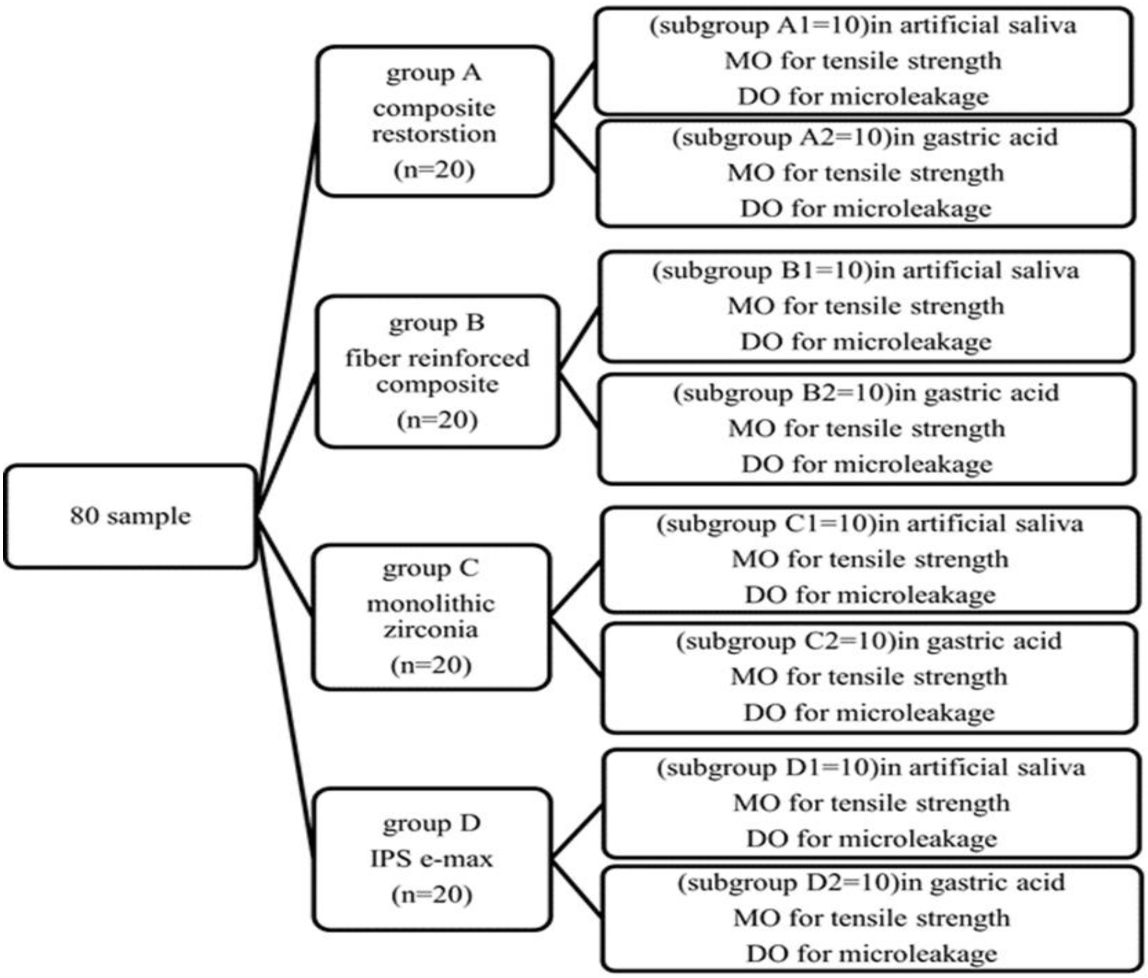

Figure (1): Grouping of the tested samples

A scanner device (Medit i600, Medit Corp, Seoul, South Korea) took digital impressions of the teeth with prepared inlay cavities to make a dying model using a 3D printing device (ASIGA, ASIGA®, Alexandria, NSW, Australia). All restorations were fabricated according to the manufacturer's instructions for the respective materials (19).

In the fabrication of indirect composite inlays, the composite material was incrementally condensed, with each increment subjected to light-curing for 40 seconds on the die model. Each inlay was meticulously refined with a sharp diamond point bur at low speed and minimal pressure (20).

For the fabrication of monolithic zirconia and IPS e.max Press ceramic inlays. The model was scanned using a fully automated optical strip-light scanner linked to a computer-aided design (CAD)/computer-aided manufacturing (CAM) system (DGSHAPE, DWX-52Di, DGSHAPE, A Roland DG Company, Hamamatsu, Japan). The cavity edges were precisely delineated on the digital image, after which the framework was constructed utilizing a specific software application for inlays. After the design phase, the frameworks underwent milling. The milled frames were subsequently refined using a carbide bur. Subsequent to the drying phase, all frameworks were positioned on a firing tray and subjected to sintering in a furnace in accordance with the manufacturer's specifications (18).

After the try-in procedures, inlay cementation was performed for each strategy according to the manufacturer's instructions. For Emax restorations, the internal surfaces of the restorations should be etched with hydrofluoric acid (FGM, Santa Catarina, Brazil, LOT:060822) for 20 seconds, followed by silane (BISCO, Illinois, United States, LOT:2100002173) application through a disposable, clean brush. It was allowed to be set for 60 s, and any remaining excess was removed with water-free air. Self-adhesive resin cement (Breeze™, Pentron, Orange, CA., United States, LOT:9676497) was applied to the inlay surface; then, the inlay was placed on the pretreated tooth surface (21). A thin silane coupling agent layer was added through a disposable, clean brush for zirconia restorations. It was allowed to be set for 60 s, and any remaining excess was removed with water-free air. Self-adhesive resin cement was applied to the inlay surface; then, the inlay was placed on the pretreated tooth surface (22). For indirect composite restorations, self-adhesive resin cement was applied to the inlay surface, and then the inlay was placed on the pretreated tooth surface (23). 30 N of pressure was applied during cementation to improve the marginal adaptation of the restoration (24). Excess self-adhesive cement should be eliminated before setting to prevent compromising the fragile initial bond with the tooth structure. Self-adhesive cement is dual-cured and, similar to all dual-cured cements, exhibits diminished binding strengths and wear resistance when utilized solely in the self-cure mode. Consequently, the clinician must light-activate all dual-curing cements at reachable restorative margins to enhance marginal integrity and wear resistance, following the manufacturer's guidelines, utilizing an LED light-curing instrument (Curing Pen, Eighteeth, China) (25).

Similar findings in the literature were utilized to formulate gastric acid solutions and artificial saliva solutions (26-27). Table 1 enumerates the components of the solution. A 100 mL dark container containing simulated gastric acid solution (SGAS), distilled water, and artificial saliva was utilized during the gastric acid cycle. Following 60 seconds in gastric acid, the samples were purified in distilled water for 5 seconds before being reintroduced to saliva for 30 minutes. This application was administered six times at daily intervals over a period of thirty days. Nonetheless, samples in the control group were submerged in artificial saliva for 93 hours during the cycling procedure (28).

Table 1. The contents of the solutions in the study.

Solution	Contents	pH
Artificial Saliva	0.381 g Sodium Chloride NaCl, 0.213 g Calcium Chloride Dehydrate CaCl2.2H2O,1.114 g Potassium Chloride KCl, 0.738 g Potassium dihydrogen phosphate KH2PO4, and 2.2 g mucin in 1000 ml distilled water.	7
Artificial Gastric Acid	0.113% hydrochloric acid (HCl) solution in deionized water	1.2

Tensile bond strength tests (TBS) were conducted utilizing a GESTER testing apparatus (model G7-K03B, GESTER CO., China) with a metal profile (100×10×3 mm) loading head (50 kg). The restoration was constructed with a rod protrusion on the occlusal surface, utilized to secure the restoration to the machine's loading head with orthodontic wire. Tests were conducted at a consistent velocity of 1 mm/min until the indirect restorations were dislodged. Bond strength was measured in megapascals (MPa). Post-tensile testing, the failure pattern was examined using a 10x optical microscope, and patterns were classified as:

1. adhesive along the dentin surface.
2. adhesive along the inlay–resin cement interface.
3. cohesive within the resin cement.
4. mixed when simultaneously exhibiting the dentin surface and remnants of the resin cement (29).

Following the tensile assessment, two debonded Test specimens from all of the groups were randomly chosen for SEM examination. The surfaces were sputter-coated with gold (BioRad—SC502, Fison, U.K.) and analysed using scanning electron microscopy (Axia ChemiSEM, Massachusetts, United States) at 20 kV. Mechanisms of failure were investigated [30].

The data were conveyed using descriptive statistics, including means and standard deviations. The normality and homoscedasticity of tensile bond strength data were evaluated using the Shapiro-Wilk and Levene tests. A two-way ANOVA with Tukey's Post-Hoc test was utilized to assess the tensile bond strength data both between the groups and within each group. The Kruskal-Wallis H test was employed to evaluate the failure mechanism. A Wilcoxon test was utilized for post-hoc analysis. Statistical analysis was conducted using the SPSS program version 26 (SPSS Inc., Chicago, Illinois, USA), with a significance level established at $p < 0.05$.

RESULTS

The tensile bonding strength (mean values and standard deviations, measured in MPa) of indirect inlay restorations is shown in Table 2. The value of samples tested after storage in artificial saliva for 93 hours shows that the lowest mean of tensile bond strength is for the DD cube X zirconia group (18.42), and the highest is for the IPS e-max press group (38.23). The value of samples after exposure to a simulated gastric acid cycle for 93 hours shows the minimum average tensile bond strength for the DD cubeX zirconia group (8.01), and the highest mean is for the IPS e-max press group (27.57), as shown in Figure 2.

Table (2): The mean and standard deviation of tensile bond strength values were determined for each material.

Restorative material	Saliva	HCl-treated	P-value
IPS e-max press [a]	38.23(±1.53)	27.57(±1.28)	0.000
Filtek Bulk Fill [b]	29.31(±1.20)	21.65 (±1.08)	0.000
GC EverX posterior [c]	24.15(±1.29)	12.36(±1.54)	0.000
DD cubeX zirconia [d]	18.42(±1.45)	8.01(±1.11)	0.000

*Using identical superscript lowercase characters indicates comparisons between the relevant groupings. Different letters refer to highly substantial differences ($p<0.000$) between tested materials.

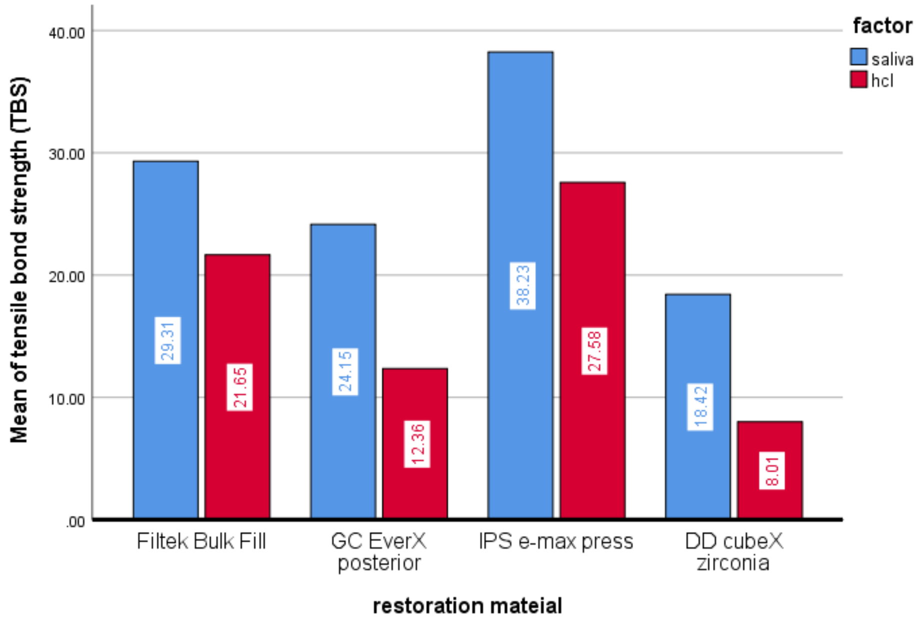

Figure (2): Means of the tested groups within different study periods.

Failure mode evaluation

Images obtained by SEM are presented in Figure 3. The surfaces of all specimens showed evidence of adhesive, cohesive, and mixed failure.

In Group A (Filtek Bulk Fill Posterior), adhesive failure on the dentin surface was predominantly noted when immersed in artificial saliva, while mixed failure occurred when both the dentin surface and remains of the resin cement were present in the simulated gastric acid solution.

In Group B (GC EverX posterior), adhesive failure along the dentin surface and mixed failure, characterized by the presence of both the dentin surface and remains of resin cement, was found when the specimens were immersed in artificial saliva. Mixed failure was predominantly noticed when the dentin surface and remnants of the resin cement were simultaneously displayed in the simulated gastric acid solution.

In Group C (DD cubeX^2 zirconia), adhesive failure along the inlay–resin cement interface occurred primarily when immersed in artificial saliva. mixed failure when simultaneously exhibiting the dentin surface and remnants of the resin cement occurred within the simulated gastric acid solution.

In Group D (lithium disilicate glass-ceramic IPS e.max press), adhesive failure along the dentin surface occurred primarily when immersed in artificial saliva and mixed failure when simultaneously exhibiting the dentin surface and remnants of the resin cement within the simulated gastric acid solution.

The results show a change in the failure mode between artificial saliva and gastric acid. The Kruskal-Wallis H test was conducted to compare the failure mode between different groups. The results showed no significant difference between the groups, as shown in Table 3.

Table (3): The Kruskal-Wallis H test for comparison of the mode of failure between different groups.

media	Restorative material	Mean ±SD	p-value
saliva	Filtek Bulk Fill posterior	2.05 (±1.239)	.687
	GC EverX posterior		
	IPS e-max press		
	DD cubeX zirconia		
HCL	Filtek Bulk Fill posterior	3.35 (±1.051)	.619
	GC EverX posterior		
	IPS e-max press		
	DD cubeX zirconia		

For further comparisons, a Wilcoxon test was used post-hoc to compare the failure mode within each testing period of the same material group. The results, shown in Table 4, showed a significant difference between artificial saliva and gastric acid within the same material group, as illustrated in Figure 4.

Table (4): Wilcoxon post-hoc comparisons of the failure mode within each group.

Restorative material	Saliva	HCL-treated	p-value
Filtek Bulk Fill posterior	1.70 (±1.160)	3.60 (±.966)	.010
GC EverX posterior	2.30 (±1.418)	3.40 (±.966)	.026
IPS e-max press	2.10 (±1.449)	3.30 (±1.252)	.039
DD cubeX zirconia	2.10 (±.994)	3.10 (±1.101)	.039

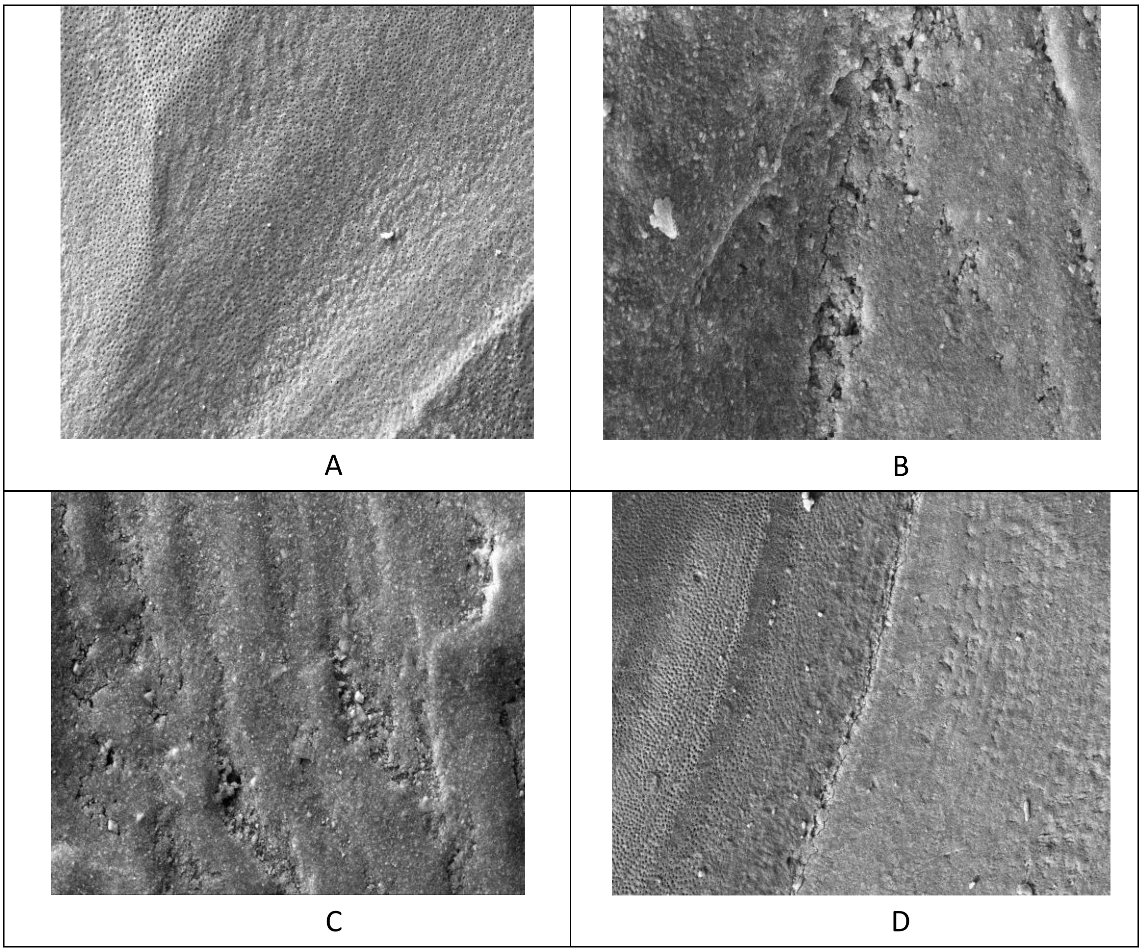

Figure (3): A. Adhesive failure along the dentin, **B.** Adhesive failure along the inlay–resin cement, **C.** Cohesive failure within the resin cement**, D.** Mixed failure when simultaneously exhibiting the dentin surface and remnants of the resin cement.

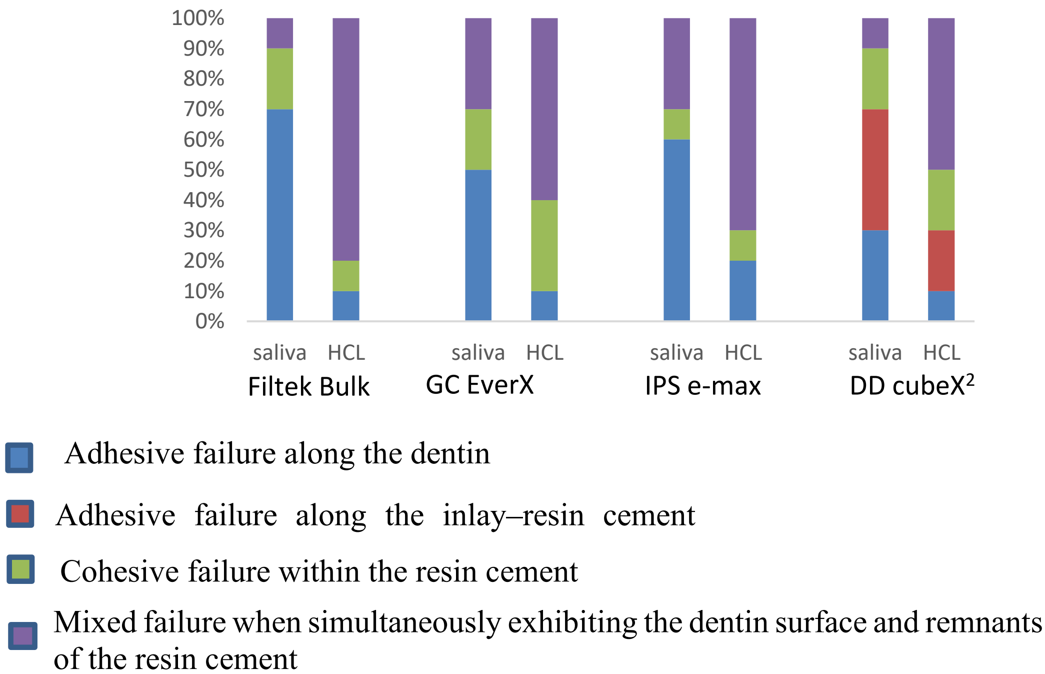

Figure (4): Distribution of failure modes among experimental groups.

DISCUSSION

The choice of restorative materials is one of the most crucial elements in conservative dentistry. Optimal aesthetic treatments are essential for maintaining self-esteem and trust in dental procedures. It is widely acknowledged that selecting the appropriate restorative material for the indication can prevent the need for additional costly and intricate procedures in the event of restoration failure (31).

Gastric acid can induce demineralization in dental hard tissues and may also degrade the resin matrix of composites during reflux, owing to its low pH, which ranges from 1 to 1.5. A systematic study determined that the median prevalence of dental erosion in individuals with GERD is 24% (ranging from 5% to 47.5%), while 17% (ranging from 21% to 83%) of patients with dental erosion have gastroesophageal reflux (32).

The in vitro simulation approach for gastric acid exposure to the intraoral complex has not been established, and many researchers have proposed different immersion durations ranging from 1 day to 1 month. Cengiz et al. employed a gastric acid solution (pH = 1.2) for 24 hours at 37°C to replicate the most severe conditions of a patient experiencing reflux episodes (33). A separate study indicated that the 6-hour and 18-hour testing durations correspond to roughly 2 and 8 years, respectively (34). Unal et al. established that the in vitro storage of composite samples in gastric acid for 14 days simulates 13 years of intraoral conditions (27).

In this investigation, sample groups underwent a gastric acid erosive cycle for 1 minute, six times daily for 30 days; the materials were rinsed in distilled water for 5 seconds before being immersed in artificial saliva for a minimum of 30 minutes. Test durations were employed to achieve a plausible immersion period equivalent to 15.5 years within the intraoral environment. This experiment is important since it simulates the conditions of a bulimic patient who typically vomits three times daily, with the interaction time between vomit and restorative substance being under one minute (2). Samples in the control group were submerged in artificial saliva for 93 hours during the cycling method (35).

Self-adhesive resin cement has been recently developed. The aim of designing this cement was to merge the handling convenience (requiring no preparation) provided by conventional cement types with the advantageous mechanical qualities, appealing aesthetics, and strong tooth adherence characteristic of resin cement. Manufacturers claim that adherence to dental tissue can be achieved without prior treatments such as etching, priming, or adhesion. These self-adhesive universal resin cements employ advanced monomers, filler materials, and initiation technologies. The organization asserts that the organic matrix comprises newly synthesized multifunctional phosphoric-acid methacrylates. The acid-phosphate groups found in these molecules alter the tooth's surface and improve adherence [36].

Following the gastric acid cycle, we discovered a statistically significant decrease in the tensile bond strength of each tested group for many reasons, such as self-adhesive resin cement and indirect composite restorations being susceptible to degradation in acidic environments. Gastric acid, which primarily consists of hydrochloric acid with a low pH, can hydrolyze the resin matrix, weakening the chemical structure of the cement. The acidic environment breaks down the cross-linked polymer chains within the resin, compromising the material's mechanical properties and bond strength over time [37].

Combined with acid exposure, water absorption leads to hydrolytic degradation of the resin cement. This can affect the cement's bonding to the tooth and the restoration of the ceramic. Acid accelerates the adhesive interface's breakdown, reducing the strength of the restoration's tensile bond [38].

Osorio et al. discussed this: Prolonged exposure to gastric acid can weaken the interface between the cement and the tooth structure (especially dentin), increasing microleakage and reducing overall retention. The acid may penetrate micro gaps, compromising the bond's integrity [39].

Also, some studies have reported that acidic conditions increase the surface roughness of ceramic materials like lithium disilicate and cause ion leaching from the cement, leading to further degradation of the bonded interface [40].

The results of the present study, when comparing all tested groups, Show a significant difference in the tensile bond strength values between restorative materials. Lithium disilicate (E.max) has greater bond strength than zirconia and indirect composite restoration. This might be attributed to several factors, such as. Lithium disilicate (E.max) is a glass-ceramic material, which makes it etchable with hydrofluoric acid. This etching creates a micro-roughened surface that significantly enhances micromechanical retention. It also responds well to silane coupling agents, which form strong chemical bonds with the glassy phase in lithium disilicate. In contrast, zirconia is a polycrystalline ceramic lacking this glass phase, making it less receptive to silane, a critical factor in adhesive bonding, and cannot be easily etched, relying primarily on mechanical retention and adhesion promoters like silanes or MDP primers [21].

Also, indirect composite restorations rely on mechanical and chemical bonding, but their surface treatment options, such as air abrasion, do not provide the same level of micromechanical retention. Moreover, composite restorations lack the ability to form chemical bonds as strong as the silane-glass interaction in E.max [23].

CONCLUSIONS

Within the limitations of the current study, it is possible to conclude that:

It significantly decreased the tensile bond strength of the studied restorations after exposure to the simulated gastric acid cycle. However, Material Composition, Surface Treatment, and Bonding Mechanism influence the tensile bond strength of a restorative material. Also, according to the results of this study, Lithium disilicate (E.max) is a more stable option for patients with GERD than the other materials examined. This can be ascribed to its glassy phase nature, etchability, and ability to form silane-glass interaction.

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Authors' Contribution

Conceptualization: Al-Qaissei YK, Al-Naimi AM, Suliman AA. Formal analysis: Al-Qaissei YK, Al-Naimi AM, Suliman AA. Funding acquisition: Al-Qaissei YK, Al-Naimi AM. Investigation: Al-Qaissei YK, Al-Naimi AM. Methodology: Yasser K. Al-Qaissei, Ali M. Al-Naimi. Project administration: Ali M. Al-Naimi. Resources: Al-Qaissei YK, Al-Naimi AM, Suliman AA. Software: Al-Qaissei YK. Supervision: Al-Naimi AM. Validation: Al-Naimi AM, Suliman AA. Visualization: Al-Qaissei YK, Al-Naimi AM, Suliman AA. Writing–original draft: Al-Qaissei YK, Al-Naimi AM. Writing–review editing: Al-Naimi AM, Suliman AA. All authors have read and approved the final manuscript.

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Ethical statement: The protocol of this study was approved by the Research Ethical Committee at the University of Mosul (UoM.Dent.23/58).

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript

Availability of data and materials: All data generated or analyzed during this study are included in this published article and its supplementary information files.

Declaration of Generative AI and AI-assisted technologies

During the preparation of this work, the authors used Grammarly software to edit and proofread the text. The authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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تأثير حمض المعدة المُحاكي على قوة الشد في الترميمات غير المباشرة من الفئة الثانية

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الملخص

الأهداف: هدفت الدراسة الحالية إلى تحديد تأثير استخدام حمض الهيدروكلوريك (HCl) على قوة الشد لأربع مواد ترميمية مميزة. ومن خلال القيام بذلك، سعينا إلى تقديم رؤى قيمة حول متانة هذه المواد وقدرتها على الصمود في مواجهة التعرض لحمض المعدة. **المواد والطرائق العمل:** تم تضمين ثمانين ضاحكًا أوليًا سليمًا في هذه الدراسة؛ تم توزيع الأسنان عشوائيًا على أربع مجموعات (ن = 20) وفقًا لمواد الترميم. تم ترميم المجموعة الأولى باستخدام Filtek Bulk Fill Posterior Restorative (3MTM). تم ترميم المجموعة الثانية باستخدام مركب الأسنان المقوى بالألياف الخلفية EverX (GCTM). تم ترميم المجموعة الثالثة باستخدام زركونيا cubeX عالية القوة متعددة الطبقات (Dental Direkt TM)، وتم ترميم المجموعة الرابعة باستخدام IPS e-max press (Ivoclar/VivadentTM). تم تصنيف العينات في الفئات الرئيسية الأربع إلى مجموعتين فرعيتين (ن = 10) بناءً على غمرها إما في اللعاب الاصطناعي أو محلول حمض المعدة المُحاكي (SGAS). خضعت العينات لتقييم قوة رابطة الشد باستخدام جهاز اختبار عالمي. تم فحص البيانات باستخدام تحليل التباين ثنائي الاتجاه واختبار فريدمان. تم تحديد عتبة الدلالة الإحصائية عند $p < 0.05$. **النتائج:** كان تأثير حمض الهيدروكلوريك واضحًا على جميع المواد المختبرة، مع وجود فرق كبير لوحظ بين المجموعات بعد الغمر في حمض الهيدروكلوريك ($p<0.000$). أظهرت مجموعة ثنائي سيليكات الليثيوم أكبر قوة رابطة شد، بينما أظهرت مجموعة مكعب X الزركونيا أقلها. أظهرت جميع العينات انخفاضًا ملحوظًا في قوة رابطة الشد بعد التعرض لحمض المعدة المُحاكي. ومع ذلك، اختلف مدى انخفاض رابطة الشد في جميع المجموعات المختبرة. الاستنتاج: يقلل حمض المعدة المُحاكي، بغض النظر عن نوعه، بشكل كبير من قوة رابطة الشد للمواد المختبرة. وهذا يؤكد الحاجة إلى إجراء المزيد من الأبحاث وتطوير مواد ترميمية أكثر مقاومة للأحماض.**الاستنتاجات:** كانت مادة NeoSEALER flo هي الأقل سمية للخلايا ، بينما كانت مادة Endovit هي الأكثر سمية للخلايا ،وتقل حيوية الخلية مع مرور الوقت.

الكلمات المفتاحية: الشره العصبي؛ حمض المعدة؛ مرض الارتجاع المعدي المريئي؛ قوة الرابطة الشد.