

Coloration of provisional restoration materials: a comparison of the effects of mouth rinses and green tea

Purpose

The present study aimed to evaluate the color stability of provisional restorative materials stored in different mouth rinses and green tea extract for 14 days.

Materials and methods

Forty cylinders of fixed provisional restoration material of 15-mm diameter and 2-mm thickness were prepared. The samples were separated into four storage solutions (three different mouth rinses and green tea) (n=10). The values of L*, a*, and b* were determined before and after storage in the solutions using a spectrophotometer, and the ΔE^* value was calculated. The effect of mouth rinses and green tea extract on the color change of provisional restoration materials was determined with one-way analyses of variance. The Tamhane multiple comparison analysis was used to determine the differences between the groups ($p < 0.05$).

Results

The color stability of the provisional restoration materials varies depending on the solution. Listerine mouth rinse showed more color change than Sensodyne or Colgate did. Minimal color change was found in the green tea solution.

Conclusion

The effect of mouth rinses on the color stability of fixed temporary restorative materials is remarkable. As green tea shows less color change, it can be suggested as an alternative to mouth rinses.

Keywords: Provisional dental materials, color stability, mouth rinses, green tea, spectrophotometer

Introduction

It is essential that provisional restoration should be used in order not only to protect the teeth having already been prepared while fixed restorations are being fabricated but also to provide the patient with comfort until the treatment ends. Provisional restorations should be able to withstand the chewing pressure for as long as they are used, apart from keeping the prepared teeth stable during any act of occlusal functioning. It is also necessary that provisional restorations should protect the dental pulp against thermal mechanic and bacterial interactions, and that they should protect the periodontium through edge matching. Finally, provisional restorations should also achieve aesthetic perfection (1-3).

In the fixed prosthetic treatment, provisional restorations are known to be good diagnostic tools because they are, in a sense, a kind of aesthetic and functional rehearsal for permanent restoration, which helps the dentist assess whether the prosthesis being planned will sufficiently meet aesthetic, biomechanical and physiological needs of the patient (4).

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While permanent restoration can be accomplished within two weeks in the prosthetic treatment, provisional ones can also be used for very long. It is necessary that long-term provisional restorations should be used in predicting treatment results of the patients who require changes in vertical dimension before the soft tissues in the anterior regions, where aesthetics is of great importance, can be shaped. They should also be used in treating temporomandibular joint disorders, and during the period when osseointegration is expected to take place after an implant treatment as well as in evaluating the prognosis of the teeth during a periodontal treatment (5, 6). Great care should be taken so that there are no big differences between good provisional and permanent restorations, because carelessly prepared provisional restorations are doomed to result in repetitions, waste of time, periodontal problems or a damaged oral mucosa (7).

Discoloration in the provisional restorations that have been used for very long in the anterior region, where aesthetics is of paramount importance, is known to adversely affect both quality of the restoration and patient satisfaction (8). Provisional restorative materials to be used should possess colour stability and resistance to discoloration in the oral cavity as far as diverse drinks and teeth-cleansing solutions are concerned (9, 10). Today, polyvinyl methacrylate, urethane dimethacrylate, polymethyl methacrylate, polyethylene methacrylate, Bis-acrylic resin and resin composites are used as temporary restorative materials. Polymerization of these materials is achieved either through chemical means or using light or employing both methods at the same time (11, 12). Acrylic resin restorations that are polymerised with heat are widely preferred due to their high resistance and durability merits (13). However, Bis-acrylic resins are increasingly used due to such properties as being practical, having minimal polymerization shrinkage and low exothermic reaction apart from providing remarkably satisfactory aesthetic results (10).

Gargling with mouthwash is an effective method for maintaining perfect plaque control and periodontal health. Depending on their ingredients, commercially available gargle preparations are used in treating gingivitis, preventing secondary infections following radiotherapy or chemotherapy, or supplementing an antibacterial treatment of inflammatory cases such as tonsillitis, sinusitis, pharyngitis, and laryngitis (14). Certain curative herbs like green tea are also used for oral rinse in addition to various conventional mouthwash solutions. We know of some studies that are working on a viable alternative substance to disinfecting dental materials (15, 16). Green tea is derived from the leaves of the *Camellia sinensis* and is processed in a different way than black tea. Green tea comes from ripe, fresh leaves, while black tea is derived from leaves oxidized in the sun. Green tea, which can have two or more phenol units, includes a larger number of antioxidants than all other drinks and helps remove free radicals. Several studies have reported that green tea helps prevent cancer, cardiovascular diseases and Alzheimer's disease apart from having neuroprotective and antimicrobial properties. Other studies have also proved that green tea helps reduce candida albicans involvement on dental materials (17, 18).

Teeth and restorations in the oral cavity tend to lose their colour stability due to internal and external factors. Today, when aesthetics is viewed as highly as oral hygiene, discoloration is undesirable not just for the dentist but also for the patient (14). Colour recognition of dental materials is achieved with digital colour measurement devices: spectrophotometer and colorimeter. These are known to be more reliable and constant than visual methods. The spectrophotometer measures the light reflected off the object in accordance with its wavelength, while the colorimeter measures the amount of blue, green and red colours reflected off the object. The amount of the three primaries used is known as the tristimulus values of the colour. Spectrophotometer and colorimeter numerically shows the tristimulus value that is present on the x, y, z level in recognition of colour. These values are calculated in accordance with Commission Internationale de l'Eclairage (CIE) and then $L^*a^*b^*$ values are obtained. According to CIE values, L^* indicates lightness while a^* and b^* indicate colour satisfaction. The value of a^* describes red-green measurement while b^* describes the measurement of the yellow-blue axis (19). The present study aims to evaluate the colour stability of three different mouthwash solutions and green tea extract upon provisional restoration with Bis-acrylic content that gets hardened via autopolymerisation. The null hypothesis tested in this study is that the mouthwash solutions and green tea extract do not affect the colour stability of provisional restorations.

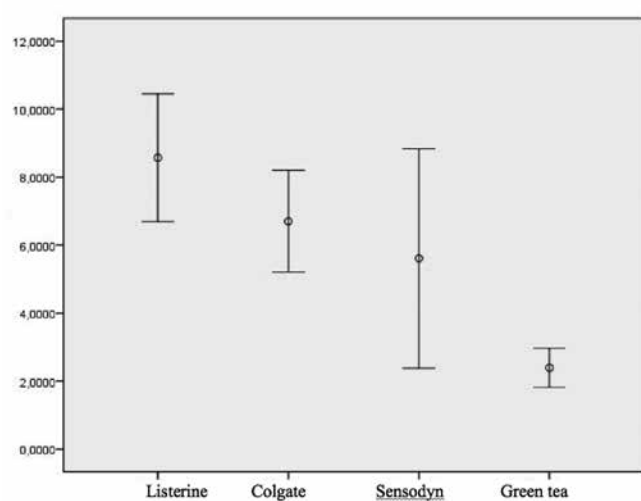
Materials and Methods

Specimen preparation

In this study, 40 disc-shaped fixed provisional restoration material (Protemp) in diameter of 15 mm and in thickness of 2 mm (Protemp 4, Bis-acryl, 3M Espe, Seefeld Germany) were prepared using stainless steel mold between two glass plates in light of the suggestions made by the producing company according to definition number 27 by American Dental Association (ADA) (20). There is Bis-acryl resin containing microparticle-fillers (GMA, UDMA, TEGDMA, bis-EMA and 5nm silanized amorphous silica) in the composition of Protemp 4, which is a provisional restorative material. Once polymerization had finished, the samples taken out of the mold were inspected with the naked eye by the same researcher for air space, surface roughness, and presence of porosity. The samples with a defective surface were picked, so that 10 test samples were prepared for each of the groups. Since the samples had been prepared in glass plates, they had a smooth surface. For this reason, there was no need for a polishing process. The samples were stored in distilled water at $37^\circ\text{C}\pm 1^\circ\text{C}$ for twenty four hours prior to the test. A teabag of green tea was put in boiling water of 150 mL to prepare a standard tea solution and was used after ten minutes of storage. 150 mL was also used for mouthrinses. The solutions were renewed daily and stored for 14 days by being fully covered. After two weeks, the samples were washed and dried before they could be made ready for colour measurement. The solutions prepared for this study have been presented in Table 1.

Table 1. The solutions used in the present study

Brand name	Composition	Manufacturer
Listerine Total Care Zero	Aqua, Sorbitol, Propylene Glycol, Potassium Nitrate, Poloxamer 188, Benzoic acid, Aroma, Sodium Benzoate, Eucalyptol, Sodium saccharine, Sucralose, Sodium Fluoride, Methyl Salicylate, Thymol, Cocamidopropyl Betaine, Menthol, BHT, CI420 53	Johnson and Johnson, Istanbul, Turkey
Colgate Total	Aqua, Glycerin, Sorbitol, Propylene Glycol, Poloxamer 407, Polysorbate 20, Aroma, Cetylpyridinium Chloride, Potassium Sorbate, Sodium fluoride, Menthol, Sodium Saccharin, CI 17200, CI42051	Colgate-Palmolive Thailand
Sensodyne	Aqua, Glycerin, Sorbitol, Potassium Nitrate, PEG-60, Hydrogenated Castor Oil, Poloxamer 407, Sodium benzoate, Aroma Disodium phosphate, Methylparaben, Propylparaben, Sodium Phosphate, Sodium fluoride, Menthol, Sodium Saccharin, CI 19140, CI42090, Potassium nitrate, Sodium Fluoride	GlaxoSmithKline, Istanbul, Turkey
Green Tea	Green tea leaves	Natural food products, Akyurt, Ankara

**Figure 1.** The relationship between the colour differences observed in the provisional restorative materials after being stored in the solutions *Values not overlapping horizontally are statistically different.

Colour assessment

The first colour measurements of the samples were made soon after they had been prepared, while the second measurements were made 14 days after they had been stored in the solutions. The measuring process was carried out with the aid of a digital spectrophotometer (VITA Easy shade Compact Advance 4.0, VITA Zahnfabrik H. Rauter GmbH & Co.KG), during which the suggestions by the producing company were taken into consideration. That is, the device was calibrated at regular intervals and measurements were made upon a white surface under D65 standard light conditions. The spectrophotometer used in this study is capable of measuring in colour values of vitapan classic and vitapan 3D-master, and has got a heat range of 15-40°C, apart from being a rechargeable device fitted with a White High Power LED light lamp. The measurements achieved upon the surface of every single sample were repeated three times before the mean values for L*, a* and b* could be recorded. The differences observed in the colour were calculated using the following formula (8, 14): $\Delta E = ((L_1^* - L_0^*)^2 + (a_1^* - a_0^*)^2 + (b_1^* - b_0^*)^2)^{1/2}$. L1, a1 and b1 values stand for CIE L* a* b* values after the samples had been stored in the drinks, while

**Figure 2.** The provisional restorative materials evaluated in terms of colour change have been presented below from top to bottom: listerine, colgate, sensodyn and green tea samples, respectively.

L₀, a₀ and b₀ values stand for the CIE L* a* b* values that had been measured in the beginning.

Statistical analysis

The normality of the data was tested by the Shapiro-Wilk Test ($p > 0.05$). The effects of mouthwash solutions upon the colour change observed in provisional restorative materials were determined by the one-way analysis of variance (ANOVA). The analysis of our study was evaluated using a statistic analysis software programme (SPSS 18.0 for Windows; IBM Corp, SPSS Inc, Chicago, IL, USA). Since the variance was not a homogenous, the difference between the average values had to be determined, for which we used the Tamhane multiple comparison test at the level 0.05 significance.

Results

As a result of the one-way statistical analysis, it was determined that there was a statistically significant difference between the effects of mouth rinse solutions upon the colour stability of the provisional restorative materials that had been stored in a solution for 14 days ($p < 0.05$). On the other hand, less change was observed in the colour as far as the green tea extract was concerned (2.39 ± 0.81). Differences between the materials have been presented in Figure 1. The mean colour change value (ΔE) observed with the provisional restorative materials being stored in different solutions has been

Table 2. ΔE ; mean and \pm standard deviation values of the provisional restorative material after being stored in the solutions. The mean values with different letters are different according to the ANOVA (One-way) test ($p < 0.05$)

	Mean \pm standard deviation values
Listerine	8.57 \pm 2.62 ^b
Colgate	6.70 \pm 2.09 ^b
Sensodyn	5.61 \pm 3.86 ^b
Green Tea	2.39 \pm 0.81 ^a

presented in Table 2. The change in colour was seen in the samples stored in Listerine (8.57 \pm 2.62), Colgate (6.70 \pm 2.09), Sensodyn (5.61 \pm 3.86), and green tea solutions (2.39 \pm 0.81), respectively. Figure 2 shows colouration photos of the samples after 14 days of storage.

Discussion

Several studies have used colouring solutions as diverse as water, coffee, tea, cola, oral rinse, red wine and food dyes for evaluating the colour stability of provisional restorations. Our study has evaluated the colour stability of green tea can serve as substitute alternatives to standard ones and different mouthrinses that. Green tea was found to cause less change in colour when compared to other mouth rinses.

Colour stability of dental materials are affected by liquid absorption, completion of material polymerization, the type of polymerization, the amount of residual monomer, the thickness of the material and the roughness of the surface (1). In the present study optimal polymerization was aimed in keeping with the suggestions made by the company that produces the provisional restorative material containing autopolymerized Bis-acryl. Polymerization was achieved between the glass plates with a view to reducing surface roughness. All the samples prepared consistently with those of others studies into the colour stability of provisional restorative materials were standardized in such a way that each would have a thickness of 2 mm (21).

It has been suggested that no full polymerization of the surface resin plate can be ensured if samples happen to get exposure to oxygen during the polymerization process (22). It has also been reported in the literature that smoothing and polishing are applied to remove the unpolymerized plate over the material so that harder, durable and aesthetic surfaces can be obtained (23, 24). This study used glass plates for preparing the study samples. However, it is still much better to smooth and polish the samples by wet sanding so that the top layer can be removed. Koroğlu *et al.* (9) emphasized that the surface roughness values of provisional restorative materials affect the stability of colour. Colour change is observed less frequently in the samples with a low roughness value; therefore, polishing the samples while they are being prepared on a glass surface will affect their surface roughness values. In order to obtain low colour change values, the samples to be studied should be as smooth as possible. Protemp 4, fitted with a cartridge, is a Bis-acryl-based interim composite that is used with a gun. That it is fitted with a car-

tridge makes it better for miscibility and utility, which helps it gain increasing popularity (25). Bis-acryl-based Protemp 4 has been shown in some studies investigating colour stability in provisional restorative materials to possess a lower colour stability than do PMMA and PEMA (26). Bis-acryl composite resins are known to be of a heterogeneous nature due to its organic polymer matrix and inorganic filler particles. However, presence of filler particles may prevent the surface of the material from being smoothed (27). Sen *et al.* (28) reported the fillers to cause protrusions to be formed over the surface of the material when they analysed the SEM images of Bis-acryl composite resins.

Discolouration of Bis-GMA is also affected by the polar OH-groups included in its monomer structure, which accounts for a larger amount of water absorption (29). Protemp 4 is known to contain bis-GMA, UDMA, TEGDMA and bis-EMA. When the amount of TEGDMA in BisGMA rises from 0% to 1%, absorption of water also rises from 3% to 6%. As a result, discoloration increases in line with a rise in water absorption (30). Similar studies including different oral rinse agents have reported the biggest change in colour with the Listerine oral rinse (14, 31). This significant colour change was attributed to the high alcohol content of Listerine. Even though the Listerine used in our study was alcohol-free, the biggest colour change was observed with this mouthwash agent. As for the green tea, discoloration was observed due to the fact that it contained no chemical substances whatsoever. The provisional restorative materials were stored in different mouth rinses and green tea extract for 14 days, with the solutions being renewed every single day. Considering the fact that mouth rinses are used twice a day, a 24-hour storage period of the provisional restorative materials in the containers corresponds to a one-month storage period in the oral cavity. That is, a 14-day storage period equals to a 14-month aging period, which is one of the longest periods that can be used for restorative materials (31).

Studies into determining the colour of dental materials usually use the colorimeter and the spectrophotometer. The colorimeter determines the coordinates of the light reflected off the material according to the CIE system. While the colorimeter is capable of making one-dimensional measurement, the spectrophotometer can achieve a two-dimensional measurement. Because the spectrophotometer is able to measure all the spectral wavelengths reflecting off a material, it often achieves more precise and more systematic measurements. On the other hand, the colorimeter is capable of only measuring the amount of blue, red and green wavelengths (32, 33). Therefore, we used the spectrophotometer in our study for more precise results. In as much as using the ΔE value for the data obtained through the spectrophotometer is preferred more often than giving them separate values as L^* , a^* , b^* , we also used the ΔE value in evaluating the colour change in our restorative materials (34). If the ΔE value is 0 for the colour change being evaluated, it means there is no difference between colour changes. On the other hand, if this value varies between 0.5 and 1.5, it indicates perfect colour stability. If this value varies between 1 and 2, it means 'good' while a value between 2 and 3.5 is viewed as 'acceptable'. However, if the ΔE value is bigger than 3.5, it shows that discolouration of the

material cannot be accepted clinically (8, 21, 35). In our study, the sample groups showed a ΔE value over 3.5 with the exception of the green tea group.

The samples had been stored in distilled water for 24 hours at 37°C before they were transferred to the solutions was in order to imitate the oral medium. However, a wearing medium can be created for in-mouth dental materials. Depending on the person's dietary habits, the content of the food consumed, poor oral hygiene, smoking, and the makeup of the saliva can damage the chemical structure of the materials used for dental restorative materials (36). The resin matrix of dental composites has been shown to soften when exposed to organic acids and different food. The structure of the Bis-acryl composite, which we have used as provisional restorative materials in this study, bears similarity to that of dental composites. It can also be affected by oral fluids and chemical mediums induced by food (6).

One of the limitations of this study is that it is impossible to imitate the factors to be produced in the oral medium under the given experimental conditions. Another limitation is that the shape of the samples does not match those of eligible for clinical applications. The samples for this study were prepared over disc-shaped glass plates in such a way that they would have smooth surfaces. However, the provisional restorative materials used in the oral medium will have an indented surface just as natural teeth do. Unfortunately, it is not possible to apply polishing to all surfaces or to prepare between glass plates due to the uneven surface structures. Therefore, there arises a need for clinical studies that can help overcome this problem.

Conclusion

As a result of the 14-day aging process of the samples used in the study groups, where Listerine, Colgate, and Sensodyne mouthrinses were used, and within the limits of this in-vitro study, we determined the ΔE values above 5. As to the group using green tea extract, this value was 2.29, which seems to be clinically acceptable. We, therefore, concluded that green tea could be used as an alternative to the commercially available mouth rinses. However, the dentist should consider that the mouth rinses in question may fail to retain their colour stability, and devise a treatment schedule accordingly. We suggest that our results should be supported and confirmed by further studies although we are providing essential knowledge about discolouration in relation to mouth rinses and green tea.

Ethics Committee Approval: Not required.

Informed Consent: Not required.

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Türkçe öz: Ağız gargaraları ve yeşil çayın geçici restorasyon materyalinin renklenmesi üzerindeki etkilerinin karşılaştırılması. Amaç: Bu çalışmanın amacı 14 gün farklı ağız gargaraları ve yeşil çay ekstratında bekletilen geçici restoratif materyallerinin renk stabiliteelerini değerlendirmektir. Gereç ve yöntem: Kırk adet silindir şeklinde 15 mm çapında 2 mm kalınlığında sabit geçici restorasyon materyali hazırlandı. Örnekler solüsyonlarda bekletilmek üzere 4 gruba ayrıldı (3 farklı ağız gargarası ve yeşil çay) (n=10). Hazırlanan örneklerin solüsyonlarda bekletilmeden önce ve sonra L*, a*, b* değerleri spektrofotometre kullanılarak tespit edildi, ΔE * değeri hesaplandı. Ağız gargaralarının ve yeşil çay ekstratının geçici restorasyon materyallerinin renk değişimi üzerindeki etkisi tek yönlü varyans analizi ile tespit edildi. Ortalamalar arasındaki farklılığın tespit edilmesi amacıyla Tamhane çoklu karşılaştırma analizi kullanıldı. (p<0,05) Bulgular: Geçici restorasyon materyallerinin renk stabilitesi kullanılan solüsyona göre değişmektedir. Listerine, Sensodyne ve Colgate ağız gargaralarından daha fazla renk değişimi göstermiştir. En az renk değişimi yeşil çay solüsyonunda bulunmuştur. Sonuç: Ağız gargaralarının sabit geçici restoratif materyallerin renk stabilitesi üzerine etkisi fazladır. Yeşil çay daha az renk değişimi gösterdiği için gargaraların yerine alternatif olarak hastalara önerilebilir. Anahtar kelimeler: Geçici restorasyon materyali, renk stabilitesi, ağız gargarası, yeşil çay, spektrofotometre

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