How to Cite:
Galale, M. D., Jankar, A. S., Nagargoje, Y., Kamble, S. S., Bangar, B. R., Langote, P., & Raut, S. (2022). Comparative evaluation of marginal accuracy of different provisional restorative materials fabricated by direct technique: An in vitro study. *International Journal of Health Sciences*, *6*(S7), 2404–2416. https://doi.org/10.53730/ijhs.v6nS7.11869

Comparative evaluation of marginal accuracy of different provisional restorative materials fabricated by direct technique: An in vitro study

Dr. Madhavi D. Galale
Post Graduate Student, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Ajit S. Jankar
HOD & PG guide, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Yogesh Nagargoje
Senior Lecturer, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Suresh S. Kamble
Principal, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Bhushan R. Bangar
Professor Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Pooja Langote
Post Graduate Student, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India

Dr. Shivani Raut
Post Graduate Student, Department of Prosthodontics, MIDSR Dental College, Latur, Maharashtra, India.
Corresponding author: Dr. Madhavi D. Galale madhu98dj@gmail.com

***Abstract*---**Objective: The most essential requirement of a provisional crown is an adequate marginal fit which is necessary for maintaining optimal periodontal health and protect the tooth from physical, chemical, thermal, and bacterial injuries. The purpose of this in vitro study was to evaluate and compare the vertical marginal accuracy of

provisional crown materials using four different material systems (Autopolymerized PMMA powder-liquid system, light-activated UD single paste system, chemically activated Bis-GMA two paste auto mix system and dual cure polymerized resin two paste auto mix system) using a direct technique. Materials and Methods: Two customized stainless-steel dies, simulating prepared and unprepared tooth were used to fabricated a total no. of 48 provisional crowns. A vacuum-formed polypropylene sheet was used as a matrix. Twelve crowns, each of the four material systems used in the study (n = 12 × 4) were fabricated using the direct technique. The vertical marginal accuracy was analyzed by using stereomicroscope 20X magnification at four different points. The results were analyzed using descriptive statistics and comparisons between various groups were made using t-test. Results: The mean marginal accuracy of Group I PMMA autopolymerized resin 149.2500, Group II Bis-GMA composite resin 105.0821, Group III Light cured resin 107.7471 and Group IV Dual cured resin 123.1783 using the direct technique. Conclusion: This study has shown that provisional crowns fabricated with Bis-GMA composite resin material (two paste auto mix system) registered the best marginal accuracy.

***Keywords*---**Bis-phenol A glycidyl methacrylate (Bis-GMA), Polymethyl methacrylate (PMMA), Light cured resin, Stereomicroscope, Stainless steel die.

Introduction

In the present era of dentistry esthetics has become the prime concern for the majority of population. The smile, which is the definition of humankind, crosses all gender, age, cultural, and religious boundaries to express emotion. When enhancing or restoring a smile with aesthetic dentistry, the provisionalization phase is critical in conveying information regarding function, occlusion, phonetics and the patient's expectations among the members of the restorative team. In fixed partial denture case, one of the major steps is the fabrication of provisional restoration.[1] Provisional restoration should be provided to the patient within the timeframe between the tooth preparation and placement of definitive prostheses. It should be fabricated in such a way that it completely mimics the definitive prostheses and fulfills the biological, mechanical and aesthetic principles, so that the patient is able to associate it with the definitive prostheses and gets acquainted with it.[2] Few of the biological necessities comprises pulpal protection (against physical, chemical, thermal injuries), maintenance of periodontal health, provision of occlusal stability, maintenance of tooth position and structural durability.[3,4] One of the crucial predictors of the long-term success of any dental restoration is its marginal fit. Marginal failure leads to microleakage (as the main cause of tooth sensitivity), postoperative sensitivity, and recurrent dental caries.

Provisional restorations can be fabricated using preformed restorations or by custom fabrication. The materials used for custom fabrication have been grouped based on their conversion from plastic to solid mass as: 1. Chemical activated

acrylic resin 2. Heat-activated acrylic resin 3. Light-activated acrylic resin 4. Dual activated resins.[5] The oldest and most commonly used materials are acrylic resins. One of the innate properties of polymer-based interim restorative materials is shrinkage during polymerization.[6] Shrinkage causes distortion that may jeopardize the accuracy of fit of the interim restorations and may also cause internal stress within the restorations.[7] Also the exothermic reaction of polymerization can damage the pulp irreversibly. In recent years, light-activated resins and composite resins have gained popularity. The ideal properties of the provisional restorative material are good marginal adaptation; adequate retention and resistance to dislodgment during normal masticatory function; strong, durable, and hard; non-irritating to pulp and other tissues; low exothermic reaction; non-porous and dimensionally stable; estheticaLy acceptable shade selection; translucent tooth-like appearance; color stability; easy to mix and load in the matrix, fabricate, reline, and repair; relatively short setting time; conductive to routine oral homecare cleaning procedures; low incidence of localized allergic reactions; finishes to a highly polished, plaque and stain-resistant surface.[5]

Depending on technique of fabrication, there are three techniques for fabrication of provisional restoration. In direct technique, for the provisional restoration patient's prepared teeth. The indirect technique involves fabrication of the provisional restoration outside the mouth. Indirect-Direct Provisional technique fabricates a custom-made preformed external surface form of the restoration, and the underprepared diagnostic casts form the internal tissue surface form[5].

Marginal accuracy of provisional restorations is important to protect the tooth from physical, chemical, thermal, and bacterial injuries. The acceptable marginal fit of provisional restoration maintains the gingival health. Poor marginal fit of provisional restorations often increases plaque retention and changes the distribution of the microflora, which can induce the onset of gingival disease, leading to complications during the subsequent treatment steps of fixed prostheses. The marginal discrepancy of a restoration can be defined best in terms of the "misfit" or the gap measured at various points between the restoration and the tooth.[8,9]

The purpose of this study is to evaluate and compare the marginal accuracy of polymethyl methacrylate, bis-acrylic composite resin, light polymerized composite resin, and dual cure polymerized resin used as provisional restorative materials by a direct technique.

Materials and Methods

In this vitro study, was used to simulate a clinical technique, in which the provisional crowns were formed directly on the prepared tooth using a matrix.

Two customized stainless-steel master dies were made with a common stainless-steel base, into which the dies could be accurately inserted and made interchangeable (Fig.1a, 1b, 1c &1d). The first die, which imitate an unprepared tooth and used to create a matrix. The second die with smaller axial and vertical dimension imitates the prepared tooth was used to fabricate the provisional crown

restoration. A shoulder finish line was produced in the prepared die, placed 1mm above the stainless-steel base.

A transparent thermoplastic, vacuum-formed polypropylene matrix was fabricated over the die which imitates the unprepared tooth. The transparent thermoplastic sheet as a matrix was used to fabricate provisional crowns using the direct technique.

The materials compared in this study are representative of four chemical types currently available in the market:

Group I - Polymethyl methacrylate (DPI) (powder and liquid, India),

Group I - Bis-GMA composite (Protemp IV) (Base and catalyst paste, 3M ESPE, India),

Group I - Light polymerized composite resin, (Urethane dimethacrylate) (Revotek LC) (single stick, GC,Japan),

Group I - Dual cure polymerized resin (Tempsmart) (10Ml cartridge syringes, GC, Japan.

Provisional crowns were formed according to the manufacturer's instructions with consideration to mixing, manipulation, proportioning, time of removal, and duration of irradiation. Test samples were fabricated in the following manner:

Fabrication of PMMA and Bis-GMA crowns using the direct technique:

The die imitates the prepared tooth was positioned in the cylindrical space present in the stainless-steel base. Manufacturer's instructions for the mixing of each material were followed. PMMA autopolymerizing acrylic resin was mixed in the ratio of 1 gm of powder to 0.45 cc of liquid, for 15 seconds, to produce a creamy mixture. After attending the dough stage which is the workable mass, with the help of mixing spatula the material was dispensed into the matrix which is made up of the thermoplastic sheet from one side in an attempt to avoid air entrapment in the mould. A finger pressure was applied over it until the initial setting time. After the complete setting of material thermoplastic was removed gently.

Bis-GMA composite resin was dispensed directly from the cartridge by means of an auto mixing tip using a dispensing gun. The mixing tip was attached and `material was dispensed into the thermoplastic sheet keeping in mind to fill it from the bottom to up to prevent voids. After that, the thermoplastic sheet was placed over the prepared die which was inserted into a common stainless steel base and left for 1min 40 sec to autopolymerize and set according to the manufacturer's specifications. Then it was kept as it is on the mould for 5 mins to achieve complete setting of the specimens. After complete setting of material thermoplastic was removed gently.

This procedure was repeated for all crowns (n = 12 × 2; 24, 12 PMMA and 12 Bis-GMA crowns, direct technique).

Fabrication of Light polymerized composite resin and Dual cure polymerized resin provisional crowns using the direct technique:

Light cured composite resin-filled transparent matrix was adapted on the master stainless steel die simulating the prepared tooth and photo-polymerized for 10 seconds with an LED light cure unit. The crown was then removed from the prepared die, excess was trimmed and light-cured for 20 seconds per surface.

Tempsmart is a dual-cured bis-acryl composite resin which was supplied in 48ml of cartridge form. The mixing tip was attached and `material was dispensed into the thermoplastic sheet and placed over the prepared die which was inserted into a common stainless-steel base. A finger pressure was applied over it and left for 2min 30sec, to autopolymerize. After setting of material thermoplastic was removed gently and again it was cure for 5 seconds.

This procedure was repeated for all crowns (n = 12 × 2; 24, 12 Light cure and 12 crowns, direct technique).

Testing Procedure:

Each provisional crown was placed on the stainless-steel master die limiting the prepared tooth. The marginal discrepancy was determined immediately after removing the thermoplastic sheet using stereomicroscope 20X magnification. Measuring the space (marginal opening) between the margin of the provisional crown and finish line of the test die at four 90 locations determined at four different points for evaluation of marginal accuracy.

The mean marginal opening was calculated for each crown from four points. Data was analyzed using IBM SPSS 24.0 at a significance level of p. The results were analzsed using descriptive statistics and compared between various groups using t–test. On comparison showed that, statistically significant difference between the all four groups.

Results

The overall mean gap values for the four groups at four different points are presented in [Table I]. [Table II] shows the mean values for all four groups. Then compared the mean ΔE value of Group I (149.2500), Group II (105.0821), Group III (107.7471) and Group IV (123.1783) by applied t-test, in order to see the difference in mean ΔE value between Group I, II, III, and IV in [Table III, Graph I]. The difference was found to be statistically highly significant i.e. p-value was 0.002 ($p < 0.001$). From the above result we have inferred that, provisional restoration fabricated with Bis- GMA composite resin (Protemp-4) material using a direct technique showed the maximum marginal accuracy 105.0821 than all four groups. Autopolymerizing resin (DPI) provisional restoration exhibited the least marginal accuracy (149.2500) using a direct technique.

Discussion

Provisional restorations are an essential and demanding interim solution, which calls for high-quality materials and great care on the part of dentistry. The functions, which a provisional restoration must fulfill, are wide-ranging and demanding.[10] There is presently no ideal provisional material suitable for all clinical conditions; however, there are many materials used to check the accuracy of materials.

Marginal gap is defined as the perpendicular measurement from the marginal surface of the restoration to the axial wall of the preparation. Marginal failure leads to microleakage (as the main cause of tooth sensitivity), postoperative sensitivity, and recurrent dental caries.[11] An increase in the size of marginal gap is of clinical significance because they facilitate plaque accumulation, which leads to gingival inflammation and ulceration of the inner wall of the gingival crevice.

In present study, vertical marginal accuracy was checked immediately after complete polymerization of the specimen by a direct technique at four different points. Vertical marginal accuracy checked using Stereomicroscope at 20X magnification. Then, after the statistical analysis following results were obtained, where initially each group was compared for the individual material (DPI, Protemp 4, Revotek LC, Tempsmart) one by one.Then compared the mean ΔE value of Group I 149.2500, Group II 105.0821, Group III 107.7471 and Group IV 123.1783. Then we have applied t-test, in order to see the difference in mean ΔE value between Group I, II, III, and IV. The difference was found to be statistically highly significant i.e. p-value was 0.002 ($p < 0.001$). From the above result we have inferred that Bis-GMA composite resin (Protemp-4) specimens in group II has the least vertical marginal discrepancy whereas these specimens in group I autopolymerized Polymethyl methacrylate (DPI) has greater vertical marginal discrepancy when compared amongst all the four groups. **Lepe et al**[12] attributed to greater polymerization shrinkage observed with PMMA acrylic resin (6% - 8%) as compared to Bis-GMA and UDMA composite resins (1-2%).[12] **Robinsons FB et al**[13] compared the effect of shrinkage of four brands of the temporary crown of self-cures resins i.e. (Scutan) epimine plastic; Snap and Trim PMMA, (Coldpac) poly methyl methacrylate and marginal fit of crowns made from them. They observed that marginal openings were mainly caused by the polymerization shrinkage of each material.

Naqash T et al[14] attributed to an increased polymerized shrinkage of UDMA composite resin as compared to Bis-GMA composite resin. Reasons are: 1) Polymerization shrinkage depends upon the degree of conversion of monomers during polymerization; the greater the degree of polymerization the greater the shrinkage. Bis-GMA has two aromatic rings in its molecule and low mobility characteristics that interfere with the degree of conversion. Aliphatic molecular chemistry gives UDMA greater mobility and flexibility than Bis-GMA; thereby, increasing the degree of conversion and subsequent greater polymerization shrinkage. 2) Polymerization shrinkage depends upon the molecular weight of the organic monomer; the lesser the molecular weight, the greater the shrinkage. UDMA has a molecular weight of 470g/mol as compared to Bis-GMA (512g/mol).[14]

Elagra M et al[15] reported that the Dual cure (TempSpan) showed the highest marginal gap formation among the self-cure (Trimplus) and composite (Success CD), at the same time no significant difference was found between the self-cure (Trimplus) and composite (Success CD) materials. They stated that, most of gap formation occurs during the auto-cure phase of polymerization of dual-cured materials. **Given J Edward et al**[16] evaluated the marginal accuracy of PEMA (Snap), Dualcure Bis-Acrylic (Luxatemp Solar), Auto-cure Bis-acrylic (Protemp Garant), Auto-cure Bis-acrylic (Integrity) using the direct technique. They observed that, dual cure bis-acrylic resin (Luxatemp Solar) exhibited the most significant discrepancy. This might suggest that the most of gap formation occurs during the auto-cure phase of polymerization of dual-cured materials.

Although all the materials and techniques used in this study may be clinically adequate, some are significantly more accurate than others.

Conclusion

Provisional restoration fabricated with Bis-GMA composite resin (Protemp-4) material using a direct technique recorded (105.0821) the maximum marginal accuracy followed by Light cure composite polymerized resin (Revotek LC) material. Autopolymerizing resin (DPI) provisional restoration exhibited the least marginal accuracy using a direct technique. The marginal fit obtained with the provisional restorations fabricated by Bis-GMA composite resin (Protemp-4) (105.0821) by a direct technique was better compared to light cure resin (Revotek LC) (107.7471), dual cure resin (Tempsmart) (123.1783), and autopolymerizing resin (DPI) (149.2500) respectively.

References

1. Stephen F. Rosenstiel, Martin F. Land. Contemporary Fixed Prosthodontics [Internet]. [cited 2022 Feb 12]. Available from: https://www.us.elsevierhealth.com/contemporary-fixed-prosthodontics-9780323080118.html
2. Shillingburg HT. Fundamentals of Fixed Prosthodontics. Quintessence Publishing Company; 1997. 600 p.
3. Federick DR. The provisional fixed partial denture. J Prosthet Dent. 1975 Nov;34(5):520–6.
4. Gratton DG, Aquilino SA. Interim restorations. Dent Clin North Am. 2004 Apr;48(2):487–97.
5. Burns DR, Beck DA, Nelson SK. 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 Nov;90(5):474–97.
6. Yasangi MK, Mannem D, Bommireddy VS, Neturi S, Ravoori S, Jyothi. Comparative Evaluation of Marginal Discrepancy in Tooth Colored Self Cure Acrylic Provisional Restorations With and Without Reinforcement of Glass Beads: An In-Vitro Study. J Clin Diagn Res JCDR. 2015 May;9(5):ZC98–101.
7. Kim SH, Watts DC. Polymerization shrinkage-strain kinetics of temporary crown and bridge materials. Dent Mater. 2004 Jan;20(1):88–95.

8. Al Rifaiy M. Evaluation of vertical marginal adaptation of provisional crowns by digital microscope. Niger J Clin Pract. 2016;0(0):0.
9. Amin B, Aras M, Chitre V. A comparative evaluation of the marginal accuracy of crowns fabricated from four commercially available provisional materials: An in vitrostudy. Contemp Clin Dent. 2015;6(2):161.
10. Nivedita S, Prithviraj D. A comparative study to evaluate the marginal accuracy of provisional restorations fabricated by light polymerized resin and autopolymerized resin: A scanning electron microscope study. J Indian Prosthodont Soc. 2006;6(3):122.
11. Rakhshan V. Marginal integrity of provisional resin restoration materials: A review of the literature. Saudi J Dent Res. 2015 Jan;6(1):33–40.
12. Lepe X, Bales DJ, Johnson GH. Retention of provisional crowns fabricated from two materials with the use of four temporary cements. J Prosthet Dent. 1999 Apr;81(4):469–75.
13. Robinson FB, Hovijitra S. Marginal fit of direct temporary crowns. J Prosthet Dent. 1982 Apr;47(4):390–2.
14. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Health and treatment of diabetes mellitus. *International Journal of Health Sciences*, *5*(1), i-v. https://doi.org/10.53730/ijhs.v5n1.2864
15. Naqash TA, Alfarsi M, Hussain MW. Marginal accuracy of provisional crowns using three material systems and two techniques: A scanning electron microscope study. Pak J Med Sci [Internet]. 2019 Jan 22 [cited 2022 Jan 31];35(1). Available from: http://www.pjms.org.pk/index.php/pjms/article/view/5
16. 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 Jul;11(03):330–4.
17. Givens EJ, Neiva G, Yaman P, Dennison JB. Marginal Adaptation and Color Stability of Four Provisional Materials: Fit and Color Stability of Provisional Materials. J Prosthodont. 2008 Feb;17(2):97–101.

Tables:

***Table I*:** Mean of vertical marginal discrepancy of all groups at four points (n=48)

Groups		**Vertical marginal discrepancy**			
		Buccal Surface (µmm)	**Lingual Surface (µmm)**	**Mesial Surface (µmm)**	**Distal Surface (µmm)**
Group I Polymethyl methacrylate (DPI	**Mean**	138.2033	138.2033	138.2033	138.2033
	Standard Deviation	40.70883	40.70883	40.70883	40.70883

Group II Bis – GMA composite resin (Protemp-4)	**Mean**	104.3333	104.3333	104.3333	104.3333
	Standard Deviation	19.56122	19.56122	19.56122	19.56122
Group III Light cured resin (Revotek LC)	**Mean**	107.3050	107.3050	107.3050	107.3050
	Standard Deviation	22.11987	22.11987	22.11987	22.11987
Group IV Dual cured resin (Tempsmart)	**Mean**	127.4850	127.4850	127.4850	127.4850
	Standard Deviation	25.32853	25.32853	25.32853	25.32853

***Table II*:** Individual Group overall mean of vertical marginal discrepancy (N = 48)

Groups	**vertical marginal discrepancy**	
	Mean	**Standard Deviation**
Group-I Polymethyl methacrylate (DPI)	149.2500	10.06524
Group-II Bis – GMA composite resin (Protemp-4)	105.0821	1.47935

Group-III Light cured resin (Revotek LC)	107.7471	1.88213
Group-IV Dual cured resin (Tempsmart)	123.1783	4.14195

Table III: Inter-group comparison of mean of vertical marginal discrepancy among the Group-I (DPI), Group-II (Protemp-4), Group-III (Revotek LC) and Group-IV (Tempsmart) (N = 48)

Groups	**Comparison group**	**Vertical marginal discrepancy**		
		Mean (Standard Deviation)	**Mean Std. Error**	**p value#**
Group-I Polymethyl methacrylate	**Group-II Bis – GMA composite resin**	44.16790 (8.94594)	4.47297	**0.002***
	Group-III Light cured resin	41.50290 (10.77801)	5.38900	**0.005***
	Group-IV Dual cured resin	26.07165 (12.88681)	6.44340	**0.027***
Group-II Bis – GMA composite resin	**Group-III Light cured resin**	-2.66500 (2.43302)	1.21651	0.116 (NS)
	Group-IV Dual cured resin	-18.09625 (5.24894)	2.62447	**0.006***
Group-III Light cured resin	**Group-IV Dual cured resin**	-15.43125 (5.49504)	2.74752	**0.011***
Total samples		48		

Figures:

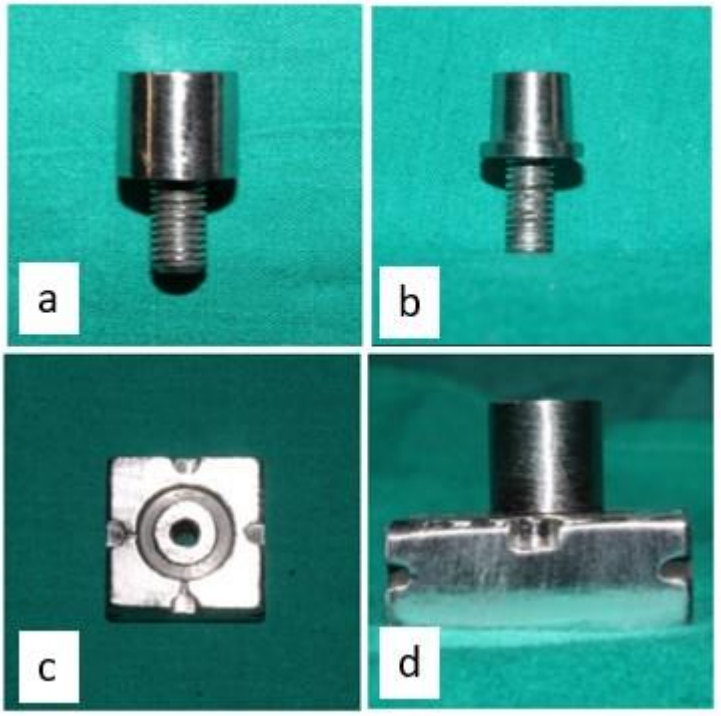

Fig.1: Master dies to simulating (a) unprepared die (b)prepared die (c) a common base and (d) unprepared die inserted in common stainless steel base.

Fig. 2: Thermoplastic sheet filled with provisional material and inserted in prepared die.

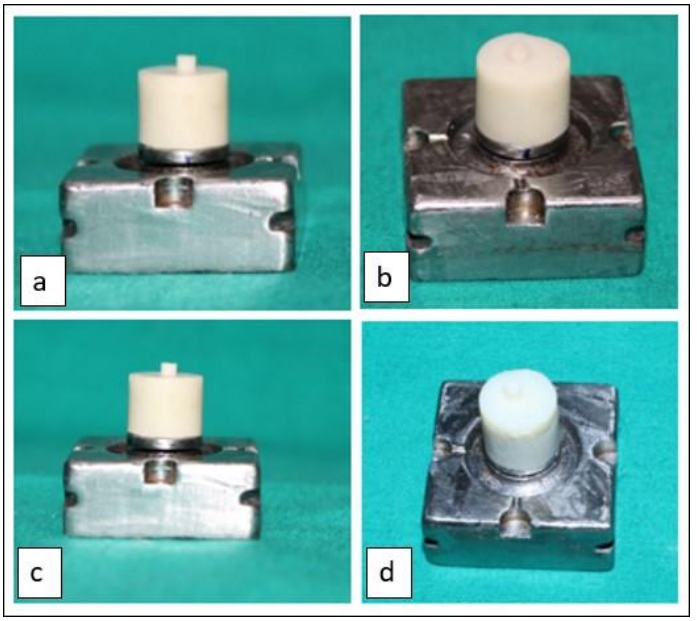

Fig.3: Fabrication of (a) PMMA (DPI), (b) Bis-GMA (PROTEMP-4), (c) Light cure resin (REVOTEK LC) and (d) Dual cure (TEMPSMART) provisional crown using a direct technique.

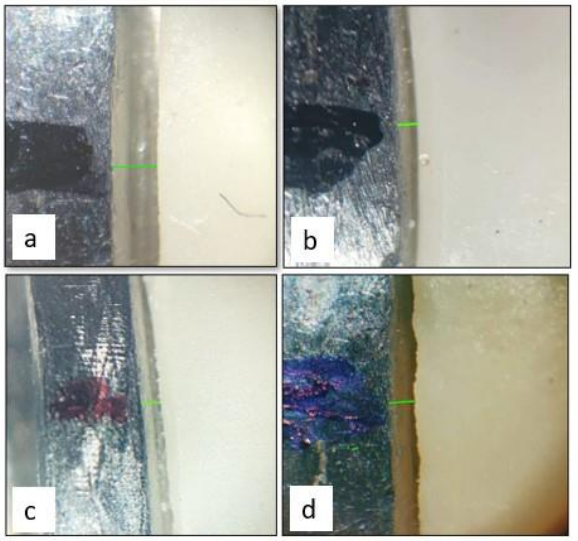

Fig.4: Vertical marginal discrepancy of (a) PMMA (DPI), (b) Bis-GMA (PROTEMP-4), (c) Light cure resin (REVOTEK LC) and (d) Dual cure (TEMPSMART) by indirect technique

Graph I: Inter-group comparison of mean of vertical marginal discrepancy among the Group-I (DPI), Group-II (Protemp-4), Group-III (Revotek LC) and Group-IV (Tempsmart)