Published online: 2019-09-25

Original Article

Color stability and marginal integrity of interim crowns: An *in vitro* study

Marwa I. Elagra[1], Mohammad R. Rayyan[1], Maisam M. Alhomaidhi[1], Areej A. Alanaziy[2], Mona O. Alnefaie[2]

[1]Department of Prosthodontic, Riyadh Colleges of Dentistry and Pharmacy, Riyadh, Saudi Arabia, [2]Department of Restorative Dentistry, Riyadh Colleges of Dentistry and Pharmacy, Riyadh, Saudi Arabia

Correspondence: Dr. Mohammad R. Rayyan
Email: mohammadrayyan1979@gmail.com

ABSTRACT

Objective: Many commercial dental materials are used to fabricate interim restorations. This study aimed to compare the color stability and the marginal integrity of four different interim crown materials. **Materials and Methods:** An ivorine right maxillary central incisor was prepared for a full coverage all-ceramic restoration. A total of 36 specimens in the form of crowns were fabricated on the master die using four different materials ($n = 9$); Polymethyl methacrylate (PMMA) resin (TrimPLUS), PMMA computer-aided design, and computer-aided manufacturing (CAD-CAM) blocks (Ceramill TEMP), cold cure bis-acryl resin (Success CD), and bis-acryl resin dual-cure composite (TempSpan). Color change ΔE for each sample was calculated by measuring its color as Commission Internationale de l'Eclairage L* a* b* with a spectrophotometer before and after immersing in a concentrated tea solution for 7 days. Marginal gap was measured at four reference points using stereomicroscope at ×40. One-way ANOVA and the Tukey multiple comparisons test were used to determine any statistically significant difference between the four groups, ($\alpha = 0.05$). **Results:** Success CD showed significantly the greatest color change (7.7) among all the tested materials, while no significant difference was found between the other three materials. TempSpan showed significantly the highest marginal gap formation (430.15 μm), while no significant difference was found between the three other materials. **Conclusions:** Bis-acryl resin composite materials demonstrated clinically noticeable change in color while PMMA materials demonstrated superior color stability. Dual cure interim materials exhibited significantly higher marginal discrepancy in comparison to PMMA and cold cure bis-acrylic resin materials. CAD-CAM PMMA material exhibited the best color stability and marginal integrity.

Key words: Color stability, interim restorations, marginal fit

INTRODUCTION

Interim restorations play an important role in the success of dental treatment. They are essential to provide protection for dentin, restore esthetic and function, maintain positional stability, and promote gingival health. Although interim restorations are used for limited period, they still have to meet certain biologic, mechanical, and esthetic requirements to achieve these functions.[1]

Polymethyl methacrylate (PMMA) has been long in use for the fabrication of interim restorations. Although this material has provided satisfactory interim restorations in regard to esthetics and function, it has been accompanied with drawbacks such as heat generation, shrinkage, excess monomer, and color changes.[2] In the past few decades, several other materials have come into usage. These

Access this article online

Quick Response Code:

Website: www.eurjdent.com

How to cite this article: Elagra MI, Rayyan MR, Alhomaidhi MM, Alanaziy AA, Alnefaie MO. Color stability and marginal integrity of interim crowns: An *in vitro* study. Eur J Dent 2017;11:330-4.

DOI: 10.4103/ejd.ejd_66_17

include ethylmethacrylate, vinylmethacrylate, and butylmethacrylate, bis-acrylics (bisphenol A-glycidyl methacrylate and urethane dimethacrylate).[3]

Recently, computer-aided design and computer-aided manufacturing (CAD-CAM) technology have been utilized to fabricate interim restorations. Crosslinked PMMA blocks which have been previously polymerized are milled to produce interim restorations of better strength as well as homogeneity. Unlike conventional PMMA materials, PMMA blocks do not undergo polymerization shrinkage or have excess monomer as they are fully polymerized before milling. Moreover, studies have suggested superior physical and mechanical properties of this material and promoted its use for long-term interim restorations.[4,5]

Materials used for the fabrication of interim restorations varies greatly in their physical and mechanical properties such as stains resistance, dimensional stability, polishability, strength, surface hardness, and biocomaptability.[6-10] Yet no material is superior in all aspects and the restorative dentist should make the assessment of these materials' advantages and disadvantages to decide which to use.[11]

The current study aimed to compare four different materials used to fabricate interim restorations in terms of their marginal integrity and color stability.

MATERIALS AND METHODS

The study was registered and approved by the Institutional Review Board of Riyadh Colleges of Dentistry and Pharmacy (FUGRP/2012/5).

Preparation of samples

An ivorine right maxillary incisor was prepared for a full coverage all-ceramic restoration with a heavy chamfer margin. Four points were engraved at a distance of 1 mm below the facial, lingual, mesial, and distal margins[12] [Figure 1].

A total of 36 specimens in the form of crowns were fabricated on the master die using four different interim materials.

The samples were divided according to the material used into four groups of nine specimens in each group (n = 9) [Table 1].

For each interim crown in group PM, BC, and DC, the material was mixed and cured according to its manufacturer instructions. For group PMCAD, an impression for the master die was made and the working die was scanned. Crowns were designed and milled using Ceramill Mind software and Ceramill Motion Milling Machine (Amann Girrbach, Austria). Specimens of all groups were then finished and polished according to manufacturers' instructions. All specimens were then stored in a light-protected container until ready for testing.

Testing

Marginal adaptation

Crowns were fitted on the master die and tested for marginal adaptation using stereomicroscope at ×40 magnification (Nikon Stereoscopic Microscope, SMZ1000), and photographed (Nikon Digital Camera, DXM1200F). At each of the four engraved reference points, the vertical marginal gap between the finish line and the crown margin was measured to the nearest 0.01 μm [Figure 2]. The average marginal gap was calculated and tabulated for each sample.

Figure 1: Master die

Table 1: Interim crown materials under investigation

Group	Material type	Brand	Manufacture
Group PM	Polymethyl methacrylate	Trimplus	Bosworth, USA
Group PMCAD	Polymethyl methacrylate CAD-CAM blocks	Ceramill TEMP	Hersteller, Germany
Group BC	Bis-acryl composite resin	Success CD	Promedica, Germany
Group DC	Dual cure composite resin	Temspan	Pentron, USA

CA-CAM: Computer-aided design and computer-aided manufacturing

Color stability test

Baseline color measurements

Baseline color measurements for all specimens were done using spectrophotometer (Color-Eye 7000A, X-Rite Europe GmbH, Switzerland). The measurements were established in mathematic coordinates referred to the international color space Commission Internationale de l'Eclairage L* a* b*. For each sample, three readings at the labial surface were taken. The average L*, a*, and b* values for the three readings were calculated and tabulated as the baseline color measurements.

Staining solution

Specimens were immersed in a high concentration tea solution (Lipton, Unilever Gulf FZE, UAE) at 37°C. Temperature was controlled using a thermostatically controlled incubator. The solution was constantly changed every 2 days. After 7 days of immersing crowns in the tea solution, the specimens were rinsed with distilled water, brushed with Aquafresh, soft brush (GlaxoSmithKline, the UK), and blotted dry with tissue paper before the second color measurement.

Poststain color measurements

The color of the specimens was measured again using the spectrophotometer and tabulated as described previously. The calculation of the color change Δ E* between the two color positions (after storage and baseline) was calculated according to the following formula: $\Delta E = ([L_2^* - L_1^*]^2 + [a_2^* - a_1^*]^2 + [b_2^* - b_1^*]^2)^{1/2}$.[13]

Color change >3.3 was considered clinically unacceptable.[14]

Statistical analysis

The measurements were analyzed using one-way ANOVA with a Tukey *post hoc* multiple comparison to determine any statistically significant difference in color change and marginal gap between the four materials. Analysis was done using the Statistical Package for Social Sciences (SPSS version 17.0 SPSS Inc, Chicago, USA). The level of statistical significance was set at $P < 0.05$.

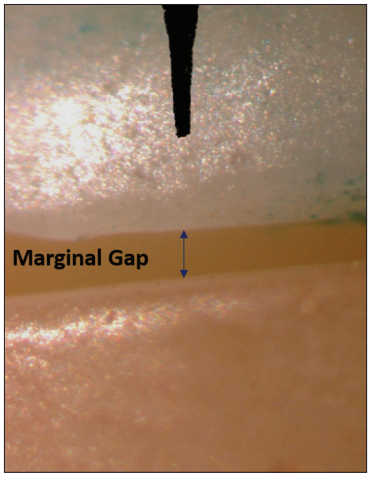

Figure 2: Vertical marginal gap at the labial reference point of one of the samples

RESULTS

Color stability

The mean color change Δ E values of the four materials are shown in Figure 3. TempSpan and Success CD are the only two materials that exhibited clinically noticeable color change (ΔE >3.3). Analysis of results showed significant difference between the four materials (P = 0.00). Success CD showed significantly the greatest color change among all the tested materials, while no significant difference was found between the other three materials [Table 2].

Marginal adaptation

The mean gap formation for each group is shown in Figure 4. Analysis of results showed significant difference between the four materials (P = 0.00).

Table 2: One-way ANOVA comparison for the color change between groups

Material (I)	Material (J)	Mean difference	SE	Significant
TrimPLUS	Ceramill TEMP	0.52766	1.11133	0.964
	Success CD	−5.37315*	1.11133	0.000
	TempSpan	−1.51732	1.11133	0.530
Ceramill TEMP	TrimPLUS	−0.52766	1.11133	0.964
	Success CD	−5.90081*	1.11133	0.000
	TempSpan	−2.04498	1.11133	0.274
Success CD	TrimPLUS	5.37315*	1.11133	0.000
	Ceramill TEMP	5.90081*	1.11133	0.000
	TempSpan	3.85583*	1.11133	0.008
TempSpan	TrimPLUS	1.51732	1.11133	0.530
	Ceramill TEMP	2.04498	1.11133	0.274
	Success CD	−3.85583*	1.11133	0.008

*$P < 0.05$. SE: Standard error

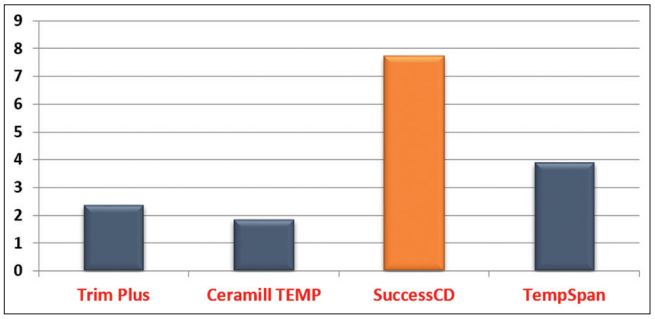

Figure 3: Mean color change ΔE

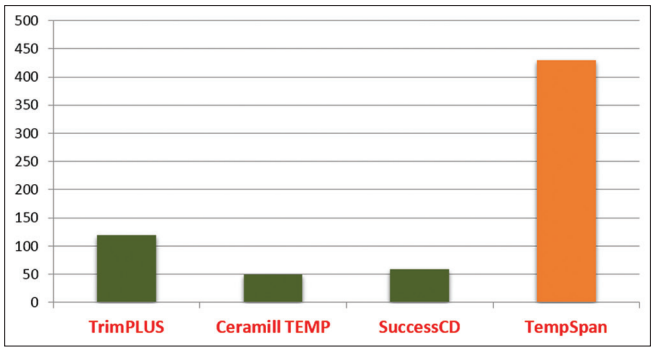

Figure 4: Mean marginal gap in μm

TempSpan showed significantly the highest marginal gap formation among the tested materials, while no significant difference was found between the three other materials [Table 3].

Table 3: One-way ANOVA comparison for marginal gap between groups

Material (I)	Material (J)	Mean difference	SE	Significant
TrimPLUS	Ceramill TEMP	70.18214	67.42602	0.728
	Success CD	60.66071	67.42602	0.805
	TempSpan	−310.21429*	67.42602	0.001
Ceramill TEMP	TrimPLUS	−70.18214	67.42602	0.728
	Success CD	−9.52143	67.42602	0.999
	TempSpan	−380.39643*	67.42602	0.000
Success CD	TrimPLUS	−60.66071	67.42602	0.805
	Ceramill TEMP	9.52143	67.42602	0.999
	TempSpan	−370.87500*	67.42602	0.000
TempSpan	TrimPLUS	310.21429*	67.42602	0.001
	Ceramill TEMP	380.39643*	67.42602	0.000
	Success CD	370.87500*	67.42602	0.000

*P < 0.05. SE: Standard error

DISCUSSION

Despite being used for limited time, color stability of interim crowns is a concern, particularly when the interim restoration is in the esthetic zone, and must be worn for extended periods of time. Moreover, an interim restoration needs to seal and insulate the prepared tooth from the oral environment, thereby protecting the underlying pulp from insult and injury and the prepared dentin from recurrent decay. Yet, many studies have reported significant color changes and marginal discrepancy of interim restorations made of different materials.[5,8,9] Unlike permanent restorations, interim restorations are usually used for limited times. Thus, in the current study, samples were immersed in high concentration tea solution for 1 week. This method does not exactly reflect the clinical reality. However, similar protocol to evaluate color stability of interim restorations was adopted in previous studies and was considered adequate.[9]

Various studies have reported different thresholds of color difference values ranged from 1 to 3.7 above which the color change is perceptible by the human eye.[14] In the present study, a color change (ΔE*) >3.3 was considered visually perceptible as well as clinically unacceptable. Both bis-acryl methacrylate based resins in this study; TempSpan and Success CD demonstrated visually perceptible and clinically unacceptable color change (3.88 and 7.74, respectively). Moreover, the auto-cured bis-acryl (Success CD) crowns showed significantly the highest color change. Those results were in agreement with previous studies.[8-10] Proprietary variations in chemistry, such as size distribution of the PMMA particles, polarity of the monomers, pigment stability, and efficiency of the initiator system for interim resins may lead to differing degrees of polymerization, water sorption, and consequently, color stability.[8]

As with permanent restorations, marginal adaptation of interim restorations is detrimental for the success of treatment and maintenance of teeth and gingival health.[1] The results of the present studies showed that dual cured bis-acryl interim material (TempSpan) demonstrated significantly the highest mean marginal gap (430.15 μm) when compared to the other groups. This was in agreement with Givens *et al.* who suggested that that the majority of gap formation occurs during the auto-cure phase of polymerization of dual-cured materials.[9]

In this study, the machined CAD-CAM material demonstrated the lowest mean color change (1.84) and lowest mean marginal gap (49.76 μm). This can be attributed to the industrially optimized conditions under which the polymerization of this material happens so it has no or minimal residual unreacted monomers and lower polymerization shrinkage. This supports the recommendation of similar studies to use machined CAD-CAM resin blocks for the fabrication of long-term interim restorations.[4,5]

CONCLUSIONS

Under the conditions of this study, the following can be concluded:

1. The bis-acryl resin composite materials demonstrated clinically noticeable change in color while PMMA materials demonstrated superior color stability
2. Dual cure interim materials exhibited significantly higher marginal discrepancy in comparison to

PMMA and cold cure bis-acrylic resin materials
3. CAD-CAM PMMA material exhibited the best color stability and marginal integrity.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Nejatidanesh F, Lotfi HR, Savabi O. Marginal accuracy of interim restorations fabricated from four interim autopolymerizing resins. J Prosthet Dent 2006;95:364-7.
2. Young HM, Smith CT, Morton D. Comparative *in vitro* evaluation of two provisional restorative materials. J Prosthet Dent 2001;85:129-32.
3. Comisi JC. Provisional materials: Advances lead to extensive options for clinicians. Compend Contin Educ Dent 2015;36:54, 56-9.
4. Samra AP, Pereira SK, Delgado LC, Borges CP. Color stability evaluation of aesthetic restorative materials. Braz Oral Res 2008;22:205-10.
5. Rayyan MM, Aboushelib M, Sayed NM, Ibrahim A, Jimbo R. Comparison of interim restorations fabricated by CAD/CAM with those fabricated manually. J Prosthet Dent 2015;114:414-9.
6. Yannikakis SA, Zissis AJ, Polyzois GL, Caroni C. Color stability of provisional resin restorative materials. J Prosthet Dent 1998;80:533-9.
7. Burns DR, Beck DA, Nelson SK; Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. A review of selected dental literature on contemporary provisional fixed prosthodontic treatment: Report of the Committee on Research in Fixed Prosthodontics of the Academy of Fixed Prosthodontics. J Prosthet Dent 2003;90:474-97.
8. Haselton DR, Diaz-Arnold AM, Dawson DV. Color stability of provisional crown and fixed partial denture resins. J Prosthet Dent 2005;93:70-5.
9. Givens EJ Jr., Neiva G, Yaman P, Dennison JB. Marginal adaptation and color stability of four provisional materials. J Prosthodont 2008;17:97-101.
10. Sham AS, Chu FC, Chai J, Chow TW. Color stability of provisional prosthodontic materials. J Prosthet Dent 2004;91:447-52.
11. Strassler HE. Fixed prosthodontics provisional materials: Making the right selection. Compend Contin Educ Dent 2013;34:22-4, 26.
12. Patil A, Singh K, Sahoo S, Suvarna S, Kumar P, Singh A. Comparative assessment of marginal accuracy of grade II titanium and Ni-Cr alloy before and after ceramic firing: An *in vitro* study. Eur J Dent 2013;7:272-7.
13. Wyszecki G, Stiles WS. Colour Science: Concepts and Methods: Quantitative Data and Formulae. 2nd ed. New York: John Wiley and Sons; 1982. p. 164-9.
14. Ceci M, Viola M, Rattalino D, Beltrami R, Colombo M, Poggio C. Discoloration of different esthetic restorative materials: A spectrophotometric evaluation. Eur J Dent 2017;11:149-56.