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Evaluation of Colour Stability of Temporary Fixed Partial Denture Materials : In -Vitro Study

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Citation

Abstract

Aim: The aim of this study is to evaluate the color stability of five different temporary fixed partial denture materials against external staining caused by commonly consumed beverages and medicament, using a Spectrophotometer. Materials and methods: Twenty samples of each five materials of which 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) , were prepared with a diameter of 30±1mm and 2mm thickness. After immersion in staining solution of synthetic saliva and tea, synthetic saliva and cold beverage, synthetic saliva and Chlorhexidine mouth wash, and synthetic saliva (control), the color measurements were made. Result: Colour measurements were made using reflectance spectrophotometer at baseline and at intervals of 1week, 2weeks, 4weeks, 6weeks and 8 weeks respectively and were evaluated by using the CIELAB system, a method developed in 1978 by the Commission Internationale de l'Eclairage for characterizing color based on human perception.Conclusion: 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.

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)

A provisional restoration is an integral part of successful treatment for fixed prosthesis as they protect the prepared abutment teeth, while the final prosthesis is being fabricated. They 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.

Since provisional treatment promotes numerous adjunct

benefits to definitive prosthodontic treatment, thus, the materials and techniques used for this purposes must reflect these variable treatment demands and requirements. (3)

Over the years various materials have been used for making provisional restorations but the selection of these materials should be based on the strengths and weakness of a given material relative to the clinical mandates for specific treatment. (4)

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.(4-8)

Crispin and Caputo 1979 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. (9) Later on, Yannikakis et al 1980 immersed these materials in various staining solutions for up to 1 month.(10) They reported that all materials showed perceptible color changes after one week but after one month, 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 bis-acryl and polycarbonate crowns showed no difference in color in comparison to methacrylate materials. (11)

In-spite 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 colour 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 colour stable among them.

MATERIALS AND METHODS

Twenty samples in the form of discs of each five materials of which 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), were prepared with a diameter of 30±1mm and 2mm thickness. To attain the specified dimensions, a three-layered metal mould locked in glass sheets from above and below.

Since, Extrinsic factors are known to cause staining of oral tissues and restorations especially in combination with dietary factors. Thus, three different types of staining agents (tea, cold beverage, and Chlorhexidine) along with synthetic saliva as control were used in the present study. These solutions were mixed with synthetic saliva in order to create intraoral environment to certain extent. Tea and cold beverage were found to be commonly consumed beverages, so they were included in our study. Chlorhexidine was considered as it is a commonly prescribed mouth wash to the patients.

Test solutions were prepared using synthetic saliva mixed with tea, cold beverage and mouth wash. The 250 ml test solution of tea and synthetic saliva was prepared in the ratio of 2:1. Tea was prepared using 150ml of boiling distilled water, with a tea bag, two sugar cubes and a teaspoon of powdered milk, simmered for 5min and then filtered through a filter paper. Similarly, test solution of cold beverage and synthetic saliva was prepared in the ratio of 2:1. The 250 ml test solution of Chlorhexidine mouth wash and synthetic saliva was prepared in the ratio of 1:1. A sample of 250 ml of synthetic saliva was taken as control.

METHOD OF STAINING

The samples were 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. the colour measurements were made at baseline and at intervals of 1week, 2weeks, 4weeks, 6weeks and 8 weeks respectively after immersion in staining solution of synthetic saliva and tea for three times per day for ten minutes each, in synthetic saliva and cold beverage for one time per day for ten minutes, in synthetic saliva and Chlorhexidine mouth wash for total two times per day for two minutes each, and synthetic saliva (control) for whole day. The sample was rinsed with the distilled water and then gently cleaned with soft brush and then evaluated for colour change. The same procedure was followed subsequently for next immersion periods (i.e. two weeks, four weeks, six weeks and eight weeks respectively). Solution was changed on every dipping.

OBSERVATION

Color measurements were made using reflectance spectrophotometer. The spectrophotometer used in the study was "Macbeth Color Eye 7000A" (Macbeth, USA) spectrophotometer. The illuminant used was D65 (normal daylight). The software used was Novoscan Color matching and analysis software.

SAMPLE ANALYSIS PROCEDURE

1. The samples were exposed to staining distilled water and were dried.

2. The spectrophotometer was calibrated using a standard white tile. Then the specimen was placed in viewing port for Color measurement.

3. After Color measurements at the indicated time intervals, the samples were kept aside.

EVALUATION OF COLOR CHANGE

Color characteristics of all the samples were evaluated by using the CIELAB system. (12)

1. ▯L - CHANGE IN LIGHTNESS/ DARKNESS

2. ▯a - CHANGE IN REDESS- GREENNESS

3. ▯b - CHANGE IN YELLOWESS- BLUENESS

Color changes were calculated by using the formula:

Figure 1

$$\text{Change in Color } \Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^2$$

To relate the amount of colour change (▯E*) 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▯▯E* ×0.92, where critical remarks of colour differences as expressed in terms of NBS units. Data were analyzed statistically.

A total nine parameters were recorded from in-vitro measurements performed on a sample size of hundred samples. The measurements were taken at six different time intervals that are baseline, 1 week, 2 weeks, 4 weeks, 6 weeks and 8 weeks. A master chart was prepared for all the data and complete data was fed into a computer using the statistical software Minitab 14 (Minitab Inc., USA). The data was checked for errors during data feeding. Thus purified files containing raw data were obtained for computerized statistical analysis.

STATISTICAL ANALYSIS
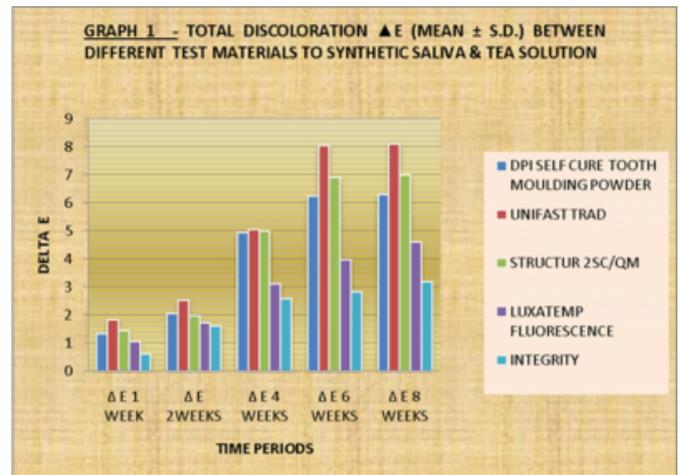
The following statistical tests were applied-

1. Descriptive statistics: Mean and Standard Deviation were calculated for each variable, for each group.
2. Bon-ferroni test: one way ANOVA with multiple range test was applied to see significant difference among the groups.
3. Friedman's test: to see the trend or impact of different beverages within the group, two way ANOVA with multiple range test was applied.

RESULTS

The results indicated the presence of strong interaction between material and storage solution regardless of the aspect of Colour considered (p< 0.05 for ▯E, ▯L*, ▯a*, and ▯b*). This is evidence that the material and solution were not additive in effects. Further, the data presented strong

evidence (p< 0.001 for ▯E, ▯L*, ▯a*,and ▯b*) 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 colour change. Because changes after 2 months of storage were deemed to be of greatest clinical importance when considering a provisional material for longer term use, detailed results of colour changes after 8 weeks are also presented. (Graph-1-4).

Figure 2

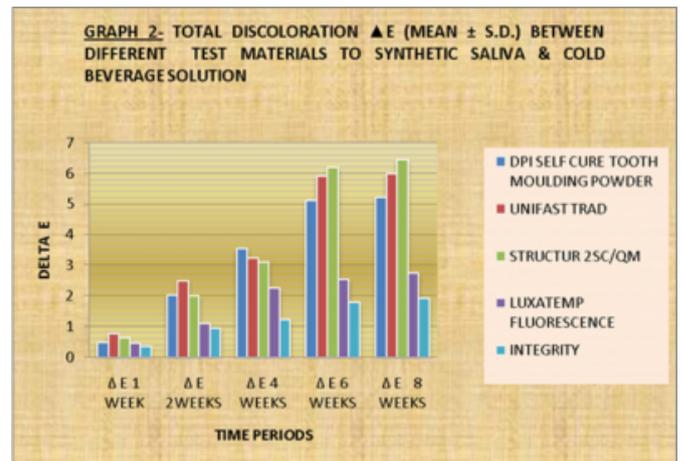GRAPH 1 - TOTAL DISCOLORATION ▲E (MEAN ± S.D.) BETWEEN DIFFERENT TEST MATERIALS TO SYNTHETIC SALIVA & TEA SOLUTION

Figure 3

GRAPH 2- TOTAL DISCOLORATION ▲E (MEAN ± S.D.) BETWEEN DIFFERENT TEST MATERIALS TO SYNTHETIC SALIVA & COLD BEVERAGE SOLUTION

Figure 4

GRAPH 3 - TOTAL DISCOLORATION ▲E (MEAN ± S.D.) BETWEEN DIFFERENT TEST MATERIALS TO SYNTHETIC SALIVA & CHLORHEXIDENE SOLUTION

Figure 5

GRAPH 4 - TOTAL DISCOLORATION ▲E (MEAN ± S.D.) BETWEEN DIFFERENT TEST MATERIALS TO SYNTHETIC SALIVA
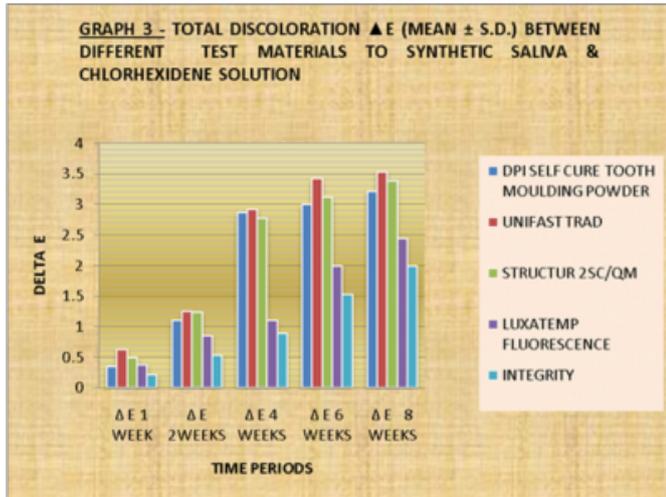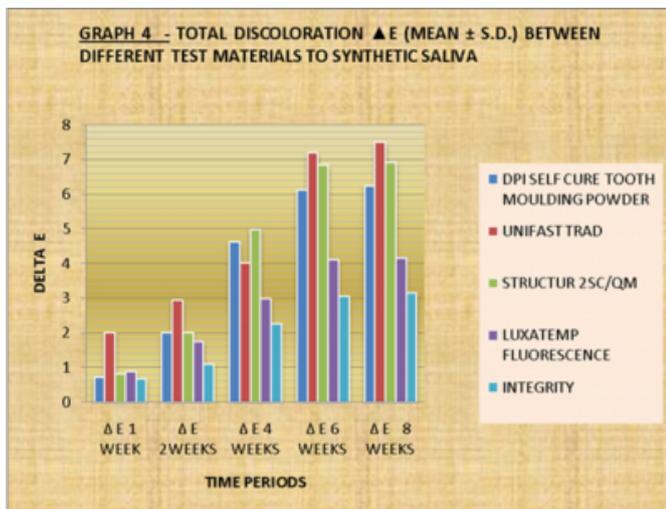
Unifast trad had statistically significant difference in total colour change ⏃E (p<0.05) when compared to other four temporary crown and bridge material (DPI self cure tooth moulding powder, Stuctur 2SC/QM, Luxatemp Fluorescence, and Integrity) after exposure to synthetic saliva and tea, synthetic saliva and Chlorhexidine, and synthetic saliva solutions. With the exception of synthetic saliva and cold beverage solution; in this statistically significant difference in total colour change was shown by Stuctur 2SC/QM when compared to Unifast Trad, DPI self cure tooth moulding powder, Luxatemp Fluorescence, and Integrity .

Structur 2SC/QM had significant difference in colour change after exposure to synthetic saliva and tea, synthetic saliva and Chlorhexidine, and synthetic saliva solutions in comparison to DPI self cure tooth moulding

powder,Luxatemp Fluorescence and Integrity).

The change was found to be significant at all the observed time periods except the difference between structure 2SC/QMand DPI self cure tooth moulding powder, and structure 2SC/QM and Unifast trad in synthetic saliva and tea, synthetic saliva and Chlorhexidine at 4weeks, 6weeks and 8 weeks was non-significant (p< 0.5)

DPI self cure tooth moulding powder in comparison to structure 2SC/QM and Unifast Trad showed less difference in colour change after exposure to synthetic saliva and tea , synthetic saliva and cold beverage solution, synthetic saliva and Chlorhexidine, and synthetic saliva solutions. But showed statistically significant difference when compared to Luxatemp Fluorescence, and Integrity

Luxatemp Fluorescence, and Integrity in comparison to DPI self cure tooth moulding powder Unifast Trad and structure 2SC/QM showed less difference in colour change after exposure to synthetic saliva and tea , synthetic saliva and cold beverage solution, synthetic saliva and chlorhexidine, and synthetic saliva solutions.

Difference between Luxatemp Fluorescence, and Integrity of total colour change was non- significant when exposed to all the four dipping solutions, though Luxatemp Fluorescence showed difference to baseline which was in clinically perceptible range after 4weeks only but in case of Integrity this was not seen in the clinically perceptible range.

DISCUSSION

The results of the present study showed that at the end of eight weeks, maximum discoloration for all the five materials was seen in synthetic saliva & tea solution. These results were consistent with earlier studies done by Jack H.Koumjian et al 1991 (13) , Ergün G, Mutlu-Sagesen L, Ozkan Y, Demirel E. 2005 (14), R Gupta, H Parkash, N Shah, V Jain 2005 (15), Begüm Türker S et al 2006.(16)

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. Similarly, clinically perceptible change in total colour difference was seen in case of Luxatemp Fluorescence (BIS-ACRYL) only at the end of 6 weeks. Non- perceptible change in colour 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 colour-stable than the methacrylate based auto-polymerized resins (DPI self cure tooth moulding powder, Unifast Trad, Structur 2SC/QM) and Auto-mixed (Luxatemp Fluorescence, Integrity and Structur 2SC/QM) temporary fixed partial denture materials were also more color stable in comparison to the hand-mixed (DPI self cure tooth moulding powder, Unifast Trad) temporary fixed partial denture material. Water absorption into an acrylic resin increases in the presence of inclusion such as air or non-reacted monomers. Because Luxatemp Fluorescence, Integrity and Structur 2SC/QM was auto-mixed instead of being mixed by hand spatulation, the entrapment of air or non-reacted 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 colour. Similar results were shown in earlier studies done by Begüm Türker S et al 2006 (16), Cal E et al 2007 (17), Mohan M, et al 2008.(18)

This probable explanation for the clinically perceptible colour change in some materials were explained because of the proprietary variations in chemistry, such as size distribution of the Polymethyl methacrylate particles, polarity of the monomers, pigment stability, and efficiency of the initiator system for provisional resins which in turn lead to different degrees of polymerization, water absorption, and consequently the Color stability.

Most bis-acryl polymers are polar than PMMA polymers and therefore have a greater affinity towards water and other polar liquids. This could account for some degree of colour change in the bis-acryl when compared to Polymethylmethacrylate resins, but additionally, it has a very fine particle size distribution combined with powders of various sizes that allow a very dense packing of the polymer particles in the resin leading to the better surface smoothness in comparison to PMMA resins. These differences in chemistry may explain why bis-acryl resins exhibit better colour stability than PMMA resins.

Thus it can be summarized from the findings of this study that colour change is dependent on the chemical composition of the material rather than related to a particular brand of materials.

CLINICAL SIGNIFICANCE

The colour perception is a subjective phenomenon and the option about the threshold for ΔE values becoming visible to human eye vary widely amongst different observers. It has been claimed that under clinical conditions in the mouth ΔE colour difference have been reported as relevant only when the value is higher than 3. Thus, the changes in acrylic resins are of relevance clinically as these changes would be apparent after prolonged and frequent exposure the four dipping solutions.

In saliva and tea solution, the numerical value of ΔE showed the most variability as compared to other three dipping solutions. Patients, therefore, may be advised to avoid or minimize consumption of this beverage during the time period of temporization, particularly when a Poly-methylmethacrylate resin is used.

It is difficult to entirely correlate laboratory findings with the clinical behavior of any restoration, since a number of factors are at play in oral environment and therefore to find a correlation between studies and laboratory measurements. Further in vivo clinical assessment is suggested.

From the literature, it is evident that the colour match of esthetic restorations can be maintained over a longer period of time in the oral cavity by observing some restrictions on the dietary habits. (15)

CONCLUSIONS

1. Among the materials studied, 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 & Chlorhexidine, and synthetic saliva solutions in comparison to baseline measurement for all the time periods with maximum discoloration seen in synthetic saliva & tea solution for all the five materials.

2. Composite based bis-acryl auto-polymerized resins (Integrity, Luxatemp Fluorescence) were colour stable than the methacrylate based auto-polymerized resins (DPI self-cure tooth moulding powder, Unifast Trad, Structur 2SC/QM), while two Auto-mixed (Integrity, Luxatemp Fluorescence, Structur 2SC/QM) temporary fixed partial denture materials were more colour stable than the hand-mixed (DPI self-cure tooth moulding powder, Unifast Trad)

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