Research Article

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An In-Vitro Spectrophotometric Analysis of Colour Stability of Provisional Restorative Materials in Indian Food Colourants

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ABSTRACT

Aim: To compare the colour stability different types of provisional restorative materials in commonly consumed food colorants in India.

Materials and Methods: The six different types of provisional restorative materials used were heat-cured polymethyl methacrylate provisional restorative material, self cured poly methyl methacrylate temporary material, light cured composite resin material, chemically cured bis-acrylic composite resin temporary material, self cured composite resin composite resin temporary material and dual cured composite resin. 50 specimens in the shape of discs were prepared from each material. 10 specimens of each type were immersed in 4 staining solutions - tea, coffee, cola and rasam. The color change of the specimens was recorded using a reflectance spectrophotometer. The results were analysed using ANOVA analysis.

Results: All the materials showed statistically significant color change in all the colorants. Heat-cured polymethyl methacrylate material showed the least color change while light cured composite resin showed the maximum color change in all solutions.

Conclusion: The provisional restorative materials tested in the present study did not show satisfactory color stability in the food colorants that are commonly consumed in India.

Keywords: Colour stability, Spectrophotometer, Provisional Restorations.

INTRODUCTION

Achieving optimum esthetics has been one of the goals in fixed prosthodontics. However short-termed the treatment might be the patients demand good esthetics. Amongst many things the failure and success of any esthetic restoration depends first on the color match and on the ability of the material to maintain the color matched within the oral environment. The provisional restoration may be required to be placed in the patient's mouth for a few days to few weeks. While the provisional restoration is in use, it is prone to come in contact with various food colorants that may discolor the restoration and adversely affect the esthetics of the patient. Indian food is particularly known to have strong colourants like turmeric. Thus color stability of the material becomes an important criterion for the selection of the provisional restorative material. Today there are a number of new provisional materials available that differ in their chemical composition and curing methods thus having different physical properties. Thus a need of comparative analysis of the color stability of these materials in food colorants was felt. This

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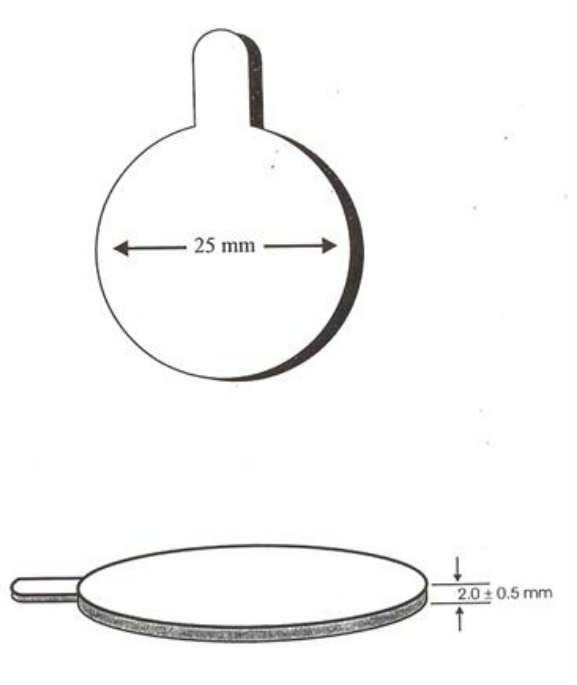


Fig 1: Dimensions of the sample used.

Fig 2: Specimens in an incubator.

investigation aims at an in vitro comparative analysis of color stability of provisional restorative materials in food colorants commonly consumed in India. Such a comparative analysis shall help a clinician to choose a material that is best suited for a patient tht would not only restore esthetics but also maintain the esthetics till the final prosthesis is fabricated.

Fig 3: Spectrophotometer.

MATERIAL AND METHODS

This investigation was designed to evaluate and analyze the color stability of the provisional restorative materials of different chemical compositions and curing techniques. The effect of four staining solutions – tea, coffee, cola and rasam was investigated on the color of six different types of provisional restorative materials. The study was conducted at the Department of Prosthodontics Crown and Bridge with Implantology, Bharati Vidyapeeth Dental College and Hospital, Katraj-Dhankawadi, Pune. The spectrophotometric analysis was done at Primier Colorscan, Mahape, New Mumbai. The colour stability was measured using a portable spectrophotometer with the measurements being taken in the CEILAB colour system.

SPECIMEN FABRICATION

50 specimens in the shape of discs, 25 mm in diameter and 2 mm in thickness were prepared from each material using similar shade groups (Fig 1) using a stainless steel die. To ensure uniform thickness of the material in the die, the material was placed in the die and a stainless steel slab was placed on it and the whole apparatus was placed under pressure. This size of the specimen allowed ease of manipulation and polishing to approximately 2.0 ± 0.5 mm, which is generally the thickness of the material at the facial and the occlusal surfaces.

Table 1: Provisional materials used.

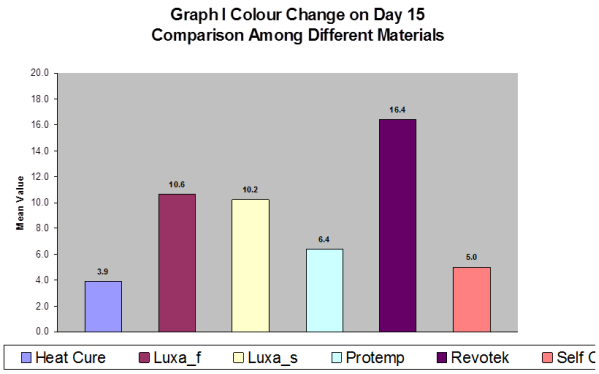
NAME	CHEMISTRY	COLOUR	MANUFACTURER
DPI HEAT CURE	Heat-cured polymethyl metha acrylate.	A	DPI, 9 Wallace street, Mumbai
DPI SELF CURE	Autopolymerising poly methyl metha acylate.	A	DPI, 9 Wallace street, Mumbai.
PROTEMP II	Chemically cured BIS-acryl-composite-based resin	A1	ESPE Dental-Medizin GmbH & Co. KG.,Seefeld, Germany
LUXATEMP SOLAR	Dual-cured (chemically&light) composite-based resin	A2	DMG Hamburg, GmbH, Hamburg, Germany
REVOTEK	Light cured single component composite resin.	B2	GC corporation, Tokyo, Japan.
LUXATEMP FLOURESCENCE	Self-cured composite based resin.	A2	DMG Hamburg, GmbH, Hamburg, Germany

Table 2: Mean Δ E of each material.

1. MATERIAL – HEATCURE			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	1.135	2.147	3.143
COLA	1.911	2.155	2.811
RASAM	4.761	6.402	7.211
TEA	1.600	1.899	2.454
2. MATERIAL – LUXATEMP (F)			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	2.679	3.642	4.739
COLA	2.447	2.864	3.628
RASAM	14.143	21.428	29.460
TEA	3.238	3.852	4.722
3. MATERIAL – LUXATEMP (S)			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	2.582	3.501	4.379
COLA	2.197	2.476	3.318
RASAM	14.975	22.278	28.760
TEA	2.901	3.585	4.488
4. MATERIAL- PROTEMP			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	1.517	2.439	3.178
COLA	1.505	1.929	2.651
RASAM	23.974	23.821	30.904
TEA	2.181	2.909	3.574
5. MATERIAL – REVOTEK			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	2.394	5.467	6.507
COLA	1.572	2.529	3.052
RASAM	23.651	29.865	37.870
TEA	2.626	4.692	5.115
6. MATERIAL – SELFCURE			
SOLUTION	DAY 1	DAY 7	DAY 15
COFFEE	2.034	2.636	3.294
COLA	1.683	2.067	2.498
RASAM	9.604	10.301	11.435
TEA	1.645	1.784	2.674

Table 3: Mean ΔE after 15 days.

MATERIALS	DAY 15 MEAN ΔE
DPI HEAT CURE	3.904
LUXATEMP (F)	10.637
LUXATEMP (S)	10.236
PROTEMP II	6.401
REVOTEK	16.362
DPI SELF CURE	4.947



Graph 1: Colour change on day 15th, Comparision among different materials.

The wax pattern for the heat-cured material (DPI heat cure) was made with hard baseplate wax using the stainless steel die. The patterns were then processed in gypsum molds in the denture flasks packed and processed in a clean water bath at 100⁰ C for 45 minutes. The materials used are given in Table I. The DPI autopolymerizing provisional restorative material was directly added with the monomer polymer ratio given by the manufacturer in the stainless steel mold (1:1.3), and allowed to cure for 30 min.

The Protemp II provisional restorative material is an autopolymerzing composite based resin. It was mixed according to the manufacturers instructions and added directly onto the die in the similar manner and allowed to cure. The Revotek light cured material is a UDEM based light curable composite resin. It was added on the stainless steel die and subsequently cured using the Densply curing unit for initial 10 seconds, followed by final curing for 20 seconds at a distance of 10 mm. Luxatemp Flourescence is a Bis- acryl based composite provisional material that is auotopolymerizing. It is supplied in an automix system which was used. The automix system was then used to dispense the material into the die carefully so as to avoid void formation. The stainless steel slab was placed on the material to allow uniform thickness. The discs were removed after 4 min.

Luxatemp Solar is a dual cured Bis-acryl composite resin that is also supplied as an automix system. The material was dispensed into the die. The initial auto-curing occurred, as it is a dual cure system. The final curing was done using the Densply curing unit.

Upon polymerization, the specimens were removed from their molds and were polished. One operator using timed and controlled steps polished the specimens. The polishing media used was coarse pumice powder and distilled water which was measured to obtain a consistent mixture for each specimen. A dental lathe (KaVo Polishing unit) operating at 1500 rpm was used for all procedures. Specimens were polished using a 15 second application of pumice applied with moist muslin wheel. A single individual polished all the specimens so as to avoid intra individual variation. Before the initial color measurement, the visual observation of polished surface of all specimens was made and any obvious porosity was noted and those specimens were discarded. The specimens were divided into groups of four, with ten samples each. The discs were randomly picked and serially numbered using an acrylic bur and the data was recorded accordingly.

STAINING SOLUTIONS

For the evaluation of the color stability the specimens were immersed in staining solutions. Three staining solutions were prepared using a standardized method. The staining solutions prepared were tea, coffee, cola and rasam. Coffee

was prepared using one tablespoons of coffee (Nescafe Classic) in 500 ml of distilled water, one tablespoon of sugar and 2 tablespoons of milk powder (Nestle Everday). After 10 minutes of stirring it, it was passed through a filter paper. The coffee was diluted with saliva in a ratio of 1:2 taking 50 ml of coffee in 100 ml of saliva.

The tea solution was prepared using 500 ml of distilled water. To this, 2 teaspoons of tea (Tata Tea) were added with 1 tablespoon of sugar and 1 tablespoon of milk powder (Nestle Everyday). After the boil the tea was filtered and it was diluted using artificial saliva with a ratio of 1:2. The cola used was Coca cola, which was also diluted using artificial saliva in the ratio of 1:2 with cola being 50 ml and artificial saliva being 100 ml. Rasam was prepared using the commercially available Rasam powder (Everest Batch no RP0505), which is a mixture of many of the Indian spices used (Chilly, coriander, cumin, black pepper, fenugreek, pigeon pea, turmeric tamarind, common salt, cassia, asafoetida and curry leaf). The rasam was prepared following manufacturers instructions. 50 gm of pigeon peas was taken in half a liter of distilled water and half a teaspoon of Everest Turmeric Powder. In a separate vessel, 200 ml of distilled water was taken. To it, 2-teaspoons of Everest Rasam powder were added and boiled for 30 minutes and the cooked mixture of pigeon peas was added to this mixture. In a separate small vessel, two teaspoons of pure ghee was heated. To this one red chilly, half a teaspoon of mustard seeds and a pinch of asafetida were added. The cooked ghee mixture was finally added to the pigeon pea mixture and cooked for two minutes and stirred well.

The rasam was diluted with saliva with the ratio of 1:2. For each group, the standard was artificial saliva. The specimens were immersed in artificial saliva and against this the color change in the samples immersed in the staining solutions were recorded at an interval of one day, seven days and fifteen days. The samples were immersed at 37^0 C in an incubator, (Fig 2) to simulate the temperature of the oral environment and evaluated for the color change after one day, 7 days, and 15 days. New solutions were made every day to avoid fungal growth and debris collection. The spectrophotometer used was a portable reflectance spectrophotometer -Techkon, Premier Colorscan. (Fig 3)

Values of the color change were recorded in the CIELAB color system. The CEILAB color system is an approximately uniform color space with coordinates for lightness, namely, white- black (L), redness – greenness (a) and yellowness-blueness (b). The L, a and b values of each specimen was measured 3 times, and a mean of each was calculated. The color was measured of the specimens dipped in saliva, which were taken as standard against which the color change was measured under the different staining solutions at the time interval of one day, seven days, and fifteen days. The color difference was calculated from the means using the following formula:

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

Where ΔL, Δa, Δb are the differences in L, a, b values of the samples in the solutions and the samples immersed in saliva; ΔE is the color difference between the samples immersed in the colored solutions and the samples in immersed in artificial saliva. Readings were taken of three randomly selected areas of the discs and a mean of these was calculated. All data recordings were taken by the same investigator to minimize inconsistency of the technique.

RESULTS

The results were analyzed using ANOVA analysis. The provisional materials, the staining agents, and their interaction were statistically significant ($P \geq 0.000$). All the materials showed statistically significant color change in all the colorants over the period of one day, seven days, and fifteen days. The values of the difference in color or ΔE of all the ten samples of each type of provisional material in the four groups of each immersion solution is given in Table II. If we consider the color changes that occur on the first day, then irrespective of the solution 'DPI Heat-cured' provisional material showed the minimum change $\Delta E = 2.35$, while the maximum changes were seen in Revotek $\Delta E = 9.66$ with the difference being statistically significant ($p=0.000$).

If the value of the fifteenth day is considered, DPI Heat-cured shows the minimum

changes ΔE= 3.91, while Revotek shows the maximum changes ΔE= 16.36, irrespective of the solutions they were immersed in. The difference in the materials being statistically significant p = 0.000.

If the solutions are considered individually irrespective of the material, then it becomes evident that rasam shows the greatest colour change ΔE= 24.97, while cola shows the least changes in the colour ΔE= 2.99 on the first day. However, if the comparison is made over a period of 15 days, Rasam shows the minimum change in the colour, while the maximum change in the colour is shown by coffee.

DISCUSSION

Coffee has been found to be a stronger chromatogen than tea or cola and this result is similar to the previous studies [1,2]. It has been previously found that discoloration by tea was due to adsorption of polar colorants onto surface of the material, which was removed by tooth brushing, whereas discoloration by coffee was due to both adsorption and absorption of colorants [3]. The yellow colorants of coffee were less polar than the yellow colorants tea. Absorption and penetration of the colorants into the organic phase of the resin-based materials is probably due to compatibility of the polymer phase with yellow colorants of coffee [3]. Both tea and coffee contain large amount of tanning agents like gallic acid, which could be another reason of the stainability of these materials [4]. Rasam which was the representative liquid of Indian food having the spices added, showed the maximum discoloration in all the materials. The combination of strong chromatogens and spices being cooked in the hot oil could be the reason for the significant discoloration produced by this solution.

The stainability of the various materials is not just related to the chromatogens but also to the chemical composition of the materials that are being tested. Amongst all the materials tested, methyl metha-acrylate polymers showed better color stability than the other materials. This result is similar to the results previously obained [5,6]. The stainability of the composite restorative materials can be related to the type of matrix resin, particle size and filler, degree of polymerization, length of time between polishing and finishing, degree of glossy surface, water sorption type of staining agent and the duration of the contact of the staining agent [7]. The discoloration of resin- based materials can be caused by various factors. The cause of chemical discoloration has been attributed to the change or oxidation of the amine accelerator, oxidation in the structure of the polymer matrix, and oxidation of unreacted pendant methacrylate groups [8].

It was found that the light polymerized materials – Revotek and Luxatemp S showed significant colour change after immersion at all intervals in all the solutions. The discoloration might be due to both surface adsorption and absorption of colorants. Fine colorant particles may have deposited into the pits of the light polymerized material. Large filler particles highly exposed on the surface could produce large surface roughness values resulting in high discoloration [9]. In the BIS-GMA resins, the benzoyl peroxide initiator in chemically cured resins is unstable, especially at elevated temperatures. This instability leads to polymerization of the resin pastes during storage, even in the absence of tertiary amine activators. Breakdown of the tertiary amine and reactions between benzoyl peroxide and inhibitor molecules have been reported to produce coloured reaction products in these dental resins [10]. The Bis-acryl resins (Luxatemp, Protemp) showed the lesser color stability as compared to the PMMA. Most bis-acryl polymers are more polar than PMMA polymers and therefore have a greater affinity towards water and other polar liquids [11]. This could account for the high degree of color changes observed in these materials.

The following conclusions can be drawn:

1. DPI Heat-Cure material showed the least color change on the first day, seventh day and fifteenth day in all solution.

2. Revotek showed the maximum color change in all solutions on the first day, seventh day and fifteenth day.

3. All the provisional materials showed the color change that was clinically not acceptable over a period of fifteen days.

4. Rasam caused the maximum discoloration on the first day; however the over all percent of colour change due to continuous immersion is maximum by coffee. While cola caused the least discolouration. Tea showed colour change greater than cola but less than coffee and rasam.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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