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Henry RK, Bauchmoyer SM, Moore W, Rashid RG. The effect of light on tooth whitening: a split-mouth design.

The effect of light on tooth whitening: a split-mouth design

Abstract: *Objectives:* Conflicting research exists on the effect that various lights have on in-office tooth whitening. The aim of this study was to determine whether a sodium arc bulb lamp used with 25% hydrogen peroxide shows significant differences in shade using a split-mouth design. *Methods:* Forty-nine subjects meeting study criteria had anterior teeth whitened with a 25% hydrogen peroxide in-office whitening system. The light was used on a randomly selected right or left half of the mouth. The opposing side was whitening only with gel. Shades were recorded using a spectrophotometer before, immediately after, 1 and 2 weeks post-whitening. Sensitivity was also recorded using a visual analogue scale. Values were analysed with a Friedman test with a stepdown Bonferroni adjustment for multiple comparisons. *Results:* All teeth increased in lightness after whitening procedures. The only significant differences between use of the light and without use of the light were on the maxillary arch 1 week after whitening ($P = 0.010$). Sensitivity was greatest immediately after whitening but subsided within 1 week of whitening. *Conclusions:* The use of a sodium arc bulb lamp with 25% hydrogen peroxide in-office whitening produces better results on maxillary teeth up to 1 week after whitening is completed. Subjects could not distinguish differences on each side of the mouth.

Key words: dental hygiene; dental hygiene research; light; sensitvity; tooth whitening

Introduction

Tooth whitening has been established as a popular dental procedure since the 1980s (1). The options for tooth whitening are numerous, and in-office whitening procedures are a common option in dental offices. In-office whitening procedures offer the benefit of fast results and professional supervision. Most in-office methods use a high concentration of peroxide and some use a type of light activation in addition to the peroxide. Research is conflicting on whether the use of a light increases the whiteness of teeth during in-office whitening (2–4). Current literature on whitening with a light spans many different products and techniques.

Tavares *et al.* found that using 15% hydrogen peroxide gel with a light showed significant differences in shade as compared to using no light or just the light (5). An *in-vitro* study examined several in-office whitening products and light sources. The study concluded that a 35% hydrogen peroxide with an infrared light produced the largest shade change after 1 week (6). An *in-vivo* study using 25% hydrogen peroxide found that the use of a light increased initial whiteness, but had a significant rebound effect after 1 week (7). Multiple other studies have shown

similar results with differences in shades when using a light activated in-office whitening procedure (8–15).

Conversely, other literature demonstrates that the light does not produce a significant difference when compared to whitening without a light. A study using 35% hydrogen peroxide with and without light sources found that there was no significant difference between use of the light for up to a 6-month period (12). LED lights were also shown to have no difference in whiteness as compared to no light. Light activation with whitening has also been to increase sensitivity (13).

The purpose of this study was to determine whether whitening with a light showed significant differences in shade over a 2-week period. This study is unique as it used a split-mouth design and only one type of whitening gel and light.

Study population and methodology

The Institutional Review Board at The Ohio State University, Columbus, OH, reviewed and approved the study procedure and consent. This study was a randomized split-mouth design utilizing a sample of 49 subjects who responded to a study advertisement and met established criteria (Table 1). Informed consent was obtained before the study began. All subjects received a dental screening and a prophylaxis on anterior teeth (numbers 6–11 and 22–27) 1 week before the start of tooth whitening. Quadrants were randomized as to whether the right or left half of the arch would receive whitening with the light. Throughout the duration of the study, subjects were instructed to use Fluoridex toothpaste (Discus Dental), a manual toothbrush (Oral B Cross Action-soft Procter and Gamble) and dental floss (Oral B Satin Floss, Procter and Gamble) twice a day. Subjects were given oral hygiene instructions and products at the first visit, 1 week prior to whitening. Shades were recorded using the Vita Easyshade (Vident) on anterior teeth. All statistical analyses were carried out using SAS 9.2 (SAS, Inc., Cary, NC, USA).

Whitening procedure

Three examiners were trained and calibrated on whitening and study procedures. Subjects' lips were retracted and isolated using manufacturer-provided retractors and gauze (Zoom 2, Discus Dental). Gingival tissue was isolated around all teeth with a light-cured resin dam (Liquidam, Discus Dental). A 2-mm-thick application of 25% hydrogen peroxide whitening gel (Zoom 2, Discus Dental) was applied to either the right or left maxillary and mandibular teeth based on random assignment. A sodium arc bulb lamp was placed in alignment with retractors for 15 min. Whitening gel was removed with high volume evacuation, and a new application of whitening gel was applied. The light was replaced and the procedure was repeated once more, totalling three 15-min whitening sessions with the light. Whitening gel was rinsed and evacuated. Whitening gel was then applied to the opposite side of the mouth for 15 min, based on assignment, but the light was not used. Whitening gel was removed with high volume evacuation, and a new application of whitening gel was applied. Three 15-min whitening sessions were completed on the opposite side. Whitening gel was rinsed and evacuated, and retractors were removed. Subjects were given ACP gel (Relief ACP, Discus Dental) in a custom tray after whitening was completed. Subjects were instructed to use as needed for sensitivity.

Table 1. **Inclusion and exclusion criteria**

Inclusion criteria
18 years of age or older
In general good health
Tooth shade of A3 or darker on all anterior teeth
Presence of anterior teeth (canine to canine)
Exclusion criteria
Significant medial problems
Pregnant or nursing
Presence of caries in anterior teeth as determined by a clinical examination
Periodontal disease in anterior teeth as indicated by a PSR score of ≥ 3
Facial restorations on anterior teeth
Tooth whitening done in the last 6 months
Evidence of gross pathology
Taking photosensitive medications

Shade evaluation

Shades were evaluated at five points throughout the duration of the study: the initial screening visit, before whitening, immediately after whitening, 1 week after whitening and 2 weeks after whitening. Shades were evaluated with the Vita Easyshade (Vident) placed halfway between the incisal and cervical edge of the teeth and halfway between the distal and mesial edges. Shade values (Table 2) were analysed by arch using a Friedman test with a stepdown Bonferroni adjustment for multiple comparisons.

Table 2. **Value-oriented Vita Easyshade* guide rankings used for colour assessment**

Value	Vita Easyshade	Assigned numerical colour ranking
Lightest	B1	1
	A1	2
	B2	3
	D2	4
	A2	5
	C1	6
	C2	7
	D4	8
	A3	9
	D3	10
	B3	11
	A3.5	12
	B4	13
	C3	14
	A4	15
Darkest	C4	16

*Classical Vita Shade Guide is manufactured by Vident, Brea, CA, USA.

Sensitivity evaluation

Sensitivity was evaluated at five points throughout the duration of the study using a visual analogue scale (VAS). Sensitivity values were recorded at the initial screening visit, before whitening, immediately after whitening, 1 week after whitening and 2 weeks after whitening. Sensitivity values were analysed using a Friedman test with a stepdown Bonferroni adjustment for multiple comparisons.

Results

Forty-nine subjects completed the study (Table 3). Shade changes were evaluated by arch. All teeth in both groups and arch increased in lightness (decreased in numerical value) (Table 4). Shades recorded immediately after whitening were skewed and unreliable and were omitted from the analysis. The only significant difference ($P = 0.010$) was between the baseline and 1 week after whitening readings on the maxillary arch (Table 4). No significant differences were found 2 weeks after whitening was completed (visit 4).

Sensitivity as measured by the VAS was greatest (mean = 13.60) immediately after whitening. Sensitivity decreased significantly at each subsequent visit after treatment was completed ($P < 0.001$). Table 5 shows VAS score means at each visit, subjects were most sensitive immediately after whitening, but the sensitivity levels returned to normal values within 1 week.

Table 3. **Demographic data of study participants (*n* = 49)**

Gender	
Male	*n* = 24 (48.98%)
Female	*n* = 25 (51.02%)
Age	Mean = 38.39 (±13.64)
Race	
White	*n* = 39 (79.59%)
Asian	*n* = 3 (6.12%)
African American	*n* = 2 (4.08%)
Hispanic	*n* = 4 (8.16%)
Tobacco use	*n* = 5 (10.20%)

Table 4. **Change in shade comparison by visit and arch**

		Without light	With light	
	Visit	Change in shade (SD)	Change in shade (SD)	*P* value
Mandibular	1 week after baseline	−2.51 (±3.88)	−3.69 (±3.51)	0.241
	2 weeks after baseline	−2.64 (±4.02)	−3.72 (±4.30)	0.463
Maxillary	1 week after baseline	−2.06 (±3.78)	−3.83 (±4.29)	0.010*
	2 weeks after baseline	−1.66 (±4.07)	−2.95 (±4.21)	0.463

*Significant difference.

Table 5. **Sensitivity visual analogue scale values**

	Mean (SD)
Baseline	2.14 (±3.43)
Immediately after whitening	13.60 (±16.08)
One week after whitening	4.25 (±8.62)
Two weeks after whitening	1.33 (±2.68)

Discussion

While the literature explores the effect of light on tooth whitening, very few studies employ a split-mouth design using only one whitening product (12, 16, 17). This study used a split-mouth design to control for variants in the behaviour of participants and oral conditions. This study only investigated the use of one type of in-office whitening system to allow for a significant number of teeth to be randomized into treatment groups. Therefore, the results of this study add to the literature on in-office whitening procedures.

While the overall change in shade was greater on teeth that were whitened with the light, the only significant differences were on the maxillary teeth 1 week after whitening. Maxillary teeth that were whitened with the light were significantly lighter than maxillary teeth whitened without the light after 1 week. The shade measurement 2 weeks after whitening shows no significant difference. These results are consistent with other studies (6, 7, 10). Possible reasons for significant differences only showing on maxillary teeth may involve the increased surface area and the position and angle of maxillary teeth to the light as compared to mandibular teeth. No differences were found when results were analysed and compared by gender.

Also of interesting note is shades that were taken with the spectrophotometer immediately after whitening produced unreliable and skewed results. Some shades taken immediately after whitening recorded darker than the initial shade value. This may be due to dehydration of teeth or other unknown factors. Other studies have found differences between the shade taken with a spectrophotometer and shades taken with a Vita shade tab (9).

The mean change in shade for maxillary and mandibular teeth using the light was 3.55 shade values. This should be of note to dental professionals as they explain expected results to their patients who are completing in-office whitening procedures. Other studies have shown mean shade changes from 3 to 11 shade changes after similar procedures. Our results support the findings of shade changes in other studies using in-office whitening procedures (6, 8, 9, 18).

Even though tooth sensitivity is one of the most commonly reported side effects of tooth whitening (1), the results related to sensitivity in this study were favourable. As expected, patients were most sensitive immediately after whitening, but the relative sensitivity was very mild (13.60 mean on a VAS scale of 0–100). One week after treatment, patients were close to their baseline sensitivity levels, and after 2 weeks, their average sensitivity was less than reported at the baseline.

These results are most likely a result of the use of Fluoridex toothpaste 1 week prior to whitening and throughout the duration of the study. Fluoridex toothpaste has 1.1% neutral sodium fluoride and 5% potassium nitrate. Patients also had the option to use Relief ACP gel as needed after whitening was completed. Use of the Relief ACP gel was not recorded. It is important for dental professionals to instruct patients on proper use of products to help alleviate sensitivity during whitening. Future studies should examine whether the above protocol was an effective intervention for sensitivity relief during in-office whitening.

It should also be noted that patients who participated in this study were all satisfied with the tooth whitening. None of the patients reported a noticeable difference in whiteness on the right or left side of their mouth. Only two incidences of minor gingival irritation were observed. This finding brings up the discussion that patient may perceive the change in shade differently than the dental professional. Previous research has shown that perception of shade is different to lay people than it is to dental professionals and realistic expectations for shade change should be established during treatment planning (19–21).

Limitations to this study include that follow-up was only completed 2 weeks after whitening. No long-term follow-up data were collected. No positioning devices were used during the collection of shades with the spectrophotometer. Examiners and subjects were not blinded to treatment in this study. Further research should include blinded examiners to record shades even though objective measures (spectrophotometer) were used. This study only addresses using 25% hydrogen peroxide and did not examine lower percentages of whitening gel. The lengthy literature of in-office whitening procedures using light activation lacks standardization, making it difficult to compare conflicting research.

Conclusion

In-office whitening procedures using 25% hydrogen and a sodium arc bulb lamp whitened teeth regardless of use of the light. Whitening with the light was shown to be significantly greater on maxillary teeth at 1 week post-treatment only. Patients could not identify shade differences on either side of the mouth. This in-office whitening procedure was effective and safe, and dental professionals should weigh the benefits and risks of any type of in-office whitening product when making treatment decisions. Dental professionals should also consider the desires of the patient when making whitening recommendations.

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Conflict of interest

The authors declare that they have no conflict of interests.

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