Original article

Treatment outcome and treatment experience: Factors associated with patient satisfaction after at-home tooth bleaching

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Received: 10/09/2026; **Accepted**: 03/10/2026; **Published:** 15/11/2026

DOI:10.34071/jmp.2026.S-3.19

Abstract

Background: Satisfaction is usually reported as a single global rating, which does not show which aspect of care patients respond to. This secondary analysis examined how measured colour change and treatment-related sensitivity relate to two components of satisfaction, and compared those components between treatment groups.

Materials and Methods: Secondary analysis of a randomised, two-arm parallel trial in 68 adults allocated 1:1 by drawing lots (34 per group), without blinding of participants or assessors. Both groups wore custom trays with 20% carbamide peroxide 6 – 8 h daily for 14 days, blended 1:1 with glycerin (Group 1) or casein phosphopeptide–amorphous calcium phosphate (CPP-ACP) (Group 2). At day 14 participants rated perceived colour change and their experience of the procedure; a binary satisfaction classification derived from the experience item was also analysed. Dentin sensitivity (Schiff score, daily visual analogue scale, VAS) and colour change (ΔE) were examined as associated factors in exploratory analyses.

Results: ΔE was higher in participants classified as satisfied (median 9.35 versus 3.75, $p < 0.001$), perceived colour change correlated strongly with measured ΔE (Spearman $\rho = 0.84$, $p < 0.001$) and the experience item correlated inversely with mean daily VAS ($\rho = -0.27$, $p = 0.026$). Satisfaction, classified from the experience item, was more frequent in Group 2 (29/34, 85.3%) than in Group 1 (20/34, 58.8%): risk difference 26.5%, 95% confidence interval (CI) 6.1 to 46.9; $p = 0.015$. Perceived colour change did not differ between groups ($p = 0.666$), whereas the experience item differed between groups ($p = 0.010$). ΔE did not differ between groups ($p = 0.783$). Dentin sensitivity was less frequent in Group 2 (41.2% versus 79.4%, $p = 0.001$). In exploratory logistic regression, ΔE was associated with the satisfaction classification after adjustment for group (odds ratio [OR] 2.78 per unit, 95% CI 1.64 to 4.72); the association with group remained after adjustment for ΔE (OR 11.49, 95% CI 1.42 to 92.76), and its 95% CI included 1 after mean daily VAS was added (OR 6.63, 95% CI 0.75 to 58.96).

Conclusion: Greater measured colour change was associated with greater perceived colour change and with the satisfaction classification, whereas poorer ratings of the treatment experience were associated with higher daily sensitivity. The CPP-ACP group reported a better treatment experience despite a similar ΔE. The associations were exploratory.

Keywords: *patient satisfaction; patient-reported outcome measures; dentin sensitivity; at-home tooth bleaching; CPP-ACP.*

1. INTRODUCTION

Patient satisfaction affects whether elective treatment is completed and recommended, yet it is usually reported as a single global rating, which shows that a patient was satisfied but not what they were satisfied with. Satisfaction may arise from both the perceived treatment outcome and the experience of undergoing treatment. The distinction is clinically relevant, because treatment-related discomfort is often easier to modify than the perceived outcome, but few studies have separated the two.

At-home tooth bleaching with a custom tray allows both domains to be measured objectively and independently. The clinical result is quantifiable as a colour difference in the CIEL*a*b* colour space, and the dominant source of treatment-related discomfort, dentin sensitivity, is quantifiable on established scales. Dentin sensitivity is reported by 55 – 75% of patients within two weeks of tray wear [1] and is the most frequently reported adverse effect of these protocols [2, 3].

Casein phosphopeptide–amorphous calcium phosphate (CPP-ACP) provides calcium and phosphate ions, counteracts peroxide-induced

demineralisation and restores surface microhardness [4-6]. When applied with carbamide peroxide it has been reported to reduce sensitivity in randomised clinical trials [7, 8] without reducing the whitening achieved in in vitro studies [9, 10]. Adding CPP-ACP to the gel may therefore change the treatment experience without changing the clinical result. Whether such a difference is reflected in patient-reported satisfaction has rarely been examined, and has been addressed only in a preliminary clinical series [11].

The objectives of this secondary analysis were (1) to examine the relationships of objectively measured colour change and treatment-related sensitivity with the two components of patient satisfaction and (2) to compare patient-reported satisfaction between the two treatment groups.

2. MATERIALS AND METHODS

2.1. Study design and participants

This is a secondary analysis of a prospective, randomised, controlled, two-arm parallel clinical trial conducted at the Department of Odonto-Stomatology, Hue University of Medicine and Pharmacy Hospital, between August 2020 and August 2022. Sixty-eight adults requesting at-home tooth bleaching were consecutively recruited until the target sample size was reached.

Eligible participants were in good general and oral health with no spontaneous pain, no pre-existing dentin sensitivity and no use of a desensitising product in the preceding three months. Exclusion criteria were pregnancy or lactation, unstable general health, active caries or tooth wear, acute periodontal, pulpal or periapical disease, cracked teeth, ongoing orthodontic treatment, large restorations or prostheses on the teeth to be bleached, severe intrinsic discolouration (tetracycline grade III–IV, fluorosis grade 3), enamel hypoplasia, allergy to the study materials, previous bleaching, marked pre-existing sensitivity, and cervical gingival recession on the anterior teeth.

Participants were randomly allocated in a 1:1 ratio to Group 1 or Group 2 by drawing lots. Sixty-eight allocation slips were prepared, with 34 designating each treatment group. Each slip was folded to conceal the assignment and thoroughly mixed. After enrolment, each participant personally drew one slip, which was removed from the pool after allocation. Neither participants nor outcome assessors were blinded to treatment assignment.

The sample size of the parent trial was calculated prospectively for the dentin sensitivity endpoint. Assuming a sensitivity incidence of 75% in Group 1, the upper bound of the 55 – 75% range reported for tray bleaching [1], and a reduction to 40% with adjunctive CPP-ACP, a two-sided alpha of 0.05 and 80% power required 31 participants per group; allowing approximately 10% for loss to follow-up gave 34 per group. Patient satisfaction was not the endpoint on which the calculation was based, and all satisfaction analyses and analyses of associated factors reported here are secondary and exploratory.

2.2. Interventions

Group 1 (CP + glycerin group, n = 34) used 20% carbamide peroxide (Opalescence, Ultradent, South Jordan, UT, USA) blended with glycerin in a 1:1 (w/w) ratio. Group 2 (CP + CPP-ACP group, n = 34) used the same peroxide blended with CPP-ACP (Tooth Mousse, GC International, Tokyo, Japan) in a 1:1 (w/w) ratio. Both groups received the same bleaching agent at the same concentration. This proportion follows previously reported at-home protocols in which a CPP-ACP paste was blended with carbamide peroxide without reducing the colour change achieved (an in vitro study [10] and a preliminary clinical series [11]).

Following alginate impressions and stone cast fabrication, soft custom trays 1 mm thick were vacuum-formed. Participants were instructed to place two to three drops of gel on the facial surface of each tooth in the tray, to remove excess gel with a cotton swab, and to wear the tray for 6–8 hours daily for 14 days. All participants received scaling and oral hygiene instruction before starting and were asked not to use desensitising toothpaste or mouthrinse during the study. The two protocols were identical apart from the material blended with the peroxide. Daily tray wear was not recorded.

2.3. Patient-reported outcomes

Four terms are defined for use in this article. Measured colour change is the objectively recorded colour difference (ΔE) between baseline and day 14. Perceived colour change is the participant's own rating of how much the colour of the teeth changed (questionnaire item 1). Treatment experience is the participant's rating of the experience of undergoing the treatment (questionnaire item 2). Satisfaction classification refers to the binary satisfied/not satisfied variable held in the source dataset, which is derived from the experience item as described below. The two questionnaire items are the primary patient-reported measures; the satisfaction classification is a secondary, derived variable.

At the end of the 14-day protocol participants

completed a two-item self-assessment questionnaire adapted from Cardoso et al. [12]. Both items used five-point ordinal scales. The two items were adapted for the present study and administered in Vietnamese. A formal forward–backward translation with cross-cultural adaptation was not undertaken, and the psychometric properties of the adapted items (content validity, construct validity, internal consistency and test–retest reliability) were not evaluated in this population.

Item 1, perceived colour change: (1) no colour change detected; (2) slight change not noticed by others; (3) slight change noticed by others; (4) moderate change; (5) marked change.

Item 2, experience of the procedure: (1) very dissatisfied; (2) dissatisfied; (3) satisfied; (4) very satisfied; (5) extremely satisfied.

The two items are reported separately. The source dataset also contains a binary satisfied / not satisfied variable, referred to here as the satisfaction classification. In 67 of the 68 participants this variable follows item 2 alone (a rating of dissatisfied or worse is classified as not satisfied, and satisfied or better as satisfied). In the single exception, a participant who rated the experience as dissatisfied but reported a marked perceived colour change (item 1 = 5) was classified as satisfied. The threshold and the handling of that case were not documented in a prespecified analysis plan and were reconstructed from the dataset. All analyses of the satisfaction classification are secondary and exploratory.

2.4. Dentin sensitivity

Sensitivity was assessed clinically by an air blast from the dental unit syringe (4 kg/cm², one second, perpendicular and 1 cm from the tooth surface) applied to all bleached teeth at baseline and on days 3, 7 and 14, and graded 0–3 on the Schiff scale [13]: 0, no discomfort; 1, discomfort but not severe; 2, discomfort or pain during the stimulus; 3, discomfort and pain during the stimulus, persisting after its removal. Teeth were assessed alternately with a 5-second interval, adjacent teeth were isolated, and a 5-minute interval separated stimulations. Each assessment was repeated twice and the higher score recorded. The participant's score was the highest score among all teeth assessed. Participants also rated their sensitivity daily at home on a 10 cm visual analogue scale (VAS, 0 = none, 10 = severe) throughout the 14 days. A participant was classified as having dentin sensitivity if the home VAS exceeded 0 or the air-blast score was 1, 2 or 3.

2.5. Colour assessment

Tooth colour was recorded at baseline and day 14 by digital photographic analysis. Standardised cross-polarised photographs of the middle third of the facial surface of the maxillary right central incisor were taken with a Nikon D90 camera and a 100 mm macro lens (1:1 magnification, 1/125 s, f/22, ISO 100, flash at full power) and analysed in Adobe Photoshop Lightroom Classic 10.1.1 after white balancing, yielding L*, a* and b* values in the CIEL*a*b* colour space [14]. Colour change was calculated as ΔL*, Δa* and Δb* (day 14 minus baseline) and combined as $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\wedge}½$. $\Delta E \geq 4$ was taken to represent a clinically relevant colour change [7], [9], [10]. The maxillary right central incisor was used as the single reference tooth.

2.6. Statistical analysis

Analyses used SPSS 26.0 (IBM, Armonk, NY, USA), with confirmatory computation in Python 3. Normality was assessed with the Shapiro-Wilk test; continuous variables were mostly non-normal and are given as median (interquartile range), compared with the Mann-Whitney test, with mean ± standard deviation in table footnotes. Ordinal questionnaire and Schiff scores were compared with the Mann-Whitney test and correlated with continuous variables using Spearman's rho (ρ). Categorical variables are given as n (%) and compared with the chi-square test, or Fisher's exact test when more than 20% of expected counts were below 5. Effect sizes are reported alongside p values for the principal comparisons: the Hodges–Lehmann median difference with its 95% confidence interval (CI) for continuous variables, the rank-biserial correlation for ordinal comparisons, and the risk difference with 95% CI for binary variables. For the satisfaction classification the risk difference is the primary measure of association; the odds ratio (OR) and the number needed to treat are also reported. Associated factors were examined univariately and then in exploratory logistic models built from treatment group, ΔE, mean daily VAS and baseline b*: group alone (Model A), group and ΔE (Model B), group, ΔE and mean daily VAS (Model C), and group, ΔE and baseline b* (Model D). No stepwise or automated selection was used, and no interaction terms were fitted. With 19 participants in the smaller outcome category there are fewer than five events per variable in the larger models. Firth penalised likelihood was applied as a robustness analysis, with profile penalised-likelihood intervals. The resulting odds ratios are reported as exploratory estimates. A two-sided $p < 0.05$ was considered significant; post hoc power is not reported.

2.7. Ethical considerations

The parent trial was approved by the Ethics

Committee in Biomedical Research of Hue University of Medicine and Pharmacy (approval no. H2020/205) 05 June, 2020s. All participants received an explanation of the objectives, procedures, duration, benefits and risks of the study, participated voluntarily and gave written informed consent before enrolment. Participant data were coded and kept confidential.

3. RESULTS

3.1. Participants and baseline characteristics

All 68 enrolled participants completed the 14-day protocol; there were no withdrawals. Fifty-three participants (77.9%) were women. Median age was 22.0 years (interquartile range 22.0 – 24.0; range 19 – 27). Coloured foods and drinks were consumed by 55 participants (80.9%), calculus was present in 61 (89.7%) and 3 participants (4.4%), all men, smoked.

Baseline characteristics are presented in Table 1. Baseline b* was higher in Group 2 than in Group 1 (median 20.00 versus 17.55; p = 0.043). This was the only baseline variable that differed between the groups.

Table 1. Baseline characteristics and trial outcomes by treatment group

	Group 1 (n = 34)	**Group 2 (n = 34)**	***p***
Baseline			
Male, n (%)	8 (23.5)	7 (20.6)	0.770
Age, years	23.0 (22.0 – 24.0)	22.0 (22.0 – 24.0)	0.240
L*	68.95 (63.73 – 70.90)	69.70 (66.45 – 71.88)	0.232
a*	9.75 (8.97 – 11.12)	10.85 (9.27 – 11.75)	0.169
b*	17.55 (15.65 – 19.67)	20.00 (16.88 – 22.18)	0.043
Dentin sensitivity			
Any sensitivity, n (%)	27 (79.4)	14 (41.2)	0.001
Mean daily VAS	3.30 (2.48 – 3.73)	0.00 (0.00 – 2.18)	< 0.001
VAS on day 4	3.90 (3.08 – 4.30)	0.00 (0.00 – 2.38)	< 0.001
Schiff score at day 14	1 (0 – 1)	0 (0 – 1)	0.002
Colour change at day 14			
ΔL*	3.05 (1.75 – 7.25)	3.60 (1.92 – 4.75)	0.717
Δa*	2.45 (1.90 – 3.88)	2.85 (2.02 – 3.80)	0.690
Δb*	5.05 (2.45 – 6.45)	5.70 (3.82 – 8.17)	0.153
ΔE	7.99 (4.27 – 10.21)	7.63 (6.71 – 9.94)	0.783
ΔE ≥ 4, n (%)	27 (79.4)	30 (88.2)	0.323

Values are median (interquartile range) unless stated. Categorical variables compared with the chi-square test; continuous and ordinal variables with the Mann-Whitney test. Mean ± SD for ΔE: Group 1, 8.35 ± 5.34; Group 2, 8.45 ± 4.02. Within each group, L*, a* and b* changed significantly from baseline to day 14 (Wilcoxon signed-rank test, all p < 0.001). Schiff score 0 at day 14 was recorded in 29.4% of Group 1 and 67.6% of Group 2. ΔE ≥ 4, number of participants reaching a colour difference of at least 4 units, compared with the chi-square test (risk difference 8.8%, 95% confidence interval −9.2 to 26.5). Between-group effect sizes: ΔE, median difference −0.29 (95% confidence interval −2.28 to 1.25); mean daily VAS, median difference 1.90 (0.70 to 3.10); any sensitivity, risk difference −38.2% (−56.2 to −15.0) for Group 2 versus Group 1.

3.2. Patient-reported satisfaction

Perceived colour change (item 1) did not differ between groups (median 3, interquartile range 2–4 in Group 1; median 3, interquartile range 3–3 in Group 2; p = 0.666; rank-biserial correlation −0.06). The experience item (item 2) differed between groups: 15 participants (44.1%) in Group 1 and 5 (14.7%) in Group 2 rated the experience as dissatisfied (p = 0.010; risk difference 29.4%, 95% CI 7.7 to 47.8; rank-biserial correlation 0.30) (Figure 1).

Perceived colour change was strongly correlated with measured ΔE (Spearman ρ = 0.84, p < 0.001). The experience item was weakly and inversely correlated with mean daily VAS (ρ = −0.27, p = 0.026).

The satisfaction classification indicated satisfaction in 29 of 34 participants (85.3%) in Group

2 and 20 of 34 (58.8%) in Group 1 (chi-square test, p = 0.015). The risk difference was 26.5% (95% CI 6.1 to 46.9) and the number needed to treat 3.8 (95% CI 2.1 to 16.4). The corresponding odds ratio was 4.06 (95% CI 1.26 to 13.07).

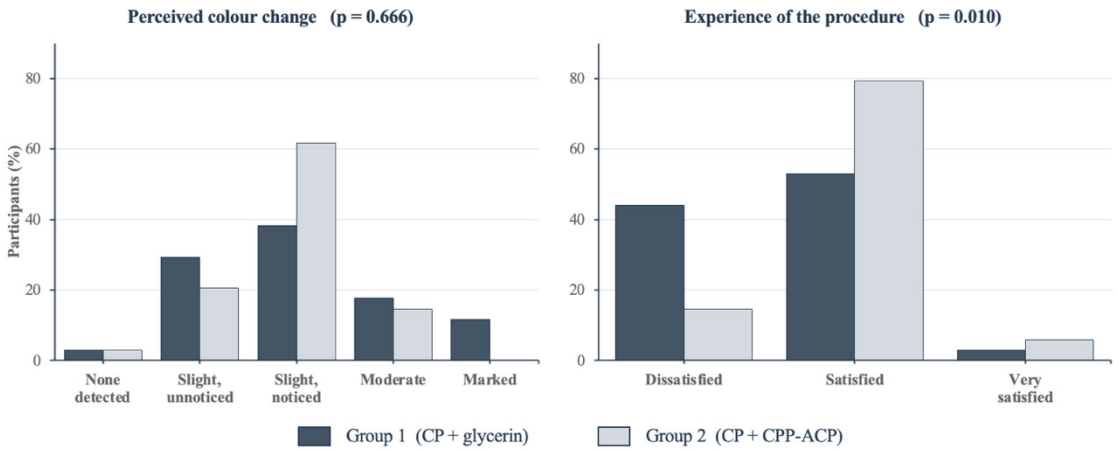


Figure 1. Distribution of the two satisfaction questionnaire items by treatment group

Mann-Whitney test on the ordinal responses. No participant selected "very dissatisfied" on item 2, and no participant selected the two highest experience categories. Item 1, perceived colour change; item 2, experience of the procedure. Between-group comparison of item 2: risk difference for a dissatisfied rating 29.4% (95% confidence interval 7.7 to 47.8).

3.3. Factors associated with satisfaction

Colour change variables were higher among participants classified as satisfied: median ΔE 9.35 (interquartile range 6.99 – 10.46) versus 3.75 (2.83 – 5.40) among those not satisfied (p < 0.001; median difference 5.06, 95% CI 3.74 to 6.45; rank-biserial correlation 0.84). All 49 participants classified as satisfied reached ΔE ≥ 4, compared with 8 of the 19 not satisfied (42.1%). The same pattern was seen for ΔL*, Δa* and Δb*. Sensitivity variables were lower among satisfied participants, but the differences were not statistically significant: median mean daily VAS 2.03 (0.00 – 3.40) among satisfied participants versus 3.10 (1.07 – 3.73) among those not satisfied (p = 0.054; median difference −0.53, 95% CI −1.97 to 0.00). Dentin sensitivity occurred in 27 of 49 satisfied participants (55.1%) and 14 of 19 not satisfied (73.7%) (p = 0.160). Age, sex, consumption of coloured foods and the presence of calculus were not associated with the satisfaction classification (Table 2, Figure 2).

Table 2. Factors associated with the satisfaction classification

Variable	Satisfied (n = 49)	Not satisfied (n = 19)	*p*
Colour change			
ΔE	9.35 (6.99 – 10.46)	3.75 (2.83 – 5.40)	< 0.001
ΔL*	4.20 (2.50 – 7.40)	1.90 (0.75 – 2.30)	< 0.001
Δa*	3.10 (2.10 – 4.10)	1.90 (1.60 – 2.15)	< 0.001
Δb*	6.20 (4.70 – 8.20)	2.60 (1.70 – 3.65)	< 0.001
Dentin sensitivity			
Mean daily VAS	2.03 (0.00 – 3.40)	3.10 (1.07 – 3.73)	0.054
Schiff score at day 3	1 (0 – 2)	1 (0.5 – 2)	0.055
Schiff score at day 7	1 (0 – 2)	1 (0.5 – 2)	0.086
Any sensitivity, n (%)	27 (55.1)	14 (73.7)	0.160

Variable	Satisfied (n = 49)	Not satisfied (n = 19)	*p*
Participant characteristics			
Age, years	23.0 (22.0 – 24.0)	22.0 (22.0 – 23.0)	0.359
Female, n (%)	38 (77.6)	15 (78.9)	1.000
Coloured food/drink, n (%)	39 (79.6)	16 (84.2)	1.000
Calculus, n (%)	45 (91.8)	16 (84.2)	0.390

Values are median (interquartile range) unless stated. Continuous and ordinal variables compared with the Mann-Whitney test. "Any sensitivity" compared with the chi-square test; sex, coloured food/drink and calculus compared with Fisher's exact test because more than 20% of cells had an expected frequency below 5. Schiff score at day 14 did not differ (p = 0.272). ρ, Spearman rank correlation coefficient. Satisfaction classification, the binary satisfied / not satisfied variable derived from questionnaire item 2. Effect size for ΔE: median difference 5.06 (95% confidence interval 3.74 to 6.45); rank-biserial correlation 0.84.

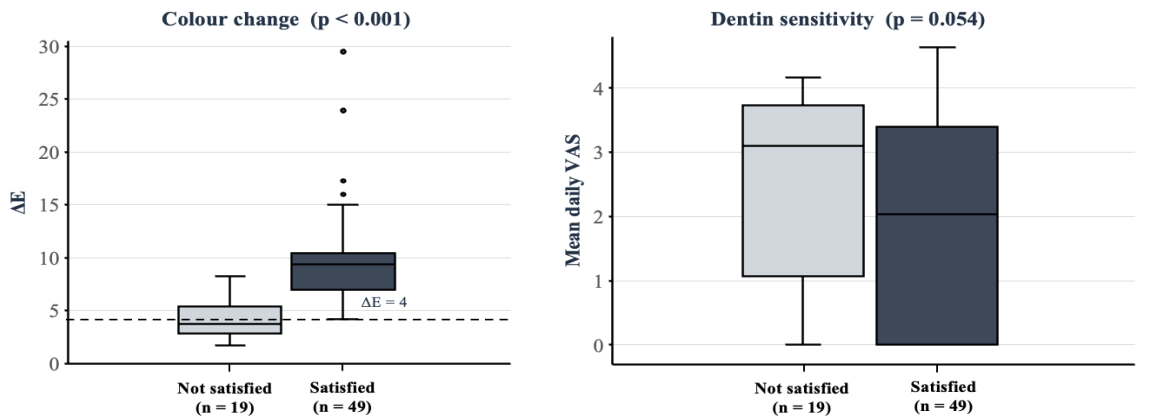


Figure 2. Colour change and sensitivity by satisfaction classification

Boxes show median and interquartile range; whiskers extend to 1.5 × interquartile range. The dashed line marks ΔE = 4, the threshold used to describe a clinically relevant colour change. Mann-Whitney test. Satisfaction classification, the binary satisfied/not satisfied variable derived from questionnaire item 2.

3.4. Exploratory multivariable analyses

Logistic regression models are presented in Table 3. In all models ΔE was associated with the satisfaction classification. The association between treatment group and that variable persisted after adjustment for ΔE, and was attenuated after mean daily VAS was added. Confidence intervals around the group estimates were wide in all adjusted models. Firth penalised estimates were consistently smaller in magnitude than the maximum-likelihood estimates. Adding baseline b* to the model containing group and ΔE (Model D) left the group and ΔE estimates essentially unchanged, and baseline b* itself was not associated with the outcome (OR 0.90, 95% CI 0.66 to 1.21, p = 0.482; Firth OR 0.91, 95% CI 0.69 to 1.21). The group and ΔE estimates in Model D were OR 13.34 and 3.09, compared with 11.49 and 2.78 in Model B.

Table 3. Exploratory logistic regression for the satisfaction classification

Model and predictor	OR	95% CI	*p*	Firth OR (95% CI)
Model A: group				
Group 2 vs Group 1	4.06	1.26 to 13.07	0.019	3.79 (1.28 to 12.67)
Model B: group + ΔE				
Group 2 vs Group 1	11.49	1.42 to 92.76	0.022	8.30 (1.53 to 74.57)
ΔE, per unit	2.78	1.64 to 4.72	< 0.001	2.42 (1.66 to 4.26)

Model and predictor	OR	95% CI	*p*	Firth OR (95% CI)
Model C: group + ΔE + VAS				
Group 2 vs Group 1	6.63	0.75 to 58.96	0.090	4.64 (0.77 to 42.21)
ΔE, per unit	3.26	1.67 to 6.35	<0.001	2.59 (1.70 to 5.27)
Mean daily VAS, per unit	0.56	0.26 to 1.23	0.147	0.63 (0.29 to 1.19)
Model D: group + ΔE + baseline b*				
Group 2 vs Group 1	13.34	1.51 to 117.70	0.020	8.88 (1.59 to 84.87)
ΔE, per unit	3.09	1.63 to 5.87	< 0.001	2.57 (1.65 to 5.11)
Baseline b*, per unit	0.90	0.66 to 1.21	0.482	0.91 (0.69 to 1.21)

Outcome: satisfied (49 events) versus not satisfied (19) among 68 participants. OR and 95% CI from maximum-likelihood logistic regression with Wald confidence intervals; p values from Wald tests. Firth OR from penalised maximum-likelihood estimation with profile penalised-likelihood confidence intervals, presented as a robustness analysis. Model D is a sensitivity analysis addressing the baseline b* imbalance. All models are exploratory; with 19 participants in the smaller outcome category, the number of covariates that can be supported is limited and the confidence intervals are wide. Covariates were not selected by stepwise procedures.

4. DISCUSSION

In this secondary analysis, greater measured colour change was associated with greater perceived colour change and with the satisfaction classification in every regression model. Poorer ratings of the treatment experience were associated with higher daily sensitivity. The group using CPP-ACP alongside 20% carbamide peroxide reported a better treatment experience and was more often classified as satisfied (a classification derived from the experience item), with a comparable colour change. The study was neither designed nor powered to rank the relative importance of the factors examined, and the variables compared are measured on different scales.

The two questionnaire items appeared to reflect different aspects of satisfaction. Perceived colour change was strongly correlated with ΔE and was similar between groups. In contrast, ratings of the treatment experience were poorer in participants reporting greater sensitivity and differed between treatment groups. Because the satisfaction classification is derived from the experience item, its agreement with treatment experience follows from how it was constructed and is not independent evidence. Independently of that classification, measured ΔE and perceived colour change did not differ between the groups, whereas dentin sensitivity and the experience rating did. The between-group difference therefore appears to relate to the experience of treatment rather than to whitening efficacy.

These sensitivity findings agree with earlier clinical trials. Rashid and ElSalhy reported reduced bleaching-related sensitivity with CPP-ACP alongside 15% carbamide peroxide, with no effect on colour, in a randomised split-mouth clinical trial [8], and Yassin and Milly reported a similar direction of effect with 20% carbamide peroxide in a randomised double-blind clinical trial [7]. The sensitivity incidence in Group 1 (79.4%) is at the upper end of the 55–75% range described by Haywood for tray bleaching [1], which is compatible with the higher peroxide concentration used here. The absence of between-group differences in ΔL*, Δa*, Δb* and ΔE is in keeping with the in vitro reports of Borges et al. [9], de Vasconcelos et al. [10] and Malekipour et al. [15], although laboratory findings cannot show that colour outcomes are unaffected in patients. Few studies have reported satisfaction outcomes for comparison; Cardoso et al., whose questionnaire was adapted here, also reported patient judgement to be responsive to the experience of treatment as well as to the shade obtained [12], and Piknjač et al. observed divergence in patient-reported sensitivity between whitening techniques with comparable objective outcomes [2]. The close agreement between perceived and measured colour change suggests that patients' expectations before treatment should be aligned with the colour change that can realistically be achieved, and that reducing treatment-related discomfort may improve their experience. The present findings are exploratory and do not establish a routine indication for CPP-ACP.

A strength of this study was the separate assessment of colour change and treatment

experience, with complete follow-up. The study also has limitations. Although participants were randomly allocated, neither participants nor the outcome assessor were blinded after allocation. Participants who knew which material they had received may have rated their treatment experience, perceived colour change and home VAS sensitivity differently (performance and reporting bias), and an assessor aware of allocation may have influenced the air-blast scoring and the relocation of the photographic measurement site (detection bias). Because the experience rating, perceived colour change and sensitivity scores are subjective, these biases could have inflated or obscured the between-group differences in the patient-reported measures. ΔE is derived from standardised photographs and is probably less affected but not free of this bias. The higher baseline b* in Group 2 may represent a chance imbalance despite randomisation; adjustment for baseline b* left the estimates essentially unchanged. The questionnaire was adapted from Cardoso et al. [12] and administered in Vietnamese without formal forward–backward translation or cross-cultural adaptation. Neither its validity (content and construct) nor its reliability (internal consistency and test–retest) was tested in this population. Each construct was measured with a single ordinal item, so measurement error could not be estimated. It is also unclear whether the items reflected perceived colour change and treatment experience as intended. Any misclassification arising from this may have weakened or distorted the reported associations. There is no record that the rule for classifying satisfaction was prespecified. Comparisons involving the classification are not independent of the experience item on which it is based; those analyses are exploratory. With only 19 participants in the smaller outcome category the adjusted intervals were very wide, and the attenuation after adding mean daily VAS cannot establish mediation. Satisfaction was a common outcome in both groups (85.3% and 58.8%), so the odds ratios reported here are numerically larger than the corresponding risk ratios and should not be interpreted as relative risks; the risk difference is the more directly interpretable measure. Colour was measured at a single reference tooth. The maxillary right central incisor was selected because it is the most visible tooth in the smile and therefore the one patients judge whitening by, and because its broad, relatively flat facial surface allows a standardised measurement site to be relocated reliably at each visit; it is also the conventional reference tooth in bleaching trials, which aids comparison with published work. Nevertheless, its response may not represent the whole bleached segment; canines in particular are typically darker and respond more slowly, so the colour change reported here may overstate the change across the arch. Actual wear time was not recorded although participants were instructed to wear the tray for 6 – 8 hours daily for 14 days. Differences in adherence between participants or between groups therefore cannot be excluded. Shorter wear would be expected to reduce both colour change and sensitivity. Unequal adherence could therefore confound the between-group comparison of sensitivity and treatment experience as well as the association between ΔE and the patient-reported measures. Future trials should record wear time with an electronic monitor where possible or else with a daily diary. All associations are cross-sectional and do not support causal inference. The sample was predominantly young women at a single centre and follow-up ended at day 14. A participant- and assessor-blinded, placebo-controlled randomised trial sized for the satisfaction endpoint, using a validated measure and at least six months of follow-up, is required.

5. CONCLUSION

Greater measured colour change was associated with a more favourable perceived treatment result and with the derived satisfaction classification. Participants receiving CPP-ACP as an adjunct reported a better treatment experience and less dentin sensitivity while achieving a similar colour change, with a higher proportion classified as satisfied. These exploratory results indicate that the whitening result and treatment-related discomfort are both associated with patient-reported satisfaction; confirmation in a trial with a validated satisfaction endpoint is needed.

DECLARATIONS

Conflict of interest

The authors declare no conflict of interest. No manufacturer of any product used in the study had any role in its design, conduct, analysis or reporting.

Funding

This study received no specific funding from any funding agency in the public, commercial or not-for-profit sectors.

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