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Bonding treatment of CAD/CAM milled denture resins repaired with visible light-cured resin

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ABSTRACT

Aims: This study evaluated and compared the effect of bonding agents on the flexural strength (FS) of denture base resins repaired with visible light cured (VLC) denture resin.

Methods: A total of 100 specimens (65x10x2.5 mm) were fabricated using two types of denture base materials: pre-polymerized PMMA-based blocks designed for CAD/CAM milling and conventional heat-polymerized denture base acrylic resin (control). The specimens were sectioned in the middle with 2 mm repair gap and 45° margin design. Repair surfaces were first treated with various light-cured bonding agents then repaired using VLC resin. The bonding agents either conventional or combined with acrylic primers and dual cure agents were tested. All the specimens were subjected to 3-point bending test and FS was calculated. Data were statistically analyzed using two-way analysis of variance according to the denture base material and the bonding treatments ($p<0.05$).

Results: Among repaired groups, acrylic primer + G-Premio BOND produced the highest FS within each material (A3: 17.31±4.69 MPa; B3: 9.80±2.57 MPa). Between materials, CAD/CAM exceeded conventional in groups 1-4 ($p<0.05$)-including the intact controls-whereas group 5 showed no between-material difference ($p>0.05$).

Conclusion: The use of a bonding agent specifically designed for the surface treatment of acrylic resins can be clinically beneficial when repairing denture bases with VLC resin.

Keywords: Acrylic primer, bonding agent, CAD/CAM, denture repair, flexural strength

INTRODUCTION

Computer-aided design and manufacturing (CAD/CAM) technologies have gained popularity in removable denture fabrication due to their numerous clinical and technical advantages.[1-3] Digitally fabricated dentures-defined as prostheses milled from pre-polymerized polymethyl methacrylate (PMMA) blocks using CAD/CAM systems-address several limitations associated with conventionally moulded PMMA dentures, which are typically produced through compression molding of heat-polymerized acrylic resin.[4] These digitally produced prostheses have been associated with improved patient and clinician satisfaction, primarily due to fewer required clinical appointments.[5,6] Additionally, they offer superior fit, reduced polymerization shrinkage,[7] lower microbial adhesion,[8] and the advantages of digital data storage and rapid reproducibility.[9,10]

Common complications associated with complete dentures include cracks, fractures, and debonding of artificial teeth, with fractures reported as the most frequent.[11-14] Elderly patients, who constitute the majority of denture wearers, often experience accidental denture fractures due to weakened reflexes and reduced motor control.[14,15] Additionally, poor denture design[16] and insufficient mechanical properties of denture base materials contribute significantly to denture failures.[17,18]

The re-fabrication of digital prosthetic restorations is optimal in the presence of any complications, the financial implications associated with computer systems and the requisite materials represent a considerable economic drawback. Consequently, the repair of these systems, which have emerged as the prevailing treatment modality, is paramount in selecting suitable repair materials and surface modifications.[19] Repair materials must be widely used, easily accessible, and cost-effective for both dental laboratories and clinics.[13,20]

Clinically effective denture repair is highly dependent on the bond strength between repair materials and the denture base, as well as appropriate surface modifications.[21] Common repair materials include autopolymerizing, visible light-cured (VLC), and heat-cured acrylic resins.[22-24] Autopolymerizing and VLC

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resins are particularly favored in clinical practice due to their simplicity and minimal equipment requirements.[25-27] Testing VLC resin based on urethane dimethacrylate (UDMA) within standardized protocols may offer additional clinical benefits.[26,28]

Chemical and/or mechanical surface treatments are employed during denture repair to enhance surface characteristics and bond strength.[29,30] Mechanical treatments, such as sandblasting or abrasion, improve micromechanical retention by increasing surface area.[21] Chemical approaches include acid etching, methyl methacrylate (MMA) application, or organic solvents.[31,32] Limited studies have evaluated the fracture strength of CAD/CAM milled and conventionally fabricated denture bases repaired with VLC.[33,34] Although previous studies have indicated that VLC resins may present inadequate flexural strength,[24,33] their clinical advantages warrant further investigation. The incorporation of bonding agents as a chemical surface treatment may improve their bonding potential and mechanical performance in denture repair.

This study aims to evaluate the flexural strength (FS) of CAD/CAM milled and conventionally fabricated denture base materials repaired with UDMA-based VLC resin, with and without the application of chemical bonding agents. The null hypothesis of the present study is that the use of UDMA-based VLC repair material will not differ in FS at fracture between CAD/CAM milled and conventionally fabricated denture base materials when chemically treated with bonding agents.

METHODS

Ethics

This study is entirely in vitro and does not involve human or animal participants. Therefore, ethics committee approval is not required for this research. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Preparation of Test Samples

For the fabrication of denture base samples, a commercially available, pre-polymerized PMMA-based puck specifically produced for CAD/CAM techniques (Merz Dental GmbH, Lütjenburg, Germany) with standard dimensions (98 mm in diameter and 25 mm thickness) (group A) as experimental group and PMMA denture base material (Paladent 20, Heraeus Kulzer GmbH & Co. KG, Hanau, Germany) as control group (group B) were included. A VLC cured UDMA bases material (Eclipse Prosthetic Resin, Dentsply Int., New York, NY, USA) with a paste consistency were used as repair material.

The pre-polymerized PMMA-based CAD/CAM blocks were milled into standardized specimens measuring 65×10×2.5 mm using a universal lathe device (Trens SN50C/1000, Slovakia). Initially, cylindrical blocks were trimmed into rectangular forms, followed by horizontal and vertical cutting using 2 mm cutting burs.

For the control group (group B) acrylic resin was prepared at a powder/liquid ratio of 23.4 g/10 ml, according to the manufacturer's recommendations. The mixture homogenized at room temperature (23±2°C) for 60 seconds and then allowed to rest for 15 minutes. Afterward, the mixture was poured into plaster molds. For the polymerization process, the metal flasks were first placed in a thermostatically controlled water bath (Kavo Elektrotechnisches Werk GmbH, Biberach, Germany) at room temperature and then heated to 74°C according to the manufacturer's instructions. After keeping at 74°C for 30 min, the temperature was raised to 100°C and held for an additional 30 minutes. The flasks were then allowed to cool to room temperature in the water bath. Once the flasking process was completed, the acrylic samples were removed, and excess material was cleaned using a hand tool and a tungsten carbide bur.

Preparation of Repair Surfaces

To simulate the clinical repair process, intact samples were initially placed into plaster molds. Each sample and its corresponding mold were numbered and recorded, after which the samples were removed from the molds.

To simulate a denture fracture, the samples were divided into two equal parts using a tungsten carbide bur (Rapidy Microbur, Bredent GmbH, Senden, Germany) at a speed of 2,000 rpm. To set the repair gap at 2 mm with a 45° angle, guide marks were drawn on the sample surfaces, with a distance of 2 mm from the top and 7 mm from the bottom. All repair surfaces of the samples were milled with a tungsten carbide bur (Frank Dental, Gmund am Tegernsee, Germany) at a speed of 1,000 rpm and then smoothed under running tap water using two different grades of sandpaper (200 and 400 grit, Waterproof silicon carbide paper, English Abrasives Ltd., London, UK). The final dimensions of the samples were checked using a digital caliper (Absolute Digimatic Caliper, Mitutoyo, Kawasaki, Japan). Once the samples were adjusted to the desired dimensions, each pair of samples was placed into the corresponding mold cavities.

For VLC resin repair, samples in molds were preheated (55°C, 2 min) in an oven (Eclipse Conditioning Oven, Dentsply Sirona Int., Ontario, Canada) to facilitate resin adaptation.

Surface Treatments

After the heating, the plaster molds were removed and samples were divided into five subgroups for surface treatments (Table 1, 2):

Table 1. Information on the trade name, manufacturer, abbreviation and polymerization type of the denture base materials used in this study

	Manufacturer	Group	Polymerization type
CAD/CAM M-pm disc	Merz Dental GmbH, Lütjenburg, Germany	A	prepolymerized puck
Paladent 20	Heraeus Kulzer GmbH, Hanau, Germany	B	Heat-activated polymerization powder and liquid

CAD/CAM: Computer-aided design and manufacturing

Table 2. The groups in the study and the surface treatments applied

	Group A	Group B
Control group	A1	B1
G-Premio BOND	A2	B2
GC acrylic primer + G-Premio BOND	A3	B3
GC acrylic primer + G-Premio BOND DCA	A4	B4
G-Premio BOND DCA	A5	B5

Group 1 (control group-group A1-B1): No repair or surface treatment applied.

Group 2 (G-Premio BOND-group A2-B2): G-Premio BOND (GC, Tokyo, Japan) was applied to the repair surfaces with a clean, dry brush as shown in Figure 1.

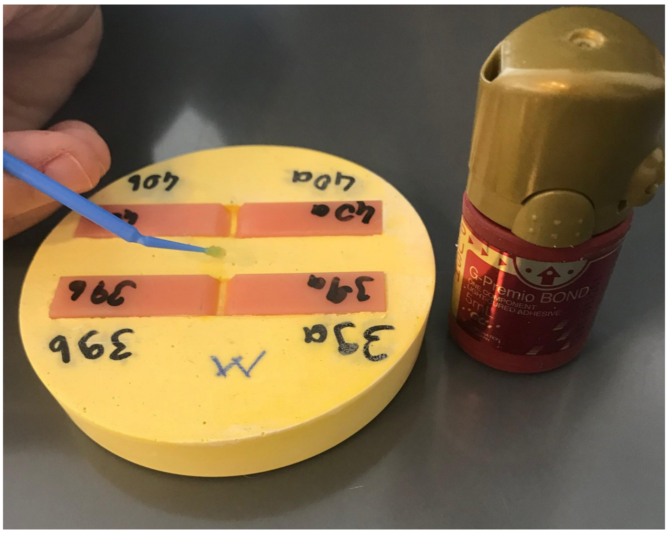

Figure 1. Application of G-Premio BOND to the repair interface using a clean microbrush

Group 3 (acrylic primer+G-Premio BOND-group A3-B3): GC acrylic primer (GC, Tokyo, Japan) was applied first, followed by air drying for 30 seconds, then G-Premio BOND was applied with a new brush as shown in Figure 1, 2.

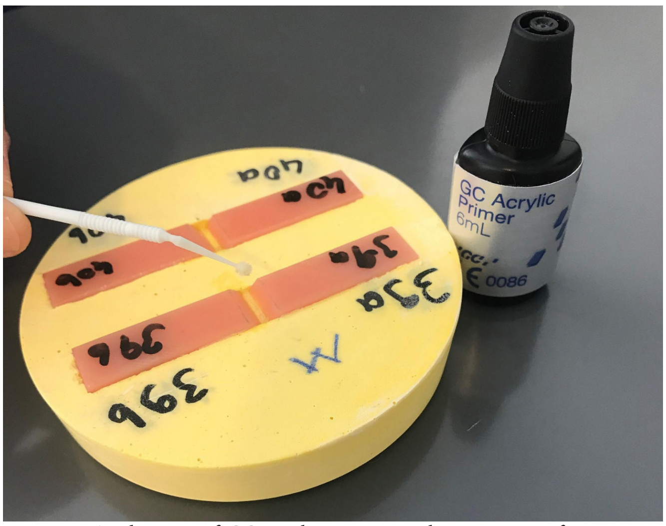

Figure 2. Application of GC acrylic primer to the repair interface using a clean microbrush

GC: Gradia composite

Group 4 (acrylic primer+G-Premio BOND DCA-group A4-B4): GC acrylic primer was applied and air-dried, then G-Premio BOND DCA (GC, Tokyo, Japan) was applied using a separate brush as shown in Figure 2, 3.

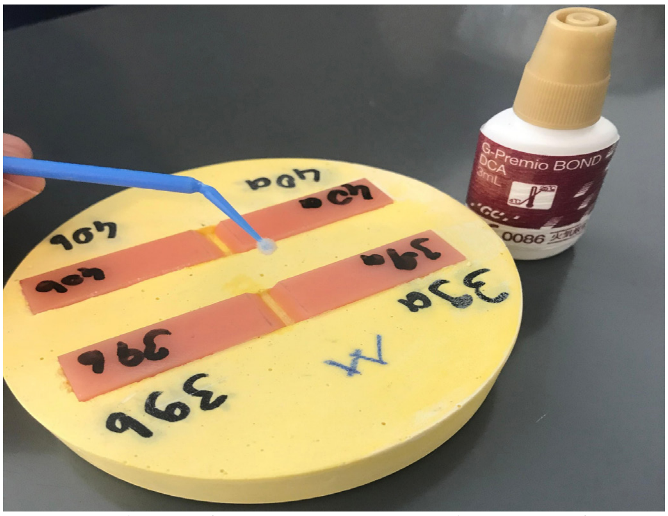

Figure 3. Application of G-Premio BOND DCA to the repair interface using a clean microbrush

Group 5 (G-Premio BOND DCA group A5-B5): G-Premio BOND DCA was applied directly with a clean brush as shown in Figure 3.

Separate clean brushes were used for each bonding agent to prevent cross-contamination. In all treatment groups, bonding agents were uniformly spread into a thin layer using air spray and polymerized (20s) with a light-curing device (Smartlite Max, Model 644050, Dentsply, USA, intensity: 1000 mW/cm^2) as shown in Figure 4.

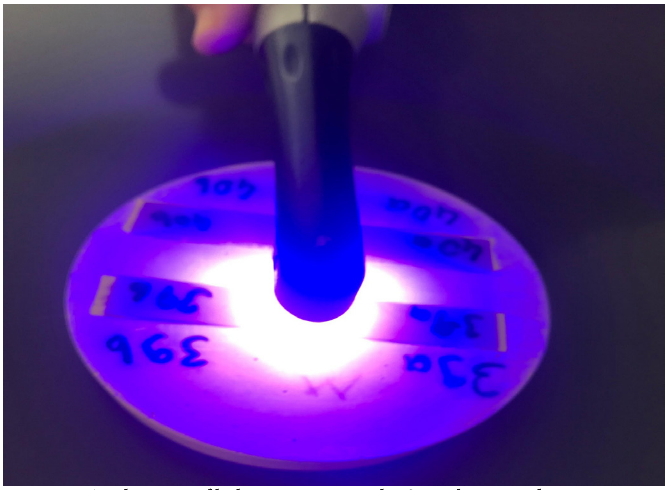

Figure 4. Application of light-curing using the Smartlite Max device

Subsequently, 2 mm of the VLC repair material in a paste form was applied and condensed firmly into the repair gap using finger pressure. To prevent oxygen inhibition during polymerization, an air barrier coating (Eclipse Air Barrier Coating, Dentsply Sirona Inc, New York, USA) was applied over the repair resin with a brush. Polymerization was performed (10 min) using the Eclipse Junior light-curing unit (Dentsply Sirona, Germany), according to the manufacturer's instructions.[34]

Samples were cooled to room temperature (23±2°C), rinsed with distilled water to remove the coating, and carefully removed from the plaster molds using a fine-tipped spatula. All samples repaired were finished using a hard bur (Frank Dental GmbH, Gmund, Germany) at 1000 rpm and then smoothed under running water using 200 and 400 grit sandpapers (Waterproof silicon carbide paper, English Abrasives Ltd., London, United Kingdom). The final sample dimensions were verified at three separate points using a digital caliper (±0.01 mm precision), and the average of these measurements was used to confirm compliance with dimensional criteria. Material specifications, including the chemical composition and curing recommendations of the UDMA-based VLC resin, were obtained from the manufacturer's technical datasheet (Dentsply Sirona, Eclipse Prosthetic Resin, MSDS).[35]

The samples prepared for the 3-point bending test were grouped according to their respective group, and all samples were stored in distilled water at 37°C for 48 hours after the complete repair process, prior to mechanical testing.

The sample size was determined based on a previous study that conducted power analysis using the G*power software (version 3.1.9.7) with an effect size (d=0.861) and standard deviation of 6.[33] According to that analysis, a minimum of five specimens per group was sufficient to detect statistically significant differences at a power of 80% and an alpha level of 0.05. In the present study, 10 specimens were included in each subgroup. A total of 100 specimens were tested in this study.

Flexural Strength Test

The flexural strength was assessed using a 3-point bending test on a Universal Testing Machine (EZ Test Series, Shimadzu, Japan). The span length between the metal supports was set at 50 mm, and the crosshead speed was maintained at 5 mm/min. A compressive force was applied perpendicularly to the midpoint of each specimen until fracture occurred. The maximum load (N), deflection at fracture (mm), and corresponding flexural data were automatically recorded via the connected software. Flexural strength (FS) in megapascals (MPa) was calculated using the following formula, as previously described:[33] $FS=3FL/(2bd^2)$ where F is the maximum load at fracture (N), L is the support span (mm), b is the specimen width (mm), and d is the specimen thickness (mm).

Statistical Analysis

Data analyses were performed using the SPSS 22 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were reported mean±standard deviation (SD). A two-way analysis of variance (ANOVA) was conducted to investigate differences in flexural strength (FS) among different acrylic materials and surface treatment groups. The model included main effects for material (CAD/CAM milled vs. conventional), surface treatment (group 1 to group 5), and the interaction term (material×surface treatment). When significant interaction effects were observed, post-hoc comparisons were performed using simple effects analysis with Bonferroni correction. A p-value <0.05 was considered statistically significant for all analyses.

RESULTS

The statistical evaluation of the flexural strength values of the experimental groups was performed using arithmetic mean values and two-way ANOVA, and the results are presented in Table 3, 4, respectively. There was a statistically significant difference after the surface treatments, except for group A5-B5 (p<0.001) (Table 4).

Table 3. Description statistics of flexural strength

	Group A			Group B		
Group	n	Mean±SD	(min-max)	n	Mean±SD	(min-max)
1	10	81.73±8.21	(68.28-91.88)	10	75.75±3.86	(70-80.94)
2	10	11.13±2.03	(8.13-14.06)	10	5.47±2.43	(1.56-10.47)
3	10	17.31±4.69	(10.94-25.78)	10	9.8±2.57	(7.19-15)
4	10	11.56±2.95	(5.94-15.78)	10	3.25±1.73	(1.09-5.63)
5	10	1.11±0.27	(0.78-1.72)	10	3.39±1.50	(1.41-6.09)

Values are shown in MPa

Table 4. Comparison of fracture forces by groups and materials

	Material				p		
	Group A		Group B				
Group	n	Mean±SD	n	Mean±SD	Material	Group	Material* group
1	10	$81.73±8.21^{a,A}$	10	$75.75±3.86^{a,B}$	<0.001	<0.001	<0.001
2	10	$11.13±2.03^{c,A}$	10	$5.47±2.43^{bc,B}$			
3	10	$17.31±4.69^{b,A}$	10	$9.8±2.57^{b,B}$			
4	10	$11.56±2.95^{c,A}$	10	$3.25±1.73^{c,B}$			
5	10	$1.11±0.27^{d,A}$	10	$3.39±1.50^{c,A}$			

A, B: Different uppercase letters in the same row indicate statistically significant differences between materials within each surface treatment (p<0.05). a, b, c, d: Different lowercase letters in the same column indicate statistically significant differences between surface treatments within each material group (p<0.05). (Post-hoc comparisons performed with Bonferroni correction)

In group A, the highest fracture strength was observed in the intact samples (group A1: 81.73±8.21 MPa, SD), followed by groups where the bonding agent was applied with the acrylic primer (group A3: 17.31±4.69 MPa, SD); group A4: 11.56±2.95 MPa,SD). Moderate FS was recorded in the G prime bonding group (group A2: 11.13±2.03 MPa, SD). In group B, the highest FS was also observed in the intact specimens (group B1: 75.75±3.86 MPa, SD), a statistically significant difference was noted when the acrylic primer was applied in combination with the G-Premio BOND agent [group B3: 9.8±0.81 MPa (SD)], followed by the G-Premio BOND group (group B2: 2.57±2.43 MPa, SD), and the acrylic primer with DCA Bond (group B4: 3.25±1.73 MPa, SD). The lowest fracture strength in both groups was found in the group where only the dual cure activator agent was applied [group A5: 1.11±0.27 MPa (SD); group B5: 3.39±1.50 MPa (SD)].

The pairwise comparisons were performed using Bonferroni post-hoc test, and significant differences were denoted with superscript letters in Table 4. A statistically significant interaction was observed between material and surface treatment group (p<0.001).

DISCUSSION

The null hypothesis of the present study was rejected, as significant differences were found between the FS of CAD/CAM milled and conventionally produced denture base materials after surface modifications with different chemical agents, except for one group when using VLC polymerized UDMA repair material.

Denture base materials produced by CAD/CAM systems exhibit a range of FS values. Previous studies have demonstrated that these materials provide significantly greater FS compared to conventionally heat-polymerized denture base resins.[32,33] The results obtained from the present study, which show higher FS in intact CAD/CAM specimens than in conventionally polymerized ones, are in agreement with earlier reports.[24,33] This enhancement can be attributed to the optimized material properties, the employment of pre-polymerized blocks fabricated under elevated pressure,[27,28] reduced polymerization shrinkage,[4] and a minimal residual monomer presence.[35]

To date, there is limited in vivo evidence concerning the mechanical failure of digitally fabricated complete dentures. While intraoral fractures in CAD/CAM dentures are infrequent, extraoral fractures remain a possibility.[37] With the expanding clinical use of CAD/CAM denture base materials, further in vivo investigations on intraoral and extraoral failure modes are needed to comprehensively assess their long-term mechanical performance.

The primary objective in denture repair is to re-establish the mechanical strength and ensure adequate bonding between the base and repair material. Surface geometry plays a vital role in this process. Literature supports that a 45° beveled joint with rounded edges increases bonding area and modifies stress distribution from tensile to shear forces, which enhances repair durability.[28,37] In the present study, the selection of a 45° angled repair surface design was made to promote effective preparation and to assure an improved distribution of adverse stresses.

The gap between the fractured surfaces is another crucial parameter. Research suggests ideal repair gaps ranging from 1.5 to 3 mm, although gaps as large as 10 mm have been tested.[37] In our study, a 2 mm repair gap was chosen due to ease of application and aesthetic concerns, as narrower gaps can create application difficulties due to the thickness of the bur, and variations in the repair gap could affect the results. For future studies, a new study design could be proposed using different repair gaps.

Despite their mechanical inferiority to autopolymerizing and heat-polymerizing resins, VLC resins are still used in clinical applications. Their advantages include reduced residual monomer content and superior color stability.[21,29,31] However, previous studies such as Lewinstein et al.,[38] which reported no significant differences in bond strength between these materials, were conducted under different surface preparation and polymerization conditions, limiting direct comparisons. Additionally, VLCs are commonly hand-mixed and applied without pressure, increasing the risk of internal voids and defects.[32] Consequently, their mechanical performance may be compromised. Nonetheless, they may be suitable in specific clinical situations prioritizing esthetics and reduced irritation over mechanical strength. In a study examining the repair process of milled denture base materials using VLC repair resin,[28] the authors suggested that, in addition to investigating surface treatments for milled PMMA, there is a need to develop a bonding agent when VLC material is preferred. In this study, different commercially available bonding agents were used as repair resins for milled and conventionally produced PMMA, and their effect on flexural strenght was investigated.

In this study, several commercially available bonding agents were tested. In the CAD/CAM group, the highest FS (17.31±4.69 MPa) was achieved when bonding agent was used together with acrylic primer (group A3). This indicates that primer application enhances surface energy and facilitates bonding agent adhesion. In contrast, the bonding agent alone (group A5: 1.11 ± 1.09 MPa) resulted in lower FS. Therefore, the combined use of primer and bonding agent is advised for repairs of CAD/CAM milled PMMA bases. These findings support the notion that the bonding agent alone may be insufficient due to inadequate interaction with the CAD/CAM substrate, which has low surface energy and high crosslinking density. The primer enhances wettability and promotes better diffusion and micromechanical interlocking.

Similarly, in conventional specimens, the combination of bonding agent and primer (group B3: 9.8±2.57 MPa) yielded superior FS. The lowest FS was observed in the group treated solely with a dual-cure activator (group B5: 3.39±1.50 MPa). These results confirm that using bonding agents alone may be insufficient, highlighting the importance of surface pre-treatment.

Clinically, although CAD/CAM denture repairs may incur higher costs, combining primers with bonding agents can enhance repair strength and patient satisfaction. Appropriate selection of materials and protocols can improve prosthesis longevity and treatment outcomes.

Nevertheless, the claim that reproduction is superior to repair should be made with caution. While re-fabricating a denture using stored digital data can provide excellent mechanical results, it is not always feasible due to clinical, economic, or logistic constraints. In many cases, repair remains a valid and timely solution.

Limitations

Limitations of this study include its in vitro setting, the use of only one VLC resin, and the absence of long-term clinical or aging simulations. Although power analysis was performed and the sample size was above the minimum threshold, future research should involve larger and more diverse samples to enhance generalizability.

CONCLUSION

This study has demonstrated the impact of different bonding agents and surface treatments on the repair of PMMA denture base materials, showing that the combination of acrylic primer and bonding agents provides the highest flexural strenght. These findings highlight the importance of selecting appropriate repair materials and surface treatments in clinical practice and offer guidance for achieving more durable and long-lasting denture repairs.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study is entirely in vitro and does not involve human or animal participants. Therefore, ethics committee approval is not required for this research.

Informed Consent

Since the study was conducted without the participation of any living being, no written consent form was obtained.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. Carlsson GE, Omar R. The future of complete dentures in oral rehabilitation. A critical review. *J Oral Rehabil.* 2010;37(2):143-156. doi:10.1111/j.1365-2842.2009.02039.x
2. Yilmaz B, Azak AN, Alp G, Ekşi H. Use of CAD-CAM technology for the fabrication of complete dentures: an alternative technique. *J Prosthet Dent.* 2017;118(2):140-143. doi:10.1016/j.prosdent.2016.10.016
3. Kalberer N, Mehl A, Schimmel M, Müller F, Srinivasan M. CAD-CAM milled versus rapidly prototyped (3D-printed) complete dentures: an in vitro evaluation of trueness. *J Prosthet Dent.* 2019;121(4):637-643. doi:10.1016/j.prosdent.2018.08.002
4. Goodacre BJ, Goodacre CJ, Baba NZ, Kattadiyil MT. Comparison of denture base adaptation between CAD-CAM and conventional fabrication techniques. *J Prosthet Dent.* 2016;116(2):249-256. doi:10.1016/j.prosdent.2016.02.017
5. Fouda A, Tonogai J, McDermott P, Wang D, Dong CS. A systematic review on patient perceptions and clinician-reported outcomes when comparing digital and analog workflows for complete dentures. *J Prosthodont.* 2024. doi:10.1111/jopr.13723
6. Ohara K, Isshiki Y, Hoshi N, et al. Patient satisfaction with conventional dentures vs. digital dentures fabricated using 3D-printing: a randomized crossover trial. *J Prosthodont Res.* 2022;66(4):623-629. doi:10.2186/jpr.JPR_D_21_00149
7. Arslan M, Murat S, Alp G, Zaimoglu A. Evaluation of flexural strength and surface properties of prepolymerized CAD/CAM PMMA-based polymers used for digital 3D complete dentures. *Int J Comput Dent.* 2018;21(1):31-40.
8. Al-Fouzan AF, Al-Mejrad LA, Albarrag AM. Adherence of *Candida* to complete denture surfaces in vitro: a comparison of conventional and CAD/CAM complete dentures. *J Adv Prosthodont.* 2017;9(5):402-408. doi:10.4047/jap.2017.9.5.402
9. Infante L, Yilmaz B, McGlumphy E, Finger I. Fabricating complete dentures with CAD/CAM technology. *J Prosthet Dent.* 2014;111(5):351-355. doi:10.1016/j.prosdent.2013.10.014
10. Steinmassl O, Dumfahrt H, Grunert I, Steinmassl PA. CAD/CAM produces dentures with improved fit. *Clin Oral Investig.* 2018;22(8):2829-2835. doi:10.1007/s00784-018-2369-2
11. Dimitrova M, Vlahova A, Hristov I, Kazakova R. Bonding efficiency between artificial teeth and denture base in CAD/CAM and conventional complete removable dentures. *Materials (Basel).* 2024;17(13):3138. doi:10.3390/ma17133138
12. Wiegand A, Stucki L, Hoffmann R, Attin T, Stawarczyk B. Repairability of CAD/CAM high-density PMMA-and composite-based polymers. *Clin Oral Investig.* 2015;19(8):2007-2013. doi:10.1007/s00784-015-1424-8
13. Jeong KW, Kim SH. Influence of surface treatments and repair materials on the shear bond strength of CAD/CAM provisional restorations. *J Adv Prosthodont.* 2019;11(2):95-104. doi:10.4047/jap.2019.11.2.95
14. Kumari R, Bala S. Assessment of cases of complete denture fracture. *J Pharm Bioallied Sci.* 2021;13(Suppl 2):S1558-S1560. doi:10.4103/jpbs.JPBS_726_20
15. Bosanceanu DN, Beldiman A, Baciu RE, Bolat M, Bosanceanu DG, Forna NC. Complete dentures fractures-causes and incidence. *Ro J Oral Rehabil.* 2017;9(1):54-59.
16. Ates M, Cilingir A, Sulun T, Sunbuloglu E, Bozdag E. The effect of occlusal contact localization on the stress distribution in complete maxillary denture. *J Oral Rehabil.* 2006;33(7):509-513. doi:10.1111/j.1365-2842.2005.01578.x
17. Ali IL, Yunus N, Abu-Hassan MI. Hardness, flexural strength, and flexural modulus comparisons of three differently cured denture base systems. *J Prosthodont.* 2008;17(7):545-549. doi:10.1111/j.1532-849X.2008.00357.x
18. Huggett R, Bates JF, Packham DE. The effect of the curing cycle upon the molecular weight and properties of denture base materials. *Dent Mater.* 1987;3(2):107-112. doi:10.1016/s0109-5641(87)80023-9
19. Murakami N, Wakabayashi N, Matsushima R, Kishida A, Igarashi Y. Effect of high-pressure polymerization on mechanical properties of PMMA denture base resin. *J Mech Behav Biomed Mater.* 2013;20:98-104. doi:10.1016/j.jmbbm.2012.12.011
20. Venkat R, Gopichander N, Vasantakumar M. Comprehensive analysis of repair/reinforcement materials for polymethyl methacrylate denture bases: mechanical and dimensional stability characteristics. *J Indian Prosthodont Soc.* 2013;13(4):439-449. doi:10.1007/s13191-013-0303-4
21. Sahin Z, Ozer NE, Akan T, Kılıcarslan MA, Karaagaclıoglu L. The effect of various surface treatments on the repair bond strength of denture bases produced by digital and conventional methods. *Odontology.* 2024;112(3):782-797. doi:10.1007/s10266-023-00808-1
22. Tuğut F, Koyu T. Effect of repair and thermal cycling on the flexural strength of denture base materials fabricated from different methods. *Cumhuriyet Dent J.* 2023;26(2):150-156. doi:10.7126/cumudj.1201130
23. Stipho HD, Talic YF. Repair of denture base resins with visible light-polymerized reline material: effect on tensile and shear bond strengths. *J Prosthet Dent.* 2001;86(2):143-148. doi:10.1067/mpr.2001.117055
24. AlQahtani M, Haralur SB. Influence of different repair acrylic resin and thermocycling on the flexural strength of denture base resin. *Medicina (Kaunas).* 2020;56(2):50. doi:10.3390/medicina56020050
25. Bural C, Aktaş E, Deniz G, Ünlüçerçi Y, Kizilcan N, Bayraktar G. Effect of postpolymerization heat-treatments on degree of conversion, leaching residual MMA and in vitro cytotoxicity of autopolymerizing acrylic repair resin. *Dent Mater.* 2011;27(11):1135-1143. doi:10.1016/j.dental.2011.08.007
26. Cilingir A, Bilhan H, Geckili O, Sulun T, Bozdag E, Sunbuloglu E. In vitro comparison of two different materials for the repair of urethane dimethacrylate denture bases. *J Adv Prosthodont.* 2013;5(4):396-401. doi:10.4047/jap.2013.5.4.396
27. Mahajan H, Chandu GS, Mishra SK. An in vitro study of the effect of design of repair surface on the transverse strength of repaired acrylic resin using autopolymerizing resin. *Niger J Clin Pract.* 2014;17(1):38-42. doi:10.4103/1119-3077.122835
28. Vasthare A, Shetty S, Kamalakanth SK, Shetty M, Parveen K, Shetty R. Effect of different edge profile, surface treatment, and glass fiber reinforcement on the transverse strength of denture base resin repaired with autopolymerizing acrylic resin: an in vitro study. *J Interdiscip Dent.* 2017;7(1):31-37. doi:10.4103/jid.jid_76_16
29. Al-Dwairi ZN, Tahboub KY, Baba NZ, Goodacre CJ, Ozcan M. A comparison of the surface properties of CAD/CAM and conventional polymethylmethacrylate (PMMA). *J Prosthodont.* 2019;28(4):452-457. doi:10.1111/jopr.13035

30. Minami H, Suzuki S, Minesaki Y, Kurashige H, Tanaka T. In vitro evaluation of the influence of repairing condition of denture base resin on the bonding of autopolymerizing resins. *J Prosthet Dent.* 2004;91(2): 164-170. doi:10.1016/j.prosdent.2003.11.016
31. Özcan M, Alander P, Vallittu PK, Huysmans MC, Kalk W. Effect of three surface conditioning methods to improve bond strength of particulate filler resin composites. *J Mater Sci Mater Med.* 2005;16(1):21-27. doi:10.1007/s10856-005-6442-4
32. Erbulak Z, Ergun G. The effects of different surface treatments applied to milled PMMA denture base material on repair bond strength. *Odontology.* 2023;111(4):953-970. doi:10.1007/s10266-023-00794-4
33. Özatik Ş, Bural Alan C. Flexural strength of repaired denture base materials manufactured for the CAD-CAM technique. *J Oral Sci.* 2024; 66(2):120-124. doi:10.2334/josnusd.23-0220
34. Dentsply Sirona Prosthetics. Eclipse® Prosthetic Resin Materials (Baseplate, Set-Up and Contour Resin) Safety Data Sheet. Rev. 5. York, PA: Dentsply Sirona; 2019. Available from: https://www.dentsplysirona.com
35. Menon RK, Xin YH, Wei BCT, et al. CADCAM versus conventional denture bases: network meta-analysis of in vitro studies comparing accuracy and surface properties. *Int Dent J.* 2025;75(3):2062-2070. doi: 10.1016/j.identj.2024.12.032
36. Ölçer Us O, Yüzbaşıoğlu E, Özdemir G, Albayrak B. Clinical outcomes and complications of CAD-CAM fabricated complete dentures: an update and review. *J Exp Clin Med.* 2021;38(S2):92-97. doi:10.52142/ omujecm.38.si.dent.3
37. Beyli MS, von Fraunhofer JA. Repair of fractured acrylic resin. *J Prosthet Dent.* 1980;44(5):497-503. doi:10.1016/0022-3913(80)90067-0
38. Lewinstein I, Zeltser C, Mayer CM, Tal Y. Transverse bond strength of repaired acrylic resin strips and temperature rise of dentures relined with VLC reline resin. *J Prosthet Dent.* 1995;74(4):392-399. doi:10.1016/ s0022-3913(05)80377-3