Original Article

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Dentistry Section

Evaluation of Colour Stability of Conventional versus 3D-printed Crown and Bridge Resins after Surface Treatment and Artificial Tooth Brushing: An In-vitro Study

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ABSTRACT

Introduction: Three-Dimensional (3D)-printing is becoming increasingly popular, especially for Interim Fixed Dental Prostheses (IFDPs). However, there is limited evidence regarding the colour stability of 3D-printed IFDPs and the combined effects of advanced surface treatment along with good oral hygiene practices.

Aim: To evaluate the effect of surface treatment and artificial tooth brushing on the colour stability of conventional and 3D-printed crown and bridge resin after immersion in a colouring medium.

Materials and Methods: An in-vitro study was conducted in the Prosthodontics and Crown and Bridge Department at Karpaga Vinayaga Institute of Dental Sciences, Chennai, Tamil Nadu, India, between December 2023 and May 2024. A total of 30 specimens were divided into three groups: Group 1 - Polymethyl Methacrylate (PMMA), Group 2 - 3D-printed polished, and Group 3 - 3D-printed glazed, with 10 specimens in each group. All specimens were immersed in coffee and subjected to artificial tooth brushing for 12 days, equivalent to three months of oral exposure to coffee and tooth brushing. Colour stability was assessed using Vita EasyShade spectrophotometer at baseline (T0), on the 4th day (T1), the 8th day (T2), and the 12th day (T3) for all groups. The data were analysed using Statistical Package for the Social Sciences (SPSS) software version 20.0. Repeated measures Analysis of Variance (ANOVA) was used for intragroup comparisons, and an independent Student's t-test was employed for intergroup comparisons to interpret the results. A p-value of <0.05 was considered significant.

Results: The mean and Standard Deviation (SD) of colour change (ΔE - Delta E) for the three groups were 6.6, 4.8, and 11.2 at T1, showing decreased colour change at T3. A statistically significant difference was found between groups ($p<0.001$). The highest colour change was observed for Group 2 (mean=4.5), followed by Group 3 (mean=2.8).

Conclusion: The results conclude that the glazed 3D-printed group showed better colour stability than the polished 3D-printed group and was comparable to the conventional group. A 3D-printed sample can be glazed to reduce the adhesion of stains to its surface.

Keywords: 3D-printing, Additive manufacturing, Colouring agent, Crown and bridge resin, Oral hygiene, Staining

INTRODUCTION

The ability of dental materials to resemble natural teeth is one of their most important characteristics. The aesthetic demands of patients are continually increasing, leading to a greater need for dental restorations that can achieve high levels of colour stability, biocompatibility, and mechanical properties [1].

Digital technology has significantly transformed various aspects of our lives. Because 3D-printing can provide patient-specific restorations with the required accuracy and precision, it is being extensively utilised in the healthcare industry [2]. This technology is emerging as a new frontier, developing materials and enhancing 3D printers to address the shortcomings of conventional dental systems [3]. However, there is still limited data on the colour stability of 3D-printed IFDPs and the combined effects of advanced surface treatments and good oral hygiene practices.

Additive manufacturing techniques like Selective Laser Sintering (SLS), Digital Light Processing (DLP), and Stereolithography (SLA) now allow for the production of dental prostheses with complex geometries and intricate structures that would be challenging to achieve through traditional manufacturing methods [4]. Furthermore, compared to Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology, 3D-printing offers benefits such as waste reduction, simultaneous processing of multiple prostheses, reduced chair time, and customisation [5].

In the dental office, 3D-printing technology can also be utilised, particularly for the fabrication of temporary crowns and bridges. This advancement has made it possible to reduce the number of appointments. The computer's databases are used to modify the design of future temporary restorations. While the dentist is preparing the patient's teeth, the dental assistant can use 3D-printing to create a temporary bridge or crown [6].

Maintaining colour stability is especially important in clinical settings where temporary restorations are used for extended periods [7]. Numerous factors, including exposure to various stains, material composition, surface roughness, and duration of exposure, affect the colour stability of restorative materials [8]. Several beverages, such as coffee, red wine, orange juice, and burqa juice, have been found in studies to be agents that may alter the colour of materials, including 3D-printed components [9].

An essential factor in the variations in surface roughness of restorative materials is brushing with abrasive toothpaste and a toothbrush [10]. An increase in roughness may lead to discolouration of the restoration, thereby impairing its aesthetic appearance [11]. Therefore, it is essential to investigate the colour stability of 3D-printed dental materials and assess the impacts of various surface treatments and tooth brushing to ensure the longevity and aesthetic quality of dental restorations.

It is believed that 24 hours in the staining solution replicates food consumption for 30 days, based on prior in-vitro experiments

reported in the literature [12]. To date, no in-vitro study has investigated the combined effects of advanced surface treatments and simulated tooth brushing on the colour stability of 3D-printing resins used for crowns and bridges under conditions that mimic the oral environment. Therefore, the purpose of the present study was to assess and compare the colour stability of conventional and 3D-printed crown and bridge resin after surface treatment and artificial tooth brushing.

The first null hypothesis for this in-vitro research was that there would be no difference in discolouration characteristics based on the surface treatment of the material, no difference in discolouration according to storage time in the colourant, and no effect of artificial tooth brushing on discolouration. The first alternative hypothesis for this invitro research was that there would be a difference in the discolouration characteristics based on the surface treatment of the material, difference in discolouration according to storage time in the colourant, and difference in the effect of artificial tooth brushing on discolouration.

MATERIALS AND METHODS

The present in-vitro study was conducted in the Prosthodontics and Crown and Bridge Department at Karpaga Vinayaga Institute of Dental Sciences, Chennai, Tamil Nadu, India, Chinna Kolambakkam, India, between December 2023 and May 2024, after obtaining Institutional ethical approval (KIDS/IEC/2023/III/001).

Sample size calculation: The sample size was calculated using G* Power software version 3.1.9.3. The inputs included an effect size of 0.8, a power of 0.9, and α=0.05, which required a minimum of nine samples in each group based on statistics obtained from a previous study by Dimitrova M et al., [13]. The sample size was rounded upto 10 samples in each group.

The study groups were divided as follows:

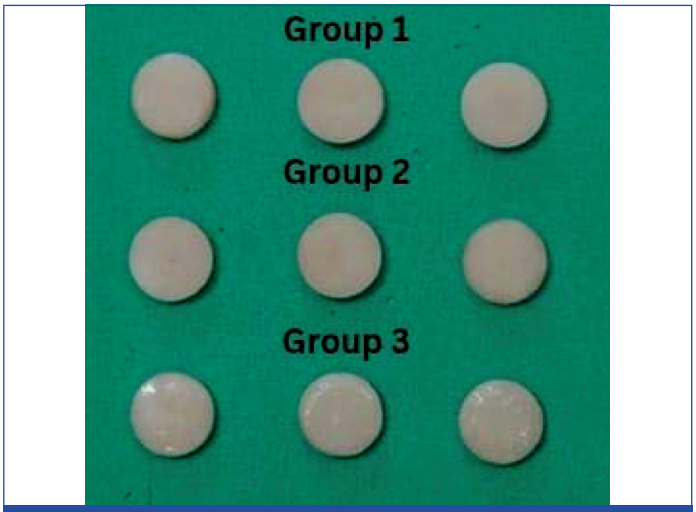
1. Group 1: Conventional crown and bridge resin - 10 specimens are trimmed and polished with pumice.
2. Group 2: 3D-printed crown and bridge resin - 10 specimens are trimmed and polished with pumice.
3. Group 3: 3D-printed crown and bridge resin - 10 specimens are trimmed and glazed.

Study Procedure

Sample preparation: In the present study, two different types of materials were used, and three different types of surface treatments were applied. Thirty disk-shaped specimens (10 mm diameter and 2 mm thickness) were fabricated from each material. For the 3D-printed crown and bridge specimens, the digital specimen STL file was imported into operational standard slicing software (Anycubic Photon Workshop, China) equipped with the 3D printer (Anycubic Photon Ultra, China). The 3D-printing resin was poured into the printer, and the specimens were printed layer by layer at a thickness of 50 µm at 0° in a predetermined dimension by the Mask SLA (MSLA) technique. The objects were carefully removed from the build platform using a spatula. The printed specimens were then treated with ethanol, which effectively removes residue that leaves marks or deposits.

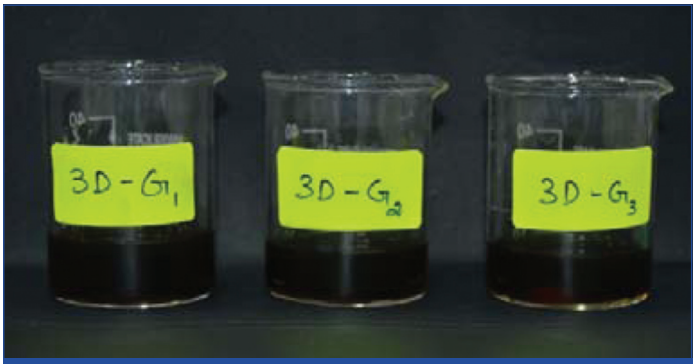
The present study used ethyl alcohol, a prevalent solvent for cleaning 3D-printed objects in countries where isopropyl alcohol is not easily accessible due to safety issues related to its flammable properties [14]. Post-printing, the specimens were cured for an additional 30 minutes using a post-curing oven (Blur Lux Unit, Delta, India) to ensure the reaction of any remaining monomers. The 3D-printed specimens were obtained after this process. They were then trimmed, polished, and glazed [Table/Fig-1].

For the conventional crown and bridge resin specimens, the lost wax technique was followed. The prepared wax pattern was processed using the flask-press-pack method to create a self-cure PMMA. Following deflasking, the excess resin from all the specimen surfaces was trimmed using a tungsten carbide bur.



[Table/Fig-1]: Sample preparation (Group 1, Group 2, Group 3).

Outcome variable: The outcome variable is the colour stability of different surface-treated materials after artificial tooth brushing. Standard testing solutions for colour changes in prosthetic restorations include red wine and coffee solutions [15]. For this study, the colourant used was a coffee solution. Two hundred milliliters of boiling water were added to 1.8 grams of coffee powder (Bru, Hindustan Unilever Limited, India) in a cup to prepare the coffee, and the mixture was manually stirred for three minutes. The specimens were immersed in coffee for six hours each day [Table/Fig-2]. The coffee solution was changed daily, after which the specimens were subjected to artificial tooth brushing.



[Table/Fig-2]: Specimens immersed in coffee-picture showing Group 3 3D-Glazed (G) sample 1, 2 and 3.

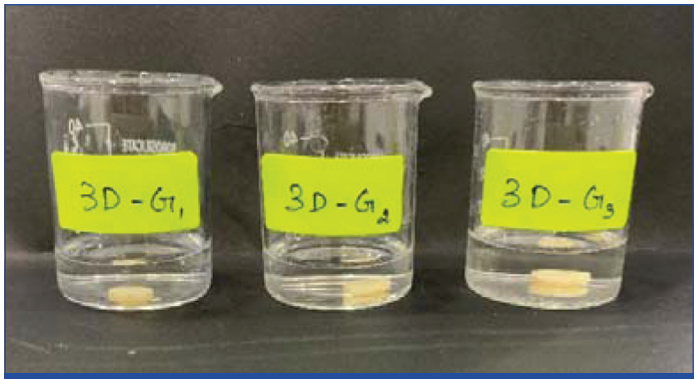
The specimens were fixed onto die stone molds. In total, eight dental brushes (Sensodyne, soft bristle, Haleon, Japan) were positioned in eight different slots within the brushing simulator model ZM-3. Each brush directly imparted a 300 g vertical force to the specimen's surface. Toothpaste slurries were prepared and poured into each slot of the brushing apparatus until the specimen surfaces were covered. Eight specimens were mechanically brushed with a vertical load of 300 g and a stroke path of 8 mm diameter [Table/Fig-3]. After brushing, the specimens were removed from the brushing apparatus, cleaned with distilled water, and allowed to air dry gently. For the remainder of the day, they were stored in artificial saliva to simulate an oral environment [Table/Fig-4].

Calculation of immersion time: A commonly cited calculation in the literature estimates that 288 hours of immersion in a staining solution simulates 12 months of exposure to staining agents [12]. To evaluate the colour stability of the specimens over a three-month period, the equivalent immersion time was calculated as follows:

288 hours / 12 months=24 hours/month

24 hours/month × 3 months=72 hours

[Table/Fig-3]: Artificial tooth brushing.



[Table/Fig-4]: Specimens stored in artificial saliva-picture showing Group 3 3D-Glazed (G) sample 1, 2 and 3.

Given the calculated immersion time of 72 hours, the study was conducted over 12 days to evaluate the colour stability of the specimens.

72 hours / 12 days=6 hours/day.

Therefore, the specimens were immersed in coffee for 6 hours daily.

Calculation of stroke count: A literature-based calculation was utilised to simulate tooth brushing, where 10,000 strokes are estimated to correspond to one year of brushing [16]. To simulate three months of tooth brushing, the total number of strokes was calculated as follows:

- 10,000 strokes / 12 months ≈ 833 strokes/month

- 833 strokes/month × 3 months ≈ 2,500 strokes

The study was designed to simulate three months of intraoral brushing over a 12-day period. To achieve this, the daily stroke count was calculated by dividing the total number of strokes by the number of days:

- 2,500 strokes / 12 days ≈ 210 strokes/day

Therefore, the specimens were subjected to 210 strokes of artificial tooth brushing daily.

Data collection: Initially, baseline (T0) colour measurements were recorded using a Vita EasyShade spectrophotometer (VITA Zahnfabrik, US) before immersion in the colourant.

Then, the specimens were immersed in coffee and stored at 37°C in a separate beaker for six hours, followed by 210 strokes of artificial tooth brushing daily for 12 days, simulating three months of intraoral use. During the remaining hours, the specimens were stored in artificial saliva.

Colour measurements of the specimens were recorded using a Vita EasyShade spectrophotometer after 4 days (T1 - one month of simulation), 8 days (T2 - two months of simulation), and 12 days (T3 - three months of simulation). Prior to each colour measurement, the specimens were thoroughly dried using a disposable tissue [17].

The colour differences were recalculated as Delta E using the equation [1].

$$\Delta E=\sqrt{(L1-L0)^2+(a1-a0)^2+(b1-b0)^2}$$

where,

L1 - L0- the difference between the brightness of the specimen before and after placement in the staining solutions.

a1 - a0- colour change on the red-green axis

b1 - b0- colour change on the yellow-blue axis

Furthermore, in relating the colour difference to a clinical situation, the ΔE values were converted to National Bureau of Standards (NBS) units [18]. The NBS value was determined by multiplying the degree of colour difference by 0.92. The NBS grading system [Table/Fig-5], which indicates how perceptible a colour shift is to the human eye, is used to determine colour stability [13]. The NBS value was determined by multiplying the value indicating the degree of colour difference by 0.92.

NBS	Critical remarks of colour differences	
0.0-0.5	Trace	Extremely slight change
0.5-1.5	Slight	Slight change
1.5-3.0	Noticeable	Perceivable change
3.0-6.0	Appreciable	Marked change
6.0-12.0	Much	Extremely marked change
12.0 or more	Very much	Change to another colour

[Table/Fig-5]: National Bureau of Standards (NBS) ratings.

STATISTICAL ANALYSIS

The data were entered into Microsoft Excel and analysed using SPSS version 20.0. Continuous data were described as mean and SD. Independent Student's t-tests were performed for intergroup comparisons between Group 1 and Group 2, Group 2 and Group 3, and Group 3 and Group 1 at different time intervals (T0-T1, T0-T2, T0-T3), respectively. Repeated measures ANOVA was conducted for intragroup comparisons among Group 1, Group 2, and Group 3 at different time intervals (T0-T1, T0-T2, T0-T3), respectively.

RESULTS

The baseline data for Group 1, Group 2, and Group 3 are as follows:

- The baseline, T1, T2, and T3 laboratory data of Group 1, Group 2, and Group 3 has been shown in [Table/Fig-6].
- The colour changes within groups at three different intervals has been shown in [Table/Fig-7].

Groups	Data	Baseline	T1	T2	T3
PMMA (Group 1)	L	84.1±1.54	84.0±0.75	86.3±1.15	86.2±1.59
	A	3.8±0.66	0.8±0.43	4.1±0.44	4.1±0.37
	B	28.3±0.99	21.9±0.99	29.4±0.62	28.7±0.75
3D-Polish (Group 2)	L	82.7±0.78	84.9±1.00	83.7±1.73	83.8±1.38
	A	0.78±0.28	1.3±0.33	1.7±0.52	1.6±0.49
	B	19.6±0.62	23.5±1.85	24.1±2.12	23.8±2.25
3D-Glaze (Group 3)	L	82.54±0.65	87.1±1.49	83.0±0.87	82.9±1.25
	A	-0.09±0.36	3.9±0.31	0.9±0.49	0.9±0.49
	B	19.0±0.40	29.4±0.49	21.7±1.05	21.7±1.48

[Table/Fig-6]: Baseline, T1, T2 and T3 laboratory data of Group 1, Group 2, Group 3.

Significant colour changes were observed in Group 1 (ΔE=7.2±1.67, 2.7±1.08, 2.7±1.44; p<0.001) and Group 3 (ΔE=12.2±0.88, 2.9±0.89, 3.0±1.41; p<0.001) at three different intervals. In contrast, Group 2 showed no statistically significant colour change (ΔE=5.2±1.59, 5.3±1.91, 4.9±2.21; p=0.466).

The colour changes within groups at three different intervals in NBS units has been shown in [Table/Fig-8]. Significant colour changes were observed in Group 1 (ΔE=6.6±1.53, 2.5±0.99, 2.5±1.33; p<0.001) and Group 3 (ΔE=11.2±0.81, 2.7±0.82, 2.8±1.30;

Group	Time	Mean±SD	F	p-value
PMMA (Group 1)	T0-T1	7.2±1.67	24.916	<0.001*
	T0-T2	2.7±1.08		
	T0-T3	2.7±1.44		
3D-Polished (Group 2)	T0-T1	5.2±1.59	0.623	0.466
	T0-T2	5.3±1.91		
	T0-T3	4.9±2.21		
3D-Glazed (Group 3)	T0-T1	12.2±0.88	332.634	<0.001*
	T0-T2	2.9±0.89		
	T0-T3	3.0±1.41		

[Table/Fig-7]: Colour changes within groups at three different intervals.
*p-value <0.001 - highly statistically significant; p-value<0.05 - statistically significant; p-value>0.05 Non Significant (NS), Repeated measures of ANOVA

Group	Time	Mean±SD	F	p-value
PMMA (Group 1)	T0-T1	6.6±1.53	24.865	<0.001*
	T0-T2	2.5±0.99		
	T0-T3	2.5±1.33		
3D-Polished (Group 2)	T0-T1	4.8±1.46	0.623	0.466
	T0-T2	4.9±1.76		
	T0-T3	4.5±2.04		
3D-Glazed (Group 3)	T0-T1	11.2±0.81	332.614	<0.001*
	T0-T2	2.7±0.82		
	T0-T3	2.8±1.30		

[Table/Fig-8]: Colour changes within groups at three different intervals in NBS units.
* p-value<0.001 - highly statistically significant; p-value <0.05 - statistically significant; p-value>0.05 Non Significant (NS), Repeated measures of ANOVA

p<0.001). In contrast, Group 2 displayed no statistically significant colour change (4.8±1.46, 4.9±1.76, 4.5±2.04).

Based on the NBS ratings:

- Group 1: Initially showed an extremely marked change, reducing to a perceivable change over time.
- Group 3: Exhibited similar changes. In contrast, **Group 2* showed marked colour change (ΔE=4.8±1.46, 4.9±1.76, 4.5±2.04; p=0.466) across all intervals.

The colour changes between the groups at three different intervals has been shown in [Table/Fig-9].

Intergroup comparisons revealed significant differences in colour change between Group 1 vs Group 2: p=0.014 (T0-T1), 0.002 (T0-T2), 0.019 (T0-T3); Group 2 vs Group 3: p<0.001 (T0-T1), 0.003 (T0-T2), 0.041 (T0-T3); and Group 3 vs Group 1: p<0.001 (T0-T1), with no significant difference at T0-T2 and T0-T3.

The colour changes between the groups at three different intervals in NBS units has been shown in [Table/Fig-10]. Significant differences in colour change were observed between all group pairs at various intervals:

- Group 1 vs Group 2 : Significant differences at all intervals p=0.014 (T0-T1), 0.002 (T0-T2), 0.019 (T0-T3).
- Group 2 vs Group 3 : Significant differences at all intervals p<0.001 (T0-T1), 0.003 (T0-T2), 0.041 (T0-T3).
- Group 3 vs Group 1 : A significant difference only at T0-T1, p<0.001, but no significant difference at T0-T2 and T0-T3.

According to NBS ratings, the groups exhibited varying levels of colour change:

- Group 1 : Extremely marked change at T0-T1, reducing to perceivable change at T0-T2 and T0-T3.
- Group 2 : Marked change at all intervals.
- Group 3 : Extremely marked change at T0-T1, reducing to perceivable change at T0-T2 and T0-T3.

DISCUSSION

The present study demonstrates that 3D-printed temporary crowns and bridge specimens (Group 3), with advanced surface treatment (glazing), exhibit superior colour stability compared to those with conventional polished specimens (Group 1). Although glazed 3D-printed specimens showed inferior colour stability to conventional PMMA specimens initially, no significant difference was observed in the later stages. This suggests that both can be used for long-term temporary restorations. The findings highlight the importance of surface treatment and good oral hygiene practices in maintaining colour stability, particularly in reducing extrinsic stains. These results have implications for the clinical use of 3D-printed temporary restorations when long-term use is anticipated, emphasising the need for proper surface treatment and patient education on oral hygiene.

The optical characteristics of temporary dental crown and bridge resins used for long-term applications must be able to withstand discolouration from both intrinsic and extrinsic stains. Therefore, when choosing these materials, colour stability must be carefully considered. The present study demonstrates that using a glazing agent improves the colour stability of 3D-printed specimens, offering an easy and cost-effective alternative.

A previous study by Gruber S et al., examined the colour stability of conventional heat-polymerising (pink and tooth-shade) CAD/CAM

Groups	T0-T1	T value	p-value	T0-T2	T value	p-value	T0-T3	T value	p-value
PMMA-3D Polished	7.2±1.67	2.738	0.014*	2.7±1.08	-3.641	0.002*	2.7±1.44	-2.572	0.019*
	5.2±1.59			5.3±1.91			4.9±2.21		
3D Polished-3D Glazed	5.2±1.59	-12.190	<0.001*	5.3±1.91	3.485	0.003*	4.9±2.21	2.206	0.041*
	12.2±0.88			2.9±0.89			3.0±1.41		
PMMA-3D Glazed	7.2±1.67	-8.404	<0.001*	2.7±1.08	-0.453	0.656 (NS)	2.7±1.44	-0.494	0.627 (NS)
	12.2±0.88			2.9±0.89			3.0±1.41		

[Table/Fig-9]: Colour changes between the groups at three different intervals.
*p-value <0.001 - highly statistically significant; p-value<0.05 - statistically significant; p-value>0.05 Non Significant (NS), Independent student t-test

Groups	T0-T1	T value	p-value	T0-T2	T value	p-value	T0-T3	T value	p-value
PMMA-3D Polished	6.6±1.53	2.727	0.014*	2.5±0.99	-3.641	0.002*	2.5±1.33	-2.572	0.019*
	4.8±1.46			4.9±1.76			4.5±2.04		
3D Polished-3D Glazed	4.8±1.46	-12.191	<0.001*	4.9±1.76	3.486	0.003*	4.5±2.04	2.206	0.041*
	11.2±0.81			2.7±0.82			2.8±1.30		
PMMA-3D Glazed	6.6±1.53	-8.423	<0.001*	2.5±0.99	-0.453	0.656 (NS)	2.5±1.33	-0.494	0.627 (NS)
	11.2±0.81			2.7±0.82			2.8±1.30		

[Table/Fig-10]: Colour changes between the groups at three different intervals in NBS units.
*p-value <0.001 - highly statistically significant; p-value<0.05 - statistically significant; p-value>0.05 Non Significant (NS), Independent student t-test

subtractively manufactured and additively manufactured (pink and tooth-shade) denture resins after four different aging processes. The study concluded that additively manufactured denture resins demonstrated the maximum colour change compared to conventional heat-polymerised and CAD/CAM subtractively manufactured denture resins [19].

In contrast, Alfouzan AF et al., reported that 3D-printed denture resins exhibited lower colour changes compared to conventional heat-polymerised PMMA following exposure to aging, mechanical brushing, and staining agents [12]. However, their study shared a similar observation that colour changes in all tested materials decreased significantly over time, regardless of the staining medium used.

Previous research by Shin JW et al., examined the colour stability of dental restorations manufactured with traditional CAD/CAM blocks and 3D-printed crown and bridge resins, focusing on the effects of different colourants and storage times [20]. It was concluded that after being subjected to grape juice, curry, and distilled water for two, seven, and 30 days, a 3D-printing resin showed noticeably more deterioration than CAD/CAM blocks. These results emphasise the importance of considering discolouration when employing 3D-printed resins for dental restorations.

A study by Raszewski Z et al., used samples that were not subjected to any surface treatment following curing and washing with alcohol, samples that were polished in a standard way, and samples that were covered with light-curing varnish [1]. They reported that the highest changes were observed in 3D samples that were not subjected to any treatment after curing and washing with alcohol. They concluded that a polished 3D surface would resist stains better than an unpolished one, but the varnish protection may eventually peel. Therefore, it is essential to ensure adequate polishing to avoid areas with greater roughness that may absorb dyes.

In the oral environment, saliva is crucial as it naturally prevents discolouration and preserves the integrity of dental restorations [21]. Additional variables that may affect colour stability include the duration of immersion and the frequency of exposure to staining solutions. Literature shows that extended contact with staining agents, such as red wine, coffee, or tea, can cause dental materials to undergo more noticeable colour alterations [14].

It is important to consider how the pH of the staining solution affects the colour stability of dental materials [22]. Understanding how the acidity of common beverages interacts with dental materials is essential, as it can help create more durable and resistant dental restorations [23].

Another important factor is biocompatibility, which must be considered to prevent patients from experiencing negative responses to dental restorations. To improve patient outcomes by lowering the risk of allergic reactions or infections, dental practitioners must take the biocompatibility of dental materials into account [24].

The risk of discolouration in dental restorations can be reduced by emphasising patient education and preventive actions. Patients should be counseled on maintaining their oral hygiene, as well as on the potential impact of staining beverages such as red wine, coffee, and tea on the colour stability of their restorations.

This study also examines the cumulative effects of various surface treatments, artificial tooth brushing, saliva, and its interaction with dental materials—an area that has received little attention in prior research. By investigating the complex relationship between saliva and dental materials, valuable information for improving the colour stability of dental restorations in clinical settings will be obtained.

Therefore, the null hypothesis stating that there is no difference in discolouration characteristics based on the surface treatment of the material, no difference in discolouration according to storage time in the colourant, and no effect of artificial tooth brushing on discolouration has been rejected.

Further research is needed to investigate the long-term durability and colour stability of 3D-printed temporary crowns and bridges beyond three months. It is also important to develop new materials and surface treatments that enhance their aesthetic and functional properties. Randomised controlled clinical trials would provide valuable insights into their clinical performance and validate these findings.

Limitation(s)

The present in-vitro study has the following limitations. Firstly, the findings are limited to the use of soft brushes, and the results may not be generalisable to medium or hard toothbrushes. Additionally, the study's results are specific to the type of resin and 3D printer used. Variations in resin composition, degree of polymerisation, and 3D-printing technology may affect the colour stability of dental restorations. Furthermore, the post-curing process and light oven used in this study may also influence the results. Future studies should investigate the effects of different resins, 3D printers, and post-curing protocols on the colour stability of 3D-printed dental restorations to provide a more comprehensive understanding of their clinical performance.

CONCLUSION(S)

The present study highlights the importance of surface treatment and oral hygiene measures, as tooth brushing reduces stains. The findings show that 3D-printed temporary crowns and bridges with glazing exhibit superior colour stability compared to conventionally polished ones. Although initially inferior to conventional PMMA specimens, glazed 3D-printed specimens demonstrate comparable colour stability over time. Notably, glazed 3D-printed temporary restorations can be a suitable option when long-term use is anticipated, provided good oral hygiene is maintained. These findings underscore the significance of surface treatment and oral hygiene in maintaining aesthetics, supporting the clinical use of 3D-printed temporary restorations with proper care.

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