RESEARCH PAPER

EFFECT OF SIMULATED GASTRIC ACID ON COLOUR STABILITY AND COMPRESSIVE STRENGTH OF POLYMETHYL METHACRYLATE DENTURE BASE RESIN: AN IN VITRO STUDY

Dr. Vaibhav Deshpande[1*], Dr. N. Vasantha Vijayaraghavan[1], Dr. Rajashree Jadhav[1], Dr. Vasanthi Swami[1], Dr. Abhijit Patil[1], Dr. Agarwal Nirali Jitendra[2]

[1]Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Pune, Maharashtra, India
[2]Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India
[1]ORCID: https://orcid.org/0009-0007-8873-5050 | Email: vaibhavdeshpande177@gmail.com
[1]ORCID: https://orcid.org/0000-0003-1760-9747 | Email: vasantha.vijayragvan@bharatividyapeeth.edu
[1]ORCID: https://orcid.org/0000-0002-5645-8112 | Email: rajashree.jadhav@bharatividyapeeth.edu
[1]ORCID: https://orcid.org/0000-0002-8183-7210 | Email: vasanti.swami@bharatividyapeeth.edu
[1]ORCID: https://orcid.org/0000-0002-8921-5133 | Email: abhijit.a.patil@bharatividyapeeth.edu
[2]ORCID: https://orcid.org/0009-0005-8251-1043 | Email: dr15nirali@gmail.com
***Corresponding Author:** Dr. Vaibhav Deshpande, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Pune, Maharashtra, India | ORCID: https://orcid.org/0009-0007-8873-5050 |
Email: vaibhavdeshpande177@gmail.com

ABSTRACT

Background: Polymethyl methacrylate (PMMA) is the most common material used in making dentures. People suffering from GERD are constantly exposed to an acidic oral environment. Nevertheless, little is known about the impact of gastric acid on the color stability and compression strength of heat-cured PMMA. In this study, color stability and compression strength were measured after submersion in artificial gastric acid and artificial saliva, respectively.

Materials and Methods: Fifty standardized specimens of heat-polymerized PMMA were fabricated: twenty disc-shaped (10 mm × 2 mm) for colour analysis and thirty cylindrical (3 mm diameter × 6 mm height) for compressive strength testing. Specimens were immersed in artificial saliva (pH 6.5, control, Group A) or simulated gastric acid (0.06 M HCl, pH 1.257) for 24 hours (Group B1) and 96 hours (Group B2). Colour change (ΔE) was measured with a digital spectrophotometer (Vita Easyshade V) using CIE L*a*b*, and compressive strength was determined using a universal testing machine (ACME Unitest 10). Data were analysed by independent t-tests, one-way ANOVA, and Tukey HSD post-hoc tests ($\alpha = 0.05$).

Results: Simulated gastric acid caused significant increases in ΔE (1.51 ± 0.37 at baseline vs 3.08 ± 0.88 at T24 and 5.18 ± 0.83 at T96; $p < 0.001$) and significant reductions in compressive strength (92.15 ± 5.06 MPa vs 77.38 ± 5.24 MPa at T24 and 73.14 ± 8.91 MPa at T96; $p < 0.001$). There was no significant difference in compressive strength between T24 and T96 ($p = 0.21$), though colour change continued to increase significantly.

Conclusion: Simulated gastric acid significantly degraded both the aesthetic and mechanical properties of heat-polymerized PMMA. Colour deterioration was progressive and time-dependent, while mechanical weakening occurred predominantly during early exposure. These findings have clinical implications for denture management in patients with chronic GERD or frequent acidic exposure.

Keywords: polymethyl methacrylate; denture base resin; gastric acid; colour stability; compressive strength; GERD; in vitro

HOW TO CITE THIS ARTICLE: VAIBHAV DESHPANDE, N. VASANTHA VIJAYARAGHAVAN, RAJASHREE JADHAV, VASANTHI SWAMI, ABHIJIT PATIL, AGARWAL NIRALI JITENDRA. EFFECT OF SIMULATED GASTRIC ACID ON COLOUR STABILITY AND COMPRESSIVE STRENGTH OF POLYMETHYL METHACRYLATE DENTURE BASE RESIN: AN IN VITRO STUDY. INT J DRUG DELIV TECHNOL. 2026;16(78S):1406-1413. DOI: 10.25258/IJDDT.16.78S.191.

INTRODUCTION

Polymethyl methacrylate (PMMA) has been the most predominant denture base material for over eight decades, attributed to its lightweight composition, satisfactory aesthetics, cost-effectiveness, ease of processing, and acceptable mechanical behaviour.[1,2] Commercially supplied as a powder–liquid system, PMMA undergoes free-radical polymerisation of methyl methacrylate monomers to form a long-chain polymer network that confers mechanical stability.[3]

Despite its widespread adoption, PMMA is susceptible to fracture. Mandibular dentures are particularly prone to impact-related fractures, with approximately 80% attributed to accidental drops, while maxillary dentures often fail from combined fatigue and impact stresses.[4] Evaluation of mechanical properties of PMMA is tested by flexural strength, compressive strength, impact strength, and hardness, the latter being highly associated with material life expectancy.[5,6]

In the oral environment, denture base materials are exposed to thermocycling, occlusal forces, bacterial action, and chemical effects. Acidic attack, either extrinsic factors such as dietary acids, carbonated drinks or intrinsic factor such as acid reflux, is a key factor in material deterioration.[7] Gastroesophageal Reflux Disease (GERD) is a chronic disorder of the gastrointestinal system where stomach contents reflux into the esophagus and mouth, thereby maintaining a constant acidic environment in the mouth. GERD prevalence in India has been reported to be around 15.6%, with a greater likelihood of GERD among older adults, who also make up the largest group of denture users.[8]

Studies indicate that simulated gastric acid causes adverse effects on denture base resins by inducing surface roughness and decreased microhardness following immersion in gastric acid among conventional, milled CAD/CAM, and 3D-printed polymers. On a molecular level, acid exposure results in the degradation of the ester bonds along the PMMA backbone, causing decreased strength between chains, plasticizing effects, and microcracking, each of which leads to the deterioration of mechanical strength.[9] Acids cause surface changes that affect optical properties through the increase in light scattering and reduced translucency, resulting in visible discoloration.[10]

Current evidence suggests that acidic exposure can adversely affect denture base polymers, although the extent of deterioration appears to depend on the material type, processing method, and duration of exposure. Previous studies have shown that simulated gastric acid can increase surface roughness and reduce hardness in conventional heat-polymerized resins as well as CAD-CAM milled, and 3D-printed denture base resins, indicating that acidic challenge may compromise both surface integrity and long-term clinical performance.[11,12] In parallel, investigations on other resin-based dental materials have demonstrated clinically perceptible colour alterations after exposure to hydrochloric acid-based media, supporting the view that low-pH environments can influence not only mechanical behaviour but also optical stability.[13,14] Collectively, these findings indicate that endogenous acidic insults such as gastric reflux may represent an under-recognised factor in the degradation of removable prosthodontic materials. However, the existing literature remains fragmented. The majority of research studies have concentrated on roughness, microhardness, and flexural behavior, whereas there has been relatively little study on the compressive strength of denture base materials, even though this property plays an important role in their resistance to functional loads associated with chewing.[5,7] Moreover, few research efforts have evaluated color stability and mechanical behavior in combination using the same test method, which makes it hard to assess whether the two deteriorations happen simultaneously when subjected to artificial gastric acid conditions.[10,13] Specific data concerning heat-cured PMMA are scarce, especially in relation to immersion experiments that mimic long-term GERD cases. This lack of integrated data highlights the need for studies evaluating both colour stability and compressive strength in conventional PMMA subjected to simulated gastric acid. The present study was therefore designed to evaluate the colour stability and compressive strength of PMMA under simulated acidic exposure conditions.

MATERIALS AND METHODS

This investigation follows the design of an in vitro study and is conducted in accordance with the Checklist for Reporting In vitro Studies in Dentistry (CRIS) guideline.[15]

Specimen Fabrication

Fifty specimens were made from heat-polymerised PMMA (Lucitone 199, DENTSPLY Sirona) with stainless steel moulds. Two sets of twenty specimens were produced; one set of ten-millimetre diameter and two-millimetre thick circular disc-like samples for colour stability and thirty three-millimetre diameter and six millimetres high cylindrical specimens for compressive strength. The specifications for the dimensions were chosen as per ISO 20795-1 for denture base polymer.

Polymer and monomer ratios were taken as 3cc : 1mL according to the manufacturer's guidelines. The mixed material was spatulated for fifteen seconds, attained dough consistency, and packed into the moulds. Bench curing was done for thirty minutes at room temperature. Curing was achieved using a short curing protocol: 73°C for 90 minutes, then 100°C for 30 minutes, in an Acrylizer (C73, Unident Dental Equipment Limited, India).

The bench-cooled specimens were removed gently by tapping. Excess PMMA was removed from the moulds using tungsten carbide burs on an acrylic lathe, followed by sanding on wet/dry sandpapers 120 and 1000 grit sizes, and finishing with wet polishing with pumice slurry and dry buffing.

Preparation of Test Solutions

Artificial saliva (control, pH 6.5) was prepared by dissolving KCl (0.4 g/L), NaCl (0.4 g/L), $CaCl_2 \cdot 2H_2O$ (0.906 g/L), $NaH_2PO_4 \cdot 2H_2O$ (0.690 g/L), $Na_2S \cdot 9H_2O$ (0.005 g/L), and urea (1 g/L) in 1 L of deionised water as per the Fusayama-Meyer artificial saliva composition.[16] Simulated gastric acid (pH 1.257) was prepared using 0.06 M hydrochloric acid in deionised water.[17]

Grouping and Immersion Protocol

Specimens were divided as shown in Table 1. Every specimen was individually immersed in 10 mL of the respective solution in separate glass Petri dishes. Time points were defined as: T0 (baseline, negligible exposure in artificial saliva), T24 (24 hours of gastric acid immersion), and T96 (96 hours of gastric acid immersion), corresponding to simulated clinical exposure of approximately 48 and 192 days respectively. Following immersion, distilled water was used to rinse specimens for one minute and then they were air-dried before testing.

Table 1. Study design: specimen groups, immersion media, and time points

Group	Immersion Medium	Time Point	Test (n=10 per subgroup)
A (Control)	Artificial Saliva (pH 6.5)	T0 (Baseline)	Colour Stability + Compressive Strength
B1	Simulated Gastric Acid (pH 1.257)	T24 (24 h)	Colour Stability + Compressive Strength
B2	Simulated Gastric Acid (pH 1.257)	T96 (96 h)	Colour Stability + Compressive Strength

Colour Stability Measurement

Colour was evaluated using the CIE L*a*b* colour system with a digital spectrophotometer (Vita Easyshade V with wavelength range of 400-700nm using a contact probe-based measurement mode). Three readings per specimen were recorded against a standardised white calibration tile, and the mean was taken. Colour difference (ΔE) was calculated as:

$$\Delta E = \sqrt{[(L_1-L_2)^2 + (a_1-a_2)^2 + (b_1-b_2)^2]}$$

ΔE value ≤ 1.0 is considered imperceptible, 1.0–3.3 is clinically acceptable, and > 3.3 is clinically unacceptable.

Compressive Strength Testing

Cylindrical specimens were loaded axially in a universal testing machine (*ACME Unitest 10, ACME Engineers, India*; maximum load: 100 kN; accuracy ±1%) at a crosshead speed of 1 mm/min until fracture. Compressive strength (σ, MPa) was calculated as:

$$\sigma = P / A$$

where P is the maximum fracture load (N) and A is the cross-sectional area (mm²).

Statistical Analysis

The statistical analysis was conducted using IBM SPSS Statistics 26.00 (IBM, Armonk, USA).[18] The descriptive analysis is summarised as mean ± standard deviation. Independent samples t-test was used for comparing two groups, while one-way ANOVA was used for comparing multiple groups. Post hoc test Tukey HSD was used for multiple comparisons. A p-value of 0.05 was considered significant.

RESULTS

Colour Stability (ΔE)

The control group (artificial saliva, T0) exhibited no substantial change in colour with only an average mean ΔE of 1.51 ± 0.37, which fell well within the clinically accepted range. The simulated gastric acid had a statistically significant, time-dependent increase in ΔE, reaching 3.08 ± 0.88 at T24 and 5.18 ± 0.83 at T96, with the latter having gone well above the clinically accepted range of ΔE 3.3.

A statistical test of significance using t-test showed extremely significant differences between artificial saliva and gastric acid groups at both T24 (mean difference of 1.57, $t = -7.15$, $p < 0.001$) and T96 (mean difference of 3.68, $t = -8.75$, $p < 0.001$). Differences between T24 and T96 were also significant (mean difference of 2.11, $t = -4.37$, $p < 0.0$

Compressive Strength

The average compressive strength value obtained from the control group was 92.15 ± 5.06 MPa. The average compressive strength values were calculated to be 77.38 ± 5.24 MPa (difference: 14.77 MPa; $t = 7.03$; $p < 0.001$) at T24 and 73.14 ± 8.91 MPa (difference: 19.01 MPa; $t = 9.46$; $p < 0.001$) at T96 after gastric acid exposure. Most importantly, no significant difference was found between T24 and T96 (difference: 4.24 MPa; $t = 1.30$; $p = 0.21$), suggesting that the main process of mechanical degradation was observed during the initial 24 hours of exposure.

Descriptive statistics such as average compressive strength (MPa) and colour change (ΔE) values in different groups have been presented in Table 2, while Table 3 shows the results of pairwise independent t-tests conducted for average compressive strength and colour change. Finally, Table 4 shows Tukey's HSD post-hoc analysis for between-group comparisons.

Table 2. Descriptive statistics: mean compressive strength (MPa) and colour change (ΔE) across groups

Group	Immersion Medium	Time Point	Compressive Strength Mean ± SD (MPa)	Colour Change Mean ΔE ± SD
A	Artificial Saliva	T0 (Baseline)	92.15 ± 5.06	1.51 ± 0.37
B1	Gastric Acid	T24	77.38 ± 5.24	3.08 ± 0.88
B2	Gastric Acid	T96	73.14 ± 8.91	5.18 ± 0.83

Table 3. Pairwise independent t-test comparisons for compressive strength and colour change (ΔE). *p < 0.001; NS = not significant

Outcome	Comparison	Mean Difference	t-value	p-value
Compressive Strength	Artificial Saliva vs Gastric Acid T24	14.77 MPa	7.03	<0.001*
	Artificial Saliva vs Gastric Acid T96	19.01 MPa	9.46	<0.001*
	Gastric Acid T24 vs Gastric Acid T96	4.24 MPa	1.30	0.21 (NS)
Colour Change (ΔE)	Artificial Saliva vs Gastric Acid T24	1.57	-7.15	<0.001*
	Artificial Saliva vs Gastric Acid T96	3.68	-8.75	<0.001*
	Gastric Acid T24 vs Gastric Acid T96	2.11	-4.37	<0.001*

Table 4. Tukey HSD post-hoc analysis for between-group comparisons. *Significant (p < 0.05); NS = not significant.

Outcome	Comparison	Mean Diff.	95% CI Lower	95% CI Upper	Sig.
Compressive Strength	Artificial Saliva vs Gastric Acid T24	14.77	7.40	22.14	*
	Artificial Saliva vs Gastric Acid T96	19.01	11.64	26.38	*
	Gastric Acid T24 vs Gastric Acid T96	4.24	-3.13	11.61	NS
Colour Change (ΔE)	Artificial Saliva vs Gastric Acid T24	1.57	0.76	2.37	*
	Artificial Saliva vs Gastric Acid T96	3.68	2.87	4.48	*

	Gastric Acid T24 vs Gastric Acid T96	2.11	1.30	2.92	*

DISCUSSION

The present study was undertaken to assess the influence of simulated gastric acid (0.06 M HCl, pH 1.257) on color stability and compressive strength of the heat polymerized PMMA (Lucitone 199) with clinically relevant periods of immersion of 24 hours and 96 hours, which equate to about 48 and 192 clinically significant days, respectively. It should be noted that the effect of the acid medium on color stability and compressive strength of the polymer showed different tendencies over time.

In the case of artificial saliva, the average value of ΔE was 1.51 ± 0.37; it falls within the clinically accepted level. After gastric acid treatment, the average values of ΔE were 3.08 ± 0.88 for 24-hour exposure and 5.18 ± 0.83 for 96-hour immersion period, which is beyond the clinically unacceptable level (ΔE > 3.3).

Tinastepe et al.[19] studies surface properties of denture base acrylic resins processed by different ways followed by immersion in simulated gastric acid (0.06 M HCl, pH 1.2) using identical T0, T24, and T96 time points. They reported that compression-moulded specimens exhibited the greatest surface hardness reduction at T24, with progressive changes continuing to T96, particularly for conventional resins. These degradation trends align with the significant colour and strength changes observed in the present study, and directly support the hypothesis that early exposure drives the bulk of material alterations.

Similarly, Gil-Pozo et al.[20] demonstrated that CAD-CAM milled specimens showed relatively less degradation compared to conventional compression-moulded resin under gastric acid exposure, attributing this resistance to higher molecular weight stability and reduced internal porosity. The present study used exclusively heat-polymerized conventional PMMA, which, as Tinastepe et al.[19] indicated, is more susceptible to acid-induced surface and bulk degradation due to greater residual monomer content and polymer microporosity.

Çengiz et al.[21] investigated the effect that simulated gastric juice would have on colour stability, surface roughness, and microhardness of laboratory-processed composites and reported that even short-term acid exposure (as little as 24 hours at pH 1.2) produced significant colour shifts exceeding clinical acceptability thresholds. Although their material was composite rather than PMMA, the ΔE magnitude and temporal progression parallel the present findings, reinforcing the general vulnerability of polymer-based dental materials to hydrochloric acid-dominated acidic environments.

The mechanism behind colour change in these cases is due to hydrolysis of ester linkages in the PMMA chain by acid. This leads to scission of the polymer chain, increasing surface roughness and forming micro voids which lead to changes in optics. The softer matrix material erodes away exposing filler material resulting in a decrease in translucency.[22] When the value of ΔE exceeds 3.3 at 96 hours, it means that long term exposure to acid as in GERD patients will make the dentures discoloured.[23]

The average compressive strength value obtained for the control group specimens (92.15 ± 5.06 MPa) agrees well with the previously reported baselines for heat-polymerized PMMA and falls in the range of 75-110 MPa. Compressive strength was decreased to 77.38 ± 5.24 MPa after T24 (16.0% decrease) and further lowered to 73.14 ± 8.91 MPa at T96 corresponding to a 20.6% decrease in compressive strength. Notably, no further decline in compressive strength was noticed between T24 and T96 ($p = 0.21$) showing that the maximum degradation occurs in the initial stage of acid exposure.

These findings are consistent with those of Bollepalli et al.[11], who investigated the mechanical behavior of reinforced and un-reinforced PMMA with polypropylene mesh immersed in simulated gastric acid (0.06 M HCl, pH 1.2) for 96 hours. In their research, it was reported that there were considerable decreases in flexural strength of the un-reinforced PMMA in gastric acid compared to artificial saliva, whereas there was partial protection against the deterioration effect due to the limited penetration of the gastric acid by the polypropylene mesh reinforcement.

From the mechanistic viewpoint, the decrease in compressive strength is due to several factors acting simultaneously: hydrolysis of ester bonds caused by acidic hydrolysis leads to the weakening of the polymer matrix;[24] further, absorption of the acid results in plasticization, leading to decreased stiffness and mechanical resistance finally, the appearance of microcracks and microporosity serves as stress concentrators that promote crack growth under compression.[25] The observed plateau at times T24-T96 might be due to the saturation of the polymer structure with absorbed acid and the exhaustion of easily hydrolysable surface ester bonds.

Yoshida et al.[26] showed that the decrease in compressive and flexural strengths after acid soaking of acrylic denture base resins is 15–20%, which is similar to 16–20.6% of reduction found here. Furthermore, as was stated by Yoshida et al.,25 most damage occurs during the first period of acid soaking, which is expected for a diffusion-controlled process.

Mohammed et al. performed finite element analysis which revealed that the acid-induced microporous network creates stress concentrations in PMMA and increases the crack growth rates under chewing forces.[27]

One of the most notable differences between the two properties that were examined in this experiment is the difference in their degradation process. While color exhibited a continuous decline throughout the test period and continued to decrease from T24 to T96, compressive strength did not show any further decline past T24. Colour change is primarily a surface-level optical phenomenon driven by progressive surface roughening, micro-void formation, and superficial polymer erosion, all of which continue to accumulate with extended exposure. In contrast, mechanical degradation appears to be governed largely by early-phase bulk plasticisation and ester bond hydrolysis, which may equilibrate as acid penetration becomes diffusion-limited within the denser polymer interior. The baseline ΔE observed in the control group may be attributed to alteration in the optical characteristics of the resin materials due to water absorption. Previous studies have similarly reported negligible colour changes in specimens stored in artificial saliva, indicating that such values fall within the clinically acceptable range.[28] Therefore, baseline values were used as a reference for comparison.

Clinical Relevance

These findings carry direct clinical implications for prosthetic rehabilitation in patients with GERD. With an estimated Indian prevalence of 15.6%[8], disproportionately affecting the elderly population most likely to wear removable dentures, chronic exposure to intraoral gastric acid represents a significant clinical risk factor for accelerated denture degradation. The significant colour changes observed at 96-hour immersion ($\Delta E > 5.0$) and the early mechanical weakening (>16% compressive strength reduction at 24 hours) suggest that PMMA dentures may require more frequent monitoring, maintenance, or replacement in this patient cohort.

Limitations

Several limitations of this study must be acknowledged. The current in vitro study fails to mimic entirely the multifactorial environment of the mouth, involving thermal cycling, chewing force, biofilm function of microbes, saliva buffer action, and acidic attacks being intermittent instead of constant. Restricting the study to only one PMMA material (Lucitone 199) reduces its applicability to other heat-cured materials. Future research must consider various types of PMMAs, different fabrication methods such as CAD/CAM or 3D printing, extra mechanical properties such as flexural and impact strengths, and thermal cycling to create a more realistic setting. Clinical studies among GERD-affected people are also warranted.

CONCLUSION

The findings of this study showed that simulated gastric acid led to considerable reduction in the color stability and compressive strength properties of heat-cured PMMA denture base material. Color changes were gradual and time-dependent and became greater than the clinically acceptable limits by 96 hours. Mechanical strength reductions were observed mostly within the first 24 hours of exposure, without further decrease at 96 hours. The contrasting degradation dynamics indicate that the processes involved are different between surface-based and bulk polymer-based degradation mechanisms. The study highlights the significance of replacing PMMA dentures periodically in individuals with intraoral gastric acid contact.

REFERENCES

1. Zafar MS. Prosthodontic Applications of Polymethyl Methacrylate (PMMA): An Update. *Polymers (Basel)*. 2020;12(10):2299. doi:10.3390/polym12102299
2. Alqutaibi AY, Baik A, Almuzaini SA, et al. Polymeric Denture Base Materials: A Review. *Polymers (Basel)*. 2023;15(15):3258. doi:10.3390/polym15153258
3. Ahamad Said MN, Hasbullah NA, Rosdi M RidhwanHafiz, et al. Polymerization and Applications of Poly(methyl methacrylate)–Graphene Oxide Nanocomposites: A Review. *ACS Omega*. 2022;7(51):47490-47503. doi:10.1021/acsomega.2c04483
4. Alhareb AO, Akil HM, Ahmad ZA. Impact strength, fracture toughness and hardness improvement of PMMA denture base through addition of nitrile rubber/ceramic fillers. *The Saudi Journal for Dental Research*. 2017;8(1):26-34. doi:10.1016/j.sjdr.2016.04.004
5. Alhotan A, Yates J, Zidan S, Haider J, Silikas N. Flexural Strength and Hardness of Filler-Reinforced PMMA Targeted for Denture Base Application. *Materials*. 2021;14(10). doi:10.3390/ma14102659
6. Swaroop N, Katiyar P, Pandey KK, et al. A Comparative Evaluation of Flexural and Impact Strength of Polymethyl Methacrylate (PMMA) Reinforced With Graphene and Multi-Walled Carbon Nanotubes: An In Vitro Study. *Cureus*. 15(6):e40024. doi:10.7759/cureus.40024
7. Gil-Pozo A, Medina-Sotomayor P. Two possible in vitro alternatives to evaluate the effect of gastric acid on resin-based composites. *J Clin Exp Dent*. 2022;14(9):e719-e725. doi:10.4317/jced.59782

8. Rai S, Kulkarni A, Ghoshal UC. Prevalence and risk factors for gastroesophageal reflux disease in the Indian population: A meta-analysis and meta-regression study. *Indian J Gastroenterol*. 2021;40(2):209-219. doi:10.1007/s12664-020-01104-0
9. Yıldırım-Işık H, Büyükgöze-Dindar M. Effect of Simulated Gastric Acid on Surface Characteristics and Color Stability of Hybrid CAD/CAM Materials. *Polymers (Basel)*. 2025;17(19):2591. doi:10.3390/polym17192591
10. Porwal A, Khandelwal M, Punia V, Sharma V. Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. *J Indian Prosthodont Soc*. 2017;17(1):61-67. doi:10.4103/0972-4052.197940
11. Bollepalli A, Viswanathan AK, Balasubramaniam M. Effect of simulated gastric acid on the mechanical properties of conventional and polypropylene mesh reinforced poly methyl methacrylate denture base resin. *J Indian Prosthodont Soc*. 2025;25(3):251-257. doi:10.4103/jips.jips_130_25
12. Kizilirmak B, Tunçdemİr AR. The effect of gastric acid on the bonding of 3D printed and CAD/CAM denture acrylics to denture teeth. *Sci Rep*. 2025;15:16648. doi:10.1038/s41598-025-00542-0
13. Özer NE, Oğuz Eİ. The Effect of Erosive Media on Color Stability, Gloss, and Surface Roughness of Monolithic CAD/CAM Materials Subjected to Different Polishing Methods. *Sci Rep*. 2025;15:23774. doi:10.1038/s41598-025-08773-x
14. Schmohl L, Roesner AJ, Fuchs F, et al. Acid Resistance of CAD/CAM Resin Composites. *Biomedicines*. 2022;10(6):1383. doi:10.3390/biomedicines10061383
15. Krithikadatta J, Gopikrishna V, Datta M. CRIS Guidelines (Checklist for Reporting In-vitro Studies): A concept note on the need for standardized guidelines for improving quality and transparency in reporting in-vitro studies in experimental dental research. *J Conserv Dent*. 2014;17(4):301-304. doi:10.4103/0972-0707.136338
16. de Sá J, Vieira F, Aroso CM, Cardoso M, Mendes JM, Silva AS. The Influence of Saliva pH on the Fracture Resistance of Three Complete Denture Base Acrylic Resins. *Int J Dent*. 2020;2020:8941876. doi:10.1155/2020/8941876
17. Mourouzis P, Tsiveli A, Tsetseli P, Gogos C, Tolidis K. Impact of erosion and aging simulation on chairside materials. *Microscopy Research and Technique*. 2023;86(8):943-954. doi:10.1002/jemt.24361
18. IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.
19. Tinastepe N, Malkondu O, Kazazoglu E. Hardness and surface roughness of differently processed denture base acrylic resins after immersion in simulated gastric acid. *J Prosthet Dent*. 2023;129(2):364.e1-364.e9. doi:10.1016/j.prosdent.2022.12.001
20. Gil-Pozo A, Astudillo-Rubio D, Ferrando Cascales Á, et al. Effect of gastric acids on the mechanical properties of conventional and CAD/CAM resin composites - An in-vitro study. *J Mech Behav Biomed Mater*. 2024;155:106565. doi:10.1016/j.jmbbm.2024.106565
21. Cengiz S, Sarac S, Özcan M. Effects of simulated gastric juice on color stability, surface roughness and microhardness of laboratory-processed composites. *Dent Mater J*. 2014;33(3):343-348. doi:10.4012/dmj.2013-265
22. Fernández A, Redondo A, Martín-de-León J, Cantero D. PMMA stability under hydrothermal conditions. *The Journal of Supercritical Fluids*. 2023;198:105938. doi:10.1016/j.supflu.2023.105938
23. Dincer G, Şeşen P. Effect of Gastric Acid on Surface Roughness and Color Stability of 3D-Printed Permanent Resins. *Essentials of Dentistry*. 2025;4:1-8. doi:10.5152/EssentDent.2025.25042
24. Spencer P, Jonggu Park QY, Misra A, et al. Durable bonds at the adhesive/dentin interface: an impossible mission or simply a moving target? *Braz Dent Sci*. 2012;15(1):4-18. doi:10.14295/bds.2012.v15i1.790
25. Szeląg M. Evaluation of Cracking Patterns in Cement Composites—From Basics to Advances: A Review. *Materials (Basel)*. 2020;13(11):2490. doi:10.3390/ma13112490
26. Yoshida K, Takahashi Y, Sasaki H, Hamanaka I, Kawaguchi T. Flexural strengths of reinforced denture base resins subjected to long-term water immersion. *Acta Biomater Odontol Scand*. 2016;2(1):20-24. doi:10.3109/23337931.2015.1135745
27. Gad MM, Fouda SM, Al-Harbi FA, Näpänkangas R, Raustia A. PMMA denture base material enhancement: a review of fiber, filler, and nanofiller addition. *Int J Nanomedicine*. 2017;12:3801-3812. doi:10.2147/IJN.S130722
28. Alfouzan AF, Alotiabi HM, Labban N, Al-Otaibi HN, Al Taweel SM, AlShehri HA. Color stability of 3D-printed denture resins: effect of aging, mechanical brushing and immersion in staining

medium. *J Adv Prosthodont*. 2021;13(3):160-171. doi:10.4047/jap.2021.13.3.160

Orcid id of all authors
Dr. Vaibhav Deshpande
Orcid 0009-0007-8873-5050
Vaibhavdeshpande177@gmail.com.
Dr. N. Vasantha vijayaraghavan
Orcid 0000-0003-1760-9747
Vasantha.vijayragvan@bharatividyapeeth.edu
Dr. RAJASHREE JADHAV
0000-0002-5645-8112
Rajashree.jadhav@bharatividyapeeth.edu
Dr. Vasanthi Swami
vasanti.swami@bharatividyapeeth.edu
orcid id 0000-0002-8183-7210
Dr. Abhijit Patil
Orcid id - 0000-0002-8921-5133
Email- abhijit.a.patil@bharatividyapeeth.edu
Dr. Agarwal Nirali Jitendra
ORCID – 0009-0005-8251-1043
dr15nirali@gmail.com