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Original Research

An in Vitro Evaluation of effect of Bleaching Agents on Composite Colour

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ABSTRACT:

Background: The aesthetic goals of our patients in dentistry have become a major concern in today's world. Discoloured vital anterior teeth have long been treated with different approaches including crowns, direct and indirect veneers, composite resin, and most conservatively bleaching. The use of composite resins is increasing due to minimal tooth reduction and cost effectiveness as compared to ceramic veneers to achieve the optical properties of natural teeth. But very often in daily dental practice, tooth-coloured restorations already exist in the teeth that are planned to be bleached. **Materials and Methodology**: 40 disc shaped composite specimens (A2 shade) were fabricated measuring 10mm in diameter and 2mm in thickness using a stainless steel mould. The mould was placed on a mylar strip using a glass slab and overfilled with composite resin. Another mylar strip was placed on top of the mould and pressured with a glass slab to eliminate possible voids and remove excess material. The light-cured composite material used in the study was Gaenial GC A2 shade (GC Corporation, Japan). The composite resin was covered with acetate matrix strips and light cured. Specimens were light-cured for 9 seconds by a light-curing unit- (LCU) based on LED (Woodpecker, China). Following light-curing, the specimens were removed from the molds and placed at 37◦C distilled water for 24 hours to assure complete polymerization. Elastomeric putty impression of the samples (10 per group) were taken in an impression tray and casts were poured. Composite of 0.5 mm thickness was placed over the cast surface which acted as a separator. Four vacuum forming trays were fabricated using vacuum forming machine for each group. **Results**: The variables used in this study were one restorative material with three bleaching agents and artificial saliva as the control group. Statistical analysis done using Analysis of variance (ANOVA) with 'p' value <0.05 showed that the results between all the groups was statistically insignificant. **Conclusion**: Among the bleaching agents, 9% hydrogen peroxide ($\Delta E=0.615$) had the highest colour change when compared to 10% carbamide peroxide ($\Delta E=0.482$) and sodium perborate ($\Delta E=0.425$). However the results were statistically insignificant with the control group. Gaenial GC, a microfilled hybrid composite has better colour stability when exposed to 9% hydrogen peroxide, 10% carbamide peroxide and sodium perborate which is in the clinically acceptable range.

Key words: Bleaching Agents, composite Colour, hydrogen peroxide, carbamide peroxide, sodium perborate.

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INTRODUCTION:

The response of resin composites to the whitening materials is associated with the type, the concentration of bleaching agent and the total bleaching time.[1]Vital tooth bleaching can be performed at home and in-office. Four different approaches for tooth whitening have been recognized and reviewed by Barghi (1998):(a) dentist-administered bleaching—the use of a high concentration of hydrogen peroxide (from 35 to 50%) or carbamide peroxide (from 35 to 40%), often supplemented with a heat source; (b) dentist-supervised bleaching—by means of a bleaching tray loaded with high concentrations of carbamide peroxide (from 35 to 40%) that is placed in the patient's mouth for 30 min to 2 hrs while the patient is in the dental office; (c) dentist-provided bleaching— known as "at-home" or "night-guard" bleaching and administered by the patient applying from 5 to 22% solution of carbamide peroxide in a custom-made tray; (d) over-the counter products, often based on carbamide peroxide or hydrogen peroxide of various concentrations are placed in a pre-fabricated tray, or by the recently introduced strips both to be used by the patient. With the introduction of the dentist-monitored home bleaching technique, the application of peroxide-based agents with carriers has increased substantially during the past decade.[2]Night guard bleaching is simple, apparently safe and comparatively inexpensive bleaching alternative for patients. It involves the placement of mild bleaching agents in a custom made vacuum formed tray which is worn by the patient. Currently available home bleaching agents often contain up to 10% hydrogen peroxide (HP) or 22% carbamide peroxide (CP) as active ingredients, but products containing 10% CP appear to be most popular.[2] Home bleaching agents (Carbamide peroxide and hydrogen peroxide) provide whitening of tooth structure through decomposition of peroxides into unstable free radicals. These radicals further breakdown the large pigmented molecules into colourless compound either through an oxidation or a reduction reaction. Accordingly, the application of bleaching agents affect human teeth and tooth restorative materials.[2] Sodium perborate is a hydrogen peroxide releasing agent, and since 1907 it has been employed as an oxidiser and bleaching agent. It comes in powder form and can be mixed into a paste or putty with either pure water or hydrogen peroxide and is mostly used for non vital bleaching procedures. Several studies have reported bleaching effectiveness by comparing mixtures of sodium perborate with distilled water or hydrogen peroxide. Mixing sodium perborate with hydrogen peroxide had shown to accelerate the rate of colour change. In the case of severe discolouration, it is safe to mix sodium perborate with a 3% solution of hydrogen peroxide; however it is not appropriate to use 30% hydrogen peroxide because of the possible risk of inducing cervical root resorption.[3] Recently, sodium perborate in the form of strips and gels have been introduced which are available for home bleaching procedures. Bleaching agents deteriorate the surface of existing surface restoration which may induce bacterial adhesion. The type of the resin composite with respect to the organic and inorganic phase has is a crucial factor for the degree of colour and surface alterations induced by the bleaching products. Resin materials are especially more prone to chemical alteration compared to inert metal or ceramic composite resin.4 The colour change of polyacid-modified composites is generally higher than the change recorded for hybrid and macrofilled composites. These composites combine the aesthetics of traditional composite resins with the fluoride release and adhesion of glass-ionomer cements. Macrofilled composites have a particle size of 1-40um. The major disadvantage of traditional rein based composites included insufficient wear resistance as a consequence of which differential wear would take place which led to rapid loss of resin compared to the filler. This resulted in the large wear facets and dislodgment of filler particles from the surrounding matrix. Moreover, conventional resin based composite restorations exhibited increased surface roughness and were more susceptible to stain and plaque deposition. Therefore, researchers developed smaller and rounded fillers with a suitable particle size distribution, in an attempt to avoid the aforementioned problems. Nanofilled composites of particle size 100 nm or less with novel characteristics through manipulating, measuring and modelling of matter on a molecular scale. The manufacturing of nanoparticles for microfilled and nanofilled resin based composites involves a bottom-up synthetic chemical sol-gelprocess in contrast to the traditional milling technique employed for macrofilled resin based composites.[4] Microfilled composites have a homogenous distribution of fumed or pyrogenic micro filler particles with a particle size of 0.05 to 0.1 μm diameter. These materials exhibited substantially improved polishing characteristics compared with traditional resin based composites, which were most likely due to the filler particle being smaller than the wavelength of visible light. Microfilled resin based composites may have been classed as nanocomposites since the average size of the fumed silica was approximately 40 nm.[4] Gaenial GC is a microfilled hybrid composite with a combination of 2 types of pre-polymerized resin fillers, that offer clinical useful radiopacity while keeping perfect aesthetics for use in both in anterior and posterior teeth. These fillers also contribute to the low level of shrinkage found in Gaenial GC. They are produced by polymerizing a resin matrix in which micro-fillers were incorporated, and then milling the polymerized resin into particles averaging 16 to 17μ in size.[5] As the studies on the effect of bleaching agents on the colour stability of Gaenial GC is sparse in literature so the present study was conducted to evaluate the effect of various bleaching agents on the colour change of this microfilled hybrid composite with different bleaching agents (10% carbamide peroxide, 9% hydrogen peroxide, sodium perborate).

MATERIALS AND METHODOLOGY:

40 disc shaped composite specimens (A2 shade) were fabricated measuring 10mm in diameter and 2mm in thickness using a stainless steel mould. The mould was placed on a mylar strip using a glass slab and overfilled with composite resin. Another mylarstrip was placed on top of the mould and pressured with a glass slab to eliminate possible voids and remove excess material. The light-cured composite material used in the study was Gaenial GC A2 shade (GC Corporation, Japan). The composite resin was covered with acetate matrix strips and light cured. Specimens were light-cured for 9 seconds by a light-curing unit- (LCU) based on LED (Woodpecker, China). Following light-curing, the specimens were removed from the molds and placed at 37◦C distilled water for 24 hours to assure complete polymerization. Elastomeric putty impression of the samples (10 per group) were taken in an impression tray and casts were poured. Composite of 0.5 mm thickness was placed over the cast surface which acted as a separator. Four vacuum forming trays were fabricated using vacuum forming machine for each group

COLOR MEASUREMENTS.

Initial quantitative colour (ΔE) measurements were performed by the use of a spectrophotometer. During baseline measurements, three measurements were performed for each specimen, and the mean of the readings was calculated. The mean of each specimen was calculated by use of the CIE Lab uniform colour scale. The magnitude of the total colour difference is represented by a single number ΔE(CIE,1971) : $\Delta E = [(\Delta L*)2 + (\Delta a*)2 + (\Delta b*)2]1/2$, where L∗ represents lightness, a∗ redness-greenness and b∗ yellowness-blueness. This formula provides numeric data that represent the differences in colour perceived between 2 objects.

The specimens were then randomly divided into 4 groups (n = 10):

(i) Group A: Specimens were treated with 10% Carbamide peroxide for four hours per day for two weeks;

(ii) Group B: Specimens were treated with 9% hydrogen peroxide for four hours per day for two weeks;

(iii) Group C: Specimens were treated with Sodium perborate mixed with distilled water (freshly prepared mixing 2gm powder with 1ml water) for four hours per day for two weeks;

(iv) Group D: Specimens were stored in artificial saliva at 37◦C for two weeks and served as control;

During the test period, the specimens were kept at 37oC and 100% relative humidity. Each day after the active treatment period the specimens were rinsed with distilled water to remove the bleaching agents and were stored in artificial saliva. The home bleaching procedure was performed for four hours daily for 14 days. At the end of the bleaching regimen, colour change measurements of the control and the test groups were obtained as previously described. All specimens were measured three times and the average values were calculated.

RESULTS:

The variables used in this study were one restorative material with three bleaching agents and artificial saliva as the control group. Statistical analysis done using Analysis of variance (ANOVA) with ‘p’ value <0.05 showed that the results between all the groups was statistically insignificant.

DISCUSSION:

Esthetic restorations have gained popularity due to increase in esthetic demands of the patients.[5] But very often in daily dental practice, tooth-coloured restorations exist in the teeth that are planned to be bleached. Therefore, unintended application of the bleaching products on existing restorations by the patients cannot be excluded if bleaching is not performed and monitored by the dentist. The change of colour and loss of shade match of composite restorations with surrounding tooth structure are perhaps the most frequent reasons for replacement of an existing restorations after bleaching.[6,7] Many studies have evaluated the effect of bleaching agents on composite restoration. It has been reported that bleaching effect is directly related to the exposure, time and concentration of active bleaching ingredient. The longer the exposure time and the higher the concentration of whitening material, the greater will be the oxidation process and colour change. The associated side effects are namely porosity, increased surface roughness, and reduction in surface hardness of the existing composite restorations. Various reasons have been reported regarding the colour change in the resin composites such as the chemical structure, chemical activator, resin initiator and inhibitor, activator process, polymer quality, type and quantity of filler, oxidation of unreacted C=C bonds, UV illumination, heat, and water.[6-8] Currently several bleaching systems are available in the dental market which include in office bleaching, at home bleaching and over the counter bleaching products. All these agents contain peroxide (in the form of hydrogen peroxide, carbamide peroxide and sodium perborate).[6-9] All bleaching agents decompose into free radicals. These free radicals undergo oxidation or reduction reactions which can affect the teeth and the restorative materials.[2] These radicals also degrade the resinous matrix and disrupt the filler/matrix interface causing increasing water sorption and filler detachment. In addition, the oxidative capacity of peroxides may cleave the composite polymer-chains thus affecting their properties.[10,11] Both take-home and in-office bleaching techniques have proven to be effective in whitening teeth with the latter having the advantage of producing immediate results.[3] However, the in office method of bleaching requires several appointments with the dentist to achieve desired results, so an alternative method was proposed by Heyman in 1989 which is a simple, apparently safe and comparatively inexpensive bleaching alternative for patients, commonly known as Night guard home bleaching technique.[12,13] It involves the application of mild bleaching agents on the teeth by wearing a custom made vacuum formed tray.[4] To date, studies evaluating the effect of night guard bleaching agents on the colour change of composites has been scarce. So the present study was undertaken to compare the effect of three bleaching agents viz hydrogen peroxide (9%), carbamide peroxide (10%) and sodium perborate on the colour change of a microfilled hybrid composite. The hypothesis of the study was that the type of bleaching agent used would not influence the colour change of the composite. The composite material used in the study is a recently introduced microfilled hybrid composite Gaenial GC. It is mostly used for anterior aesthetic restorations. The type of resin matrix present in it is urethane dimethacrylate (UDMA) which is claimed to be more stain resistant than bis-GMA. Pearson in 1989 also documented that under normal curing conditions, a urethane dimethacrylate material showed lower water sorption than bis-GMA.[14] Gaenial GC is hydrophobically treated with dimethyl constituents rather than with silanol. This hydrophobic treatment improves the intimate contact between the silica and the matrix because both ingredients attract each other.[15] Hydrophilicity causes excessive water sorption and can increase the staining susceptibility of composite restorations. Water sorption decreases the life of resin composite by expanding and plasticizing the resin component, hydrolyzing the silane, and causing microcrack formation. These microcracks at the interface between the filler and the matrix allow stain penetration and discoloration.[1]The bleaching agents used in the study are 9% Hydrogen peroxide, 10% carbamide peroxide and sodium perborate. Hydrogen peroxide is generally used in a concentration of 3 to 9% for home bleaching procedures. However in recent years hydrogen peroxide concentration for at-home bleaching are available up to 15% H_2O_2. It is an oxidising agent and has the ability to produce free perhydroxyl and oxygen radicals. The perhydroxyl ion is a more potent free radical. In order to produce more perhydroxyl ion, hydrogen peroxide needs to be made more alkaline. The optimum pH for this to occur is 9 to 10.8. Thus the pH of hydrogen peroxide selected in the study was 9%.Carbamide peroxide is mostly used in concentration of 5 to 22%. It breaks down during oxidation into its constituents parts- water, urea and oxygen.[16,17] However in our study, 10% of carbamide peroxide was chosen as it is claimed to be safest when used as a home bleaching agent because of its lower concentration and the results obtained are generally excellent. The third bleaching agent used in the study was Sodium perborate. Sodium perborate is mostly used as a non vital bleaching agent, but recently strips and gels containing sodium perborate have been introduced which are used as home bleaching agents. It is available in monohydrate, trihydrate and tetrahydrate forms. Sodium perborate decomposes with the formation of hydrogen peroxide when it comes in contact with water. This may release active oxygen, which starts the bleaching process. The content of active oxygen depends on the content of water of crystallization. No water of crystallization is present in monohydrate, while six water molecules are connected to the sodium perborate ring of tetrahydrate form of sodium perborate.[13] Hence, in the study sodium perborate terahydrate was used. The free radicals formed undergo oxidation or reduction reactions which can affect the teeth and the restorative materials.[2] The composite samples used were kept at 2 mm thickness so as to get a more accurate measurement of change in colour. Gaenial GC composite of A2 shade was chosen so that the colour change could be easily evaluated. Bleaching trays in the study were fabricated using vacuum forming machine to mimic the custom made home bleaching procedures. The control specimens were stored in artificial saliva which was used as a standard against which the after effects of bleaching could be compared. The restorative material was subjected to bleaching agents according to the manufacturer's instructions for 4 hours daily for a period of 14 days to know the effect of colour change .A number of methods are available for measuring the colour of dental materials and teeth. Shade guides, visual evaluation or photographs are useful for colour evaluation; however, these rely on subjective options and which have been shown to be unreliable. The colorimetric instruments such as colorimeters or spectrophotometers yield numeric values and more reliable are more than the others. Another approach for measuring tooth colour is by using non-contacting camera-based digital imaging and analysis systems. The CIELab system is an approximately uniform colour space that coordinates for lightness, namely white black (L*), redness-greenness (a*) and yellowness-blueness (b*). Colour difference (ΔE) is calculated from the mean ΔL^*, Δa^* and Δb^* values for each specimen. The quantitative evaluation of colour difference (ΔE) with a spectrophotometer confers advantages such as repeatability, sensitivity and objectivity. A ΔE value of more than 1 is clinically noticeable under optimal viewing conditions by trained observers.[13] Johnston and Kao reported that, if ΔE is less than 1, this chromatic value deemed to be slight under clinical conditions in the mouth. ΔE colour differences have been reported to be relevant, clinically significant and perceptible only when higher than 3.3.[4,5] The spectrophotometric results of the study showed that there was no clinically perceptible colour change in the composite with either of the bleaching agents used. 9% hydrogen peroxide demonstrated slight change in colour (ΔE=0.615) whereas 10% carbamide peroxide (ΔE=0.482) and sodium perborate (ΔE=0.425) demonstrated trace amount of colour change according to the NBS system of expressing colour differences. The lower change in colour of sodium perborate may be due to the use of distilled water where more frequent changes of the bleaching agent might be necessary to have an effective colour change, unlike cases where sodium perborate is mixed with hydrogen peroxide (where less frequent changes in bleaching agent is required).189% hydrogen peroxide group showed higher colour change than 10% carbamide peroxide because 10% carbamide peroxide is equivalent to 3% hydrogen peroxide.[19] The results of the study are in accordance with Canay and Cehreli in 2003 showed that 10% hydrogen peroxide caused more color changes of composite resins compared with 10% carbamide peroxide which could be attributed to the polyacid content of these restorations.[6] Yalcin et al in 2005 also demonstrated that 6.5%hydrogen peroxide had higher colour change than 10% carbamide peroxide.[8] However, several other studies that evaluated a lesser concentration of hydrogen peroxide also showed a significant colour change in composite resin which could be attributed to difference in composite material. Canay et al in 2003 demonstrated that all restorative (macrofilled, polyacid and hybrid) composites had clinically detectable changes and had similar tendency to become lighter after treatment with 10% Hydrogen peroxide.[2] In contrast to this study, Robinson et al in 1997 determined that all bleaching solutions that contained 10% Carbamide peroxide discoloured all methacrylate provisional restoration materials, regardless of the base material of the bleaching agent or the presence or absence of Carbopol.[1] Pruthi G et al in 2010 determined the effect of 15% carbamide peroxide on colour change and found that it was effective in reducing the discolouration in all groups to within clinically acceptable value which may be due to superficial cleansing of the specimens.[19] Kamangar et al in 2014 determined the effects of 15% Carbamide peroxide which did not remain in the clinically acceptable range after bleaching.[20] This may be attributed to the free perhydroxyl radicals which causes oxidative cleavage of polymer chains.[4] Li et al in 2009 also demonstrated significant colour change with 15% carbamide peroxide which may be because of alteration in chemical composition in the polyacid-modified composite.[16] Artificial saliva (control) group also had least amount (ΔE=0.255) of colour change with insignificant difference when compared to the other groups. The trace amount of change in colour may be attributed to the hydrolytic degradation of the filler and due to the reaction with the coupling agent, resulting in the failure of the filler–matrix bond.[21] Further research is required to know the effect of various concentrations of bleaching agents on the colour change in patients with tooth coloured restorations sothat bleaching can be performed without the apprehension of any change in colour on the restorations especially on the aesthetically concerned areas.

CONCLUSION:

The colour change using different bleaching agents (10% Carbamide peroxide, 9% Hydrogen peroxide, Sodium perborate) was evaluated on Gaenial GC (A2 shade) composite restorative material.Based on the employed methodology and obtained results, it may be concluded that,

1. Among the bleaching agents, 9% hydrogen peroxide (ΔE=0.615) had the highest colour change when compared to 10% carbamide peroxide (ΔE=0.482) and sodium perborate (ΔE=0.425). However the results were statistically insignificant with the control group.
2. Gaenial GC, a microfilled hybrid composite has better colour stability when exposed to 9% hydrogen peroxide, 10% carbamide peroxide and sodium perborate which is in the clinically acceptable range.

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