The effectiveness of a solution containing sodium hypochlorite 0.5% in removing tea discoloration on heat-cured acrylic resin

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Abstract. Sodium hypochlorite (NaOCl) 0.5% is a solution that can be used as a disinfectant on heat-cured acrylic resin by immersion for 10 minutes. This study aimed to determine the effectiveness of a cloth bleaching agent (Bayclin) containing NaOCl 0.5% in removing tea stains from the heat-cured acrylic resin (QC-20). A total of 24 specimens of acrylic resin were used in this study. The specimens were immersed in NaOCl 0.5% solution and Aquadest as a control for five and 10 minutes. The color of the acrylic resin was measured with a spectrophotometer (VITA Easyshade) before and after tea staining, and after immersion. The color differences of the acrylic resin were characterized using the CIE L*a*b* system. The data were analyzed using dependent and independent t-tests with 0.05 significance level. The percentage of stain removal was 98.5% and 106.9% for acrylic resin immersed in NaOCl 0.5% solution for five and 10 minutes, respectively. Therefore, a cloth bleaching agent containing NaOCl 0.5% was effective in removing tea stains from heat-cured acrylic resin after five minutes of immersion.

1. Introduction

Dentures can have color alteration or discoloration as a result of the high consumption of tea [1]. Discoloration caused by tea is an extrinsic discoloration due to the adsorption of tannins on the surface of the acrylic resin [2].

Several methods are used to clean dentures, such as brushing with nonabrasive toothpaste, immersion in a denture cleansing solution, or a combination of brushing and immersion. [3] To remove stains on discolored dentures, the suggested cleaning solution is sodium hypochlorite (NaOCl) and hydrogen peroxide [4]. Based on the study of Jagger et al. [5] the denture cleansing solution Dentural contains 1.5% NaOCl, which can remove 99% of stains on acrylic resin within five minutes. This was due to chlorine, which is contained in NaOCl [5,6]. A 0.5% concentration of NaOCl was effective as a denture disinfectant with an immersion time of 10 minutes [7].

NaOCl is an active ingredient contained in the commercial cloth bleaching agent Bayclin. Bayclin is available on the public market at a relatively lower price than commercial denture cleansers. A cloth bleaching agent containing NaOCl can be used as an alternative to denture cleanser. Therefore, it was
determined whether Bayclin used as a disinfectant was effective in removing tea stains on dentures made of heat-cured acrylic resin.

2. Methods
A laboratory experimental study was conducted using 24 specimens of heat-cured acrylic resin (brand QC-20) in the form of $10 \times 10 \times 2.5$ mm plates. After the polymerization process, the acrylic plate was immersed in Aquadest for 24 hours at 37°C according to ISO 1567:1988 for acrylic resin free from residual monomer [8]. Then, the smoothing of the acrylic plate was conducted with SiC 600 sandpapers. Each specimen, then, was marked at the surface with an indicator that faced upward during immersion and the color of the surface was observed.

To obtain discolored acrylic resin by tea staining, a specimen was immersed in a Walini brand of black tea solution made by immersing 200 g black tea leaves in 1000 mL of boiled water. The tea solution was separated from the tea leaves after immersion for 1 hour at room temperature (28°C). Then, the acrylic resin specimens were immersed in the tea solution for seven days at 37°C, and the tea solution was changed daily.

Bayclin brand cloth bleaching solution containing 5.25% NaOCl was diluted with distilled water so that the final concentration of NaOCl became 0.5%. The specimens were divided into four treatment groups ($n = 6$). The tea-stained acrylic resin specimens were immersed in the NaOCl 0.5% solution for five (group 3) and 10 (group 4) minutes. The control specimens were immersed in the Aquadest solution for five (group 1) and 10 (group 2) minutes at room temperature (28°C).

The color of the acrylic resin specimens was measured before and after the immersion in the tea solution, and after the immersion in the NaOCl 0.5% bleach solution and Aquadest, using a VITA Easyshade brand spectrophotometer based on the CIE $L^*a^*b^*$ system. $L^*$ indicated the brightness value, $a^*$ the red-green value, and $b^*$ the yellow-blue value, and $\Delta E^*$ indicated the total color difference.

The Sapiro–Wilk normality test analysis showed that all the data were normally distributed. The data were analyzed using dependent and independent t-tests with a significance level of $P = 0.05$ and 95% confidence level.

3. Results
The brightness value of acrylic resin before and after tea staining, and after immersion in the NaOCl 0.5% cloth bleaching solution and distilled water are shown in Table 1.

| Group of Immersion Solutions/Immersion time | Before tea staining (Baseline) | After tea staining | After Immersion in Solution |
|-------------------------------------------|-------------------------------|-------------------|----------------------------|
| Group 1: Aquadest (5 minutes)             | 62.2833 ± 0.84                | 57.9500 ± 0.95    | 57.9500 ± 1.01             |
| Group 2: Aquadest (10 minutes)            | 62.8667 ± 1.32                | 57.0667 ± 1.80    | 57.2500 ± 1.70             |
| Group 3: Cloth bleaching agent containing NaOCl 0.5% (5 minutes) | 62.8667 ± 1.09                | 55.9167 ± 1.32    | 61.4833 ± 1.33             |
| Group 4: Cloth bleaching agent containing NaOCl 0.5% (10 minutes) | 62.4167 ± 1.33                | 55.9333 ± 0.75    | 62.2667 ± 0.76             |
Acrylic resins in all groups experienced significant reductions in brightness values after immersion in tea solution. Groups 1 and 2 showed no alteration in brightness values. Groups 3 and 4 showed a significant increase in brightness value. However, the brightness value in group 3 was not yet close to that of the acrylic resin before tea staining. Although the brightness value in group 4 approached that of the acrylic resin before staining, the difference was not significant.

The values of the red-green acrylic resin before and after tea staining, and after immersion in NaOCl 0.5% solution and distilled water are shown in Table 2.

| Group of Immersion Solutions/Immersion time | a* Value | Before tea staining (Baseline) | After tea staining | After Immersion in Solution |
|--------------------------------------------|----------|-------------------------------|-------------------|-----------------------------|
| Group 1: Aquadest (5 minutes)               |          | 25.2167 ± 1.18                | 25.2167 ± 0.85    | 25.3667 ± 0.76              |
| Group 2: Aquadest (10 minutes)              |          | 24.3167 ± 1.32                | 24.7333 ± 1.17    | 24.7500 ± 1.17              |
| Group 3: Cloth bleaching agent containing NaOCl 0.5% (5 minutes) |          | 26.9833 ± 1.55                | 26.5167 ± 1.13    | 26.9167 ± 1.30              |
| Group 4: Cloth bleaching agent containing NaOCl 0.5% (10 minutes) |          | 25.5333 ± 0.44                | 26.0167 ± 0.75    | 25.8333 ± 0.78              |

The change in red-green value was not significance in all groups after immersion in tea solution. Groups 1 and 2 showed an increase in red-green value but the increase was not significant. Group 3 showed a significant decrease in red-green value after immersion for five minutes, nearing the red-green value of the acrylic resin before tea staining, and the difference between both colors was not significant. Although group 4 showed a decrease in red-green value, it was not significant.

The yellow-blue values of acrylic resin before and after tea staining, and after immersion in a 0.5% NaOCl solution and distilled water are shown in Table 3.

| Group of Immersion Solutions/Immersion time | b* Value | Before tea staining (Baseline) | After tea staining | After Immersion in Solution |
|--------------------------------------------|----------|-------------------------------|-------------------|-----------------------------|
| Group 1: Aquadest (5 minutes)               |          | 8.9667 ± 1.00                 | 12.9333 ± 0.71    | 13.1500 ± 0.81              |
| Group 2: Aquadest (10 minutes)              |          | 8.4000 ± 1.13                 | 16.1667 ± 1.68    | 15.8833 ± 1.50              |
| Group 3: Cloth bleaching agent containing NaOCl 0.5% (5 minutes) |          | 10.6333 ± 0.65                | 15.9000 ± 1.00    | 9.3333 ± 0.65               |
| Group 4: Cloth bleaching agent containing NaOCl 0.5% (10 minutes) |          | 9.0667 ± 0.90                 | 16.8167 ± 0.98    | 8.0333 ± 0.97               |

There was a significant increase in the yellow-blue values in all groups after the immersion in tea solution. Groups 1 and 2 showed a change in yellow-blue value but it was not significant. Groups 3
and 4 showed a significant decrease in yellow-blue value and had lower values than the acrylic resin before tea staining. Meanwhile, the unpaired t-test results indicated a significant difference in yellow-blue values between the two groups. Group 4 showed a greater decreasing yellow-blue value compared to group 3.

The color difference (ΔE*) of the acrylic resin before and after tea staining, and after immersion in 0.5% NaOCl and distilled water are shown in Table 4.

**Table 4. Average color difference values (ΔE*)**

| Group 1: Aquadest (5 minutes) | Value ΔE* (1) Acrylic resin color change after immersion in tea solution compared to the color of the acrylic resin before tea staining (Average ± SD) | Value ΔE* (2) Acrylic resin color change after immersion in bleaching solution compared to the color of acrylic resin before tea staining (Average ± SD) | After Stain removal (%) |
|-----------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|------------------------|
| Group 2: Aquadest (10 minutes) | 5.9339 ± 0.91 | 5.3764 ± 0.7762 | 9.4% |
| Group 3: Cloth bleaching agent containing NaOCl 0.5% (5 minutes) | 9.7893 ± 2.14 | 8.9114 ± 2.0898 | 8.9% |
| Group 4: Cloth bleaching agent containing NaOCl 0.5% (10 minutes) | 8.7664 ± 1.08 | 0.1348 ± 0.6154 | 98.5% |

Immersion of tea-stained acrylic resin in Aquadest for five or 10 minutes indicated a color difference that was not much different from that of the acrylic resin before the immersion in tea solution. The total tea stain removal was 9.4% in group 1 and 8.9% in group 2. Group 3 showed less color difference (98.5% removal) from that of the acrylic resin before tea staining, while group 4 showed a greater color difference compared to group 3 (stain removal as much as 106.9%).

**4. Discussion**

Based on our results, the immersion of acrylic resin in the Aquadest is unable to remove tea stain. This can be seen from changes in brightness, red-green, yellow-blue, and the nonsignificant color change values.

The immersion of tea-stained acrylic resin in a 0.5% NaOCl solution for five minutes was effective in removing tea stains from heat-cured acrylic resins by 98.5%. The color of the acrylic resin after immersion approximated the color before tea staining. The stain removal after the immersion in 0.5% NaOCl bleaching solution was estimated to be due to the effect of chlorine present in the NaOCl solution. When NaOCl is dissolved in water, chlorine is released into the solution. Chlorine is a powerful oxidizing agent that can break double bonds and is capable of producing a bleaching effect [6]. Jagger et al. [5] reported that Dentural brand denture cleansers containing 1.5% NaOCl were able to remove 99% tea stains on acrylic resins within five minutes. In our study, as much as 98.5% of tea stains on acrylic resins could be removed within five minutes with the diluted Bayclin brand cloth bleach solution containing 0.5% NaOCl. This was due to the effect of the surfactant contained in the bleach solution used in our study. Surfactants are found commonly in commercial bleach solutions,
such as those found in the Clorox brand bleach solution [9]. Surfactants are added to the NaOCl solution to reduce the surface tension of the solution. When the surface tension decreases, the wetting ability of the NaOCl solution becomes better and will increase the efficiency of cleaning and disinfection. [6] It is also estimated that the surfactant helps NaOCl in removing stains on the surface of the acrylic resin, although the type of surfactant estimated to be present in the Bayclin brand bleach solution is not known, because it is not listed on the packaging.

The immersion of tea-stained acrylic resin in 0.5% NaOCl solution for 10 minutes demonstrated 106.9% tea stain removal. Although the immersion in NaOCl 0.5% solution for 10 minutes was effective as a disinfectant, [7] the stain removal was too excessive, and the color of the acrylic resin after immersion was not the same as the original color before tea staining. This acrylic resin exhibited lower yellow-blue values and a brightness value that was close to the color of the acrylic resin before tea staining; although there was a decrease in the red-green value, it was not significant. It was estimated that the larger yellow-blue values caused the acrylic resin to undergo excessive color changes due to chlorine, which already was affecting the acrylic resin plate. This study was by the research of David et al. [10] who stated that the longer immersion in NaOCl, the more faded color pigments would be found on the acrylic plate so that greater color changes occur.

NaOCl for use in tea-stained teeth cleansers, pour 20 mL (or 2 bottle caps of a large size container) of Bayclin brand bleach solution into 190 mL water (approximately one glass of water).

5. Conclusion
Based on this research, the immersion of tea-stained acrylic resin in a cloth bleaching solution containing 0.5% NaOCl for five minutes was effective in removing tea stains on the heat-cured acrylic resin.

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