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# Effects of different repolishing techniques on colour change of provisional prosthetic materials

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## SUMMARY

Objectives. To investigate repolishing effect of stained provisional prosthetic materials *in vitro*.

Methods. Thirty two cylindrical specimens (10 × 2 mm) were prepared for each of light-polymerized composites (Revotek LC, Rx-Create), bis-acryl composites (Structur Premium, Protemp Garant3, Luxatemp Fluorescence), methyl-methacrylate (UnifastTRAD) and ethyl-methacrylate (DentalonPlus) based provisional material using a mould. The specimens were divided into 4 groups (n=8) according to different repolishing techniques. The specimens were stored for 24 hours at 37°C in distilled water, and then transferred into 4 different staining agents. The colour was measured with a spectrophotometer (Vita Easyshade) before exposure and after repolishing procedures, and colour changes (ΔE) were calculated. Statistical analysis: three-way ANOVA, Tukey HSD post-hoc test ($p<0.05$).

Results. The influence of type of provisional material, polishing procedure, food colorants and combinations of them on colour change was significant ($p<0.05$). After the repolishing procedures, all the specimens stored in distilled water achieved an unnoticeable colour change ($\Delta E<3.7$), except Dentalon Plus, Rx Create, Unifast TRAD. A similar tendency was observed in artificial food colourant solution following subsequent repolishing of the specimens. As for the red wine, all repolished specimens attained unnoticeable colour change ($\Delta E<3.7$), except Dentalon Plus using Rx polishing paste, Enhance polishing set or repeated glazing procedure.

Conclusion. Repolishing was found to be an effective way to improve aesthetic appearance for provisional prosthetic materials by partially removing staining observed on the surface of the restorations


**Key words**: color stability, provisional prosthesis, repolishing.

## INTRODUCTION

A provisional restoration could be defined as an interim dental prosthesis that should maintain aesthetics, provide masticating surfaces and protect soft and hard tissues prior to the delivery of the final prosthesis. Optimal provisional restorations must meet a variety of interrelated factors that could be classified as mechanical, biological and aesthetical [1].

Aesthetically, the poor appearance of a tooth should be concealed by imitating and maintaining the essential properties of the natural teeth including size, position, shape, and colour [2], proper texture and translucency as well as it should serve as a guide to achieve optimal aesthetics in final restoration.

In practice, the use of provisional restorations could extend from several weeks to half a year [3]. As a rule, the longer the material is exposed to various surrounding factors, the higher the chance for discolouration and material wear. Smooth surface of the restoration should be achieved to reduce plaque adhesion, minimize gingival inflammation as well as to limit potential discolouration process. Currently, many surface processing techniques exist for provisional restorations. For instance, some manufacturers have certain recommendations for their products regarding polishing, others do not provide information on the recommended polishing technique, as there

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**Fig. 1.** Fabricated specimen in a metal mould

**Fig. 2.** Spectrophotometer tip placed against a specimen in a custom silicone holder

are plenty of polishing tools in the market it is hard to decided which one is the best for a specific material type [4].

Despite effect of polishing technique applied, a provisional restoration could still experience a visible colour change due to other factors including type of material, patient's diet, oral hygiene as well as incomplete polymerization. Discolouration of the restoration may result in poor aesthetic appearance and subsequently lead to patient dissatisfaction and additional expenses for replacement. In order to avoid these potential problems a chair side repolishing of provisional restorations could be suggested to reach initial or at least unnoticeable for human eye colour change ($\Delta E<3.7$).

Although research on provisional materials is almost never performed *in vivo* [3, 5, 6, 7, 8, 9] an *in vitro* experiment helps us to evaluate the effect of single factor on temporary restorations upon which a prognosis could be made for its clinical colour stability that may affect repolishing quality as well. In addition, there is no documented literature on repolishing effects of different polishing techniques for colour change of provisional prosthetic materials.

The purpose of this study was to investigate repolishing effects on colour change of light polymerized composites, two-component auto-polymerized bis-acrylic composites, methyl and ethyl methacrylate based provisional restorative materials upon exposure to different staining agents by imitating oral environment *in vitro*. The null hypothesis tested is that the material type, polishing technique and colourant solutions do not affect the colour change after repeated polishing of investigated materials.

## MATERIALS AND METHODS

Seven commonly used provisional prosthetic materials including methylmethacrylate- and ethylmethacrylate-based resins, bis-acryl composite and light-polymerized composite resins have been investigated (Table 1).

Thirty two cylindrical specimens were prepared for each material using a metal mould (Fig. 1). Each specimen had a diameter of 10 mm and a height of 2

**Table 1.** Provisional materials used in the study

| Product | Manufacturer | Resin type |
|---|---|---|
| Dentalon Plus (Liquid: Batch # 010205; Powder: Batch # 010301) | Heraeus-Kulzer, Hanau, Germany | Ethyl-methacrylate based resin |
| Unifast TRAD (Liquid: Batch # 339291; Powder: Batch # 339104) | GC Dental Products, Aichi, Japan | Methyl-methacrylate based resin |
| Luxatemp Fluorescence (Batch # 560394) | DMG, Hamburg, Germany | Bis-acryl composite resin |
| Protemp Garant 3 (Batch # B 286620; C 284362) | 3M ESPE, Seefeld, Germany | Bis-acryl composite resin |
| Revotek (Batch # 0705102) | GC Dental Products, Aichi, Japan | Light-polymerized composite resin |
| RxCreate (Batch # 220607) | Dental Life Sciences, Ince Wigan, United Kingdom | Light-polymerized composite resin |
| Structur Premium (Batch # 792365) | Voco, Cuxhaven, Germany | Bis-acryl composite resin |

mm. Materials were prepared following the manufacturer's instructions. Light-polymerized specimens were cured using a light-curing unit (Elipar Freelight 2; 3M ESPE, Seefeld, Germany) with a 1200 mW/cm$^2$ light intensity for 20 s on each side. A uniform surface roughness was created for all specimens by applying a green acrylic polisher (Hager & Meisinger, Neuss, Germany) for 10 s at 1500 rpm on each side of the specimen.

All specimens of each material type were divided into 16 groups of 2 specimens according to different surface processing procedures (n=4) and the type of colourant solution (n=4). A detailed list of polishing and coating systems is provided in Table 2. Both sides of specimens were processed. Meisinger (Hager & Meisinger) polishers consisting of coarse, medium and fine surfaces were used in the latter order. Each polisher was applied for 15 s on both sides of the specimen at 15,000 rpm. Enhance (Dentsply/Caulk, Milford, DE, USA) aluminium oxide discs were used for 30 s on each surface of the selected specimens' subsequently applying fine and then extra fine polishing. Surface coating had been applied using glazing material (Glaze & Bond; DMG, Hamburg, Germany) for the selected specimens. Each side was light-cured for 20 s as recommended by the manufacturer. A group of selected specimens had been polished using Enhance system (Dentsply/Caulk) with subsequent glazing as described earlier. Rx diamond polishing paste (Dental Life Sciences, Ince Wigan, United Kingdom) was applied for 1 min to another group of the specimens.

Specimens were stored in distilled water for 24 hours at 37°C. This imitated the first day of the service in the oral environment [6, 7, 8]. A custom made silicon (Panasil Putty; Kettenbach, Eschenburg, Germany) holder for specimens was used (Fig. 2) to hold the specimen during colour measurement with spectrophotometer (VITA Easyshade; VITA Zahnfabrik, Bäd Sackingen, Germany) as well as to minimize external light influence throughout the edge of the specimen [9]. Baseline CIE L*a*b* colour coordinates have been established using the spectrophotometer for every specimen before the exposure to a staining agent. Each side of every specimen had been measured three times. CIE L*a*b* colour space illustrates all the colours sensitive to human eye over the range of visible light in three-dimensional representation. L* describes lightness of an object, a* value indicates the colour position between red and green, whereas b* values indicate the position between yellow and blue [10]. The spectrophotometer was calibrated during every colour measurement session against a provided calibration block integrated into the machine.

Three staining agents were prepared: coffee with sugar (Jacobs Krönung; Kraft foods Inc., Northfield, Ill, USA), red wine (Gran Vino Merlot 2005; Santa Helena, Santiago, Chile), mix of sunset yellow and quinoline yellow 3 % dye (Unifine; Puttershoek, Netherlands) [11]. Three grams of this dye were mixed with 100 ml of distilled water. Black coffee was prepared by mixing 12 grams of natural coffee powder and 10 grams of white sugar with 200 ml of boiling water. Distilled water served as a control liquid. Grouped specimens were immersed into specified liquids for 7 days and stored in bath at 37°C (Bandelin Sonorex; Schalltec, Walldorf Mörfelden, Germany).

One week later the specimens were cleaned using an electric toothbrush (Colgate Motion; Colgate-Palmolive, NY, USA) with toothpaste (Colgate Total; Colgate-Palmolive, NY, USA) for 10 s on every side of the specimen, then gently rinsed in the water and dried with a paper towel. Afterwards, repolishing procedures of every specimen have been carried out as described earlier.

**Table 2.** Polishing/coating systems used in this study

| Products | Manufacturer | Composition |
|---|---|---|
| Meisinger polishers set (green,grey,yellow) | Hager & Meisinger, Neuss, Germany | Polysiloxan and indian rubber impregnated with silicium carbide particles |
| Enhance Finishing and Polishing System<br>Polishing discs: Batch # 0708201<br>Extra Fine polishing paste: Batch # 070821<br>Fine polishing paste: Batch # 070807 | Dentsply/Caulk, York, USA | Aliuminium oxide disks (40 μm), fine (1μm) and extrafine (0.3μm) aliuminium oxide pastes |
| Glaze & Bond (Batch # 589468) | DMG, Hamburg, Germany | Acrylic resin, methyl methacrylate |
| Rx polishing | Dental Life Sciences, Ince Wigan, United Kingdom | Diamond based paste |
| Goat Hair Wheel | Hager & Meisinger, Neuss, Germany | Goat hair |
| Poliresin | Siladent, Dr. Böhme & Schöps, Goslar, Germany | Pumice powder |
| Universal polishing paste | Ivoclar-Vivadent, Schaan, Liechtenstein | Paste of aluminium oxide |

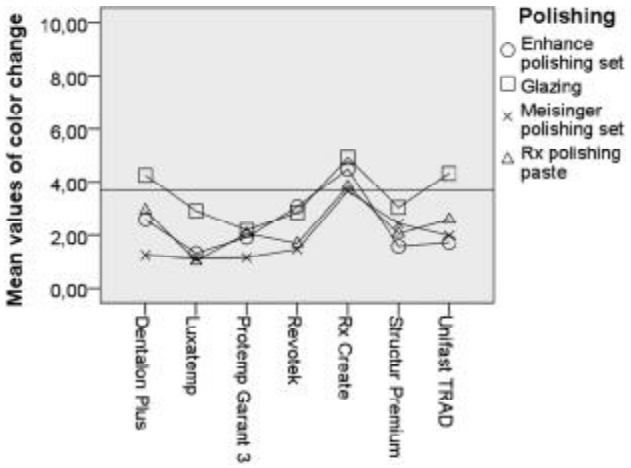


**Fig. 3.** Graphical representation of mean (ΔE) colour changes after repolishing procedures of provisional materials soaked in distilled water (control) for all polishing groups

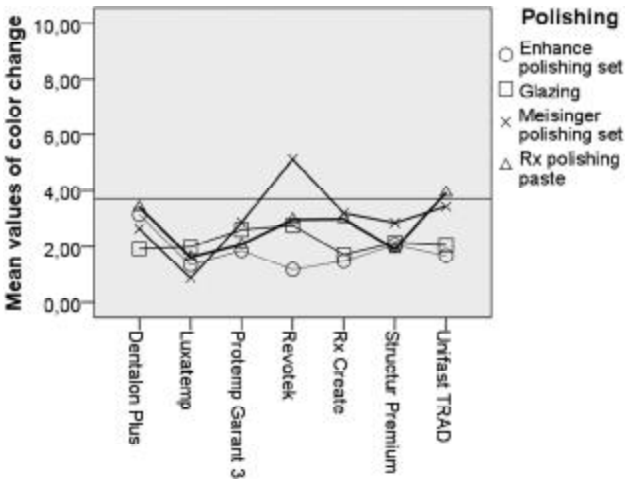


**Fig. 4.** Graphical representation of mean (ΔE) colour changes after repolishing procedures of provisional materials soaked in mix of sunset yellow and quinoline yellow 3% solution for all polishing groups

Subsequently, each specimen's colour was evaluated in the same manner as prior to exposure to the colourant. DE, known as Euclidean distance between two points in the three-dimensional colour space, was calculated from the mean values of ΔL*, Δa* and Δb* using the following formula:

$$\Delta E^* = [(L_1^* \Delta L_0^*)^2 + (a_1^* \Delta a_0^*)^2 + (b_1^* \Delta b_0^*)^2]^{1/2}$$

Three-way ANOVA using statistical software (SPSS 16.0.1 for Windows, SPSS Inc., Chicago, Ill, USA) was selected to evaluate the effect of material type, polishing procedures and staining agents on colour change after repolishing procedures. A Tukey HSD post-hoc analysis was used to define statistically significant differences between the groups. Statistical significance was set at $p<0.05$.

## RESULTS

Quality of repolishing was described as a colour change that occurred after repolishing of stained specimens as compared to initial colour of the specimens (after hydration). ΔE values below 3.7 were considered as a high quality repolishing result. Three-way ANOVA test results for the material type, polishing systems, and staining solutions after the repolishing are shown in Table 3. All combinations of comparisons that were made with the Tukey test for individual provisional material groups are provided in Tables 4 to 10.

After repolishing procedures, all control specimens stored in distilled water (Fig. 3) achieved an

**Table 3.** Influence of material type, polishing technique and colourant on color change (ΔE) after repolishing procedures

| Source | Type III Sum of Squares | df | Mean Square | F-value | p-value |
|---|---|---|---|---|---|
| Material type | 2897.103 | 6 | 482.851 | 378.726 | .000 |
| Polishing | 2507.139 | 3 | 835.713 | 655.496 | .000 |
| Colourant | 3524.522 | 3 | 1174.841 | 921.493 | .000 |
| Material type + polishing | 3045.292 | 18 | 169.183 | 132.700 | .000 |
| Material type + colourant | 3452.525 | 18 | 191.807 | 150.445 | .000 |
| Polishing + colourant | 3545.014 | 9 | 393.890 | 308.950 | .000 |
| Material type + polishing + colourant | 4774.980 | 54 | 88.426 | 69.357 | .000 |

**Table 4.** Results of Tukey test according to materials, polishing systems and staining solutions for Dentalon Plus

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 2.59* (0.99) | [0.00*] | 4.26 (0.69) | [0.61] | 1.23* (0.59) | [0.00*] | 2.94* (0.77) | [0.01*] |
| Artificial food colourant | 3.13 * (0.51) | [0.02*] | 1.92* (0.68) | [0.00*] | 2.63* (0.97) | [0.00*] | 3.39* (0.82) | [0.11] |
| Black coffee with sugar | 3.26* (1.29) | [0.05] | 2.16* (0.74) | [0.00*] | 2.84* (1.66) | [0.00*] | 2.57* (1.15) | [0.00*] |
| Red wine | 6.63 (1.46) | [0.00*] | 3.69* (0.44) | [0.38] | 2.45* (0.61) | [0.00*] | 3.71 (0.75) | [0.40] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

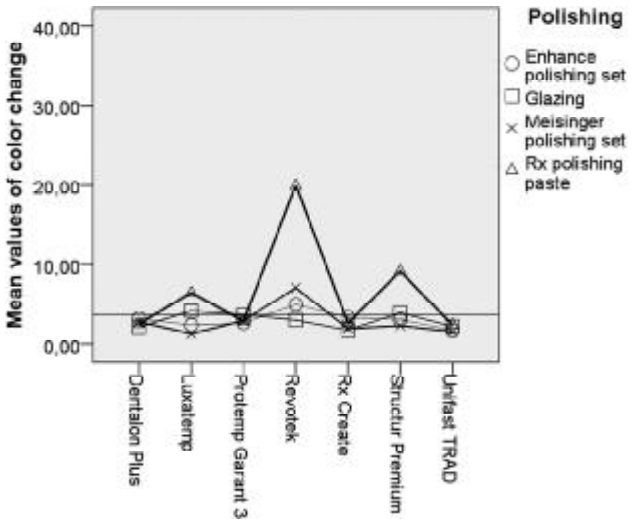


**Fig. 5.** Graphical representation of mean (ΔE) colour changes after repolishing procedures of provisional materials soaked in coffee with sugar for all polishing groups

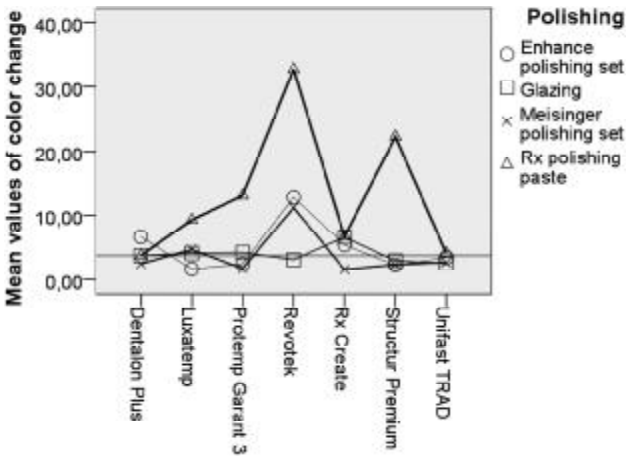


**Fig. 6.** Graphical representation of mean (ΔE) colour changes after repolishing procedures of provisional materials soaked in red wine for all polishing groups

unnoticeable colour change (ΔE<3.7), except Dentalon Plus, Rx Create, Unifast TRAD. Latter provisional materials retained visible colour change after repeated application of glaze, while Rx Create also preserved a noticeable colour change using Rx polishing paste or Enhance polishing system.

A similar tendency has been revealed in artificial food colourant solution group (Fig. 4) following subsequent repolishing of the specimens. All the provisional restorative materials retained unnoticeable

**Table 5.** Results of Tukey test according to materials, polishing systems and staining solutions for Dentalon Plus

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 1.31* (0.43) | [0.00*] | 2.92* (1.30) | [0.01*] | 1.12* (0.49) | [0.00*] | 1.02* (0.46) | [0.00*] |
| Artificial food colourant | 1.33* (0.43) | [0.00*] | 1.99* (0.66) | [0.00*] | 0.86* (0.46) | [0.00*] | 1.62* (0.36) | [0.00*] |
| Black coffee with sugar | 2.44* (0.88) | [0.00*] | 4.21 (1.04) | [0.70] | 1.37* (0.64) | [0.00*] | 6.50 (1.70) | [0.00*] |
| Red wine | 1.64* (0.36) | [0.00*] | 4.11 (0.53) | [0.89] | 4.67 (0.64) | [0.13] | 9.28 (0.64) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

**Table 6.** Results of Tukey test according to materials, polishing systems and staining solutions for Protemp Garant 3

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 1.91* (1.03) | [0.00*] | 2.19* (0.48) | [0.00*] | 1.15* (0.43) | [0.00*] | 2.06* (0.47) | [0.00*] |
| Artificial food colourant | 1.86* (0.46) | [0.00*] | 2.60* (1.40) | [0.00*] | 2.84* (0.91) | [0.00*] | 2.07* (0.26) | [0.00*] |
| Black coffee with sugar | 2.70* (0.72) | [0.00*] | 3.73 (0.73) | [0.43] | 2.98* (0.55) | [0.01*] | 2.92* (0.28) | [0.01*] |
| Red wine | 2.43* (0.59) | [0.00*] | 4.20 (0.81) | [0.72] | 1.72* (0.35) | [0.00*] | 13.10 (2.51) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

**Table 7.** Results of Tukey test according to materials, polishing systems and staining solutions for Revotek

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 3.08* (0.86) | [0.02*] | 2.86* (0.56) | [0.00*] | 1.46* (0.41) | [0.00*] | 1.68* (0.94) | [0.00*] |
| Artificial food colourant | 1.16* (0.51) | [0.00*] | 2.75* (1.16) | [0.00*] | 5.13 (2.77) | [0.01*] | 19.90 (1.47) | [0.01*] |
| Black coffee with sugar | 5.01 (0.85) | [0.02*] | 3.05* (1.04) | [0.01*] | 7.12 (0.85) | [0.00*] | 2.95* (0.80) | [0.00*] |
| Red wine | 12.82 (5.58) | [0.00*] | 3.09* (1.26) | [0.02*] | 11.20 (1.41) | [0.00*] | 32.74 (0.91) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

colour change, except Revotek using Meisinger polishing set and Unifast TRAD using Rx polishing paste. After the repolishing procedures, colour change showed no significant difference (p=0,655) between specimens stored in distilled water and artificial food colourant solution.

In coffee with sugar group (Fig. 5), after repolishing procedures, visible colour changes (3.7>ΔE) remained in Luxatemp and Structur Premium using glazing or Rx polishing paste, whereas Protemp Garant showed visible change only after reapplying glazing material. Revotek distinguished itself as the worst material for repolishing procedures as it retained visible colour changes using Rx polishing paste, Meisinger or Enhance polishing sets.

As for the red wine (Fig. 6), all repolished specimens attained unnoticeable colour change (3.7<ΔE), except Dentalon Plus using Rx polishing paste, Enhance polishing set or repeated glazing procedure, while Protemp Garant and Luxatemp showed a noticeable colour change after repeated application of glaze or Rx polishing paste. In addition, Meisinger polishers were not effective enough to reduce Luxatemp colour change (ΔE) below 3.7.

## DISCUSSION

The present study disclosed the significant influence of material type, polishing technique and colourant solution on quality of repolishing of provisional prosthetic materials. The tested null hypothesis was rejected due to latter findings. Statistical analysis revealed that the most significant factor influencing quality of repolishing was found to be colourant solution (F-value=921), followed by polishing technique (F-value=655) and material type (F-value=378). Selection of polishing technique is an essential step for controlling repolishing quality, especially if the diet and the habits of a patient possess an increased risk of discolouration of provisional restorations. Depending on the stain intensity and nature, certain types of repeated polishing techniques for appropriate provisional restorations could be suggested.

Material repolishing quality has been evaluated after one week of immersion of specimens in distilled water, artificial food colourant solution, coffee with sugar and red wine. Difference between baseline colour and repolished specimens' colour showed high

**Table 8.** Results of Tukey test according to materials, polishing systems and staining solutions for Rx Create

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 4.48 (2.53) | [0.29] | 4.91 (1.57) | [0.04*] | 3.66* (0.82) | [0.34] | 3.83 (1.29) | [0.59] |
| Artificial food colourant | 1.47* (0.72) | [0.00*] | 1.71* (0.53) | [0.00*] | 3.18* (1.68) | [0.03*] | 2.68* 0.94) | [0.01*] |
| Black coffee with sugar | 3.39* (1.19) | [0.11] | 1.82* (0.36) | [0.00*] | 1.98* (0.58) | [0.00*] | 2.97* (0.74) | [0.00*] |
| Red wine | 5.39 (1.17) | [0.00*] | 6.57 (1.38) | [0.00*] | 1.56* (0.53) | [0.00*] | 6.67 (1.99) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

**Table 9.** Results of Tukey test according to materials, polishing systems and staining solutions for Structur Premium

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 1.57* (0.48) | [0.00*] | 3.05* (0.50) | [0.01*] | 2.44* (0.70) | [0.00*] | 2.06* (0.22) | [0.00*] |
| Artificial food colourant | 2.06* (1.44) | [0.00*] | 2.15* (0.41) | [0.00*] | 2.83* (0.92) | [0.00*] | 1.90* (0.23) | [0.00*] |
| Black coffee with sugar | 3.11* (0.48) | [0.02*] | 3.96 (0.76) | [0.82] | 2.37* (0.33) | [0.00*] | 9.17 (0.26) | [0.00*] |
| Red wine | 2.23* (0.50) | [0.00*] | 2.92* (1.23) | [0.01*] | 2.34* (0.35) | [0.00*] | 22.25 (2.17) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

**Table 10.** Results of Tukey test according to materials, polishing systems and staining solutions for Unifast TRAD

| Staining solution | With Enhance | | Glazing | | With Meisinger | | With Rx polishing paste | |
|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] | Mean (SD) | [p Value] |
| Distilled water | 1.71* (0.47) | [0.00*] | 4.33 (2.41) | [0.50] | 1.98* (0.88) | [0.00*] | 2.59* (0.93) | [0.00*] |
| Artificial food colourant | 1.67* (0.83) | [0.00*] | 2.05* (0.67) | [0.00*] | 3.42* (0.66) | [0.12] | 3.92 (1.31) | [0.75] |
| Black coffee with sugar | 1.82* (0.80) | [0.00*] | 2.27* (0.72) | [0.00*] | 1.61* (0.64) | [0.00*] | 2.45* (0.87) | [0.00*] |
| Red wine | 3.43* (0.59) | [0.13] | 2.53* (0.67) | [0.00*] | 2.65* (0.72) | [0.00*] | 4.05 (0.95) | [0.00*] |

* ΔE must be ≤3.7 and significant (two-tailed) p values must be <0.05, otherwise the colour change is not significant.

quality of repolishing procedures in most materials. The nature of the stain was a substantial factor influencing reduction of discoloured specimens.

Both extrinsic (surface roughness, poor oral hygiene, nutrition and material wear) and intrinsic (composition of filler and monomers, unreacted monomers left as a consequence of incomplete polymerization) factors can be involved in the staining process of the material [12, 13, 14]. The mechanism of staining could be explained by sorption of the colourants [15]. A number of studies report that water absorption can be influenced by such factors as filler content [16, 17], unreacted monomers or inclusion of air [18, 19] and degree of cross-linking of resin molecules [20, 21]. Incomplete polymerization might diminish physical properties of the resin material, increase microleakage and its solubility as well as induce consequent colour changes.

The discolourations observed in present study proved to involve stain adsorption and subsurface absorption. Once staining has occurred, brushing with toothpaste, bleaching and repolishing procedures can remove the stains partially or even totally. Despite the fact that polishing procedures may decrease stain visibility, they can remove only extrinsic stain [22].

Only few studies [22, 23] were found that investigated effects of different repolishing or bleaching techniques on colour change of composite resin materials. Türkün et al. [22] studied effect of bleaching with 15% hydrogen peroxide and repolishing procedures with three polishing systems including Sof-lex (3M ESPE), Enhance (Dentsply/Caulk), PoGo (Dentsply/Caulk) on coffee and tea stain removal from composite resin materials. They concluded that discoloration from a composite resin material can be partially removed by bleaching and repolishing procedures.

There are many studies [3-6,9,11,12,25] indicating that polishing procedures remove surface discolourations from permanent restorations, however there are no reports on how effective repolishing is for provisional prosthetic restorations.

In distilled water group, only some provisional materials retained visible colour changes including Rx Create, Dentalon Plus and Unifast TRAD. Loyaga-Rendon et al. [24] reported that composite materials, such as Rx Create is less porous and is harder compared to other provisional materials. Due to the hardness of the material, polishers were unable to remove enough material from the superficial layer. In addition, methacrylate based materials may have had more voids and higher resin content, so more dye penetrated the material and caused both, intrinsic and extrinsic discolouration.

Greater repolishing quality results, as compared to the distilled water group, were observed in artificial food colourant solution. The following phenomena may be associated with colourant molecules that are soluble in water, possess electrostatic charges and may stain surfaces [25]. Water absorption into materials is influenced by the osmotic potential of the solution [26]. As colourant molecules increased osmolarity of the liquid, it may have limited water absorption levels and decreased possible internal colour change, so the stain was mainly extrinsic. In addition, Revotek retained visible colour changes after application of Meisinger polishers despite it is a composite resin material. Latter fact may be explained by higher resin content as it is responsible for the susceptibility to staining and water sorption values [22, 26]. Repolishing of Rx Create was more efficient after immersion in staining agent as compared to distilled water group.

Specimens in coffee with sugar and red wine groups showed worse repolishing results compared to distilled water or colourant solution. The mechanism behind discolouration by red wine and coffee may be explained by surface adsorption and absorption of the colourant particles.

Different nature and structure of the materials, individual characteristics of the particles have a direct impact on the surface smoothness and the susceptibility to extrinsic staining [27, 28, 29, 30]. Worst repolishing effect was achieved with Rx polishing paste for specimens immersed in red wine as it didn't decrease colour change below 3.7 for all materials. In our opinion, it could be related to very fine diamond particles in the paste and deep dye penetration into the material.

Enhance polishing system was not successful in removing stains from Dentalon Plus, Unifast TRAD and Revotek specimens probably because the following materials experienced higher internal colour changes.

In summary, the results of this *in vitro* study suggest that successful repolishing requires specific finishing and polishing tools, depending on the size, hardness and amount of filler of the material as well as stain origin.

## CONCLUSIONS

Repolishing was found to be an effective way to improve esthetic appearance for provisional prosthetic materials by partially removing staining observed on the surface of the restorations. Different staining agents, polishing systems and prosthetic materials influence the quality of repolishing.

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