In vitro evaluation and comparison of color stability, flexural strength and polymerization shrinkage using three provisional materials in crown and bridge

A Dissertation Submitted to the
Tamil Nadu Dr. M.G.R. Medical University
In partial fulfillment of the requirement for the degree of
MASTER OF DENTAL SURGERY
(BRANCH I - PROSTHODONTICS)

APRIL 2017

Endorsement
by the Head of the Department and Principal

This is to certify that the dissertation entitled
In vitro evaluation and comparison of
color stability, flexural strength and polymerisation shrinkage
using three provisional materials in crown and bridge
is a bonafide research work done by
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Declaration

I hereby declare
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is a bonafide and genuine research work carried out by me
at
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Acknowledgement

I am extremely thankful to ***Dr. P. Manimaran***, *MDS.*, Professor and Head of the Department, Department of Prosthodontics, J.K.K NATTRAJA Dental College and Hospital for his constant guidance, encouragement, and monitoring during this study. I also thank him for the valuable guidance he has given throughout my postgraduation.

My sincere thanks to ***Dr. A. Sivakumar***, *MDS.*, Professor, Dept of Oral and maxillo facial surgery, Principal, J.K.K NATTRAJA Dental College and Hospital, for his kind help, and permitting me to use the facilities in the institution.

I consider it my utmost privilege to express my sincere and heartful gratitude to my guide, ***Dr***. ***Chandrika Veera Reddy***, Associate professor Department of Prosthodontics, J.K.K NATTRAJA Dental College and Hospital for able guidance, support and for giving a final shape to this study

I am thankful to ***Dr.C. Dhinesh Kumar***, Reader, ***Dr.D. Sai Sadan***, Sr. Lecturer and ***Dr***. ***M***. ***Abirami***, Lecturer, Department of Prosthodontics for helping me at different stages of this study.

My sincere thanks goes to my juniors ***Dr. K.C. Gowthama Raaj, Dr. S. Preethi Suganya*** for their concern and support

I express my sincere thanks to ***Dr. B. Padhmanaban***, PhD., Professor and the Head of Department, Department of Metrology, Kongu Institute of Technology, Perundurai for allowing me to work with coordinate measuring machine (CMM) and universal testing machine- Instron in their permises.

I am thankful to ***Dr. Muthukumar***, PhD, professor, PSG Engineering college, Coimbatore for allowing me to work with UV Spectrophotoscopy in their permises.

I thank ***Dr. Kumaresan***, Phd., Principal, Minerva College, Mettur for helping me to carry out statistical analysis of the various test results.

I am highly indebted to my family and friends who have helped me in several ways during the course of the study.

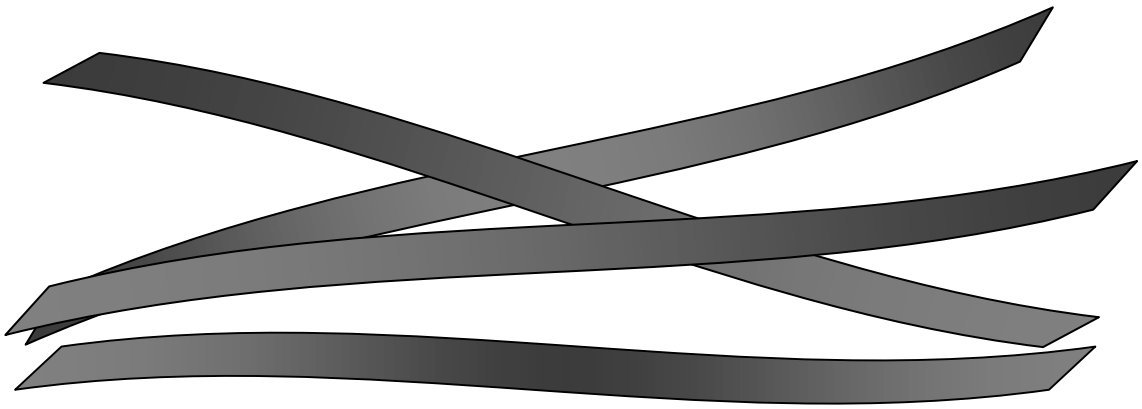
Contents

List of Figures

List of Tables

List of Graphs

Introduction



The significance of the provisional (treatment) restoration among the procedure required for successful completion of a fixed partial denture is often overlooked. Perhaps the inaccurate assignment of the term “temporary” to the interim restoration has generated the misconception that, eventual placement of the permanent restoration will immediately and miraculously remedy the detrimental effects of a poorly conceived and fabricated transitional restoration. The treatment with provisional restoration is an integral part of restorative treatment procedures with fixed prosthetic restoration i.e. crowns and bridges.[1]

Provisional has to fulfill important functions within the timeframe between preparation of a tooth and until fitting respectively luting of the final fixed metal or ceramic restoration. A well-made provisional fixed partial denture should provide a preview of the future prosthesis and enhance the health of the abutments and periodontium. The provisional restoration is often intended for diagnostic and therapeutic purposes, being a test structure where all the necessary functional, occlusal, and esthetic adjustments can be carried out to optimize incorporation of the definitive prosthesis. This is subsequently made on the basis of the information recorded from the provisional restoration, whose occlusal surface is made of resin and can be shaped and carved in accordance with the patient’s stomatognathic dynamics.[2]

Several studies revealed that provisionals with extended period in the oral cavity, which could be several months, is required to meet the above needs. Provisional restorations play an important role in restoring interim esthetics, provide pulpal protection by covering the prepared tooth structure, preserve occlusal and arch relationship, prevent migration of abutments, allow evaluation of vertical dimension, aid in developing and also evaluating occlusal scheme, provide comfort, function and maintain periodontal health, while the final

restoration is being made. They also help to gain patient's confidence and have favorable influence on the ultimate success of the final restoration.[3, 4]

A satisfactory temporary restoration can be made from auto polymerizing acrylic resin. However, the placement of polymerized acrylic resins on dentin and the gingiva may lead to thermal irritation from the exothermic polymerization reaction to the resin or chemical irritation from free or residual monomer.[5]

To combine reduced tissue toxicity and thermal irritation of the conventional resin systems with the ease of processing acrylic resins, new interim restorative materials that contains no methyl methacrylate has been introduced viz, Visible light cure resin, Bis-acrylic composite resins & visible and chemical cure (Dual cure) reins. The requirements for satisfactory provisional restorations differ only slightly from definitive crowns and fixed partial denture (FPDs). Nevertheless, the fabrication time should be short and the time of use be limited from a few weeks to 6 months.

Research on temporary restoration is almost never performed in vivo. Controlled prospective clinical trials on temporary crowns and FPDs do not exist in the dental literature. Provisional fixed partial dentures (FPDs) are an important part of many prosthodontics treatment procedures. These provisional fixed prostheses must fulfill biologic, mechanical, and esthetic requirements to be considered successful. Resistance to functional loads and removal forces are "mechanical factors" that must be considered when, choosing a provisional restorative material for clinical use. Consideration of all these factors and requirements are important because provisional resin restoration may be worn over a long period to assess the results of periodontal and endodontic therapies and also during the restorative phase of implant restorative and reconstructive procedures.

Investigators have studied factors that contribute to the mechanical requirements of provisional restorative materials. For instance, mechanical properties of provisional resin have been assessed and in these in vitro studies, valuable information has been presented regarding the strength of various materials. Because provisional restorative materials are subjected to masticatory forces, an understanding of the mechanical properties of these materials is important in determining whether the restoration will be able to survive repeated functional forces.[6]

Debra R. Haselton tested the flexural strength of 5 methacrylate based resins and 8 Bis-arylic provisional materials and showed Bis–acrylic materials exhibited higher flexural strength than the Methacrylate resins. In this study the author conclude that flexural strengths vary greatly among provisional materials due to difference in chemical composition.[4]

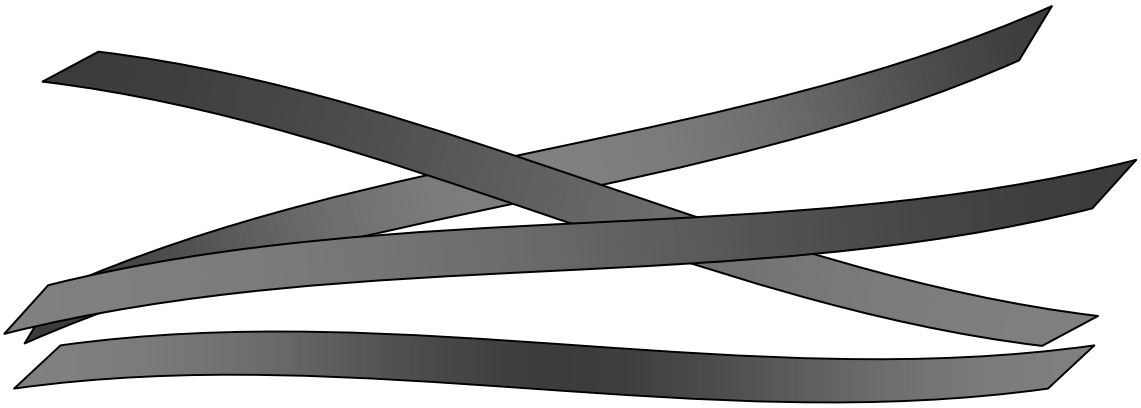
Research by Osman et al showed that 2 methyl methacrylate provisional materials had higher flexural strength than a composite material. No significant differences were found between methyl methacrylate and composite provisional materials tested by Wang et al. Farahnaz et al showed Bis-acrylic materials exhibited higher flexural strength than the methacrylate resins.

A number of studies have looked at the color stability of both Acrylic and Bis-acryl materials under a variety of conditions, such as cyclic immersion through staining solutions, as well as accelerated aging with ultraviolet (UV) light irradiation. Results from these studies suggest that the acrylic resin provisional materials tend to be more resistant to changes in color when subjected to staining through immersion in solution, whereas the Bis-acryl composite resins tend to be more resistant to discoloration when exposed to UV light irradiation.[7-9]

Polymerization shrinkage plays a major role in the fit of provisional restoration. Volumetric shrinkage was 6 % for polymethyl methacrylate and 1.0 % to 1.7 % for composites. Hence composites allows better marginal fit than polymethyl methacrylate because of less contraction due to polymerization. The characterization of the shrinkage behavior and the polymerization reaction itself are an important aspect in the development of new restorative materials.[10]

Many investigators have studied the mechanical properties of provisional materials. This study evaluated and compared the material properties such as color stability, flexural strength, and polymerization shrinkage using four different provisional materials such as Self cured polymethyl methacrylate, chemically cured Bis-acrylic, Light cured Urethane Dimethacrylate, and Multi cured Bisphenol-A-Diethoxy methacrylate based materials.

Objectives



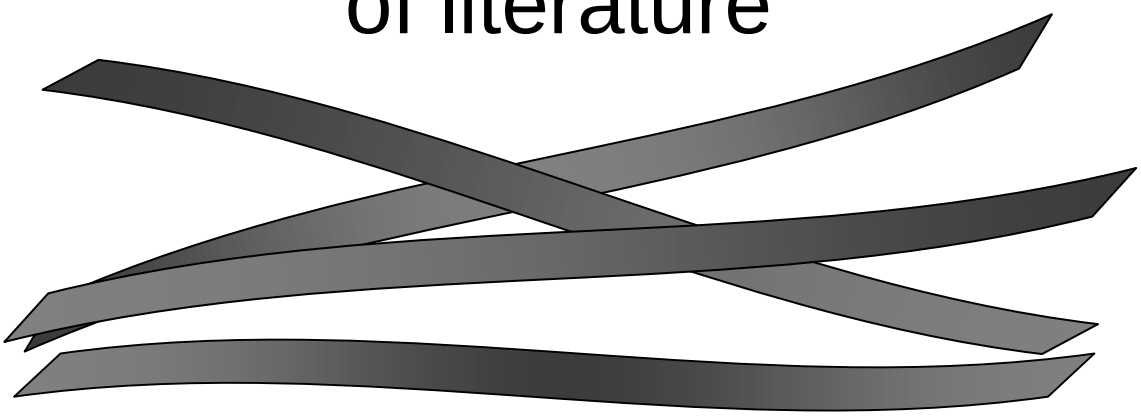
Aim

The purpose of the study is to compare and evaluate the color stability, flexural strength and polymerisation shrinkage on selfcure, light cure and multi cure provisional materials.

Objectives

- To choose a material that serve better as interim prosthetic material
- To compare the color stability, flexural strength and polymerisation shrinkage of the following three provisional material
    - Luxatemp
    - Revotek LC
    - Multicure Integrity

Review of literature



W. k. Adams[11] **(1970)** described the technique of fabrication of missing anterior teeth with temporary crown. The procedure included preparation of abutment teeth and with the help of crown forms the prepared teeth were restored with acrylic resin. The acrylic resin tooth with proper size and shade was selected and hold in position with wax over the incisal surface and joined the acrylic tooth with the abutment using acrylic powder and liquid, after it sets trimming and polishing was carried out and finally cemented with temporary material.

Alfred J. Sotera[12] **(1973)** this study evaluated the method of fabricating acrylic resin temporary crown using the omnivac V vaccum adapter. The author used acetate clear sheet which was softened using vaccum adapter that contained heating element and with the help of vaccum pump the softened acetate drawn over the stone cast. Once it was set the excess was trimmed which acted as a mask into which tooth colored acrylic resin was placed in thick consistency and it was seated over the prepared teeth. After two minutes the acetate form was removed and reseated for several times. Finally polishing was carried and cemented with temporary cement.

Bruce J. Crispin[13] **(1979)** here the author compared the color stability of materials used in fabrication of provisional restorations. He included 8 temporary materials in this study and 6 materials are labeled as shade 65, two materials trim and scutan were labeled as light and universal. Twenty disks were fabricated from each material totally 160 specimens were made with 26 mm in diameter using two silicone molds. The disks contained orientation nub so it was accurately repositioned in the testing apparatus. In 20 disks 10 were cured under normal atmospheric pressure and 10 were cured under pressure pot with 30 pounds per square inch. The materials were polished with pumice and placed into three staining solution that contains;

1) four tea bags and 100 mg of instant coffee to 1000 ml of distilled water; 2) 36 ounces of grapes concentrated to 1000 ml of distilled water and 3) distilled water used for comparison.

These solutions were stored under constant 37˚ C and color changes were measured using Gardner automatic color difference meter (CDM) the values were translated into a numerical scale 0 to 100 the lighter scores high and darker color scores lower. Experimental recordings were taken at 14, 30, and 60 days intervals. There was a statistically significant initial color difference in materials labeled shade 65. Rough materials darkened significantly more than polished materials. There was no statistically significant over all difference in the amount of staining between air cured and pressure cured samples. The methyl methacrylate materials demonstrated the least darkening followed closely by the ethyl-methyl methacrylate material.

Anthony G. Grguff and Pryor HG[14] **(1987)** the purpose of this study was to evaluate the fracture resistance of six provisional restoration materials polymerized at atmospheric pressure and in a pressure pot. It was found that the fracture resistance of the epimine and two PMMA>Composite>PEMA resins. Pressure curing, although reduced the internal porosity did not significantly increase the fracture toughness of the six resins.

Wang RL[15] **(1989)** the purpose of this study was to compare four acrylic resins and two composite resins for fabricating provisional fixed restorations. The comparative tests performed were; temperature change, surface hardness, transverse repair strength, surface roughness and polish ability, color stability and stain resistance. In comparing various provisional fixed restoration materials, no one material was superior to the others although some had advantageous properties in one or more of the tests.

Z. A. Khokhar[16] **(1991)** examined the color stability using indirect composite resin materials exposed to common dietary fluids and chemical agents commonly used for home oral hygiene. Four materials were used Dentacolor, VisioGem, Brilliant D. I, and Concept in which 26

specimens were made 6 × 2 mm diameter immersed in three solutions chlorhexidene, tea and coffee. The samples were rotated at 1 rpm in Tuccillo-Nielson apparatus was to exposure the selected fluid mediums. Color data were gathered using the Minolta Chroma Meter II Reflectance and analyzed by a Minolta Data Processor DP-100. The color measurements were taken at baseline, 6, 12, 24, and 48 hours. CIELAB system was used to measure the color changes. The result shown was Brilliant D.I. showed the most discoloration and Concept the least discoloration when exposed to commonly occurring oral fluids. Tea stains more than a coffee.

Abdul-haq suliman[17] **(1994)** Polymerization shrinkage of two posterior composite resin restorative materials was measured by dilatometry. The results were compared with a decrease in cavity width of MOD preparation in extracted premolar restored with the composite resins. A highly filled hybrid composite exhibited greater free shrinkage cuspal deformation than a hybrid composite with a lower filler content. Hydrated teeth exhibited less deformation than dehydrated teeth because of polymerization shrinkage. Greater cuspal deformations were measured with the technique than with interferometry because of differences in experimental design.

Anthony H. L. Tjan[18] **(1997)** In vitro study compared vertical discrepancies of margins for complete crowns made with six provisional materials. Six provisional materials were used in this study Provipont, Unifast LC, Triad VLC, Splintline, Protemp Garant and Jet in which the first three were photopolymerizing materials and another three were autopolymerizing materials. Five ivory maxillary molar teeth were prepared with 1 mm shoulder and 5 degree taper, before preparation index were made with silicone material. Direct technique was used to fabricate 60 provisional complete crowns 10 samples from each material. Measuring microscope was used to measure vertical marginal discrepancies at × 100. Data were analyzed with Kruskal-Wallis One-way analysis of variance and Mann-Whitney U tests (α=0.05).

Finally Interim crowns made with Splintline and Protemp Garant provisional restorative materials recorded the best marginal adaptation.

Pamela G. Dory[9] **(1997)** study was to measure the color changes of five acrylic resin and seven resin composite provisional materials when subjected to in vitro accelerated aging conditions. Five 10 × 2 mm diameter discs were made from these materials. Color was measured before and after aging were made on a reflection spectrophotometer (Color-Eye 7000; Mac- Beth Division, Kollmorgen Instruments, Newburgh, Nu) by CIE L*a*b* relative to standard illuminant A against a white background. Color change (ΔE*) was calculated and analyzed statistically. The acrylic resin provisional materials and the resin composite provisional materials changed color significantly and perceptibly when exposed to in vitro accelerated aging conditions.

Stavros A. Yannikakis[8] **(1998)** evaluated the effect of coffee and tea on the color stability of some materials used for the fabrication of tooth colored provisional restorations. Six provisional materials were used in which 1 heat-activated resin, 2 chemically activated methyl methacrylate resins, 1 chemically activated composite-based resin and 2 dual-curing resins. From each material thirty discs were made 7 mm in diameter and 2 mm thickness. Twenty specimens from each material was immersed in two staining solution coffee and tea, remaining ten specimens served as control stored in distilled water. Color changes were measured at time interval of 1, 7, and 30 days of immersion. Color measurements were obtained by using a Dr. Lange Micro Color tristimulus colorimeter and color differences (ΔE*) were estimated. The coffee solution exhibited more staining capacity than the tea solution. Provipont DC and Luxatemp Solar resins recorded the greatest ΔE* values when immersed in coffee and tea solutions. Jet, Caulk TBR, and SR-Ivocron PE resins displayed the best color stability over the 3 immersion periods and among all the solutions. Protemp Garant resin resulted in intermediate staining.

Hirobumi Uchida[19] **(1998)** evaluated the effect of shade selection on the potential degradation of color. 5 shades of composites were subjected to ultraviolet light exposure at 37° C for 24 hours after initial storage. The lightness and chromaticity of color were measured before and after ultraviolet light exposure with a Minolta chromameter. The total color change as well as changes in the lightness and chromacity values were measured in the CIE L*a*b* scale and analyzed to monitor scale degradation. It was concluded that lighter shades of composition were likely to be subjected to higher color degradation through environmental effects of ultraviolet light exposure.

Michele F. Ireland[6] **(1998)** recorded and compared the flexural elastic moduli of rupture of four materials used to make provisional restorations. Samples underwent a standard 3 point bend test on an Instron universal testing machine at a crosshead speed of 0.5 cm/minute. Stress strain curves were generated and the values for flexural elastic moduli and moduli of rupture were calculated. Provipoint DC resin exhibited the significantly highest elastic modulus and modulus of rupture values over time. Triad demonstrated the highest modulus of rupture except for the modulus of rupture demonstrated by provipoint resin at 24 hours. Triad also exhibited no differences in modulus of rupture among three test times.

Paolo Baldissara[20] **(1998)** evaluated the marginal microleakage of 4 provisional cements a cavity base compound used as a provisional cement and a zinc-phosphate cement to obtain data to choose the most suitable material for the needs of interim restorations. Thirty premolars were selected and 50-degree shoulder preparation was performed with a diamond bur. Vinyl-ethyl methacrylate (Trim, Harry Bosworth Company, Skokie, Ill.) provisional acrylic materials were used and crown was made which is placed on the prepared premolars using six groups of provisional cements. Axial load of 10 kg is applied and Specimens were thermocycled then submerged in a 5% basic fuchsin solution, then sectioned and observed under a light stereomicroscope. A 5-level scale was used to score dye penetration in the tooth/cement

interface. Microleakage existed in specimens where zinc-phosphate and cavity base compounds were used but it was lower than the other materials. A significant difference (P<.05) was found between zinc-phosphate and one eugenol-free cement and between cavity base and the same eugenol-free cement.

Robert J. Dubois[21] **(1999)** compared the effects of occlusal loading and thermocycling on changes in marginal gap of provisional crowns made with a lightpolymerized PMMA resin and those made from an autopolymerized PMMA resin. 16 crowns were made eight for lightpolymerized PMMA and eight for autopolymerized PMMA in a silicone mold which is taken from ivorine premolar teeth prepared with chamfer finish line. Low fusing metal dies were made for each sample from a polyvinyl siloxane material mold. Each crown were fused to the metal die with a tempbond cement. Marginal gaps were measured before and after thermocycling and occlusal loading. The marginal gap of light-polymerized material was significantly showed less changes when compared to autopolymerizing PMMA resin.

Xavier Lepe[22] **(1999)** evaluated the retentive properties of 2 provisional resin materials, 4 temporary cements, and 2 consistencies for 1 powder/liquid- type temporary cement. Recently extracted 40 molars were prepared and provisional crowns were constructed for each preparation with polymethyl methacrylate or Bis-acrylic composite and later cemented with Temp Bond, Temp-Bond NE, Temrex and an experimental calcium hydroxide temporary cement. A second group with Temrex was evaluated using half the recommended liquid. A cementing force of 2.5 kg for 5 minutes was used. After initial bench set followed by 24 hours in room temperature water, the crowns were removed with an Instron mechanical testing machine at 0.5 mm/min. A 2-factor ANOVA was used with a=.05 (n = 10). Mode of debonding was analyzed with a nonparametric chi-square test of association. Mean dislodgment stresses ranged from 670 to 1072 kPa for polymethyl methacrylate crowns and 554 to 884 kPa for those made of composite. Differences were nearly significant for the type of provisional material and

the cross-product interaction was not significant, whereas there were significant differences among the cements and the mode of debonding.

Ana M. Diaz-Arnold[23] **(1999)** evaluated the surface microhardness of contemporary provisional prosthodontic materials. 3 Bis-acryl resin composites and 2 methyl methacrylate type resins were included and 9 × 3 diameter acrylic plastic mold were used to make five specimens of each materials. Baseline Knoop Hardness (KHN) was measured 24 hours after specimen fabrication with a microhardness tester with a 10 gm indenter load Three microhardness measurements were obtained from each specimen. Knoop hardness was again recorded after 14 days of storage. ANOVA and Duncan's tests ($P<.05$) indicated a significant difference between the methyl methacrylate type resins and the Bis-acryl resin composites at both time intervals.

David S. Ehrenberg[24] **(2000)** compared the changes in marginal gaps and surface roughness of 3 autopolymerizing provisional resin crown materials after occlusal loading and thermal cycling. Four materials were used Alike, Jet, and Snap in which forty specimens (n = 10) were made. Specimens were first fabricated on a metal master die and fitted with and relined on the master die to standardize pretreatment marginal gap size and then the specimens were cemented to the master die with tempbond cement. Marginal gap measurement were taken after and before thermocycling and occlusal loading. Alike material shows less marginal gap when compared to Jet and Snap.

Ralph Gunnar Luthardt[25] **(2000)** compared the handling, fitting, plaque adherence, gingivitis, color stability and subjective assessment of the provisional materials by the patient and the dentist for two auto polymerizing (protemp, Luxatemp) 1 dual curing (provipoint) and one light initiated (triad–VLC) material for the manufacturing of temporary crowns and fixed

partial dentures. They found that the advantageous mechanical properties of the light curing and dual curing materials were clinically offset by disadvantages in handling.

Henry M. Young[5] **(2001)** evaluated the performance of Bis-acryl composite resin (Integrity) and PMMA resin (C & B and snap) when used by dental students to fabricate custom provisional crown restorations. 222 provisional crowns were fabricated by 17 senior dental students (Group A) and 77 second year dental students (Group B). Occlusion, contour, marginal adaptation, and finish were evaluated. The Bis-acryl composite resin material Integrity was statistically superior to the autopolymerizing PMMA resins.

Debra R Haseltonn[4] **(2002)** compared the flexural strength of 5 methacrylate –based resin and 8 Bis-acryl resins used to fabricate provisional crowns and fixed partial denture. It was concluded that within the limitations of the study, flexural strength were material than category-specific. Some, but not all, Bis-acryl resins demonstrated significantly superior Flexural strength over traditional methacrylate resins.

Wolfgang Buchalla[26] **(2002)** Studied and evaluated the color and translucency changes in a hybrid and microfilled composite after light exposure with and without water storage. Tristimulus values were determined calorimetrically and suggested that the resin restorative materials undergo measurable changes due to daylight exposure and the changes varied under the influence of water storage.

Karen A. Schulze[27] **(2003)** compared light-curing and chemically curing composites recommended for similar clinical applications from five manufacturers. Five chemically cured and light cured composite materials were selected and 8 × 5 mm discs embedded in epoxy resin. A Knoop diamond on a Micromet microhardness tester were used under a 500 g load to determine the microhardness of the surface of specimens. To determine the color stability 20 × 1 mm thickness, three discs for each materials were made and analysed the color $\Delta E^* = f$

((L*a*b)) with a spectrophotometer. After measuring the baseline for hardness and color the same specimens were exposed to a xenon arc light and water in a Weather-Ometer machine for a total radiant energy of 150 kJ/m2 and 122h. The microhardness and the color were again determined following the aging treatment. The composites showed significantly increased hardness and perceptible color changes after accelerated aging. The light-curing materials were significantly more color stable than the chemically-curing anterior materials.

David R. Burns[2] **(2003)** reviewed the topic of provisional fixed prosthodontics treatment involves a multifaceted array of clinical activities, special knowledge, material selection and management. Contemporary treatment incorporates both natural teeth and dental implants. This literature review provides a comprehensive summary of published reports on this topic. It characterized clinical method and provides clinicians with an understanding of the nature of materials used with this clinical activity. Dentistry continues to struggle with the limitations of existing materials available for fixed prosthodontic provisional treatment. Clinical techniques and indication are reasonably well characterized, but future research activities will need to focus on technological advancements to provide improved materials that demonstrate improved biocompatibility, ease of use and modification and physical properties.

Alessandro Vichi[28] **(2004)** conducted a study to test the influence of exposure to water on the color stability of three resin based composites .The samples were studied with a spectrophotometer equipped with an integrating sphere. For color determination, a 50% gray card was used as background and the datas were recorded. After the initial measurements the sample were stored for 30 days in a 60c water bath and then measured again under the same condition. The results showed that all the materials showed degree of discoloration due to aging in water. The authors concluded by saying that water acts as a discoloring agent to varying degrees for all the materials used.

Arthur S. K. Sham[7] **(2004)** evaluated the color stability of 5 autopolymerizing provisional restorative materials upon exposure to distilled water, coffee, or ultraviolet. 21 specimens were made from each materials with 20 ± 0.1 mm by 1 ± 0.05 mm diameter. Seven specimens of each materials were selected and immersed individually in distilled water, and coffee for 20 days or exposed to UV irradiation for 24 hours. Color was measured as CIE L*a*b* with a colorimeter before and after the immersion or UV exposure. Color change (ΔE) was calculated and data were analyzed with 1-way ANOVA and the Tukey multiple comparisons test (a=.05). Bis-acryl methacrylate based provisional materials exhibited significantly less color change than any of the methyl/ethyl methacrylate based provisional materials.

Ahmet Umut Guler[29] **(2005)** evaluated the stainability of auto- and light-polymerized resin provisional restorative materials, reinforced microfill and microhybrid resin composite restorative materials upon exposure to distilled water, coffee, coffee with sugar, tea, tea with sugar, red wine, coffee with artificial creamer and sugar, cola, or sour cherry juice. Forty-five cylindrical specimens (15 × 2 mm) were prepared for each of an autopolymerized Bis-acryl composite provisional restorative material, a light-polymerized composite provisional restorative material, reinforced microfill and a microhybrid composite restorative material, using a brass mold. The specimens were wet ground with 1000-grit silicon carbide abrasive paper for 10 seconds. The 5 restorative material specimens were divided into 9 groups (n = 5) and stored for 24 hours at 37˚C in different types of solutions: water, coffee, coffee with sugar, tea, tea with sugar, coffee with artificial creamer and sugar, cola, red wine, or sour cherry juice. Color of all specimens was measured before and after exposure with a colorimeter using CIE L*a*b* relative, and color changes were then calculated. The data were analyzed with a 2-way analysis of variance (ANOVA), and mean values were compared by the Tukey HSD test. The reinforced microfill material group demonstrated significantly less color change than the other materials tested.

Yong-Keun Lee[30] **(2005)** measured the correlation between color-difference values calculated with CIELAB and CIEDE 2000 formulas after polymerization and thermocycling of resin composites. Color measurements was made for each specimen before polymerization and after polymerization. Color was remeasured after polymerized samples were thermo cycled between 5° C and 55° C in distilled water for 3000 cycles with a dwell time of 15 seconds. Color was measured using a spectrophotometer and color difference by the CIELAB formula was calculated and color difference by the CIEDE 2000 formula calculated. It was found that there was significant correlation between color change values calculated by the two formulas after polymerization and thermocycling.

Debra R. Haselton[31] **(2005)** measured the color changes of twelve provisional prosthodontics material after immersion in a artificial saliva and artificial saliva-coffee solution for 1, 2, and 4 weeks. Twelve different materials consist of 5 polymethyl methacrylate and 7 Bis-acryl composite resin. Ten specimen of each materials are fabricated out of which five were stored in a artificial saliva and five in a solution of saliva and coffee. Color measurements were made using a calorimeter before immersion and after immersion at a time interval of 1, 2, and 4 weeks. It was found that all Bis-acryl composite resins exhibited significant color change after exposure to coffee solution.

Ahmet Umut Guler[3] **(2005)** conducted a study to investigate the effect of different polishing methods on color stability of 2 and 3-component autopolymerized Bis-acrylic composite and a methyl methacrylate based PR material upon exposure to staining agent. Specimens were divided into 6 groups and different polishing methods were used, including pumice, diamond polishing paste, polishing discs and combination of these. Unpolished specimens served as control. Colors of all the specimens were measured with a calorimeter before and after exposure and color changes were calculated; Authors concluded that methyl methacrylate based PR material was found to be more color stable than the autopolymerized and light polymerized

composites tested. The use of diamond polishing paste after polishing pumice significantly decreased the staining of Methyl methacrylate and Bis-acryl composites tested the highest color changes values were obtained in the groups polished with polishing discs, which were found to be significantly different compared to values obtained with other polishing techniques.

Markus Balenchola[32] **(2007)** conducted a study to investigate the flexural strength and flexural modulus of temporary crown and bridge materials at different storage times and to identify possible correlations between the mechanical properties and the degree of conversion. 4 proprietary di-methacrylate based t-c & bs were tested in a point bleeding test at various storage times after mixing (at 37c dry/water) including thermocycling (5000x5-55C) FS and FM were very low 10 min after mixing for all material tested. The mechanical properties significantly depend on the time after mixing. The DC does only partially reflect the mechanical stability of a t-c & b material. Hence DC does not allow drawing about the mechanical properties equally for all materials.

Z.F. Chen[33] **(2008)** described a technique for the fabrication of an immediate implant supported provisional restoration using a fractured natural tooth. The technique can be used with many implant systems and only simple materials and components are required.

Gabriela Queiroz de Melo Monteiroa[34] **(2011)** The purpose of this was to evaluate polymerization shrinkages of resin composites using a coordinate measuring machine, optical coherence tomography and a more widely known method, such as Archimedes principle. Two null hypothesis were tested; (1) there are no differences between the materials tested; (2) there are no differences between the methods used for polymerization shrinkage measurements.

Subbarayudu Gudapati[35] **(2014)** evaluated the effect of water absorption and thermocycling on marginal fit of new light cure resin provisional crown; to evaluate the effect of water absorption and thermocycling on the marginal accuracy of two commercially available provisional resin crowns; and to compare and evaluate the marginal fit and accuracy of new

light cure provisional crown with two commercially available provisional crown. 60 stone dies were prepared and they were divided into three groups 20 dies for each material to be tested. 3 provisional restorative materials involved in the study were cold cure acrylic resin, Protemp – II and Revotek LC. 10 samples from each group were subjected to thermocycling for 2500 cycles between 5°C and 55°C with a dwell time of 5 seconds in each water bath. The difference in marginal discrepancy at the 3 points on each surface before and after water absorption and thermocycling were evaluated using a traveling microscope. The marginal discrepancy was significantly different among the groups according to ANOVA F-test after thermocycling and water immersion respectively. The provisional restorative materials used in this study showed some marginal discrepancy before and after thermalcycling and water immersion, but GC Light cure acrylic resin had a better fit when compared to Cold Cure acrylic resin and Protemp – II provisional restorative materials before and after thermocycling and water immersion.

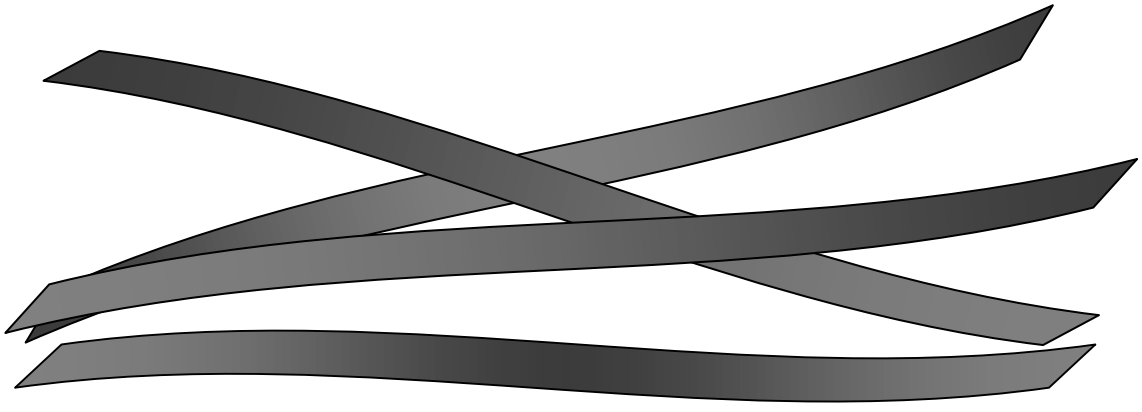
Vahid Rakhshan[36] **(2014)** summarized and compared their marginal fit in the light of the potential disrupting factors and the underlying mechanisms. It is a function of the chemical composition, setting method, and aging procedures. Interim materials include polymethyl methacrylate (PMMA), polyvinyl ethyl methacrylate (PVEMA), Bis-phenol A glycidyl methacrylate (Bis-GMA) composites, and Urethane Dimethacrylate (UDMA) composites. This review summarizes and compares their marginal fit in the light of the potential disrupting factors and the underlying mechanisms. All these materials fail in moderate- or long-term durations under oral stresses and water sorption, and should be rapidly replaced by permanent restorations before damaging teeth and adjacent tissues.

Georgios Georgakis[37] **(2014)** compared the accuracy of fit of three manufacturing methods under the test conditions in vitro and investigate the null hypothesis that there is no difference in the accuracy of fit of the three manufacturing methods under the test conditions in vitro. The accuracy of fit of provisional crowns made from isobutyl methacrylate acrylic resin with their margins refined with the 'bead on' or 'paint on' technique were compared with those made from Bis-GMA acryl resin composite relined with flowable composite and those produced using the implant abutment temporary coping. Data was analyzed with the Mann Whitney test. Reliability was determined using the Bland Altman test. Bis-GMA acryl resin composite relined with flowable composite produced significantly better fitting restorations compared to the two other groups.

Prashanthi S. Madhyastha[38] **(2014)** evaluates the effect of staining solutions and immersion time on color stability of silorane restorative material in comparison with its methacrylate counterpart. The colors of all specimens before and after storage in the solutions were measured by a reflectance spectrophotometer based on CIE Lab system and the color differences were calculated. Data were statistically analyzed by repeated measures of ANOVA and Sidak post hoc test; 't' test and one way ANOVA. Among the staining agents cocoa was found to be least staining followed by lime, yoghurt, coffee, tea whereas turmeric discolored the composites to the maximum.

José Vitor Quinelli MAZARO[39] **(2015)** evaluated the color stability of different temporary prosthetic restorative materials (Acrylic and Bis-acrylic resins) immersed in different solutions for different time intervals. 30 test specimens were fabricated, which were divided into three subgroups (n=10) with 15 mm in diameter and 2 mm thick. Color measurements were made before and after immersions, with use of a spectrophotometer, by means of the CIE L*a*b* system. The data were analyzed by the analysis of variance and the Tukey Test, at a level of significance of 5%

Methodology



The study consisted three main groups of provisional materials one self-cure Bisacrylic material (Luxatemp, DMG, Germany), one light cure Urethane Dimethacrylate material (Revotek^{TM} LC, GC corporation Tokyo, Japan), one Muticure Bisphenol-A- diethoxy methacrylate material (Integrity, Dentsply, USA), each of which was divided into three subgroups viz. subgroup A, subgroup B, subgroup C.

The influencing factors like color stability was tested on subgroup A, flexural strength on subgroup B, polymerization shrinkage on subgroup C.

Method of Fabrication of Specimens

The specimens described below were made with the help of metal mold and glass plate. The mold was placed on top of a glass plate, petroleum jelly was applied to the mold and onto the glass plate for easy separation of the specimen from the mold. The materials were mixed according to manufacturers recommendations and loaded into the mold and another glass plate was placed on top of the mold and gentle press was given for uniform flow of materials. After the material sets the specimens were grossly trimmed using tungsten carbide bur and then polished with sandpaper.

Color Stability (subgroup A)

Ten specimens from each of the four provisional materials (n=10×3) were made to the dimension of 20 × 2 mm disc as mentioned before.

The staining solution was prepared using coffee powder (Nescafe, New Delhi, India) in the following concentration. 2.8g of coffee was weighed in an electronic weighing machine and added to 150ml of boiling distilled water. To evaluate the color stability 10 specimens of each materials (n=10×3) were immersed in coffee solution at 37˚C. The color

measurement were made before immersion (the baseline measurement), 7 days and 10 days after immersion. The solution was changed every 24 hours. The specimen were rinsed with distilled water for five minutes and blotted dry with tissue paper before color measurement. The following equation was used to measure color stability;

$$\Delta E = (\Delta L^{*2} + a^{*2} + b^{*2})^{1/2}$$

Where ΔL^*, Δa^*, Δb^* are the differences in L^*, a^* and b* values before (T_0) and after immersion at each time interval (T_7, T_{10}). Where L^* represents brightness (value) of a shade, a^* represents the amount of red- green (hue) color and b^* represents the amount of yellow-blue (chroma) color.

Baseline measurement of all specimens were made using reflectance UV spectrophotoscopy with CIEL*a*b color system. The spectrophotoscopy automatically calculate the mean color measurement of 10 specimens of each material. This measurement was taken as the baseline measurement for the corresponding material to evaluate the color change after immersion in coffee solution. The mean and standard deviation estimated from the specimen for each materials were statistically analysed.

Flexural Strength (subgroup B)

Ten specimens from each provisional material (n = 10 × 3) were made with diameter of 25 × 2 × 2 mm as mentioned before.

After this the specimens were soaked in artificial saliva at 37˚ C for 10 days. Later all specimens were placed on top of the platform of the universal testing machine (INSTRON) to undergo three point bend test. A load of 10 KN load cell at a crosshead speed of 0.75 mm/min was applied. For rectangular specimens under a load in a 3 point bend setup

is $3FL/2bd^2$, where F is the load (force), L is the length of the support span, b is width of the sample, d is the thickness of the sample. The force of fracture was recorded in Newtons and calculated in MPa with the use of testing machine software. The mean and standard deviation estimated from the specimen for each materials were statistically analysed.

Polymerization Shrinkage (subgroup C)

Ten specimen from each provisional materials (n = 10 × 3) were made with diameter of 20 × 2 mm disc as mentioned before. Polymerization shrinkage of the fabricated specimen were measured with Coordinate Measuring Machine. A CMM is composed of four interconnected rigid parts, three mobile and one fixed base. A CMM with a fixed working table and a mobile bridge is the most common type. In this type of CMM, the object to be measured is placed on the fixed ceramic table and the operator dislocate each of the three mobile parts along the axis in the following sequence: the bridge (along the OX axis), the car (along the OY axis) and the probe column (along the OZ axis). Finally, a ruby probe touches a specific point on the object.

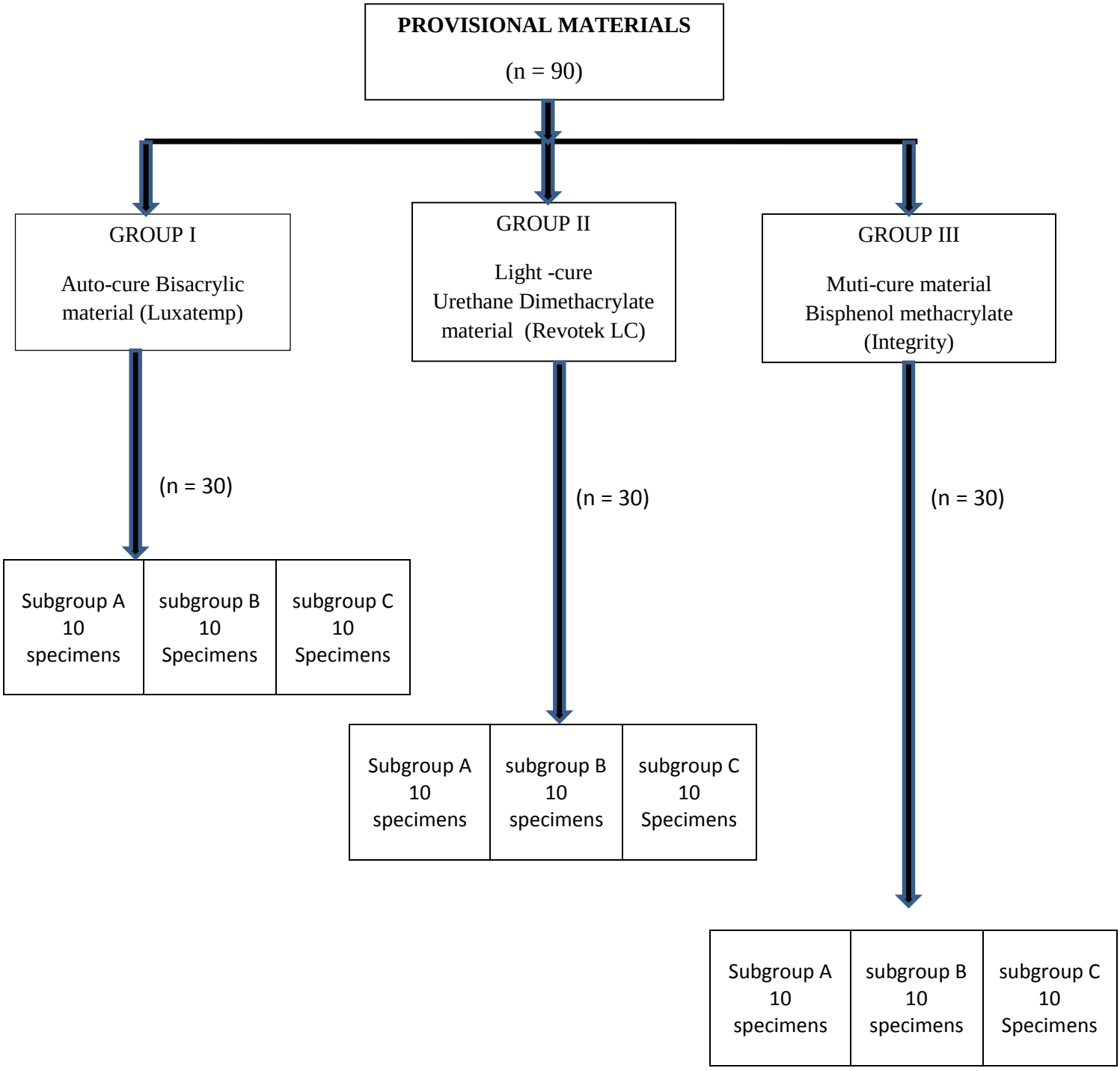
The specimen were placed on the platform of the tester. Four markings were made exactly at the centre between V shaped extensions of the specimens. The measurement were automatically calculated by the tester, where in the ruby tip of the instrument was made to touch the specimens at the four points which were marked earlier. The instrument after touching those points recognizes it to be a circle and diameter of the circle is displayed. The resulting data were mathematically processed in a computerized system to provide dimensional and geometrical measurements of the specimen with high precision. Specimens were tested 10 minutes, 20 minutes and 120 minutes after fabrication. Difference among group related to material and time were detected with statistical analysis

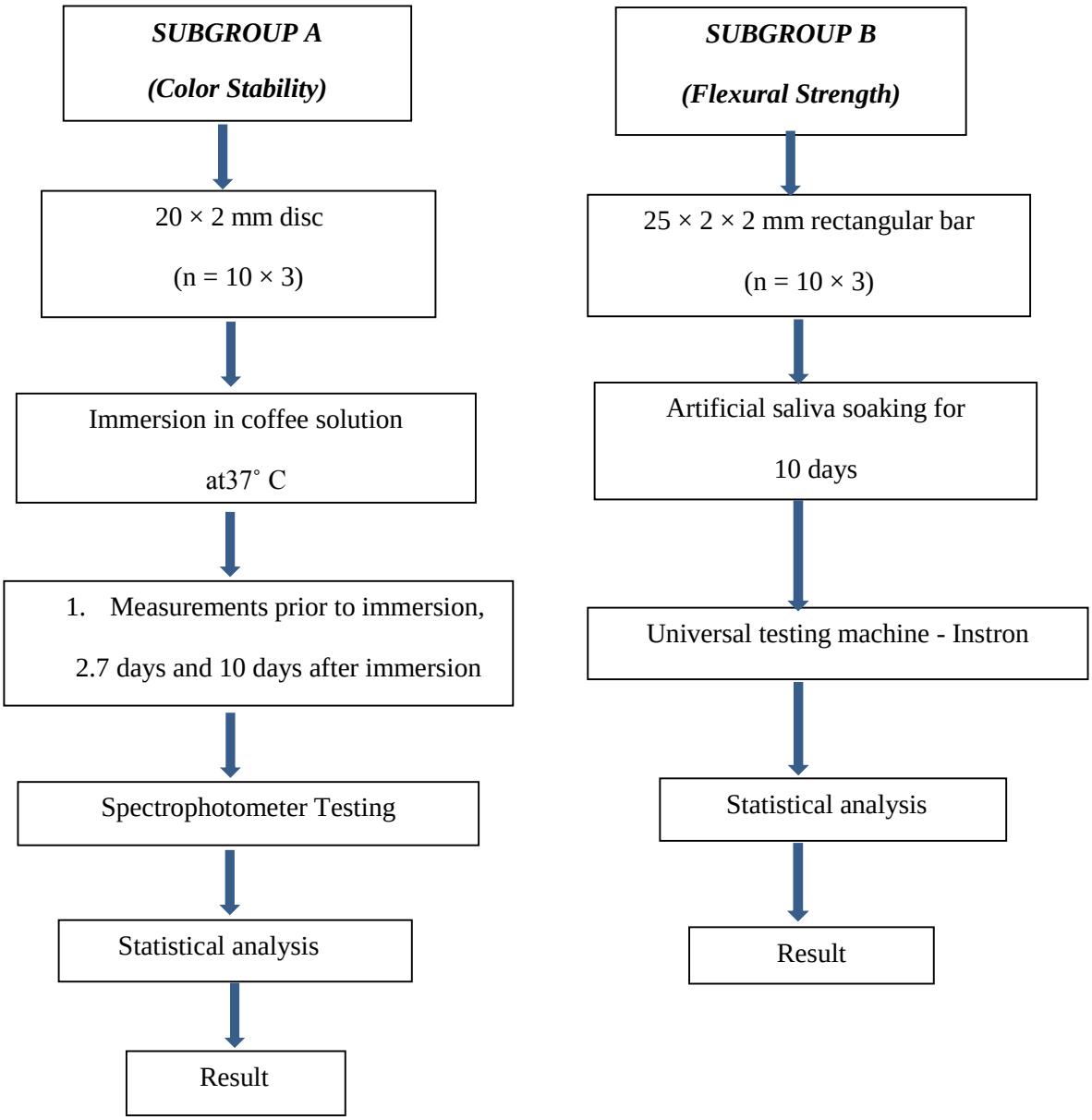
MATERIALS

1. Luxatemp fluoroscence (DMG, Hamburg, Germany) –chemically cured Bis-Acrylic based material.
2. Revotek lc (Revotek^{TM} LC, GC corporation Tokyo, Japan) –light cured Urethane Dimethacrylate resins (UDMA) based material.
3. Integrity multi-cure (Dentsply, USA) - muti cured Bisphenol - A – diethoxy methacrylate based material.
4. Laser cut stainless steel mold – 20 × 2 mm, 25 × 2 × 2 mm and 20 × 2 mm with V shaped open end.
5. Coffee powder (Nescafe, New Delhi, India)
6. Artificial saliva (Aqwet, Cipla)
7. Distilled water
8. Tungsten carbide bur
9. Glass plate

EQUIPMENTS

1. Universal testing machine – Instron (Deepak Poly Plast Pvt. Ltd. Ahmedabad, India)
2. Co-ordinate measuring machine (CMM) (Tesa micro-hite 3D, Germany)
3. UV Spectrophotoscopy (Agilent Technologies Cary 60 UV-Vis, Germany)
4. Curing unit (Delta, Blu Lux, India)


PROVISIONAL MATERIALS
(n = 90)
GROUP I
Auto-cure Bisacrylic material (Luxatemp)
GROUP II
Light -cure Urethane Dimethacrylate material (Revotek LC)
GROUP III
Muti-cure material Bisphenol methacrylate (Integrity)
(n = 30)
(n = 30)
(n = 30)
Subgroup A 10 specimens
subgroup B 10 Specimens
subgroup C 10 Specimens
Subgroup A 10 specimens
subgroup B 10 specimens
subgroup C 10 Specimens
Subgroup A 10 specimens
subgroup B 10 specimens
subgroup C 10 Specimens


SUBGROUP A
(Color Stability)
20 × 2 mm disc
(n = 10 × 3)
Immersion in coffee solution
at37˚ C
1. Measurements prior to immersion,
2.7 days and 10 days after immersion
Spectrophotometer Testing
Statistical analysis
Result
SUBGROUP B
(Flexural Strength)
25 × 2 × 2 mm rectangular bar
(n = 10 × 3)
Artificial saliva soaking for
10 days
Universal testing machine - Instron
Statistical analysis
Result

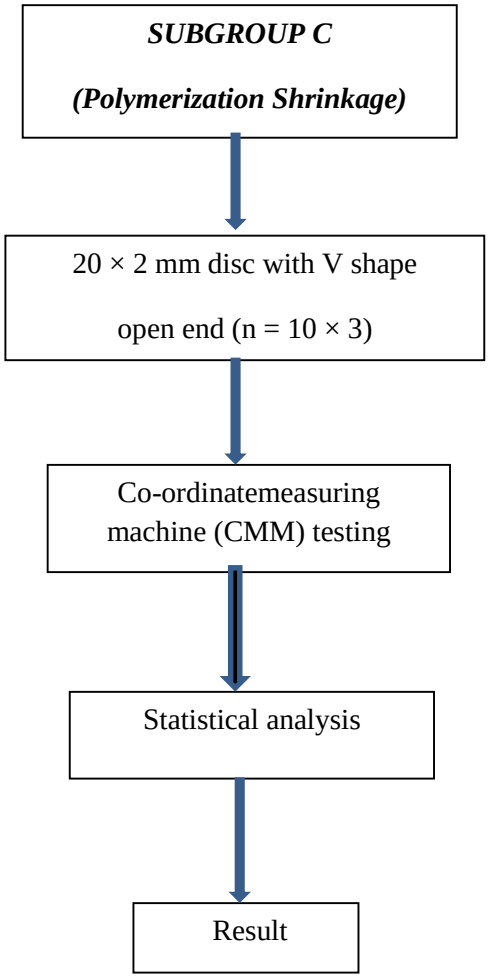

SUBGROUP C
(Polymerization Shrinkage)
20 × 2 mm disc with V shape
open end (n = 10 × 3)
Co-ordinatemeasuring
machine (CMM) testing
Statistical analysis
Result

Fig 1- Luxatemp Fluoroscence

Fig 2- Revotek Lc

Fig 3- Integrity Multi-Cure

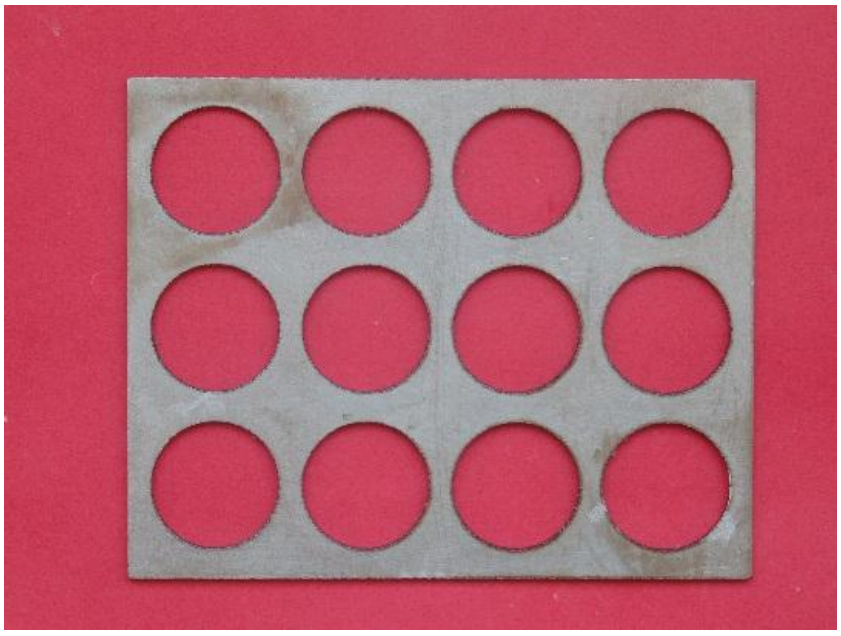


Fig 4- Stainless steel mold 20 × 2mm for color stability

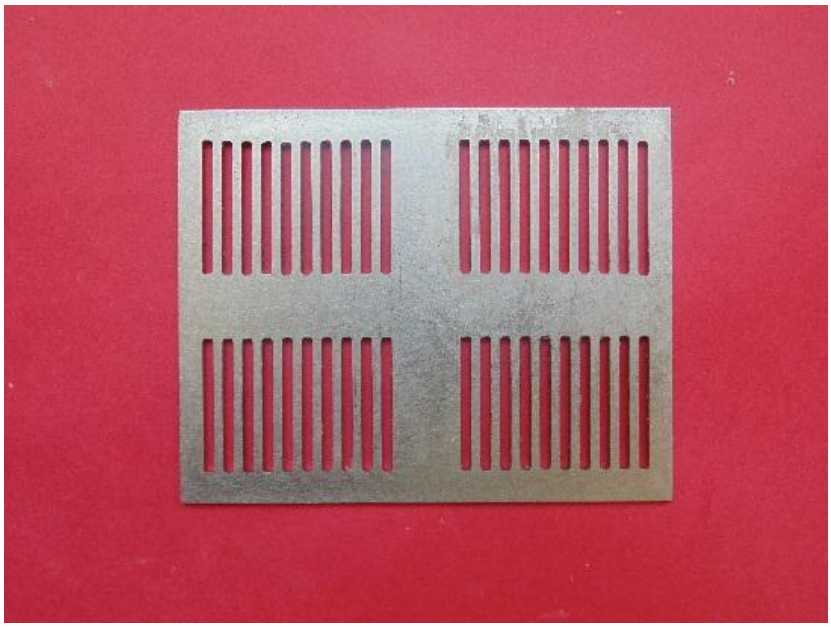


Fig 5- Stainless steel mold 25 × 2 × 2 mm for flexural strength

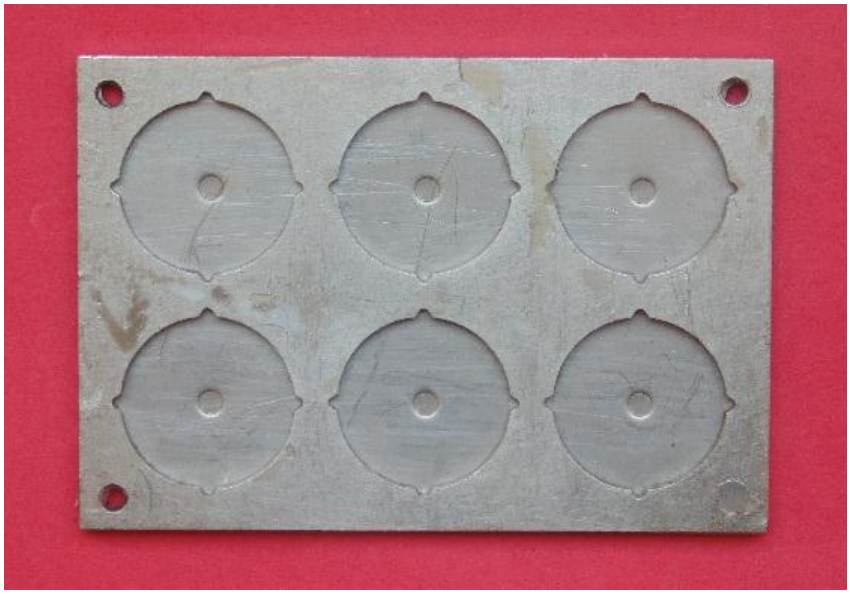


Fig 6- Stainless steel mold 20 × 2 mm with V shaped open end for shrinkage

Fig 7- Coffee powder

Fig 8- Artificial saliva

Fig 9- Distilled water

Fig 10- Glass plate

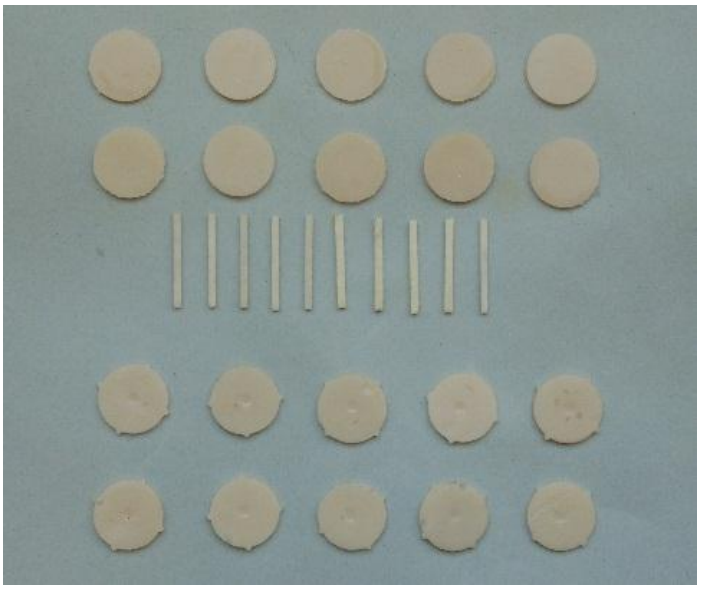


Fig 11- Luxatemp Fluroscence specimens

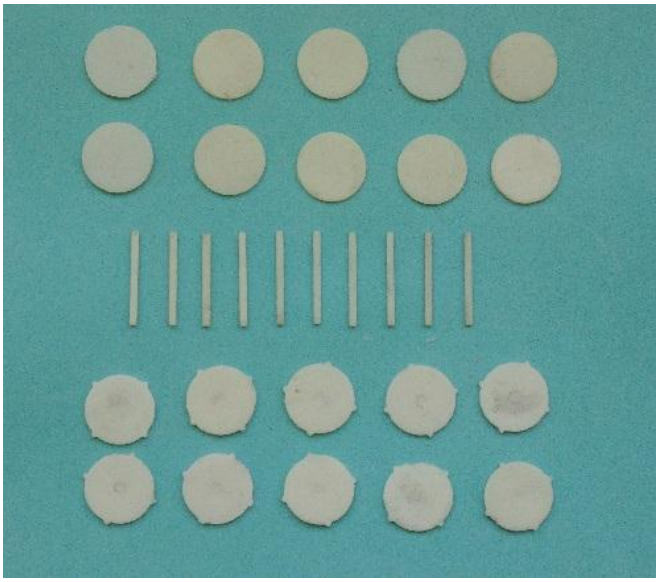


Fig 12- Revotek Lc Specimens

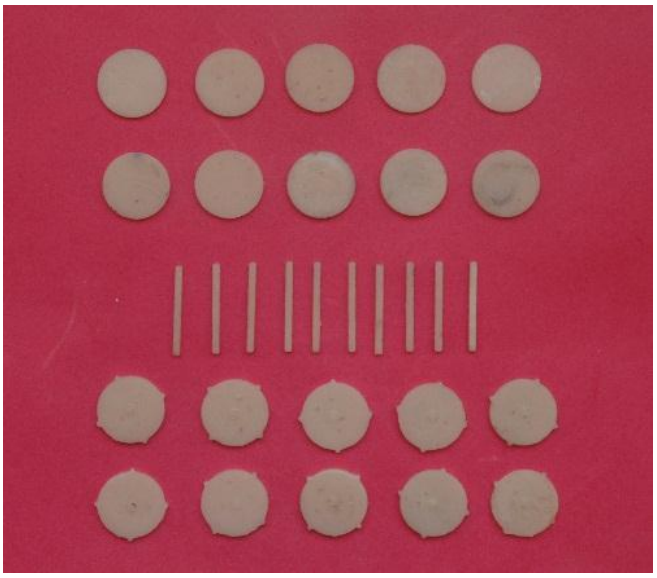


Fig 13- Integrity Multicure Specimens

Fig 14- Spectrophotometer unit

Fig 15- Sample evaluating unit

Fig 16- Universal testing machine – Instron

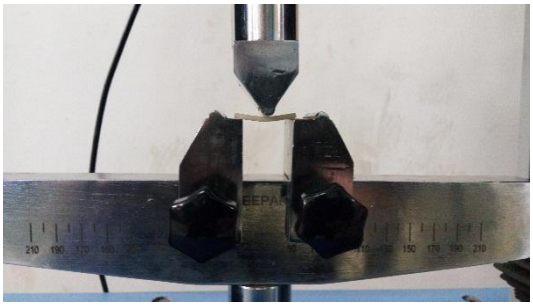


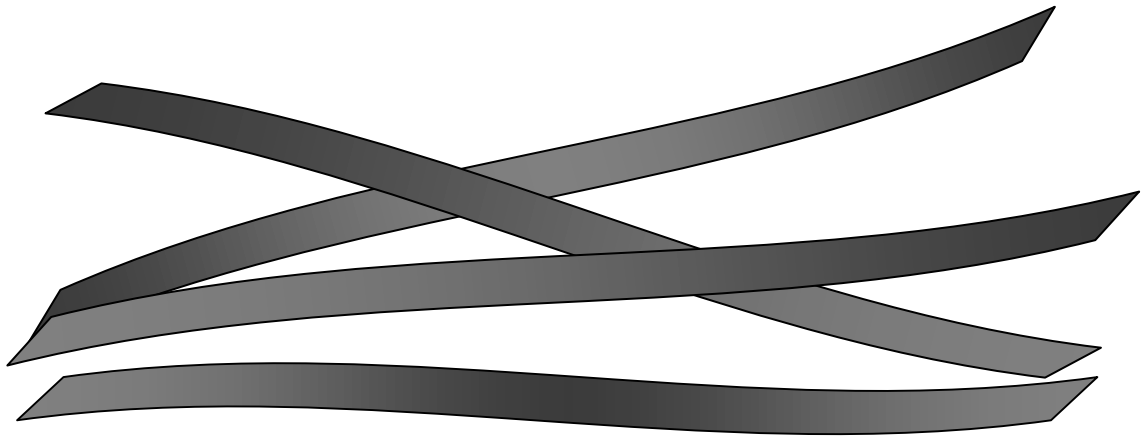
Fig 17- Specimen under flexural load

Fig 18- Co-ordinate measuring Machine (CMM)

Fig 19- X, Y, Z co-ordinates of Co-ordinate measuring machine

Fig 20- Curing unit

Results



Results of the present study are given in tables I to VII.

Table I to III present the color stability value of the specimens which were immersed in coffee solution. Table IV present the flexural strength values of the specimens which were soaked in artificial saliva. Table V to VII present the polymerisation shrinkage of the specimens which were tested 10 minutes, 20 minutes and 120 specimens after their fabrication. Table VIII to XIV present the detailed statistical analysis.

Graph 1, 2 and 3 represents colour stability, flexural strength and polymerisation shrinkage of all three provisional materials respectively.

Factorial Analysis of variance (ANOVA) was used to analyze the data statistically and also Turkey HSD method was also used to analyze the significant differences between the different provisional cements and immersion timing with respect to color stability, flexural strength and polymerisation shrinkage.

COLOUR STABILITY

Subgroup A of all 3 groups which consisted of 10 samples each were subjected to colour analysis using spectrophotometer immediately after sample fabrication. The same 30 samples were subjected to colour analysis after 7 days and 10 days. The readings were tabulated as follows:

Table- I (a): Color stability values of specimens prepared with Self cure Bisacrylic material (Luxatemp) - Base level

Samples	L	a	b	ΔE
1	9.42	-0.02	3.95	10.215
2	9.21	-0.04	3.61	9.892
3	9.47	-0.02	3.89	10.238
4	9.33	-0.01	3.73	10.048
5	9.42	-0.02	3.93	10.207
6	9.27	-0.04	3.91	10.061
7	9.39	-0.01	3.76	10.115
8	9.44	-0.02	3.96	10.237
9	9.20	-0.04	3.69	9.913
10	9.36	-0.02	3.77	10.091

Table- I (b): Color stability values of specimens prepared with Self cure Bisacrylic material (Luxatemp) - 7 days

Samples	L	a	b	ΔE
1	9.18	0.38	4.93	10.427
2	9.02	3.19	4.81	10.709
3	9.19	0.39	4.91	10.427
4	9.11	0.21	4.86	10.327
5	9.18	0.38	4.93	10.427
6	9.06	0.21	4.84	10.274
7	9.14	0.24	4.90	10.373
8	9.19	0.39	4.95	10.446
9	9.09	0.20	4.86	10.310
10	9.12	0.21	4.87	10.341

Table- I (c): Color stability values of specimens prepared with Self cure Bisacrylic material (Luxatemp) - 10 days

Samples	L	a	b	ΔE
1	8.11	0.92	5.57	9.881
2	8.07	0.79	5.23	9.649
3	8.12	0.93	5.59	9.902
4	8.09	0.83	5.36	9.740
5	8.11	0.91	5.55	9.869
6	8.10	0.89	5.53	9.848
7	8.08	0.86	5.51	9.818
8	8.12	0.92	5.57	9.890
9	8.06	0.80	5.39	9.729
10	8.14	0.86	5.41	9.812

Table- II (a): Color stability values of specimens prepared with Lightcure Urethane Dimethacrylate (Revotek LC) - Base level

Samples	L	a	b	ΔE
1	12.86	0.29	5.90	14.152
2	12.23	0.18	5.77	13.524
3	12.71	0.24	5.83	13.985
4	12.83	0.26	5.86	14.107
5	12.79	0.25	5.84	14.062
6	12.76	0.29	5.90	14.061
7	12.84	0.26	5.79	14.087
8	12.89	0.28	5.81	14.142
9	12.85	0.26	5.84	14.117
10	12.76	0.25	5.80	14.019

Table - II (b): Color stability values of specimens prepared with Lightcure Urethane Dimethacrylate (Revotek LC) – 7 days

Samples	L	a	b	ΔE
1	11.85	-0.86	3.76	12.462
2	11.77	-0.81	3.72	12.370
3	11.81	0.01	4.01	12.472
4	11.72	0.04	4.23	12.460
5	11.79	-0.74	3.91	12.443
6	11.83	-0.62	3.89	12.469
7	11.76	0.02	3.79	12.356
8	11.79	-0.62	3.99	12.462
9	11.80	-0.41	4.07	12.489
10	11.74	-0.39	4.12	12.448

Table - II (c): Color stability values of specimens prepared with Lightcure Urethane Dimethacrylate (Revotek LC) – 10 days

Samples	L	a	b	ΔE
1	11.42	-0.52	5.43	12.656
2	11.37	-0.46	5.59	12.678
3	11.31	-0.71	5.62	12.649
4	11.41	-0.78	5.41	12.652
5	11.39	-0.63	5.39	12.617
6	11.36	-0.51	5.54	12.649
7	11.39	-0.49	5.61	12.706
8	11.43	-0.50	5.80	12.827
9	11.34	-0.67	5.66	12.692
10	11.40	-0.54	5.45	12.647

Table - III (a): Color stability values of specimens prepared with Multicure Bisphenol Methacrylate (Integrity) – Base level

Samples	L	a	b	ΔE
1	8.60	-0.77	2.71	9.050
2	8.79	1.10	2.69	9.258
3	8.99	1.42	2.73	9.502
4	8.64	1.59	2.66	9.179
5	8.76	1.42	2.59	9.245
6	8.74	1.14	2.61	9.192
7	8.83	0.97	2.79	9.311
8	8.91	0.90	2.76	9.371
9	8.89	0.62	2.63	9.292
10	8.80	0.99	2.70	9.258

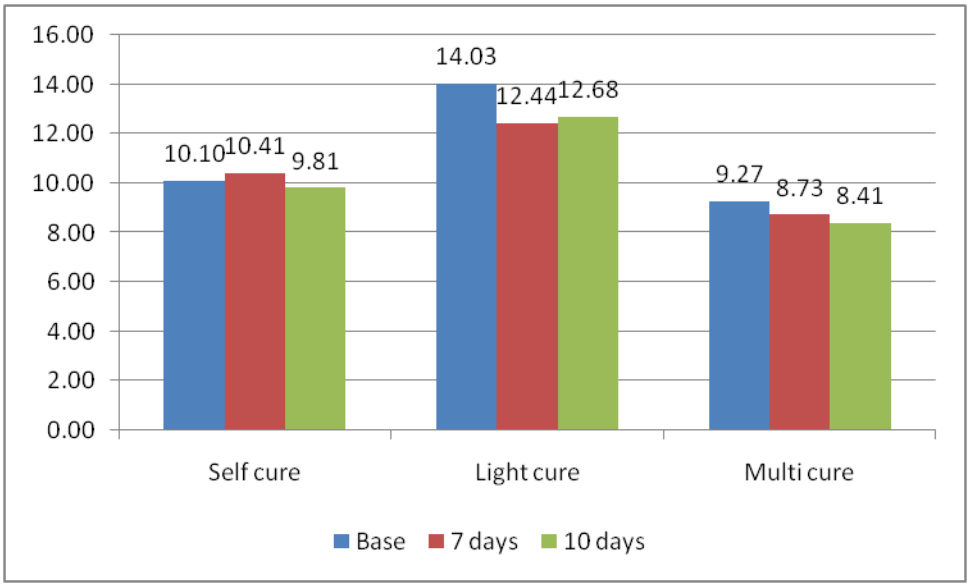
Table - III (b): Color stability values of specimens prepared with Multicure Bisphenol Methacrylate (Integrity) – 7 days

Samples	L	a	b	ΔE
1	7.70	0.41	4.07	8.719
2	7.62	0.66	4.11	8.683
3	7.66	0.71	4.01	8.675
4	7.61	0.69	4.19	8.715
5	7.69	0.79	4.24	8.817
6	7.64	0.49	4.16	8.713
7	7.71	0.64	4.12	8.765
8	7.74	0.67	4.21	8.836
9	7.63	0.59	4.09	8.677
10	7.66	0.54	4.13	8.719

Table - III (c): Color stability values of specimens prepared with Multicure Bisphenol Methacrylate (Integrity) – 10 days

Samples	L	a	b	ΔE
1	6.47	0.99	5.26	8.397
2	6.44	0.93	5.33	8.411
3	6.46	0.86	5.24	8.362
4	6.42	0.97	5.19	8.312
5	6.61	0.93	5.31	8.530
6	6.54	0.96	5.34	8.498
7	6.40	0.84	5.27	8.333
8	6.53	0.89	5.30	8.457
9	6.49	0.86	5.37	8.467
10	6.41	0.91	5.21	8.310

Graph 1 – Color stability of Self cure (Luxatemp), Lightcure (Revotek LC) and Multicure (Integrity) specimens



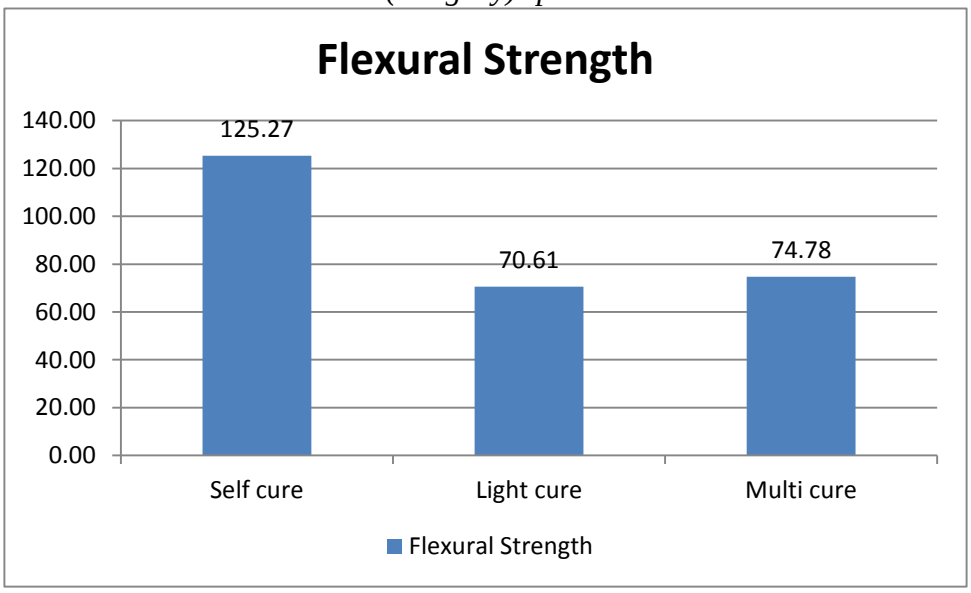
FLEXURAL STRENGTH

Subgroup B of all 3 groups which consisted of 10 samples each were subjected to flexural strength testing using universal testing machine. The readings were tabulated as follows:

Table- IV: Flexural strength values of specimens prepared with Self cure Bisacrylic material (Luxatemp), Lightcure Urethane dimethacrylate material (Revotek LC) and Multicure Bisphenol methacrylate (Integrity).

Subgroup B	Group I	Group II	Group III
Samples	Self cure	Light cure	Multi cure
1	110.95	76.23	70.01
2	122.32	71.99	69.87
3	117.17	69.13	75.67
4	121.95	70.94	77.96
5	137.09	71.01	78.20
6	127.62	68.23	77.96
7	129.99	67.14	71.87
8	127.31	69.97	74.23
9	131.86	71.01	78.12
10	126.44	70.42	73.87

Graph 2 – Flexural strength of Self cure (Luxatemp), Lightcure (Revotek LC) and Multicure (Integrity) specimens



POLYMERISATION SHRINKAGE

Subgroup C of all 3 groups which consisted of 10 samples each were subjected to evaluation of polymerization shrinkage using coordinate measuring machine. Readings were tabulated as follows:

Table- V: Polymerization shrinkage values of specimens prepared with Self cure Bisacrylic material (Luxatemp)

10 mins	20 mins	120 mins
19.814	19.764	19.701
19.834	19.783	19.724
19.846	19.799	19.747
19.871	19.805	19.776
19.863	19.800	19.773
19.827	19.771	19.713
19.859	19.799	19.753
19.809	19.757	19.709
19.834	19.779	19.748
19.854	19.783	19.717

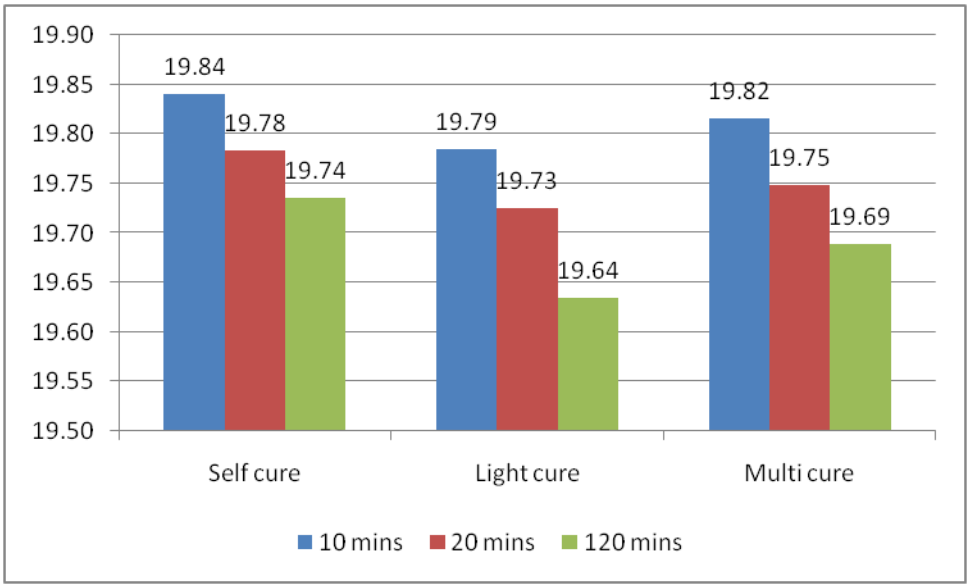
Table – VI: Polymerization shrinkage values of specimens prepared with Lightcure Urethane Dimethacrylate (Revotek LC)

10 mins	20 mins	120 mins
19.803	19.729	19.647
19.811	19.750	19.661
19.711	19.701	19.639
19.796	19.712	19.631
19.779	19.723	19.627
19.791	19.714	19.632
19.783	19.737	19.637
19.801	19.741	19.629
19.807	19.720	19.611
19.770	19.731	19.636

Table - VII: Polymerization shrinkage values of specimens prepared with Multicure Bisphenol Methacrylate (Integrity)

10 mins	20 mins	120 mins
19.806	19.740	19.683
19.799	19.700	19.667
19.813	19.752	19.691
19.811	19.743	19.689
19.832	19.759	19.693
19.824	19.762	19.697
19.819	19.743	19.681
19.821	19.766	19.699
19.821	19.766	19.698
19.817	19.753	19.690

Graph 3 – Polymerization shrinkage of Self cure (Luxatemp), Lightcure (Revotek LC) and Multicure (Integrity) specimens



STATISTICAL ANALYSIS

In this study the three different provisional materials and the three different methods of testing are used. The provision materials tested were Luxatemp, Revotek LC and Integrity. The different types of testing were color stability, flexural strength and polymerisation shrinkage.

The factors and their levels are tabulated below:

Table- VIII*: Factors considered in this study and the different levels*

Factor	Levels
Material	Luxatemp, Revotek LC and Integrity
Testing factors	Color stability, flexural strength and polymerisation shrinkage

Test Procedure:

Null Hypotheses:

$H_{0(a)}$: The interaction (joint effect) of various factors is not significant.

Alternate Hypotheses:

$H_{1(a)}$: The interaction (joint effect) of various factors is significant

Level of significance: α=0.05.

Decision Criterion: The p-values were compared with the level of significance. If P<0.05, the null hypothesis is rejected and alternate hypothesis is accepted. If P>0.05, the null hypothesis is accepted. If there is a significant difference, multiple comparisons (post hoc-test) were carried out using Bonferroni method to find out whether significant difference exists between the pairs or groups.

Statistical technique used: Factorial ANOVA

Analysis for Color Stability

Colour stability for Group I, Group II and Group III materials of Subgroup A were measured at baseline (that is before immersion in the coffee solution), 7th day and 10th day after immersion in the coffee solution. The readings were recorded. The mean, standard deviation and test of significance of mean values of the three materials at three different immersion days were tabulated and comparison was done within each group as well as between the groups.

GROUP I, II AND III

Paired t-test was used to calculate the p value.

Table - IX: Colour, Mean, Standard Deviation and Test of Significance of mean changes between Group I, II and III at baseline, 7th day and 10th day of testing

Days	Materials	Mean	Std. Deviation	Significance
Base	Selfcure	10.102	0.127	0.000 (Significance)
	Light cure	14.026	0.184	0.000 (Significance)
	Multi cure	9.266	0.120	0.000 (Significance)
7 days	Selfcure	10.406	0.122	0.000 (Significance)
	Light cure	12.443	0.044	0.000 (Significance)
	Multi cure	8.732	0.057	0.000 (Significance)
10 days	Selfcure	9.814	0.083	0.000 (Significance)
	Light cure	12.677	0.058	0.000 (Significance)
	Multi cure	8.408	0.079	0.000 (Significance)

Table reveals that the mean value of light cure (14.026) at baseline was greater than the mean values of selfcure and multi cure. Hence, it is concluded that the light cure is more stable than the other two materials.

According to the above table, the mean value of light cure (12.443) on 7th day was greater than the mean values of selfcure and multi cure. Hence, it is concluded that the light cure is more stable than the other two materials.

From the table, it is evinced that the mean value of light cure (12.677) on 10th day was greater than the mean values of selfcure and multi cure. Hence, it is concluded that the light cure is more stable than the other two materials.

Table - X: Post Hoc Tests for Multiple comparisons using Tukey HSD Method

Days	(I) group	(J) groups	Mean Difference (I-J)	Significance
Base	Self cure	Light cure	-3.923900*	0.000 (Significant)
		Multi cure	.835900*	0.000 (Significant)
	Light cure	Self cure	3.923900*	0.000 (Significant)
		Multi cure	4.759800*	0.000 (Significant)
	Multi cure	Self cure	-.835900*	0.000 (Significant)
		Light cure	-4.759800*	0.000 (Significant)
7 days	Self cure	Light cure	-2.037000*	0.000 (Significant)
		Multi cure	1.674200*	0.000 (Significant)
	Light cure	Self cure	2.037000*	0.000 (Significant)
		Multi cure	3.711200*	0.000 (Significant)
	Multi cure	Self cure	-1.674200*	0.000 (Significant)
		Light cure	-3.711200*	0.000 (Significant)
10 days	Self cure	Light cure	-2.863500*	0.000 (Significant)
		Multi cure	1.406100*	0.000 (Significant)
	Light cure	Self cure	2.863500*	0.000 (Significant)
		Multi cure	4.269600*	0.000 (Significant)
	Multi cure	Self cure	-1.406100*	0.000 (Significant)
		Light cure	-4.269600*	0.000 (Significant)

* The mean difference is significant at the 0.05 level.

It is observed from the above table that at the baseline measurement, there has been a significant between self cure, light cure and multi cure materials at $p < 0.01$.

The above table proclaims that the difference between self cure, light cure and multi cure with reference to colour stability on the 7^{th} day has been found to be statistically significant at $p < 0.01$.

The difference between self cure, light cure and multi cure materials on the 10^{th} day is proved to be statistically significant as indicated by the p value which is less than 0.01.

The provisional restorative materials and immersion in coffee solution at baseline, 7 days, 10 days significantly affected the color stability at each immersion period which is shown by Two- way ANOVA abd the interaction of these factors were found to be statistically significant ($p < 0.05$) at each immersion time.

At baseline, 7 days, 10 days, the Post- Hoc analysis represented that REVOTEK- LC exhibited higher ΔE values.

Analysis For Flexural Strength

In this study the flexural strength values of provisional composite restorative materials were calculated at 10 days after immersing in artificial saliva using a Universal testing machine. The mean, standard deviation and test of significance mean values of the three materials were tabulated and comparison was done within each group as well as between the groups.

Table – XI: Mean, Standard Deviation and Test of Significance of mean changes between Group I, II and III.

Materials	Mean	Std. Deviation	Significance
Self cure	125.270	7.505	0.000 (Significant)
Light cure	70.607	2.455	0.000 (Significant)
Multi cure	74.776	3.339	0.000 (Significant)

Using paired t test, there is a significant difference among the specimens at $p < 0.01$.

Group I Self cure Luxatemp The mean and standard deviation is 125.270±7.505 which is statistically significant at $p < 0.01$.

Group II Light cure Revotek LC The mean and standard deviation is 70.607±2.455 which is statistically significant at $p < 0.01$.

Group III Multi cure Integrity The mean and standard deviation is 74.776±3.339 which is statistically significant at $p < 0.01$.

Table - XII: Post Hoc Tests for Multiple comparisons using Tukey Hsd Method

(I) group	(J) groups	Mean Difference (I-J)	Sig.
Self cure	Light cure	54.663*	0.000 (Significant)
	Multi cure	50.494*	0.000 (Significant)
Light cure	Self cure	-54.663*	0.000 (Significant)
	Multi cure	-4.169	0.163 (Not Significant)
Multi cure	Self cure	-50.494*	0.000 (Significant)
	Light cure	0.935	0.163 (Not Significant)

*The mean difference is significant at 0.05 level.

Using Post Hoc test multiple comparison Tukey HSD method, it is found that there is a significant difference between self cure, light cure and multi cure materials at $p < 0.01$.

Group I – Multiple comparisons of flexural strength were made. Self cure has showed statistically significant difference in values from Light cure and Multi cure at $p < 0.01$.

Group II – Multiple comparisons of flexural strength were made. Light cure has showed statistically difference in values from Self cure at $p < 0.01$ whereas there has no statistically significant difference between light cure and multi cure at $p < 0.05$.

Group III – Multiple comparisons of flexural strength were made. Multi cure has showed statistically difference in values from Self cure at $p < 0.01$ whereas there has no statistically significant difference between Multi cure and light cure at $p < 0.05$.

The mean difference between three groups showed statistically significant differences. On the 10^{th} day after immersion, self cure showed greater flexural strength than multi cure which in turn is found to be lesser than the flexural strength values of light cure. Thus Self cure shows greater flexural strength values.

Analysis for Polymerization shrinkage

In this study the Polymerization shrinkage change of provisional composite restorative material was compared at 10, 20 and 120 minutes after sample preparation using a Coordinate measuring machine.

The mean, standard deviation and test of significance of mean values of the three materials were tabulated and comparison was done within each group as well as between groups.

Table – XIII: ANOVA between 10 mins, 20 mins and 120 mins of Self cure

Source of Variation	***SS***	***DF***	***MS***	***F***	***P-value***	***F crit***
Rows	0.0115	9	0.0013	15.7969	0.0000	2.4563
Columns	0.0553	2	0.0276	342.2597	0.0000	3.5546
Residual	0.0015	18	0.0001			
Total	**0.0682**	**29**				

Since the F value between rows (15.7969) is greater than the critical value (2.4563), the null hypothesis is rejected and it is concluded that there is a significant difference between rows. Similarly since the F value between columns (342.2597) is greater than the critical value (3.5546), it also falls in the rejection region and the null hypothesis is rejected. It is concluded that there is a significant difference between columns.

Table - XIV: ANOVA between 10 mins, 20 mins and 120 mins of Light cure

Source of Variation	***SS***	***DF***	***MS***	***F***	***P-value***	***F crit***
Rows	0.0057	9	0.0006	2.1188	0.0837	2.4563
Columns	0.1144	2	0.0572	190.3209	0.0000	3.5546
Residual	0.0054	18	0.0003			
Total	**0.1256**	**29**				

Since the F value between rows (2.1188) is lesser than the critical value (2.4563), the null hypothesis is accepted and it is concluded that there is no significant difference between rows. However, since the F value between columns (190.3209) is greater than the critical value (3.5546), it also falls in the rejection region and the null hypothesis is rejected. It is concluded that there is a significant difference between columns.

Table - XV: ANOVA between 10 mins, 20 mins and 120 mins of Multi cure

Source of Variation	***SS***	***DF***	***MS***	***F***	***P-value***	***F crit***
Rows	0.0041	9	0.0005	8.6906	0.0001	2.4563
Columns	0.0814	2	0.0407	771.7163	0.0000	3.5546
Residual	0.0009	18	0.0001			
Total	**0.0865**	**29**				

Since the F value between rows (8.6906) is greater than the critical value (2.4563), the null hypothesis is rejected and it is concluded that there is a significant difference between rows. Similarly since the F value between columns (771.7163) is greater than the critical value (3.5546), it also falls in the rejection region and the null hypothesis is rejected. It is concluded that there is a significant difference between columns.

Table - XVI: Post Hoc Tests For Multiple Comparisons by Tukey HSD Method

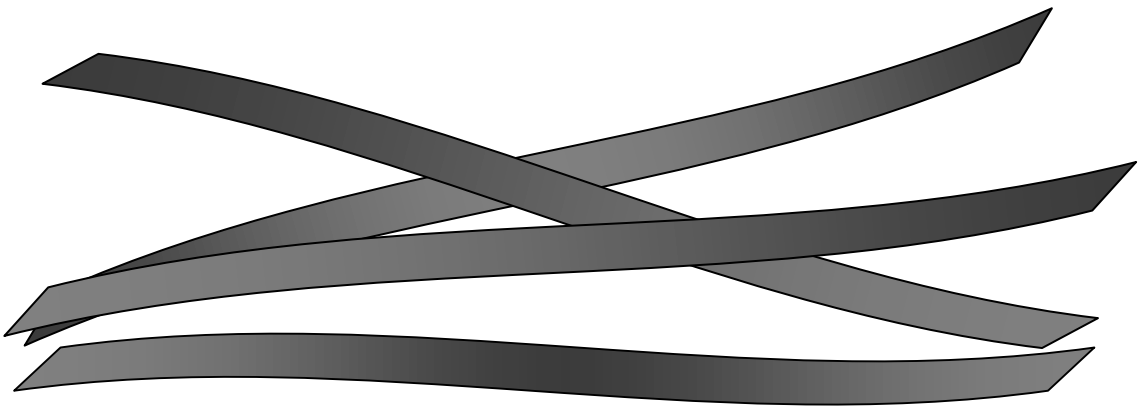
Minutes	(I) group	(J) groups	Mean Difference (I-J)	Significance
10 minutes	Self cure	Light cure	.055900*	0.000 (Significant)
		Multi cure	.024800*	0.039 (Significant)
	Light cure	Self cure	-.055900*	0.000 (Significant)
		Multi cure	-.031100*	0.008 (Significant)
	Multi cure	Self cure	-.024800*	0.039 (Significant)
		Light cure	.031100*	0.008 (Significant)
20 minutes	Self cure	Light cure	.058200*	0.000 (Significant)
		Multi cure	.035600*	0.000 (Significant)
	Light cure	Self cure	-.058200*	0.000 (Significant)
		Multi cure	-.022600*	0.017 (Significant)
	Multi cure	Self cure	-.035600*	0.000 (Significant)
		Light cure	.022600*	0.017 (Significant)
120 minutes	Self cure	Light cure	.101100*	0.000 (Significant)
		Multi cure	.047300*	0.000 (Significant)
	Light cure	Self cure	-.101100*	0.000 (Significant)
		Multi cure	-.053800*	0.000 (Significant)
	Multi cure	Self cure	-.047300*	0.000 (Significant)
		Light cure	.053800*	0.0 ignificant)

*The mean difference is significant at 0.05 level

Results of the present study can be summarized as follows:

- Revotek LC proved to be highly color stable than Luxatemp followed by Integrity.
- Luxatemp showed more flexural strength than Integrity and followed by Revotek LC.
- Luxatemp exhibited lesser values for polymerisation shrinkage than Integrity and subsequently the higher values for Revotek LC.
- Highest flexural strength (125.27 Mpa) and lowest polymerisation shrinkage values were shown by Luxatemp (19.74) and lowest flexural strength (70.61 Mpa) and highest polymerisation shrinkage (19.64) were shown by Revotek LC.
- Highest color stability was evident for Revotek LC (12.68) and least color stability was apparent for Integrity (8.41).
- Statistical significant results were discernible for Luxatemp, Revotek LC and Integrity in case of color statbility and polymerization shrinkage and no statistically significant differences were noticeable among Luxatemp, Revotek LC and Integrity in terms of flexural strength.

Discussion



Color stability is critical for the esthetics of long-term provisional restorations and has been previously studied in vitro for a variety of provisional restorative materials.[3] Provisional crown materials undergo color changes when exposed to various environmental conditions. This study evaluated the color change that occurred when three provisional resins were subjected to immersion in coffee solution and the measurement was made at baseline, 7 days and 10 days after immersion. In the present study reflectance UV spectrophotoscopy was used using CIE lab system.[40]

The two most advanced color measurement instrument types are colorimeters and spectrophotometers, both of which use sophisticated technologies to accurately and precisely quantify and define color. While colorimeters can produce highly accurate color measurements, they also have several shortcomings; they are or color stability values. As such, spectrophotometers are capable of measuring metamerism, identifying colorant strength, analyzing a comprehensive range of sample types. Ruyter et al suggested ($\Delta E \geq 3.3$) as the acceptable upper limit of color stability[41] and this value is taken as acceptable in this study.

After immersion in the coffee solution the Revotek LC showed significantly less color change compared to Luxatemp and Integrity. The discoloration by coffee might be due to both surface adsorption and absorption of colorants. Fine coffee particles may have deposited into the pits of the resin which are formed due to polymerisation shrinkage. After 7 days and 10 days of immersion in coffee all three provisional materials showed change in color in which ΔE showed a change at a statistically significant level. Paired ‘t’ test proved that intensity of color increased with the increase in immersion period of 10 days from baseline. This finding

closely matches with the studies done by Koumjian et al for the discoloration effect of coffee on selfcure and multicure materials.[42]

Paired t test proved that intensity of color increased with the increase in immersion period of 10 days from baseline. These results are in accordance with the previous studies documented.[3, 40-42]

As a second factor in this study, flexural strength of three provisional crown materials subjected to immersion in artificial saliva for 10 days were evaluated by using universal testing machine, Instron.[4] Flexural strength mimics the combined effect of tensile and compressive forces which signifies the strength of material under static load.[43] The tested results in the study may not correlate the conditions of mouth but serve the comparison of materials in a controlled situation. The obtained values may help the clinician in selection of provisional restorative materials according the needs of esthetics or function as the situation demands.

The flexural test method measures behaviour of materials subjected to simple beam loading. Flexure testing is often done on relatively flexible materials such as polymers, wood and composites.[10]There are two types of tests, 3-point flex and 4-point flex. In 3-point test the area of uniform stress is quite small and concentrated under loading points.[6] In a 4-point test the area of uniform stress exists between the inner span loading points. In a bending test, the highest stress is reached on the surface of the sample. This study underwent a 3 point bending test with rectangular specimen.

The flexural strength of provisional materials may be influenced by saliva, food components, beverages and interactions among these materials. The changes that occur to a material when subjected to various temperature regulations should be assessed when the

material is used in the long run. Immersion in artificial saliva is one such process which causes decrease in strength of the material and simulates changes in oral environment. Luxatemp showed highest flexural strength and the least flexural strength was shown by Revotek LC. Luxatemp had shown differences at a significant value of $p < 0.05$ and no significant values observed between Revotek LC and Integrity. These obtained results balance much in accordance with the reports of Koumjian and Nimmo and also the provisional material review conducted by Wang et al.[15]

Flexural strength and standard deviation values were significantly lower for Revotek LC and Integrity attributed probably for the structural differences in the material science where in the Bisacryl groups elevate the toughness and flexibility of the resin.

According to the International Organization for Standardization (ISO 4049) and the American National Standards Institute (ANSI)/American Dental Association (ADA) Specifications no. 27, an interim fixed prosthesis material must have a minimum strength of 50 Mpa when a bar of the material undergoes a 3-point bend test.[44] All the specimens tested in this study had flexural strength values more than 50 Mpa, which indicates that all the materials, can comfortably be used for the fabrication of provisional restorations.

Luxatemp material exhibited greater flexural strength than the other materials because of its chemical composition mainly cross- linking capability of monomer chains and its hydrophobicity nature, ensuring minimal water uptake and thus reducing the plasticizer action when stored in artificial saliva.[4, 45]

The flexural strength of the Revotek LC resin material was comparatively low among all the materials compared. The reason for this result was mainly because of less crystalline silica filler particles. These glass filler particles are slowly leached out in the presence of artificial saliva and thus reducing the flexural strength of the material.

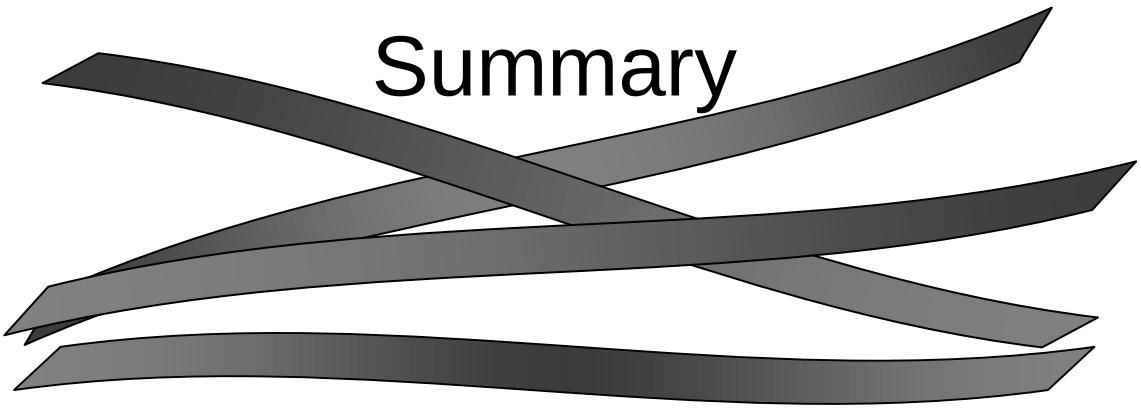
Despite the major developments in resin based provisional materials, all these materials exhibit a certain degree of volume reduction during polymerisation shrinkage. The measurement of shrinkage during polymerization is important for assessing a materials accuracy of fit. Materials with low polymerization shrinkage provide for good clinical fit of the temporary restoration. Studies have shown this volumetric contraction is dependent on the amount of filler concentration.[46]

Many methods have been described to measure polymerization shrinkage: Bonded disk method, Mercury dilatometer, Optical method, Gaspycnometer, the use of a strain gage, linear displacement free linear shrinkage.[47, 48] The polymerisation shrinkage was put to study on samples 10 minutes, 20 minutes and 120 minutes after their fabrication by using coordinate measuring machine. Coordinate measuring systems were developed at the end of the 20th century to fulfill the need for easy and quick inspections of fabricated pieces using automated manufacturing systems. The primary goal of coordinate measuring machines (CMMs) is to obtain the Cartesian coordinates of points on a solid surface.[49, 50]

In this study Luxatemp, Revotek LC and Integrity were subjected to polymerisation shrinkage using Coordinate measuring machine. Polymerisation shrinkage was highest with Revote LC and lowest with Luxatemp. ANOVA and Post Hoc test for multiple comparison showed that there was significant difference at $p < 0.05$ between groups. The reason for lesser shrinkage in Luxatemp is related to the lower molecular weight and lower viscosity monomers

present in Luxatemp[5] while the result shown in Revotek LC is because of irregular shape and large fillers present in it leading to larger volumetric shrinkage.

Conclusions and Summary



Light cure Urethane Dimethacrylate resins are highly color stable than Self cure Bisacrylic and Multicure Bisphenol whereas Selfcure Bisacrylic document excellent flexural strength which is above the accepted levels in comparison to other provisional materials. Meanwhile lesser polymerization shrinkage was discernible with Self cure Biscrylic signifying the materials capacity incorporating good clinical fit of the restoration made of these. Immersion media exaggerated the color stability values of Self Cure Bisacrylic and Multicure Bisphenol alarming that these are unfaithful in terms of esthetics when given for a longer period of time. So when long term provisional situation demands Lightcure Urethane Dimethacrylate is the choice of material.

Flexural strength was more in favorable with Self cure Biscrylics owing to its use in condition of highly anticipated forces onto the tooth provisionals. Added advantage of using this material is lesser polymerization of the material eventually leading to marginal accuracy and structural durability of the restoration. Stastical results verified that significant factors in between all the materials stated were minimal in terms of flexural strength. So again the choice of material can be either Self cure Bisacrylic or even Light cure Dimethacrylate material. Although this study indicates the usage of either of the materials, Selfcure Bisacrylic stands high in terms of its minimal polymerization shrinkage.

The present study was to determine the color stability, flexural strength and polymerisation shrinkage of the three provisional materials used in crown and bridge. A strong restorative material may possess desirable and other less desirable characteristics. For example, a restorative material may be difficult to manipulate, have tendency to stain easily, lack polishability, or may not be aesthetically pleasing. The clinician must be aware of all attributes of various materials and choose the interim material appropriate for each patient.

When the treatment planning necessitates the use of long term provisionals the esthetic problem that is looked upon is the discoloration of provisional materials as these are more susceptible to staining due to absorption of liquids. This study concluded that even as less as 10 days of immersion paraded the incremental built of stains from baseline time. This signifies the usage of preferably the Light cure Urethane Dimethacrylate in long term provisionalisation planned for more than 10 days particularly and in situations of anterior restorations. In addition to esthetics, provisionals are also meant for requiring the needs of functional loading not only in long term provisionals and also in patient having parafunctional habits. So rather than the ease of material, resiliency of the material is very vital in selection of the material and the required higher flexural strength are among the bisacrylics which incorporates the expected lower volumetric shrinkage of the material. It is finally the clinician who applies these biomechanical principles in restoring the provisionals. Although the study was designed in an attempt to simulate in-vivo conditions, this experimental design still had limitations in replicating clinical conditions accurately. Another aspect in clinical situations is that an immediate load is placed on the interim prosthesis once it is cemented into place whereas in this experiment a load was not applied until 10 days of artificial saliva storage.

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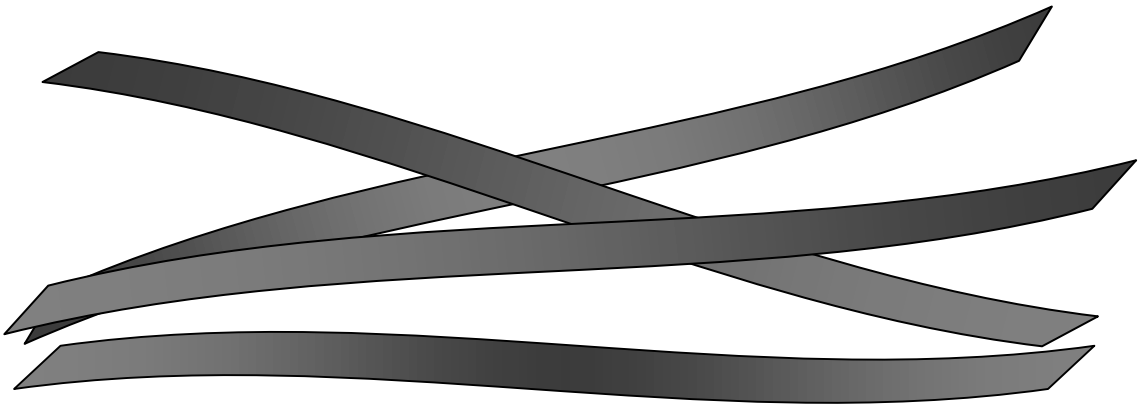

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