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An evaluation of color stability of temporary fixed partial denture materials: *In vitro* study

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Abstract
Aim: To evaluate and compare the color stability of three methyl methacrylate based auto-polymerized resins (DPI Self-Cure Tooth Moulding Powder, Unifast Trad, Structur 2SC/QM) and two composite based bis-acryl auto-polymerized resins (Luxatemp Fluorescence, Integrity) after immersion in synthetic saliva and tea, synthetic saliva and cold beverage, synthetic saliva and chlorhexidine mouth wash, and synthetic saliva (control) for one week, two weeks, four weeks, six weeks and eight weeks.
Materials and Method: 20 samples were made from each material and spectrophotometry was used to evaluate and compare colour stability of temporary fixed partial denture materials.
Results: One-way inova and friedmans test was used in this study the results indicated the presence of strong interaction between material and storage solution regardless of the aspect of Color considered ($p< 0.05$ for ΔE, ΔL^*, Δa^*, and Δb^*). This is evidence that the material and solution were not additive in effects. Furthermore, the data presented strong evidence ($p< 0.001$ for ΔE, ΔL^*, Δa^*, and Δb^*) that the pattern of changes differed over time.
Conclusion: Maximum discoloration was seen in case of Unifast trad followed by Stuctur 2SC/QM, DPI self-cure tooth moulding powder, Luxatemp Fluorescence, and Integrity after exposure to synthetic saliva & tea, synthetic saliva & cold beverage, synthetic saliva & chlorhexidiene, and synthetic saliva solutions in comparison to baseline measurement for all the time periods. Integrity is the best material out of all five, if provisional restoration has to give for longer duration in the esthetic region.

Keywords: temporary partial denture, beverages, saliva, autopolymerising resin

Introduction

Fixed prosthodontic treatment, whether involving complete or partial coverage, natural tooth or dental implant abutments, commonly relies on indirect fabrication of definitive prosthesis in the dental laboratory [1]. During this time span of fabrication of definitive prosthesis, which on an average takes about 7-10 days, prepared tooth need to be protected from the oral environment and also its relationship with the adjacent and opposite teeth need to be maintained. Thus, in order to protect these prepared abutment teeth provisional restorations are fabricated and the process is called as Temporization [2]. According to Glossary of Prosthodontic terms, A provisional restoration/prosthesis is a fixed or removable dental prosthesis designed to enhance esthetics, stabilization and/ or function for a limited period of time after which it is replaced by a definitive prosthesis [3]. A provisional restoration is an integral part of successful treatment for fixed prosthesis as they protect the prepared abutment teeth, provide pulpal protection, maintain periodontal health, occlusal relationship and tooth position of the abutment tooth and also help in deciding the shade, shape and contour of the final restoration, especially in cases of long-term anterior temporization. Materials should provide appropriate marginal adaptation, low thermal conductivity, non-irritating reaction to dental pulp and gingival tissues, ease of alterability and repair are extremely important to the success or failure of treatment outcomes. For others, specific clinical treatments have a variety of mandates for these materials and thus the importance of these requirements varies accordingly. Long-term use of provisional restorations requires materials that are more durable because of their longer period of service [5, 9, 10]. Over the years various materials have been used for making provisional restorations but the selection of these materials should be based on the strength and weakness of a given material relative to the clinical mandates for specific

Treatments [11]. Traditionally, thermoplastic acrylic (Polymethyl methacrylate, methyl methacrylate, ethyl methacrylate) materials have been used as the provisional materials of choice and have, to a certain degree, met many of aforementioned requirements such as high strength, durability, good marginal adaptation, capable of repair and high polish, and relatively inexpensive. The more modern bis-acryl composite temporization materials, however, have become an increasingly popular choice, due to their improved properties such as ease of handling, low exothermic reaction, good wear resistance and minimal pulpal irritation when compared to acrylic resins. Though color stability of both types of materials is still controversial [12-16]. Provisional restorations assist in the development and assessment of esthetic values of the planned fixed prosthesis. Most of these materials are subject to sorption (A process of adsorption and absorption) of liquids that occurs relative to the oral environmental conditions [17-18]. Crispin and Caputo studied the color stability of provisional materials. They found that methyl methacrylate materials exhibited the least darkening, followed by ethyl methacrylate and vinyl ethyl methacrylate materials. Further, Koumjian *et al.* [19] included visible light-polymerized methylacrylate based resin material in their investigation and concluded that Visible Light Cure material exhibited more adverse color changes relative to other methylacrylate based resin materials at the end of 9 weeks. Later on, Yannikakis *et al* [20]. Immersed these materials in various staining solutions for up to 1 month. They reported that all materials showed perceptible color changes after 1 week but after 1month, the methyl methacrylate materials exhibited the best color stability in comparison to the bis-acryl based composite materials the worst. On other side, Robinson reported on the effect of vital tooth bleaching on provisional restorative materials and concluded that bisacryl and polycarbonate crowns showed no difference in color in comparison to methacrylate materials [21]. Inspite of various studies being carried out to study the color changes of different provisional materials using different staining solutions, still the literature on color stability of these materials is limited. Thus, this study was directed to determine color stability of five commercially available temporary fixed partial denture materials of which three were acrylic based and other two are bis-acryls and to find out the most color stable among them.

Materials and Method

To evaluate the color changes of the five temporary fixed partial denture materials after immersion in two commonly consumed beverages (tea and cold beverage) and a medicament (Chlorhexidene mouth wash), with synthetic saliva as control, at intervals of 1week, 2weeks, 4weeks, 6 weeks and 8 weeks.

Five commercially available temporary fixed partial denture materials were taken as test materials. They were-

- Dpi self-cure tooth moulding powder
- Unifast trad
- Structur 2sc/qm
- luxatemp fluorescence
- Integrity
- All the materials used were Auto-Polymerized (Chemically Cured) and the shade used for the test materials was A2.

B) Staining Solutions

Four staining solutions were used

- Tea and Milk Powder
- Cold Beverage
- Chlorhexidene Mouth Wash
- Synthetic Saliv

Other equipments used were

- Glass Jar
- Soft brush
- Micromotor and hand piece, acrylic stone
- Mold of 30±1mm diameter and 2 mm thick with two glass sheets
- Reflectance spectrophotometer

Methodology

Sample preparation: Samples were prepared in the form of discs. Twenty samples of each material were prepared with a diameter of 30±1mm and 2mm thickness. To attain the specified dimensions a three-layered metal mold locked in glass sheets from above and below was constructed. The mold consisted of two plane sheets of brass metal at the top and bottom, and in the middle another sheet of 2mm thickness with three slots of 30±1mm diameter. The sheets were fastened onto each other after placing between the glass sheets with screws located on all the four corners. Thus, specified dimensions and smooth surface samples were obtained.

Preparation of staining solution

1. **Tea and synthetic saliva:** A 250 ml test solution of tea and synthetic saliva was prepared in the ratio of 2:1
2. **Cold beverage (Pepsi) and synthetic saliva:** A 250 ml test solution of cold beverage (Pepsi) and synthetic saliva was prepared in the ratio of 2:1.
3. **Chlorhexidine mouth wash and synthetic saliva:** A 250 ml test solution of chlorhexidiene mouth wash and synthetic saliva was prepared in the ratio of 1:1.
4. **Synthetic Saliva:** A 250 ml of synthetic saliva was taken as control.

Method of staining

The study was divided into five groups according to the test materials and four sub groups according to staining solutions. Each group consisted of twenty samples and each subgroup consisted of 5 samples comprising together a total of 100 samples.

Table 1: Time periods dipping solutions 1-8 weeks

Time periods dipping solutions	1 week	2 weeks	4 weeks	6 weeks	8 weeks
Sub Group 1 (Tea and Synthetic Saliva)	Sample no-1	Sample no -2	Sample no-3	Sample no-4	Sample no-5
Sub Group 2 (Cold Beverage and Synthetic Saliva)	Sample no-6	Sample no-7	Sample no-8	Sample no-9	Sample no-10
Sub Group 3 (Chlorhexidine Mouth Wash and Synthetic Saliva)	Sample no-11	Sample no-12	Sample no-13	Sample no-14	Sample no-15
Sub Group 4 (Synthetic Saliva)	Sample no-16	Sample no-17	Sample no-18	Sample no-19	Sample no-20

Color measurements

Color measurements were made using Reflectence Spectrophotometry. The spectrophotometer used in the study was "Macbeth Color Eye 7000A" Spectrophotometer. The illuminant used was D65 (normal daylight). The software used was Novoscan Color matching and analysis software. The spectrophotometric analysis was carried out at National Physical Laboratory, Delhi.

Evaluation of color change

Color characteristics of all the samples were evaluated by using the CIELAB system.

1. Δ L-Change in lightness/ darkness
2. Δ a- HAnge in redess- greenness
3. Δ b- Change in yellowess- blueness

Color changes were calculated by using the formula: Change in Color

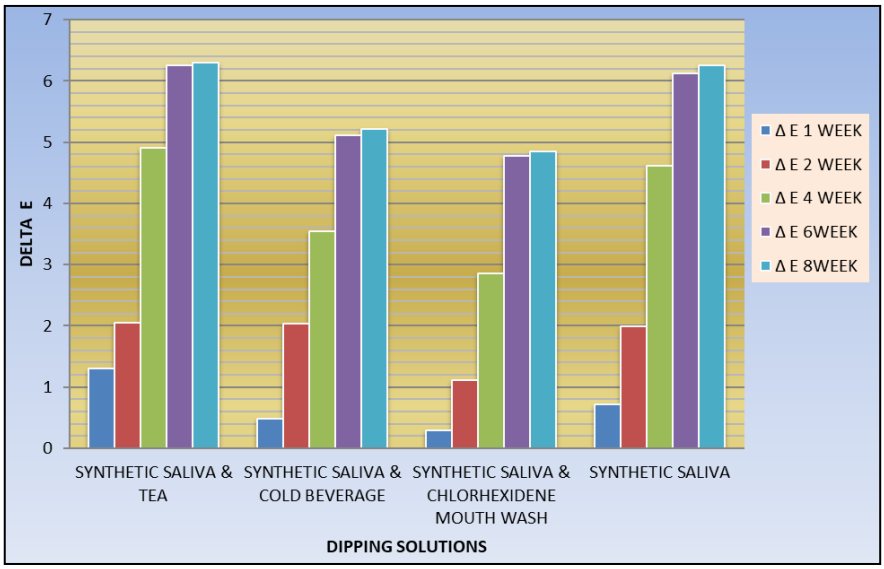
$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{2}$$

To relate the amount of color change (ΔE*) recorded by the spectrophotometer to a clinical environment, the data were converted to National Bureau of Standards units (NBS units) through the equation, NBS units=ΔE* ×0.92, where critical remarks of color differences as expressed in terms of NBS units.

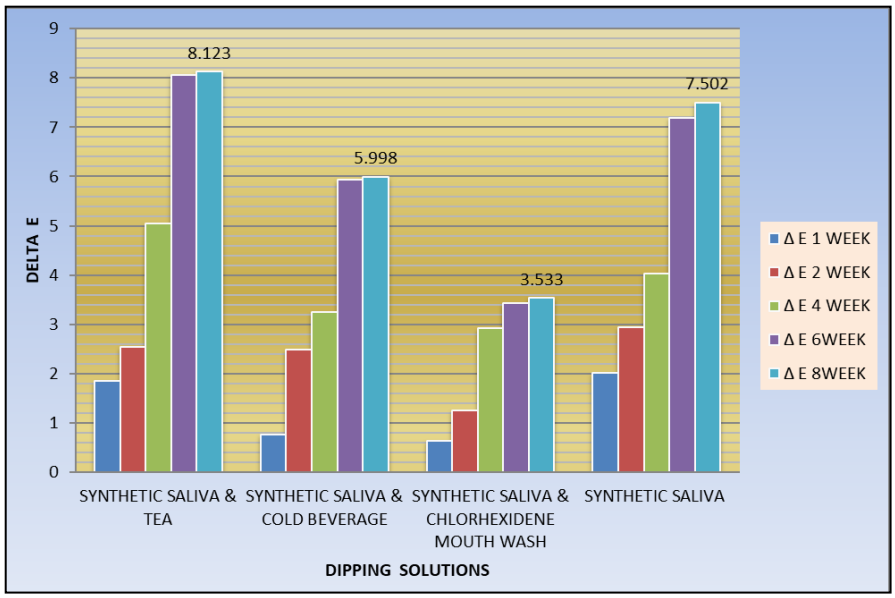
The data was analysed statistically One-way inova and friedmans test was used in this study.

Results

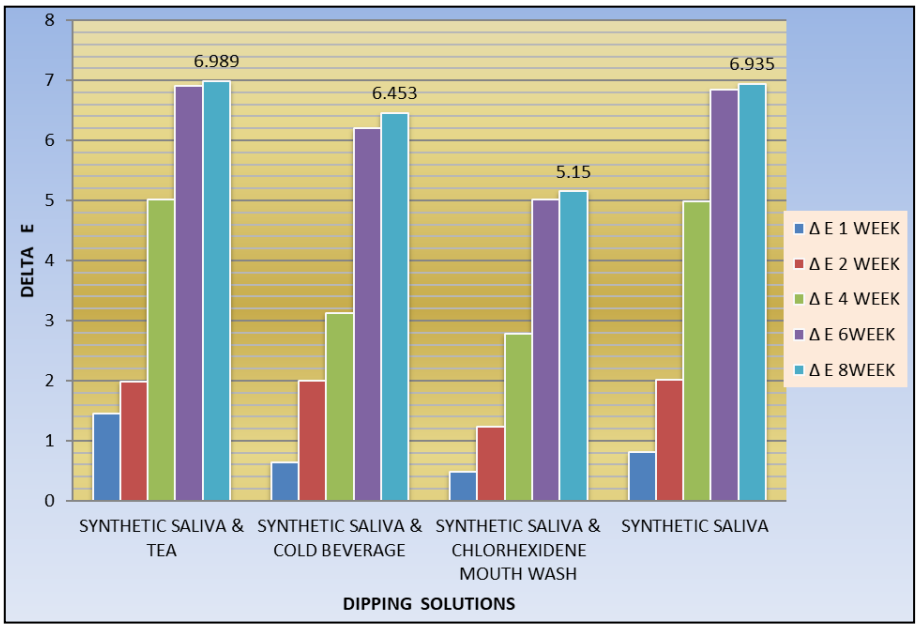
The results indicated the presence of strong interaction between material and storage solution regardless of the aspect of Color considered ($p < 0.05$ for ΔE, ΔL*, Δa*, and Δb*). This is evidence that the material and solution were not additive in effects. Furthermore, the data presented strong evidence ($p < 0.001$ for ΔE, ΔL*, Δa*, and Δb*) that the pattern of changes differed over time. These results indicated that the relationships among immersion time, material, and immersion solution cannot be summarized through a series of simple additive relationships, and it is necessary to consider the particular combination of these three factors to obtain an assessment of Color change. Therefore, the means of color changes for ΔE are given for each material, solution and time periods in Graphs 1-9.



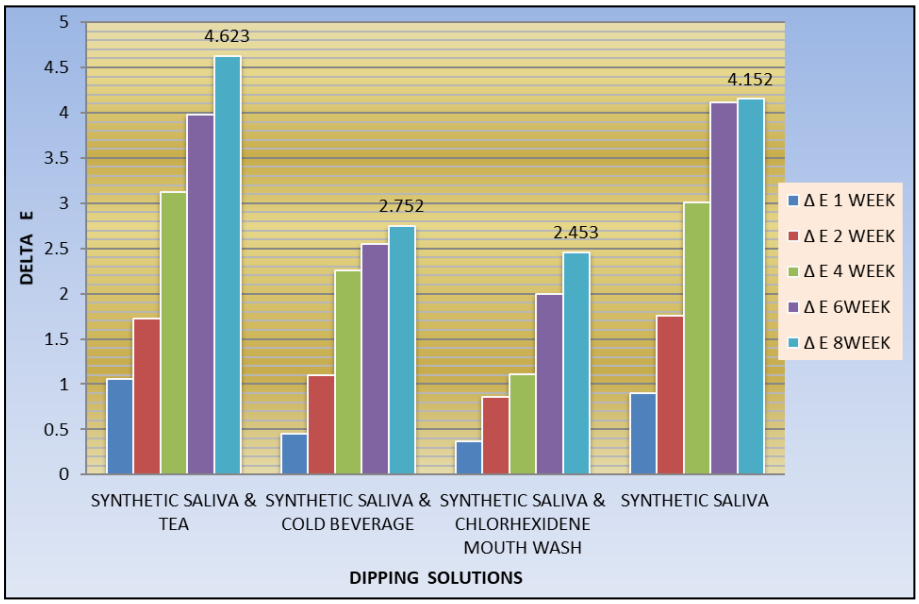
Graph 1: Total discoloration ▲E (Mean ± S.D.) In dpi self-cure tooth moulding powder in different test solutions at different time intervals



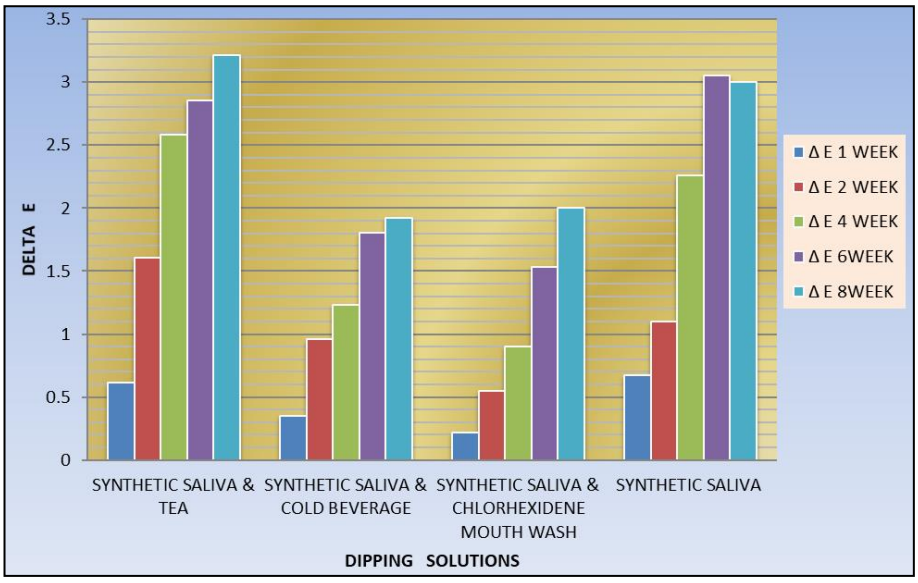
Graph 2: Total Discoloration ▲E (Mean ± S.D.) In Unicast Trad in Different Test Solutions at Different Time Intervals



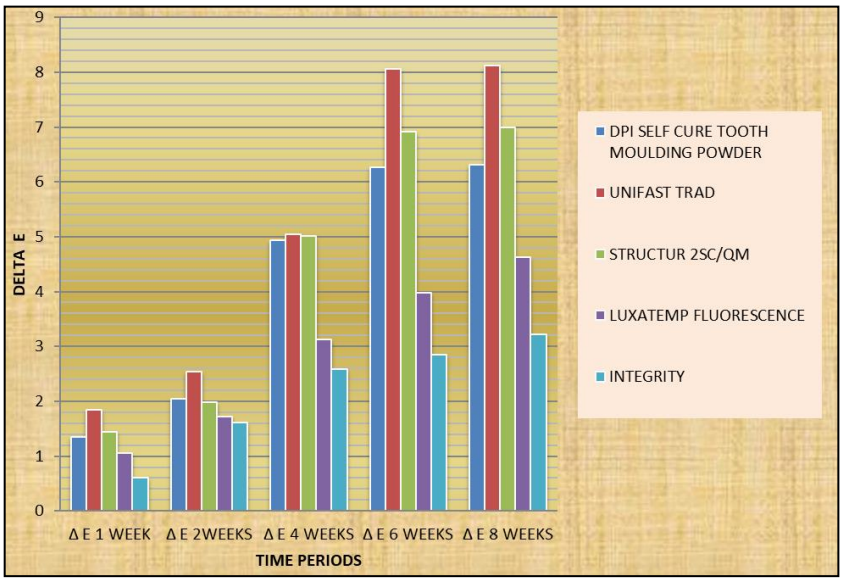
Graph 3: Total discoloration ▲E (Mean ± S.D.) in Structur 2sc/Qm in different test solutions at different time intervals



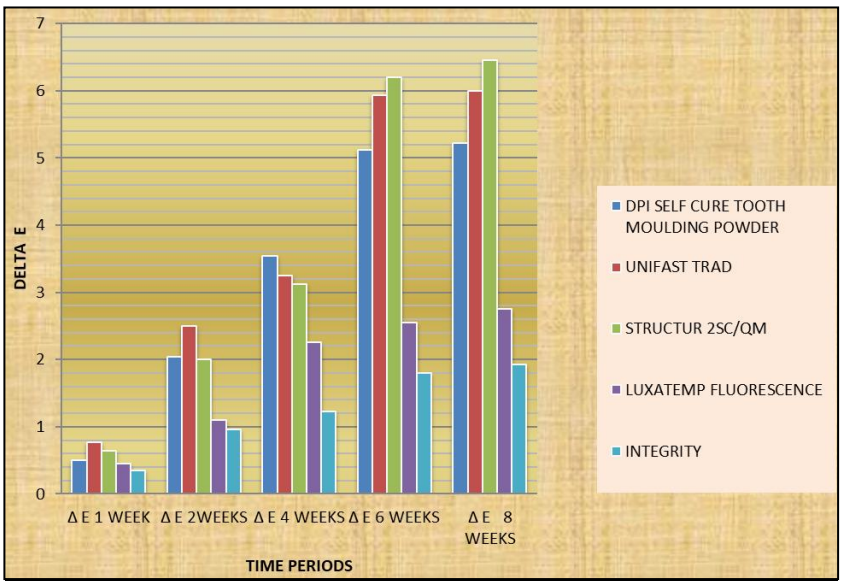
Graph 4: Total discoloration ▲E (Mean ± S.D.) in luxatemp fluorescence in different test solutions at different time intervals



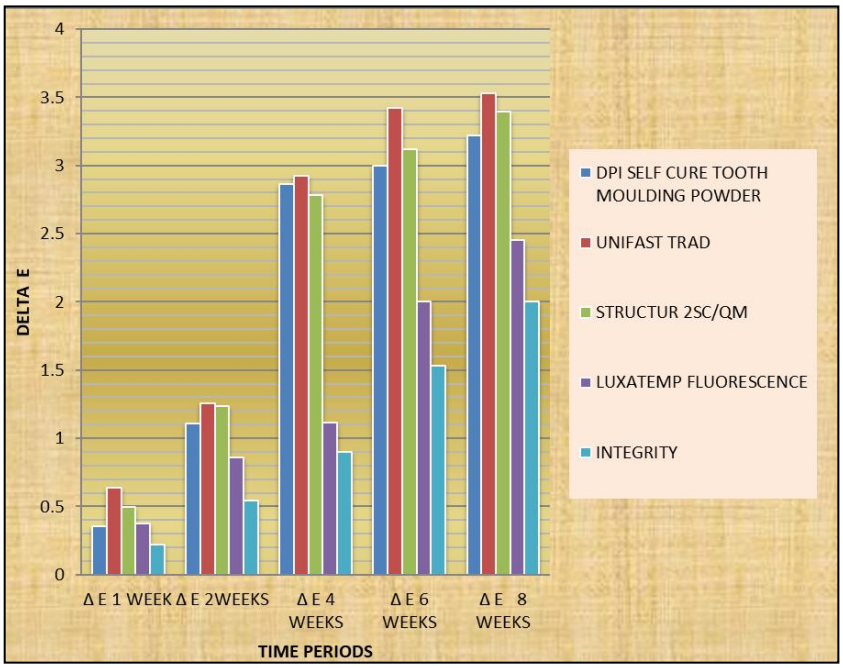
Graph 5: Total discoloration ▲e (mean ± s.d.) In integrity in different test solutions at different time intervals



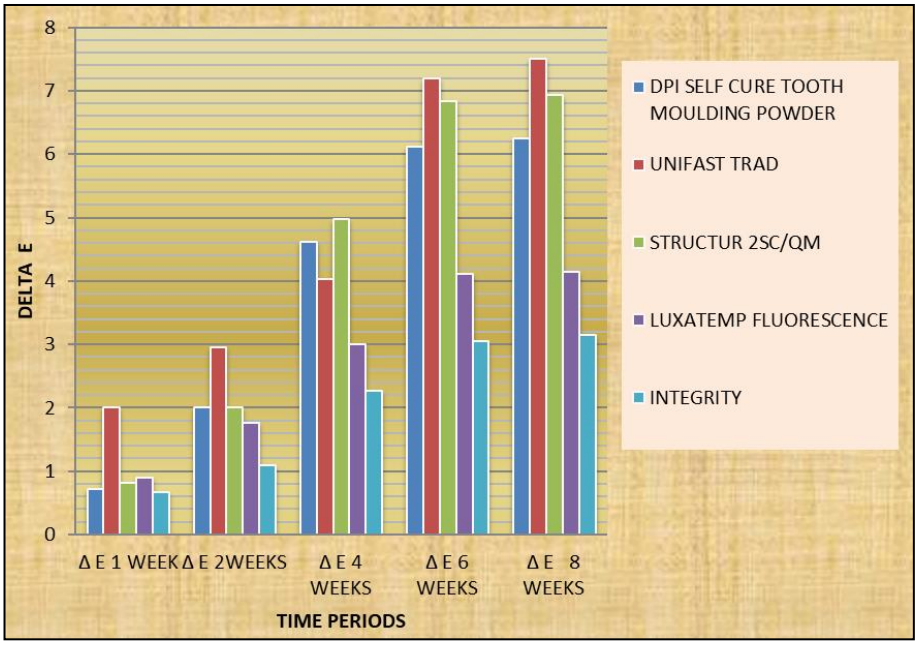
Graph 6: Total discoloration ▲e (mean ± s.d.) Between different test materials to synthetic saliva & tea solution



Graph 7: Total discoloration ▲e (Mean ± s.d.) between different test materials to synthetic saliva & cold beverage solution



Graph 8: Total discoloration ▲e (Mean ± S.D.) Between different test materials to synthetic saliva & chlorhexidene solution



Graph 9: total discoloration ▲e (Mean ± S.D.) between different test materials to synthetic saliva

Discussion

The study was divided into five groups according to the test materials (Dpi Self-Cure Tooth Moulding Powder, Unifast Trad, Structur2sc/Qm, Luxatemp Fluorescence, Integrity) and four sub groups according to staining solutions (synthetic saliva & tea, synthetic saliva & cold beverage, synthetic saliva & chlorhexidiene mouth wash and synthetic saliva (control)). Each group consisted of twenty discs and each subgroup consisted of 5 discs comprising together a total of 100 discs. Samples were immersed in the solution of tea and synthetic saliva for total three times per day for ten minutes each. In solution of cold beverage and synthetic saliva for total one time per day for ten minutes each. In solution of chlorhexidine mouth wash and synthetic saliva for total two times per day for two minutes each. During the rest time periods of the day the samples were rinsed with distilled water and kept in artificial saliva. The same procedure was followed subsequently for one week, two weeks, four weeks, six weeks and eight weeks. Solution was changed on every dipping. This was done according to the time a person in general takes to consume tea and cold beverage and rinse with chlorhexidiene mouth wash in a day. (Arthur SK; 2004 [22], Scotti R; 1997) [23] And the samples were dipped in synthetic saliva continuously for one week, two weeks, four weeks, six weeks and eight weeks, respectively as it was acing as control. The samples was rinsed with the distilled water and then gently cleaned with soft brush and before evaluation for color change in order to remove any loose sediment resulting from the immersion solution. (Debra R; 2005) [24]. Since color differences were being tested, the choice of the illuminant was not important. The colorimeter automatically generated 3 measurements (L*,a*, b*) from which it calculated a mean color measurement delta E. Three times readings were taken of all individual samples and then mean was calculated. The results of the present study showed that-At the end of 8 weeks maximum discoloration was seen in synthetic saliva & tea solution for all the five materials. These results were consistent with earlier studies done by Ergün G, Mutlu-Sagesen L, Ozkan Y, Demirel E. (2005) [25], R Gupta1, H Parkash, N Shah, Begüm Türker S *et al.* (2006) [26]. Maximum discoloration was seen in case of Unifast trad (PMMA) followed by Stuctur 2SC/QM(PMMA), DPI self-cure tooth moulding powder(PMMA), Luxatemp Fluorescence(BIS-ACRYL), and Integrity (BIS-ACRYL) after exposure to synthetic saliva & tea, synthetic saliva & cold beverage, synthetic saliva & chlorhexidiene, and synthetic saliva (control) solutions in comparison to baseline measurement for all the time periods. Clinically perceptible change of total Color difference was seen in case of Unifast trad (PMMA) followed by Stuctur 2SC/QM (PMMA) and finally DPI self-cure tooth moulding powder (PMMA) for all the four dipping solutions at the end of 2weeks and the discoloration increased continually till 8weeks; though the change in between the time periods was not constant. Clinically perceptible change in total Color difference was seen in case of Luxatemp Fluorescence (BIS-ACRYL) only at the end of 6weeks.Non perceptible change in Color was seen with Integrity (BIS-ACRYL) even at the end of 8weeks Composite based bis-acryl auto-polymerized resins (Luxatemp Fluorescence and Integrity temporary crown and bridge) were found to be more color stable than the methacrylate based auto-polymerized resins. Water absorption into an acrylic resin increases in the presence of inclusion such as air or unreacted monomers. Because Luxatemp Fluorescence, Integrity and Structur 2SC/QM was automixed instead of being mixed by hand spatulation, the entrapment of air or unreacted monomer during mixing might have been minimized. Therefore, it could be likely that the minimized amount of such entrapment defects and porosities also diminish the amount of water absorption, thus resulted in lesser change in Color. Similar results were shown in earlier studies done by Cal e *et al.* (2007) [27], Mohan M, *et al.* (2008) [28]. Thus, it can be summarised from the findings of this study that Color change is dependent on the chemical composition of the material rather than related to a particular brand of materials.

Summary and Conclusion

- Maximum discoloration was seen in case of Unifast trad followed by Stuctur 2SC/QM, DPI self-cure tooth moulding powder, Luxatemp Fluorescence, and Integrity after exposure to synthetic saliva & tea, synthetic saliva & cold beverage, synthetic saliva & chlorhexidiene, and synthetic saliva solutions in comparison to baseline measurement for all the time periods.

- Composite based bis-acryl auto-polymerized resins (integrity, luxatemp fluorescence) were color stable than the methacrylate-based auto-polymerized resins (dpi self-cure tooth moulding powder, unicast trad, structur 2sc/qm).
- Two auto-mixed (Integrity, luxatemp fluorescence, structur 2sc/qm) temporary fixed partial denture materials were more color stable than the hand-mixed (dpi self-cure tooth moulding powder, unifast trad).
- Maximum discoloration was seen in synthetic saliva & tea solution for all the five materials.
- Integrity is the best material out of all five, if provisional restoration has to given for longer duration in the esthetic region. But have a drawback of being expensive; in that case we can prefer our Indian product dpi self-cure tooth moulding powder.

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