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A Study *in vitro* to Compare Home and Surgery Vital Bleaching Techniques

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Abstract - *The aim of this study was to compare the effectiveness of three different types of commonly used bleaching techniques using an in-vitro model. Five groups of 10 tooth specimens were prepared and allocated randomly to treatment groups. The four treatment groups tested were a home tray bleaching product, an 'in surgery' tray bleaching product and an 'in surgery power bleaching' product for use with an activating light. The bleaching agent in the latter group was also tested without light activation to assess the additional benefit of the bleaching lamp. A placebo group treated with water was also included. Colour change was assessed using a Vita shade guide and an electronic chromometer. The mean change in shade guide units ranged from 10.9 to 13.2 units, with the 'in surgery' tray bleaching system producing the largest change. For the chromometer readings the mean change in tooth colour ranged from 3.6 to 25.6 units, with the night guard vital bleaching product producing the largest change. This study has demonstrated in vitro that all the different bleaching systems tested produced comparable changes in tooth colour.*

KEY WORDS: Tooth bleaching, hydrogen peroxide, bleaching lamps

INTRODUCTION

Fuelled by patients' desire for whiter teeth, bleaching has become one of the most popular and common aesthetic dental procedures in modern dentistry. It is a relatively easy and conservative procedure to deliver compared to other forms of treatment, such as veneers and crowns. There are various modes of delivery of the bleaching material, which include in-surgery power bleaching techniques, dentist prescribed or patient applied home systems, over-the-counter kits and many different whitening toothpastes. Most of the latter are directed against extrinsic stains and at this time are not permitted to contain effective levels of bleaching chemicals.

Only a small number of classical randomised blind controlled trials have been carried out to assess the efficacy of hydrogen peroxide and carbamide peroxide in tooth whitening[1] and much of the efficacy of bleaching materials has been based on case reports and anecdotal evidence[2–4]. Furthermore, these trials tended to cover the various home bleaching systems that gained great popularity following the introduction of the 'night guard vital bleaching technique' in 1989[5]. More recently the trayless polyethylene whitening strips[6] have attracted a considerable amount of research interest involving classical randomised clinical trial designs. In-office power bleaching on the other hand has still tended to rely on case report data. Thus, among early reports on power bleaching using 30% hydrogen peroxide on tetracycline stained teeth, 4 out of 6 patients showed a marked improvement in tooth colour following 4 hours of bleaching[7]. Other workers have studied a combined in surgery and home bleaching regimen, which they reported to be successful but lacked quantitative evidence[10, 11].

Most clinical and laboratory assessments of tooth whitening products now rely on electronic methods of shade assessment to remove the subjectivity associated with using clinical shade guides. Chromometers are commonly used for shade assessment and rely on the Commission Internationale de l'Eclairage (CIE) Lab system which is an internationally recognised system for recording colour in three-dimensional space using three axes; L*, a* and b*. The L* axis represents the degree of lightness within a sample and ranges from 0 (total black) to 100 (pure white). The a* axis represents the degree of green/red colouration, while the b* axis represents the degree of blue/yellow colouration. When examining changes in colour most studies, including tooth whitening studies, report changes using a parameter called ΔE* which is a composite value that takes into account changes in L*, a* and b* and is calculated using the expression:-

$$\Delta E^* = \sqrt{((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)}$$

The aim of this study was to compare the bleaching efficacy *in vitro* of a widely available home tray bleaching system (Illuminé home), a surgery/dentist applied bleaching gel (Illuminé office) and a power bleaching system which used an in surgery light (Zoom 2). In addition to this, an assessment of the efficacy of the light was also carried out.

The null hypothesis used in the study was that there would be no difference in the bleaching effects obtained with the various bleaching systems.

MATERIALS AND METHOD

The *in vitro* model used in this study has recently been reported[12] and involved the preparation of internally stained tooth specimens and two methods of tooth shade assess-

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ment. Essentially third molar teeth had their roots removed before being sectioned vertically in half beginning at the level of the occlusal fissure. The exposed dentine surface was polished and etched with 35% phosphoric acid to remove the smear layer and expose the dentinal tubule network thereby encouraging stain uptake into the tooth. The teeth were then placed in a standard tea solution for 5 days for stain development, which was measured using two shade assessment methods. Stained teeth were subsequently stored in distilled water at room temperature prior to use and were used within 48 hours of the completion of staining.

A standard Vita shade guide (SG) was used to assess stain development together with an electronic chromometer (Minolta CR 221) which had been validated in a previous study[12]. The chromometer allowed the accurate and non-subjective measurement of tooth colour using L* and a* b* values[13].

Three different bleaching systems were assessed in this study:-

- Illuminé home; this was a 10% carbamide peroxide gel used as a home tray bleaching product for 2 hours per day for 1 to 2 weeks
- Illuminé office; this was a 15% hydrogen peroxide material used as an in surgery bleaching agent for 1 hour and is manufactured to be used with a custom made bleaching tray
- Zoom 2; this was a 16% hydrogen peroxide material containing an iron based catalytic system that is used in the surgery. The product is placed onto the labial tooth surfaces and irradiated with a bleaching lamp for three consecutive 15 minute sessions

In addition to this, the effectiveness of the Zoom 2 lamp was assessed by testing the effect of the Zoom 2 bleaching gel without light application.

Finally, a negative control group was used where stained specimens were stored in distilled water at room temperature.

Therefore, five groups of 10 tooth specimens were prepared and allocated randomly to treatment groups using a random allocation table. A formal sample size calculation was not carried out. The baseline shades were assessed so that only specimens with shade C4 as assessed subjectively using the Vita shade guide were accepted for the study. The shade tabs were arranged in a sequence suggested by the manufacturer and each shade tab was assigned a numerical value ranging from 1-16 (B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, C4). In addition all specimens were assessed at baseline using the chromometer to record their L* a* b* values. The shade guide and chromometer assessments were carried out by one individual (BP). The shade guide assessments were carried out in tungsten light with the specimens placed on a black card background.

Prior to application of the bleaching products, all exposed dentine surfaces of specimens were sealed using clear nail polish before been stuck down onto a microscope slide using double sided adhesive tape so that only the enamel surface was available for the application of the bleaching agents. Prior to testing, all specimens were stored in distilled water at room temperature.

For the two tray based systems (Illuminé home and Illuminé office) plastic impression trays were cut and modified with brown stick compound before an alginate impression was taken of each group of specimens and a stone model was cast. A whitening tray was fabricated with a reservoir design to allow the bleaching agent to be applied to the enamel surface of the specimen.

For the Illuminé home group the bleaching gel was placed in the tray and the tray was applied to the stained tooth specimen and left in contact for two hours. Following treatment, both the teeth and the whitening tray were cleaned with a toothbrush and rinsed with water for 2 minutes. The teeth were then placed in water for 22 hours to allow them to rehydrate between treatments. This procedure was repeated daily to give a total treatment time of 7 days.

For the Illuminé office specimens, the bleaching gel was mixed according to the manufactures' instructions, the bleaching gel was placed in the tray and the tray was applied to the stained tooth specimen and left in contact for one hour. Following treatment, both the teeth and the whitening tray were cleaned with a toothbrush and rinsed with water for 2 minutes. The teeth were then placed in distilled water for 22 hours to allow them to rehydrate prior to shade assessment.

For the Zoom 2 group, approximately 1cm of bleaching gel was dispensed onto a mixing pad. The gel was spatulated for 30 secs and then applied to the enamel surface to produce a uniform layer approximately 2 mm thick. The Zoom 2 lamp was placed over the specimen so that the foam lining the circumference of the orange lamp cap rested just above the tooth surface. Each test tooth was irradiated with the Zoom 2 lamp for 3 x 15 minutes. The teeth were then placed in distilled water for 24 hours to allow them to rehydrate prior to shade assessment.

For the final treatment group, this process was repeated but the light irradiation was omitted.

The specimens in the negative control groups were stored in distilled water and the tooth shade was assessed at the end of each 24 hour period for a total of 7 days.

Statistical method

All groups were compared using analysis of variance followed by Tukey's test. The threshold for statistical significance was set at $p<0.05$.

RESULTS

The data for the bleaching effect of the three gels assessed using the Vita shade guide and expressed as shade guide units (SGU) change are shown in Table 1. The equivalent data determined using the chromometer are shown in Table 2 and are expressed as the difference between ΔE^* at the end of staining (prior to application of the bleaching gels) and the ΔE^* at the end of the bleaching regimen.

For the shade guide readings the mean changes ranged from 10.9 units for the power bleaching gel minus the light to 13.5 units for the in office tray bleaching system (Illuminé office).

Table 1. *Mean change in Vita SG scores (SD in parentheses)*

Treatment	*Shade change (shade guide units)*
Illumine home	13.2 (1.33)
Illumine office	13.5 (1.02)
Zoom 2 plus light	11.5 (2.06)
Zoom 2 minus light	10.9 (2.95)
Water control	0.0

Table 2. *Mean change in chromometer readings (SD in parentheses)*

Treatment	*ΔE* after tooth staining*	*ΔE* after bleaching*	*Colour change*
Illumine home	13.03 (5.33)	35.6 (3.62)	25.57
Illumine office	13.70 (6.29)	26.55 (6.81)	12.85
Zoom 2 + light	17.12 (4.66)	26.41 (5.47)	9.29
Zoom 2 - light	17.86 (8.94)	21.49 (9.04)	3.63
Control	12.19 (3.41)	12.94 (5.21)	0.75

Table 3. *Statistical comparison of the chromometer readings following application of the bleaching gels (ΔE*)*

Comparison	*Significance level*
Illumine home vs Illumine office	P<0.05
Illumine home vs Zoom 2 + light	P<0.05
Illumine home vs Zoom 2 - light	P<0.001
Illumine home vs control	P<0.001
Illumine office vs control	P<0.001
Zoom 2 + light vs control	P<0.001
Zoom 2 – light vs control	P<0.05

The chromometer readings (Table 2) followed a similar pattern to the shade guide readings with the changes ranging from 21.5 (power bleaching gel minus light) to 25.6 units (Illuminé home) with the negative water control group showing a change of 0.75 units.

Statistical analysis

Comparison of the results of the shade guide assessments showed that there was no statistical difference between the treatment groups. However, all of the bleaching treatment groups showed a change in mean shade guide value that was statistically different from the water control at the p<0.001 level.

Comparison of the results of the chromometer readings following application of the bleaching gels (ΔE*) are shown in Table 3. All treatment groups were statistically significantly different from the water control group at p<0.05 or greater. Differences between treatment groups were present at p<0.05 or greater apart from the power bleaching gel (Zoom 2) groups used with or without the bleaching lamp.

DISCUSSION

All of the bleaching methods assessed produced a whitening effect that would be observable clinically and were easily assessed using a clinical shade guide. The greatest change observed using shade guide assessment was with the 'in surgery' 15% hydrogen peroxide product (Illuminé office – 13.5 SGU), closely followed by the 10% carbamide peroxide night guard vital bleaching product (Illuminé home – 13.2 SGU). The in surgery power bleaching product (Zoom 2) produced a slightly smaller whitening effect (11.5 SGU). When the power bleaching product was used without the bleaching lamp a slightly reduced whitening effect was observed, but this difference with and without the bleaching lamp of 0.6 SGU is unlikely to be detected clinically by the naked eye.

Similar results were also seen using the electronic chromometer. This is an overall shade assessment that takes into account changes in the three colour parameters L*, a* and b*. The largest whitening change was observed with the home bleaching product (Illuniné home) with a whitening change of 25.6 units. This was closely followed by the 'in surgery' hydrogen peroxide product with a whitening change of 12.9 units. The difference between the 'in surgery' product and the 'home use' product was 12.7 units.

For the Zoom 2 product the whitening change when the surgery light was applied was 9.29 units. Exclusion of the bleaching light from the Zoom 2 product again produced a reduction in the bleaching effect. The difference was relatively small at 5.7 units.

In some respects, the comparisons made in this study are a little unfair and artificial. Although each of the products was used exactly as the manufacturers' intended, this may

not reflect fully how these materials are used in combination in the clinical environment. For example, in this study the night guard vital bleaching product was applied to the tooth specimens for 2 hours per day for 7 days giving a total contact time of 14 hours. In comparison, the 'in surgery' product (Illuminé office) was applied for 1 hour and the Zoom 2 product was applied for only 45 minutes. In reality, these types of 'in surgery' procedures are often repeated or are immediately 'topped up' with a period of night guard vital bleaching [16].

Comparison of the power bleaching product with and without the bleaching lamp proved to be interesting, as use of the lamp seemed to produce only a small amount of additional benefit. Assessment using the shade guide showed an additional benefit of 0.6 SGU and with the chromometer the difference in ΔE* was 4.92 units. These differences were not statistically significantly different.

These findings *in vitro* are similar to the clinical study of Ziémba *et al* [20]. They reported an average clinical change of 7.7 SGU with 3 x 15 minute application of the power bleaching gel Zoom 2 when used with the matching bleaching lamp. However, when the bleaching lamp was omitted, the clinical bleaching effect reduced to 6.1 SGU suggesting that the lamp contributed an average change of 1.6 SGU in a clinical study. This was close to the change of 0.6 SGU suggested in this *in vitro* study.

This small effect is not too surprising as bleaching lamps probably exert their effects in two ways. Firstly, the concentrated light will accelerate the breakdown of hydrogen peroxide and the heat generated by the lamp will also increase the rate of diffusion of the bleaching agents through the enamel and into the dentine. Unfortunately, diffusion is physically a slow process[21] so it is not too surprising that the bleaching lamps display a limited additional benefit as the contact times are always around 1 hour or less.

Furthermore, there are some limitations in comparing the results from this *in vitro* study with clinical reports as differing environments exist in the mouth compared to our laboratory model. As far as possible the bleaching materials and protocols used were identical to those used clinically. The obvious difference in the present *in vitro* study is the absence of positive outward pressure along the dentinal tubules[15] that may resist the penetration of the hydrogen peroxide.

In conclusion, this study has demonstrated *in vitro* that the different bleaching systems tested significantly change tooth colour and the systems produce roughly comparable changes in tooth colour, at least when assessed using a clinical shade guide.

MANUFACTURERS' DETAILS

1. Illuminé Home, Dentsply UK Ltd., Hamm Moor Lane, Addlestone, Weybridge, Surrey, UK.
2. Illuminé Office, Dentsply UK Ltd., Hamm Moor Lane, Addlestone, Weybridge, Surrey, UK.
3. Zoom 2 system, Discus Dental, Culver City, California, USA.
4. Vita shade guide, Vita, Zahnfabrik, Germany.
5. Minolta CR 221 chromometer, Minolta UK, 1-3, Tanner Dr, Blakelands North, Milton Keynes, UK

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