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Original Article

Effect of Staining Solutions on the Colour Stability of Direct Resin Composite

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Abstract

Background: Resin-based composite dentures or teeth are used as replacement of missing teeth. Their success depends largely on their colour stability as they undergo discoloration after prolonged exposure in oral environment and therefore, need replacement for esthetic reasons.
Objectives: To evaluate the colour stability of a nanofill composite resin (Filtek Z350) when exposed to different immersion media.
Study design and settings: An in-vitro experimental study was carried out at Dr. Ishrat-ul-ebad Khan Institute of Oral Health Sciences and colour testing was done at Al Karam textiles limited.
Materials and Methods: Forty resin-based composite specimens measuring 1 mm. of thickness and 5x5 mm. in length and breadth were prepared using a plastic sheet. Specimens were light-cured for 20 seconds from both sides and were randomized into 4 groups (n=10) according to immersion solutions: distilled water (control), coke, turmeric powder solution and coffee solution. Specimens were left immersed in these solutions for 10 days A digital spectrophotometer was used to evaluate the colour changes after 10-days and the colour differences (ΔE) were analyzed using paired t-test ($p<0.05$).
Results: After 10 days of immersion in coffee solution, coke and turmeric powder solution specimens showed significant colour change. The turmeric powder exhibited maximum staining followed by coffee and coke.
Conclusions: The composite resin was susceptible to staining by coffee, turmeric powder and coke.
Key words: Composite resins. nanoparticles, staining.

Introduction

Cosmetic dentistry offers the population to choose dental restoration that can match the colour of their teeth[1]. Due to excellent aesthetic properties, composite resins are widely used in aesthetic dentistry[1,2]. They differ in type of resin matrix, size, type, and amount of filler particles[2].

Adequate strength, high esthetic appearance, diametral tensile and flexural strengths, compressive strength, polish retention, wear and fracture resistance are the factors on which success of restoration depends[3,4]. In addition aesthetic materials should impersonate the look of natural tooth, and this is directly related to the material's colour stability[5]. Nevertheless, in spite of current improvements, colour stability of composite resins after long-standing intraoral exposure remains a concern for the dentists[5]. As a result of the polymerization reaction and interaction with the oral environment, these resins experience a series of physical changes[6], resulting in the softening of the resin matrix and a decrease in stain resistance[7]. Both intrinsic and extrinsic factors are responsible for discoloration of tooth-coloured resin-based materials, interface of matrix and fillers[7,8]. Extrinsic factors such as adsorption or absorption of stains not only cause discoloration but also affect composite structure and fillers[2,9]. Type of polymerization system and the polymerization conditions are important parameters which dictate the colour stability of composite materials[2]. The stability of these materials also depends on the conversion of matrix monomers. For obtaining excellent properties of direct resins composites, a high-intensity light polymerization unit has been developed[10]. The staining of tooth coloured composite materials is a major reason for the replacement of restorations in aesthetic areas[11].

Colour stability for a variety of aesthetic restorative materials has been studied in vitro[12-14]. Staining can be evaluated visually and by instrumental techniques (spectrophotometer and colourimeter)[15]. Colour evaluations by visual comparison are unreliable due to inconsistencies in colour perception specifications among observers[15]. Instrumental measurements eliminate the subjective interpretation of visual colour comparison[15]. Most commonly used methods to measure

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colour change in dental materials are Colourimeters and spectrophotometers[16,17]. Spectrophotometers are more accurate than colourimeters as they contain monochromators and photodiodes that measure the reflectance curve of a product's colour every 10 nm or less[18]. A study evaluated the colour stability of different composite in various drinking media and reported that water showed lowest and red wine highest colour change in of composite material. Cola, tea and coffee showed moderate colour change[19].

Materials and Methods

The material tested in this study was contemporary direct composite Filtek Z 350 (nano-filled) by 3M ESPE of shade A3.5. The effect of distilled water (control), coffee solution, turmeric powder solution and coke on colour change was evaluated. The study was conducted at Dr. Ishrat ul Ebad Khan Institute of Oral Health Sciences (Dow University of Health Sciences) and the testing was performed at Al Karam Textiles Karachi, Pakistan.

Forty samples were prepared with standard dimensions of 5x5 mm length and breadth and 1 mm thickness using night guard sheet as a mould.

The night guard sheet was placed on a glass slab. One cellophane sheet was placed on the base of the night guard sheet. On a glass slab, cellophane sheet was placed at the base of the night guard sheet. With the help of cement spatula the material was placed in the mould. Material was overfilled in the mould to ensure little excess of the material and to avoid air bubbles in the mixed material. Another cellophane sheet was placed over it and pressed uniformly, till all the three parts precisely approximated with each other. A glass coverslip was placed on top of the material to achieve a smooth surface finish. Sample discs were light cured using LED light-curing unit (Mectron Straight Pro 052KD191) from both the sides at 1 mm distance in four overlapping quadrants, to cover the whole surface area for specified duration following manufacturers' instructions (Filtek Z 350 - 20 seconds). Samples were removed from the sheet. Extra flash material at the boundaries of the specimen was removed. Finishing and polishing was performed with Sof-Lex Finishing Strips (3M ESPE).

The specimens were placed in distilled water at room temperature for 24 hours to ensure complete polymerization. The specimens were then divided randomly into four groups of 10 each. Control group was immersed in distilled water, Group 2 was immersed in turmeric powder, Group 3 immersed in coke and Group 4 in coffee.

Turmeric solution was prepared by adding 1.0 grams of turmeric powder (National Turmeric powder, National Foods Limited Pakistan) to 50 ml of boiling distilled water[2]. Coffee solution was prepared by using 10gm of coffee powder (Nescafe, Nestle Pakistan Limited) to 50ml of hot water. All the solutions were freshly prepared and replaced daily.

The samples were permanently kept in test solutions for 10 days and were gently rinsed with distilled water during changeover of solution and were air dried. Colour changes were assessed after 10 days using spectrophotometer. (Data colour 650 plus 9661)

The measurements were performed according to the CIE L*a*b* system and mean values for the material was calculated.

Results

After 10 days of immersion in coffee solution, coke and turmeric powder solution specimens showed significant colour change. The mean values of the specimens stored in distilled water (control group) were 1.84, while these values for coffee solution was 16.0, for turmeric powder was 26.5 and for coke were 3.46. All these showed significant change in colour ($p<0.00$) when compared with the control group. However, the highest value of colour change was with turmeric powder followed by coffee and coke.

Discussion

In the present study, colour change in dental resin material was observed with turmeric, coffee and coke. It is important to determine the susceptibility to colour change in restorative dental materials as they are constantly exposed to saliva, beverages and food stains. As clinical studies require long time to show results, therefore, to simulate and accelerate the discoloration; simulating oral aging conditions and laboratory tests are used to infer the changes[20].

Various studies have reported different thresholds of colour difference values above which the colour change is perceptible to the human eye. These values ranged from ΔE equal to 1[21], between 2 and 3[22], greater than or equal to 3.3[22] and greater than or equal to 3.7[15]. Values of ΔE between 0 and 2 are imperceptible, those between 2 to 3 are just perceptible, values from 3 to 8 are moderately perceptible and values above 8 are markedly perceptible[22]. A ΔE value of 3.7 or less is considered to be clinically acceptable[15, 23].

According to Guler, et al[16] storage or immersion for 15 days simulated consumption of the coffee over 1 year. In the present study the specimens were stored for 10 days which could simulate 8 months of exposure.

Results of the present study are in agreement with those reported by Gupta et al[23] where they used artificial saliva, tea, coffee, Pepsi and turmeric solution as the immersing media. They immersed the specimens for 15 days and reported that turmeric solution had the maximum staining potential followed by coffee, tea and Pepsi.

Stober et al[24] showed that turmeric solution and red wine caused the most severe discoloration (ΔE>10) than tea, coffee and mouth rinse over 4 and 8 weeks. Scotti et al[25], reported that the synthetic saliva and coffee produced greater darkening than tea and artificial saliva at 10 and 30 days period. Yannikakis et al[26], used coffee and tea as staining agents and found that coffee-stained provisional resin restorative materials more than tea. In a study conducted by Fontes et al[27] authors evaluated the colour changes at base line and 1 week after storage in coffee, yerba mate and grape juice and reported no significant difference for ΔE values than the baseline except for grape juice.

Staining of resins by fluid pigments and beverages is caused by adsorption or absorption (the uptake of substances into or through tissues) of colorants by resins[17]. Conjugated diarylhepnoids like curcumin are responsible for orange colour and highest staining of turmeric solution[17]. Staining by coffee is due to tannic acid[28] and discoloration from coffee is due to both the surface adsorption and absorption of colorants[17] and this might be the reason for coffee to be less colour stable than tea.

The staining on the composites by all the immersion media used in the present study can be justified due to the staining susceptibility of composite resins that might be attributed to their degree of water sorption and the hydrophilicity of the matrix resin[29]. Composite resins that can absorb water are also able to absorb other fluids with pigments which, results in discoloration. It is assumed that water acts as a vehicle for stain penetration into the resin matrix[30].

Cola drink does not appear to be strongly implicated in colour change of composites, despite the presence of phosphoric acid. Acids behave differently in promoting dissolution and hence in eroding the materials. In addition, the presence of phosphate ions in Coca-Cola® may suppress the dissolution since these ions have been shown to reduce the dissolution rate of calcium phosphate from the tooth[31].

The capability of resin matrix for stain is modulated by its degree of conversion[32] and water uptake[33]. The water uptake in Bis- GMA-based composite resins is increased from 3 to 6% as the proportion of TEGDMA is increased from 0 to 1%[34]. UDMA seems to be more stain-resistant than Bis-GMA[34]. Under normal curing conditions, UDMA-based composite resin presented lower water sorption[35] and higher colour stability[35] than having other dimethacrylates in their resin matrix[35].

Other factors like surface roughness, wear resistance and polishability can also affect colour stability. These should be considered areas of future study. As the solutions tested in this study do not represent all substances to which restorative materials may be exposed in the oral environment, additional studies are necessary to investigate the colour stability of composite resin-based materials.

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