Abstract

Aim: The purpose of this study was to determine the color stability of 4 different provisional restorative materials after immersion in different mouthrinses for 24 hours.

Materials and Methods: Sixty cylindrical specimens were fabricated with 4 provisional materials; vinyl ethyl methacrylate (Trim), methyl methacrylate (Temdent), ethyl methacrylate (Dentalon) and bis-acryl composite (Protemp II) according to the manufacturers’ instructions. The specimens were divided into 4 groups (n=15) and immersed in distilled water, Oral B, Listerine and Chlorhex. Color measurements were obtained using a colorimeter before and after 24 hours. Statistical analysis was performed using 2-way ANOVA and Tukey multiple comparison test (p=.05).

Results: The interaction of provisional restorative materials and mouthrinses were statistically significant (p<.05). Trim (0.96), Dentalon (0.96) and Protemp II (0.91) demonstrated acceptable color stability and were the most color stable provisional restorative materials tested compared to Temdent (1.5) provisional restorative material. Listerine mouthrinse exhibited more staining capacity than Oral B and Chlorhexidine mouthrinses.

Özet

Amaç: Bu çalışmanın amacı 24 saat farklı ağız gargaralarında bekletilmiş 4 farklı geçici restoratif materyalin renk stabelitelerini değerlendirmektir.

Gereçler ve Yöntemler: 4 geçici restoratif materyal den 60 adet silindir şeklinde örnek; vinil etil metakrilat (Trim), metil metakrilat (Temdent), Etil metakrilat (Dentalon) ve bis-akril kompozit (Protemp II) üreticileri firmalı taliyatlarına göre hazırlanı. Örnekler 4 gruba ayrıldı (n=15) ve distille su, Oral B, Listerine ve Klorheks içerisine bırakıldı. Renk ölçümleri kolorometre kullanılarak solüsyonlara daldırdan önce ve daldırdıktan 24 saat sonra yapıldı. İstatistiksel analiz 2- yönlü varyans analizi (ANOVA) ölçümleri ve Tukey çoklu karşılaştırma testi kullanılarak gerçekleştirilmiştir (p=.05).

Bulgular: Geçici restoratif materyaller ve ağız gargaları arasındaki etkileşim istatistiksel olarak farklı bulunmuştur (p<.05). Trim (0.96), Dentalon (0.96) ve Protemp II (0.91) kabul edilebilir bir renk stabelitesi göstermişlerdir ve Temdent (1.5) ile karşılaştırdıklarında en stabil renge sahip geçici restoratif materyallerdir. Listerine ağız gargarı Oral B ve Klorheksidin’den daha fazla boyama kapasitesi göstermiştir.
INTRODUCTION

Provisional restorations provide protection, stabilization, and function before fabrication of the definitive prosthesis. It may also be used as diagnostic aids when correcting irregular occlusal planes, altering vertical dimension of occlusion, or planning for changes in the location and contour of the gingiva or the size, shape, and color of definitive restorations. The prognosis of a fixed prosthodontic restoration depends on the quality of this provisional restoration. Color stability of provisional materials is a concern, particularly when the provisional restoration is in the esthetic zone and must be worn for extended periods of time. Ideally, provisional materials should not change in color or appearance subsequent to fabrication.

Materials available for fabricating provisional restorations include autopolymerizing polymethyl methacrylate, polyethylene methacrylate, polyvinyl methacrylate, urethane methacrylate, bis-acryl, and microfilled resin. These materials can be polymerized by chemical, light, or both chemical and light activation.

Discoloration of provisional restorative materials for fixed prosthodontics may lead to patient dissatisfaction and additional expense for replacement. This is particularly problematic when provisional restorations are subjected to prolonged exposure to colorants during lengthy treatment. The degree of color change can be affected by a number of factors, including incomplete polymerization, water sorption, chemical reactivity, oral hygiene and surface smoothness of the restoration.

Saliva, food components, different drinks, beverages and mouthrinses may affect the color of provisional restorations. Recently mouthrinses have become popular. Besides being an effective caries and gingivitis control method, and topical relief measure in oral lesions, people tend to use mouthrinses for social and cosmetic reasons. However, frequent mouthrinse use may exert detrimental effects on oral and dental tissues but studies about their effects on restorative materials are limited.

The quantitative evaluation of color difference (ΔE) with a colorimeter confers advantages such as repeatability, sensitivity, and objectivity, despite some limitations. In assessing chromatic differences, two of the most frequently used color systems are the Munsell and the Standard Commission Internationale de L’Eclairage (CIE Lab). Colorimeters often report color using the CIE

Conclusion: Combinations of provisional materials, mouthrinses are significant factors affecting color stability.

Keywords
Provisional crown materials, color, mouthrinses, discoloration.

Sonuç: Geçici restoratif materyaller ve ağız gargaralarının kombinasyonu renk stabilitesini etkileyen önemli faktörlerdir.

Anahtar Kelimeler
Geçici kron materyalı, renk, ağız gargarası, boyanma
MATERIALS AND METHODS

Preparation of the specimens

Provisional restorative materials and mouthrinses investigated in this study are listed in Table I and II. The color stability of each provisional material was evaluated by the color difference (ΔE) before and after its immersion in distilled water (control group) or 3 different mouthrinses.

Sixty specimen disks, 12 mm diameter and 2 mm thick, were prepared from each provisional restorative material using similar shade groups. Each material was mixed according to the manufacturers’ suggested monomer-to-polymer ratio and placed into a metal mold covered with a glass plate. Another glass plate was then placed on the mold. The plates were clamped together with 2 clamps (Record 119 Forged G; Record, Sheffield, UK) to ensure that the mold and the glass plates were in contact. The materials were placed in a controlled environment of 37°C ± 1°C for 15 minutes until the completion of polymerization. Specimens were kept dry at room temperature until all specimens were fabricated and then polished by one operator. Polishing media were silicon-carbid, flour of pumice (Whip Mix Corp, Louisville, Ky), and high shine compound (Universal Polishing Paste, Ivoclar Vivadent, Schaan/Lichtenstein). For the purpose of surface Lab color system, which is a method developed in 1978 by the Commission Intèrnationale de l’Eclairage for characterizing color based on human perception. It designates color according to 3 spatial coordinates, L*, a* and b*, where L represents the brightness (value) of a shade, a* represents the amount of red-green color, and b* represents the amount of yellow-blue color. Absolute measurements can be made in L* a* b* coordinates and color change calculated as ΔE (L’a’b’). In principle, if a material is completely color stable, no color difference will be detected after its exposure to the testing environment (ΔE=0). Various studies have reported different thresholds of color difference values above which the color change is perceptible by the human eye. These values ranged from ΔE equal to 1, between 2 and 3, greater than or equal to 3.3, and greater than or equal to 3.7. In the present study, ΔE value of 3.7 or less is considered to be visually imperceptible as well as clinically acceptable.

The purpose of this study was to evaluate the effect of three different mouthrinses on the color stability of 4 different provisional materials at 24 hours. The hypothesis for this study was that significantly different color change is found in at least 1 of the 4 provisional restorative materials before and after the exposure to distilled water and different mouthrinses for 24 hours.

<table>
<thead>
<tr>
<th>Provisional materials used in the study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trade Name</strong></td>
</tr>
<tr>
<td>Protemp II</td>
</tr>
<tr>
<td>Temdent</td>
</tr>
<tr>
<td>Trim</td>
</tr>
<tr>
<td>Dentalon</td>
</tr>
</tbody>
</table>
standardization, the specimens were wet-ground with 600-grit silicon carbide abrasive paper for 10 seconds. A dental lathe (KaVo Polishing Unit EWL 80; Ka Vo America Lake Zurich, Ill) operating at 1500 rpm was used for all polishing procedures. Specimens were polished on the testing side using an (15-second) application of pumice with a moist muslin wheel. After the polishing process, all specimens were put in an ultrasonic cleaner. Specimens were then stored in distilled water at 37°C for 24 hours. The rehydration simulated the first day of service for provisional materials in the oral environment. Before initial color measurement, visual observation of polished surfaces of all specimens was made and presence of any obvious porosity noted.

Before initial color measurement, surface roughness of samples was measured with a profilometer (Mitutoyo Surftest-B and Surftest 402 Analyzer, Mitutoyo Corporation, Tokyo, Japan).

Color Measurements of the Specimens

Baseline color measurements were made using a colorimeter (Minolta CR-300; Minolta Co, Osaka, Japan). This instrument has a 12 mm measuring head and 0-degree viewing angle geometry for color measurements. Before each measurement session, the colorimeter was calibrated according to the manufacturer’s recommendations by using the supplied white calibration standard. Measurements were made after drying, according to CIELAB color scale over a black background. The colorimeter automatically generated 3 measurements from which it calculated a mean color measurement. Repeated measures of several individual specimens were performed to assess the instrument’s accurate repeatability of measurement.

To evaluate color stability in different mouth-rinse solutions, specimens were randomly divided into 4 groups (n= 15). In group 1; specimens were immersed in % 0.2 Chlorhexidine gluconate (Klorhex, Drogsan, Ankara, Turkey), Group 2; specimens were immersed in Oral B (Oral B part of Gillette Group Ltd., London, UK), Group 3; specimens were immersed in Listerine (Pfizer Consumer Healthcare, Netherlands), and Group 4; specimens were immersed in distilled water as control group. Specimens were immersed in the respective solutions at 37°C and evaluated for color change (ΔE) at 24 hours. Before the colorimetric measurement session, each specimen was rinsed with distilled water for 30 seconds and gently cleaned with a soft bristle toothbrush (P-40; Oral B Laboratories, lawo City, Iowa) to remove any loose sediment resulting from the immersion solution. Color change was calculated for each specimen at each evaluation interval using the following formula; $\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$, where $\Delta E$ represents the color change due to immersion in different mouthrinses.

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorhex</td>
<td>%0.2 chlorhexidine gluconate, glycerin, aroma, mint flavour</td>
<td>Drogsan Drugs Corp, Ankara, Turkey</td>
</tr>
<tr>
<td>Oral B</td>
<td>9.4% Alcohol, Aqua, Glycerin, Aroma, Methylparaben, Poloxamer 407, Cetylpyridinium Chloride, Sodium Fluoride, Sodium Saccharin, Propylparaben, Cl42051, Cl47005</td>
<td>Oral B part of Gillette Group Ltd., London, UK</td>
</tr>
<tr>
<td>Listerin</td>
<td>26.9% Alcohol Aqua, Sorbitol, Aroma Poloxamer 407, Benzoic acid, Sodium saccharin, Eucalyptol, Methylsaliyclate, Thymol, Menthol, Sodium benzoate, Sodium fluoride, Cl 42053, Cl 47005</td>
<td>Pfizer Consumer Healthcare, Netherlands</td>
</tr>
</tbody>
</table>

**TABLE II**

Mouthrinses used in the study
change in all dimensions, ΔL*, Δa*, and Δb* represent color changes along the individual axes.

The ΔE values were expressed as National Bureau of Standards (NBS) units by the following formula in order to quantify the color changes according to this system: NBS unit = ΔE x 0.92. NBS color changes were given in Table III.

<table>
<thead>
<tr>
<th>Color Changes (ΔE)</th>
<th>Degree of color change</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0-0.5</td>
<td>Trace</td>
</tr>
<tr>
<td>0.5-1.5</td>
<td>Slight</td>
</tr>
<tr>
<td>1.5-3.0</td>
<td>Noticeable</td>
</tr>
<tr>
<td>3.0-6.0</td>
<td>Appreciable</td>
</tr>
<tr>
<td>6.0-12.0</td>
<td>Much</td>
</tr>
<tr>
<td>&gt;12</td>
<td>Very much</td>
</tr>
</tbody>
</table>

Statistical Analysis

All data was calculated with computer software (Excel, Microsoft, Redmond, Wash) and statistical software (SPSS 11.5 for Windows; SPSS Inc, Chicago, Ill). Statistical analysis was performed within each variable with repeated measurements of ANOVA and Tukey multiple comparison test (α = .05).

RESULTS

Results of the repeated measurements ANOVA indicated that the effects of provisional restorative materials and mouthrinses on observed differences between the baseline and after treatment color of the samples were statistically significant (p<.05) (Table IV).

Table V demonstrated the mean ΔE values, standard deviations, and statistical comparisons of the tested mouthrinses. Distilled water and Chlorhex showed the lowest ΔE values than Listerine. There were no statistically significant differences between Oral B and the other two mouthrinses and distilled water.

The color changes of the materials were quantified according to NBS units and color changes of all materials tested were found between 0.5-1.5 NBS units. Temdent had more color change; Dentalon and Trim were showed equal color changes and these are followed by Protemp. Tukey HSD analysis indicated that Temdent-Listerine combination showed the highest color changes while there were no statistically significant differences among the other provisional restorative materials (Table VI).

Although there were no statistically significant differences between Oral B and the other three mouthrinses, color differences were obviously seen by a practitioner; in addition, all of the color differences for all provisional restorative materials which were immersed in the solutions were clinically acceptable (ΔE<3.7).

DISCUSSION

The hypotheses set as the premises of this study should be accepted. In this study, provisional materials behaved differently when exposed to different testing environments.

Color stability is a critical for the esthetics of long-term provisional restorations and has been previously studied in vitro for a variety of provisional materials. This study measured the color stability of 4 different provisional materials which were immersed in 3 different mouthrinses and distilled water (control group).

Color perception by visual assessment of objects is a subjective, physiological and psychological process that varies between and within persons. This variability is a result of several factors, including the observed object and illuminant position, characteristics of the illuminant, metamerism, fatigue, aging, and emotional state of the observer. Instrumental colorimeters could potentially eliminate the subjective errors of color assessment. Nevertheless, color differences noted by means of colorimetric measurements can lead to numerical values that correlate only moderately well with visually judged color differences.
### TABLE IV

2-way ANOVA table of color change; mouthrinse and provisional restorative materials have a significant effect on $\Delta E$

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouthrinses</td>
<td>16.548</td>
<td>5.516</td>
<td>11.646</td>
<td>&lt;.000*</td>
</tr>
<tr>
<td>Provisional Restorative Materials</td>
<td>16.701</td>
<td>5.567</td>
<td>11.753</td>
<td>&lt;.000*</td>
</tr>
<tr>
<td>Mouthrinses - Provisional materials</td>
<td>19.083</td>
<td>2.120</td>
<td>4.477</td>
<td>&lt;.000*</td>
</tr>
</tbody>
</table>

* Statistically significant, $P < 0.001$

### TABLE V

Mean $\Delta E$ values and differences among groups for Protemp II

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean $\Delta E$ Values</th>
<th>NBS</th>
<th>Tukey HSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled Water</td>
<td>0.30</td>
<td>0.27</td>
<td>a</td>
</tr>
<tr>
<td>Chlorhex</td>
<td>0.38</td>
<td>0.34</td>
<td>a</td>
</tr>
<tr>
<td>Oral B</td>
<td>0.42</td>
<td>0.38</td>
<td>a</td>
</tr>
<tr>
<td>Listerine</td>
<td>0.99</td>
<td>0.91</td>
<td>b</td>
</tr>
</tbody>
</table>

*Different letters indicate dissimilarity of groups ($p<.05$)

### TABLE VI

Mean $\Delta E$ values and differences among groups for Temdent

<table>
<thead>
<tr>
<th>Materials</th>
<th>Mean $\Delta E$</th>
<th>NBS</th>
<th>Tukey HSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled Water</td>
<td>0.7</td>
<td>0.64</td>
<td>a</td>
</tr>
<tr>
<td>Chlorhex</td>
<td>0.75</td>
<td>0.69</td>
<td>a</td>
</tr>
<tr>
<td>Oral B</td>
<td>0.77</td>
<td>0.70</td>
<td>a</td>
</tr>
<tr>
<td>Listerine</td>
<td>1.63</td>
<td>1.49</td>
<td>b</td>
</tr>
</tbody>
</table>

*Different letters indicate dissimilarity of groups ($p<.05$)

### TABLE VII

Mean $\Delta E$ values and differences among groups for Trim

<table>
<thead>
<tr>
<th>Materials</th>
<th>Mean $\Delta E$</th>
<th>NBS</th>
<th>Tukey HSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled Water</td>
<td>0.30</td>
<td>0.27</td>
<td>a</td>
</tr>
<tr>
<td>Chlorhex</td>
<td>0.35</td>
<td>0.32</td>
<td>a</td>
</tr>
<tr>
<td>Oral B</td>
<td>0.42</td>
<td>0.38</td>
<td>a</td>
</tr>
<tr>
<td>Listerine</td>
<td>1.04</td>
<td>0.95</td>
<td>b</td>
</tr>
</tbody>
</table>

*Different letters indicate dissimilarity of groups ($p<.05$)
in some areas of the color space. The CIE Lab system for measuring chromacity was chosen to record color differences because it is well suited for determining the small color differences.

The value of ΔE* represents relative color changes that an observer might report for the materials after treatment or between time periods. Thus, ΔE* is more meaningful than the individual L*, a* and b* values.

The literature indicates that with visual inspection there is another threshold regarding the color stability of materials. This threshold is considered to be at higher levels of ΔE* and justifies the clinical acceptability of stained materials. Johnston and Kao evaluated the assessment of appearance match by visual observation and clinical colorimetry and stated that the average color difference between compared teeth rated as a ‘match’ in the oral environment was 3.7 (ΔE*). Seghi et al. also presumed that an acceptable color difference can often be 2 or 3 times greater than the detectable limits. The upper limit of acceptability in subjective visual evaluations has been confirmed by Ruyter et al. and Um and Ruyter, who suggested that a perceptible discoloration must be referred to as acceptable up to the value ΔE* = 3.3. In the present study, discoloration below or above the value ΔE* = 3.7 is referred to as ‘acceptable’ or ‘unacceptable,’ respectively. Wang et al. reported that Trim had a mean ΔE of 6.5 following immersion in coffee for 3 weeks, and 20.7 after UV irradiation for 24 hours. With coffee immersion, Scotti et al. demonstrated that Trim had a mean ΔE of 3.1. Güler et al. reported that Protemp II had respective mean ΔE of 1.1 following immersion in water for 24 hours and 1.5 after immersion in coffee. Apart from the differences in testing environments used in different studies, such as solutions used, duration of immersion, temperature of the solutions and the use of different colorimetric instruments may also lead to different results.

When measuring reflective surfaces, the measured color will depend on both the actual colors of the surface and the lighting conditions, under which the surface is measured. In the present study, a standard illuminant against a black background was used. Since color differences were being tested, the choice of the illuminant was not demonstrated that Trim important. Thickness and smoothness of the specimen surface also affect color. In the present study, provisional material specimens were prepared at standard thickness.

Provisional restorative materials were immersed in different mouthrinses for 24 hours in this study. This period (24h) is set as the proper length of time to determine the effect of 1-month use of 2-times daily mouthrinse.

Before initial color measurement, surface roughness of samples was measured with a profilometer. All roughness values of samples were smaller than 1µm. Also Chung stated that surfaces appear optically smooth when their roughness is smaller than 1 µm.
According to NBS marks of color difference, Temdent, Protemp, Trim and Dentalon provisional materials in Chlorhex; Protemp, Trim, Temdent in Oral B; and Trim, Protemp and Dentalon in Listerine showed ‘slight’ color changes, whereas the color change of Temdent in Oral B and Listerine was quantified as ‘appreciable’.

In this study, all provisional materials demonstrated acceptable color stability but Trim, Dentalon and Protemp II were the most color stable provisional restorative materials tested compared to Temdent. The differences in chemistry of the provisional restorative materials may explain why Temdent exhibit such a range of color change2.

Koumjian et al.42 stated that methyl methacrylate resin was less color stable than bis-acryl composite (Protemp II) in an in vivo study. The results of the current study are in agreement with the results of Koumjian et al. Their study, as an in vivo experiment, is of major clinical significance.

Protemp II was the most color stable provisional restorative material in the present study. Protemp II has Bis-GMA (bisphenol A-glycidil methacylate) resin matrix. The Bis-GMA molecule used in bis-acryl resin composites has a rigid central structure that reduces its ability to rotate and participate in the polymerization process43. Materials that contain this molecule as its major component might be less influenced than other resins during the polymerization process43. In addition, the better color stability of Bis-GMA can be explained by the fact that bis-acryl resin composites contain bifunctional acrylates with cross-link to provide increased mechanical strength and resistance to weakening and stain-ability in the presence of solvents44.

After immersion for 24 hours, most of the color changes occurred in the immersion of Listerine. This may be the result of the destruction mechanism of alcohol containing mouthrinses. Alcohol has been attributed to the softening of the polymer matrix, which results in its partial removal from the surface44. The partial removal of the resin matrix may result in the degradation of the filler-matrix interface, which can contribute to the decrease in hardness values45,46, and this may be effect the increase color changes. As a result, it may be suggested that mouthrinses with alcohol content may compromise the color stability of the provisional restorations and the clinician should warn the patients regarding the possible effects of alcohol containing mouthrinses on their provisional prostheses especially if their prostheses are expected to function over an extended period of time.

There are limited publications about the simultaneous storage conditions, which actually reflect the clinical situation. In clinical conditions, effective pattern of mouthrinses on provisional materials may be different depending on many factors that could not be replicated in vitro. Saliva, salivary pellicle, foods and beverages consumed may have additive/mitigating effects on the physical and aesthetic properties of this group of restorative materials. Color stability is only one variable that must be considered when choosing a provisional material, but it may be of great importance to patients and clinicians when working in the esthetic zone. Studies are therefore necessary to determine the effects of mouthrinses in vivo.

CONCLUSION

Color changes of 4 commercially available provisional restorative materials were evaluated after 24 hours immersion in three different mouthrinses. Within the limitations of this study, the following results were drawn:

1- Trim (0.96), Dentalon (0.96) and Protemp II (0.91) were found to be more color stable than Temdent (1.5). The largest color difference was observed in Temdent.

2- Listerine mouthrinse exhibited more staining capacity than Oral B and Chlorhexidine mouthrinses.

3- Combinations of provisional materials, mouthrinses are significant factors affecting color stability.
ACKNOWLEDGMENTS

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REFERENCES


