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Review article

Vital bleaching and oral-health-related quality of life in adults: A systematic review and meta-analysis

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ABSTRACT

Objectives: To carry out a systematic review and meta-analysis of studies that investigated changes in perceived quality of life following vital tooth bleaching.
Methods: Online searches (Medline, PubMed, the Cochrane database of systemic reviews and Google scholar), bibliographic, and manual searches were carried out. Two authors independently screened the 313 articles identified from the searches and two authors extracted data, including risk of bias using the Cochrane data collection form. Random effects meta-analysis was used to estimate the pooled standardized mean difference (with 95% CI) and the 95% prediction interval.
Results: Only four studies met the inclusion criteria, two showing statistically significant improvement, one worsening, and one inconclusive. The pooled standardized estimate for change in quality of life after bleaching was 0.04 (95% CI -0.15, 0.24) with substantial heterogeneity (I-squared 82.1%). Within these studies, there was a pattern of improvement in aesthetic-related domains (e.g. smiling and psychological discomfort) and deterioration in function-related domains (e.g. hygiene and pain).
Conclusions: Vital bleaching was not associated with improvements in overall Oral Health Related Quality of Life (OHRQoL) in these heterogeneous populations. Vital bleaching appeared to impact some domains of OHRQoL positively and some negatively, indicating the need for clinicians to treat patients receiving bleaching treatment so as to obtain the best improvement in aesthetics with minimal side effects. Clinicians should be aware of the potential impact caused by tooth sensitivity and offer proper instruction to prevent it or treatment to reduce its impact.
Clinical Significance: Bleaching treatment produces positive changes in young participants' OHRQoL in aesthetic areas such as smiling, laughing, and showing teeth without embarrassment. Tooth sensitivity, the main side-effect of vital bleaching treatment, can affect quality of life, and so oral health professionals should offer evidence-based advice to prevent and manage sensitivity.

1. Introduction

Capitalising on consumer interest, dental practices are marketing as specialists in cosmetic dentistry. According to an American Academy of Cosmetic Dentistry survey of 360 dental practices, vital tooth bleaching, the act of using hydrogen peroxide or carbamide peroxide to whiten teeth is the most commonly requested cosmetic dental procedure in the U.S.A [2]. The extent to which bleaching works depends on the type, aetiology of the tooth discolouration and the age of the patient [3]. It also depends on the type, concentration and frequency of use of the bleaching agent [3]. Low concentration products can achieve a similar degree of whitening to high concentration products as long as they are used for longer periods [4]. Studies which have compared at-home and in-office vital bleaching techniques in terms of patient satisfaction have reported similar overall outcomes in terms of comfort and whitening [8–11], demonstrating that both techniques can yield satisfactory bleaching. However, the effects of in-office bleaching are more immediately apparent to the patient whereas, with home bleaching, patients may recalibrate their perceptions over the duration of multiple treatments involved, leading them to underestimate of the total degree of bleaching. Furthermore, in-office bleaching is more expensive and this may influence patient satisfaction with the whitening procedure in either positive or negative ways. Both of these effects could influence changes in their perceived quality of life following bleaching even if the

Abbreviation: OHRQoL, Oral Health Related Quality of Life; OHIP, Oral Health Impact Profile; OIDP, Oral Impact on Daily Performance

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shade change is identical. A method to evaluate these effects is to measure Oral Health Related Quality of Life (OHRQoL). Such measures have been increasingly used to evaluate treatments in clinical trials in dentistry and also to assess changes in OHRQoL after dental treatment [6]. In part, this reflects that over the past 20 years, health has become defined in terms of optimal functioning and social and psychological well-being rather than merely the absence of disease [7].

When faced with a choice of treatments, each with potentially equal bleaching outcomes, clinicians are able to make treatment decisions based on other criteria, including time required, convenience for the patient, cost, and effects on OHRQoL. There are currently no evidence-based guidelines for whether or not a quality of life effect exists when deciding between in-office and at-home bleaching or even whether bleaching itself is associated with a change in OHRQoL. The aim of this systematic review and meta analysis was to determine whether vital bleaching treatment in adults has an effect on the perceived quality of life and, if possible, to investigate the difference, if any, between different bleaching modalities.

2. Material and method

2.1. Search strategy

A literature search was carried out using Medline via OvidSP, PubMed, the Cochrane database of systemic reviews via OvidSP, and Google scholar, complemented by manual searches of the bibliographies of all full-text articles and related reviews selected from the electronic search. Moreover, manual searching was carried out for the following publications: Journal of Dental Research, Journal of Dentistry, Journal of Oral Rehabilitation and Operative Dentistry, covering the past 20 years.

The search used the MeSH terms “tooth bleaching”, “tooth discolouration”, “tooth colour”, “quality of life”, “self-concept”, “oral health”, “social effect”, “psychological effect”, “patients’ satisfaction” and “stress” along with keyword searches. The search was limited to English language and human studies (Fig. 1). The search combination in the builder was based on “interventions AND outcomes”. The following searches and search terms were applied: (tooth bleaching[MeSH] OR tooth bleaching[keyword] OR teeth whitening[keyword] OR tooth whitening[keyword] OR tooth discoloration[MeSH] OR tooth discolouration[keyword] OR teeth discoloration[keyword] OR teeth discolouration[keyword] OR tooth color[keyword] OR teeth colour[keyword] OR tooth colour[keyword] OR teeth color[keyword]) AND (“Quality of Life”[MeSH] OR exp Self Concept[MeSH] OR Oral Health [MeSH] OR psychosocial deprivation[MeSH] OR psychosocial[keyword] OR social effect*[keyword] OR psychological[keyword] OR exp Attitude to Health[MeSH] OR attitude to health[keyword] OR Patient Satisfaction[MeSH] OR patient satisfaction[keyword] OR Stress, Psychological[MeSH] OR stress psychological[keyword].) An additional search was undertaken to identify relevant studies by screening the references lists of all included publications.

The focused question for this systematic review was: does vital bleaching of adult teeth improve an individual’s quality of life? If sufficient and appropriate studies were identified, different modalities for bleaching (in office and at home) would also be investigated.

2.2. Inclusion criteria

Clinical publications were considered for inclusion if all of the following three criteria were satisfied:

- human trials.
- randomized controlled trials (RCTs), single-arm trials, prospective case series, cohort studies, retrospective studies.
- studies comparing vital bleaching techniques in terms of oral health related quality of life.

2.3. Exclusion criteria

Publications dealing with the following topics were excluded:

- in vitro and preclinical studies, reports based on questionnaires, interviews and charts.
- Review articles (although these were used to identify potential studies).
- Studies with systemic impaired patients or patients with another health complication.
- Studies with a sample that receives a regular prescription of medication(s) or involved physical or cognitive behavior therapy guided by professional psychology and/or physiotherapy professionals or with a major psychologic disorder.

2.4. Selection of studies

The database, bibliography, and hand searches were performed by SK. Two authors (SK, TX) independently screened all titles and abstracts derived from the searches based on the inclusion criteria. If the title and abstract did not provide sufficient information to determine inclusion/exclusion, the full text article was obtained to make the final determination. Any questions that came up during the screening were discussed until consensus was achieved. Unresolved disagreements were resolved by discussion with the senior clinician (KL).

2.5. Data extraction and method of analysis

All included articles were independently screened, and data were extracted using a modified Cochrane data collection form for interventions by two reviewers (SK, AG). Any disagreement was resolved by discussion between SK and AG, with other authors consulted as needed. Data on the following were extracted: author(s), year of publication, study design, number of patients in each group at baseline and at follow-up(s), bleaching agents used, OHRQoL instrument(s) used, length of the follow-up period(s) (favouring outcomes closest to one month where alternatives were available), bleaching effects (for example, means and standard deviations at baseline and follow-up times or mean changes and standard deviations over the follow-up period) and OHRQoL effects (for example, means and standard deviations at baseline and at follow-up(s) or mean changes and standard deviations over the follow-up period). Where necessary, the effects of the interventions were obtained from other reported statistics (for example, confidence intervals or test statistics) and data extracted from other studies (for example, standard deviations or correlation coefficients between repeated measures) were used where this was not available (Table 1).

As the studies were ultimately all treated as single group pre-post comparisons; random sequence generation (selection bias), Allocation concealment (selection bias), blinding of participants and personnel (performance bias), and blinding of outcome assessment (detection bias) were not considered applicable with only three items from the Cochran risk of bias instrument assessed.

Following the systematic review, a random effects meta-analysis (using the DerSimonian and Laird method with the Mantel-Haenszel model) was used to estimate the overall change in overall OHRQoL following bleaching and to estimate the 95% prediction interval. Statistical analyses were performed using Stata 15.1.

3. Results

The initial database searches revealed 313 articles and the title search narrowed this down to 59 articles (Fig. 1). A further nine articles not written in English were identified by the database searches but these were not relevant based on their translated titles and abstracts. The abstracts of those 59 articles were read, and this led to five articles

1	Tooth Bleaching/	2576
2	tooth bleaching.mp.	2774
3	teeth whitening.mp.	40
4	tooth whitening.mp.	474
5	Tooth Discoloration/	3061
6	tooth discolouration.mp.	44
7	teeth discoloration.mp.	12
8	teeth discolouration.mp.	2
9	tooth color.mp.	373
10	teeth colour.mp.	10
11	tooth colour.mp.	115
12	teeth color.mp.	25
13	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12	5243
14	"Quality of Life"/	172587
15	exp Self Concept/	102708
16	Oral Health/	14630
17	Psychosocial Deprivation/ or psychosocial.mp.	76819
18	social effect*.mp.	798
19	psychological.mp.	422357
20	exp Attitude to Health/	385749
21	attitude to health.mp.	188322
22	Patient Satisfaction/	76127
23	patient satisfaction.mp.	86781
24	Stress, Psychological/	112266
25	stress psychological.mp.	112342
26	14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25	1089249
27	13 and 26	313
28	limit 27 to english language	304

Fig. 1. Search example.

being identified for possible inclusion [12–16]. No additional articles were identified using bibliographic or hand searches. These five full text articles were read and inclusion and exclusion criteria applied. Upon reading the full text article for Wong, et al. (2007) and McGrath, et al. (2005), it was found that both papers, which were by the same authors, appeared to be reporting results from the same study, so only the article by McGrath, et al. (2005), the publication with the richest information, was added to the systematic review. In total, four articles [13,14,15,16] were included in the systematic review and meta-analysis (Fig. 2).

The Martin, et al. (2015) article reported a clinical randomized double-blinded split mouth study that assessed the effectiveness of light activated 6% hydrogen peroxide compared to nitrogen-doped titanium dioxide and 35% hydrogen peroxide bleaching agents with participants assigned to each group with equal probability. The study involved 31 participants with 30 (97% retention) completing the study (19 [63%] female and 11 [37%] male) who had a mean ± SD age of 24.1 ± 5.8 years for men and 25.2 ± 7.4 years for women, and with A2 or darker shades on the central incisors. The authors reported no difference in the baseline tooth shade between two groups. The authors used the OHIP-14 questionnaire to measure OHRQoL; 30 participants completed the survey at all four times (baseline, immediately after the three bleaching sessions, one week and one month after the last session). In relation to the OHIP-14 score, there was a statistically significant improvement in the score from baseline to one month post-bleaching (baseline mean ± SD 51 ± 25.93, one month post bleach 46 ± 24.22, Signed Wilcoxon test for change $p = 0.023$) showing maintenance of the effect evident at one week (mean ± SD 49 ± 24.41, Signed Wilcoxon test for change from baseline $p = 0.006$). The improvements noted were in the functional limitation (mean ± SD 4.80 ± 1.86 at baseline to 4.29 ± 1.59 at one week and 4.45 ± 1.87 at one month) and psychological discomfort scores (mean ± SD 5.58 ± 1.50 at baseline to 5.09 ± 1.46 at one week and 4.83 ± 1.59 at one month) (p-values not presented but both differences are described as statistically significant at one week and psychological discomfort at one month also). The objective measurement in the colour change over one month using ΔE was reported as 7.98 ± 2.45 and 5.57 ± 3.71 with 35% and 6% hydrogen peroxide respectively with similar changes noted after one week. The authors reported mild changes in sensitivity with both bleaching materials (35% and 6% hydrogen peroxide 6.80 + 17.16 and 3.53 + 9.10 respectively after the third session with smaller effects after the first and second sessions). In conclusion, there was a difference in the colour change at both one week and one month after use of a

Table 1
overview of the included studies.

Author & year	Type of study	Sample size and tooth shade at baseline	Bleaching agents and groups	OHRQoL scale and related instruments used	Follow up period	Bleaching effect	OHRQOL changes
Martin, et al. 2015	Double blinded split mouth randomized controlled trial (participants and examiners)	31 volunteers A2 or darker central incisors Mean age ± SD Male-24.1 ± 5.81 Female – 25.2 ± 7.4	6% hydrogen peroxide with nitrogen-doped titanium dioxide light activated bleaching agent 35% Hydrogen peroxide	-OHIP-14 aesthetic - spectromonometer meter color change -Subjective colour change -VAS sensitivity measurement	1 week and 1 month	Noticeable difference greater than 5 units of delta E	Positive change from a mean of 51 to 46
Meireles, et al. 2013	Double blinded randomized controlled trial (participants and examiners)	92 volunteers shade C1 or darker 6 maxillary anterior teeth Mean age not given Age range from 18-30 yrs	10% and 16% carbamide peroxide	- Self reported general health quality of life- OIDP	1 month	Similar effect 10 and 16 CP (numbers not mentioned)	Negative change from a mean of 0.42 to 0.60 (not tested in terms of means in manuscript)
Bruhn, et al. 2012	Single blinded randomized controlled prospective (examiner)	62 participants older than 50 years of age. Mean age not given	Whitening strips 14% hydrogen peroxide	- Tooth color satisfaction scale - OHIP-49	3 weeks	36.8% improvement in tooth color	Negative change of 0.96 (not statistically significant in manuscript)
McGrath, et al. 2005	Prospective cohort	87 university students Mean age ±SD 20.5 ± 1.5	Tooth paste, adhesive trips, paint on gel etc. Varying concentration hydrogen peroxide	- Tooth color satisfaction scale - OHIP-49	8 weeks	Not measured	Positive change from a mean of 31.33 to 25.81.

bleaching agent. Positive change in psychological discomfort was evident at the end of bleaching and one month later, which supports the proposal that the self-perception of dental aesthetics is modified positively by teeth bleaching. The analyses also showed a temporary effect on the functional limitation dimension, probably by a positive psychological effect that led participants to think temporarily that there was a functional improvement [14]. For the meta-analysis, the one-month post-bleaching changes were used, rather than the one-week changes, and the study was treated as a single group pre and post comparison as only a single oral health related quality of life measure could be obtained from each participant at each time point despite each study participant simultaneously receiving two different forms of bleaching. Martin and colleagues did not report the standard deviation for changes (or confidence intervals for changes) and this standard deviation was estimated based on that required for a paired *t*-test to produce the same p-value as their reported p-value for a Signed Wilcoxon test.

The Meireles, et al. (2013) study was a double blinded (participants and examiners) randomized controlled trial that evaluated the bleaching effectiveness and change in OHRQoL with 10% and 16% carbamide peroxide at-home bleaching on 92 young volunteers (45 [49%] 20 years old or younger, all under 30; 31 [34%] Males and 61 [66%] Females) assigned randomly with equal probabilities to the experimental groups with C1 or darker six maxillary anterior teeth. The authors used the OIDP questionnaires to measure OHRQoL. Most of the participants had a high level of educational achievement and were from higher socioeconomic groups. In total, 91 participants completed the study (99% retention). In relation to the tooth colour and tooth sensitivity, there were no significant differences between the groups after bleaching using 10% or 16% carbamide peroxide. They reported a non-statistically significant worsening of OHRQoL based on the OIDP with any impacts increasing from 30% to 41% (McNemar p = 0.08) but did not report formally testing the change in the OIDP mean ± SD of 0.42 ± 0.74 before to 0.60 ± 0.83 afterwards (both clearly positive skewed). In relation to symptoms, there was a higher number of participants who reported pain after treatment than at baseline (10.9% to 20.7%, McNemar p = 0.05) and a statistically significant decrease was observed in individuals who reported being unhappy with their appearance (8.7% to 3.3%, McNemar p = 0.03). There was also a non-statistically significant tendency for an increase in discomfort (16.3% to 26.1%, McNemar p = 0.09). For the OIDP items, the proportion of participants who reported difficulty with oral hygiene increased (9.8% to 22.8%, McNemar p = 0.02) with a decrease in smiling-related impacts (9.8% to 3.3%, McNemar p = 0.03). There was also a non-statistically significant tendency for an increase in eating impacts (18.5% to 28.3%, McNemar p = 0.10). For the meta-analysis, the study was again treated as a single group pre-post comparison. Means and standard deviations were reported for baseline and follow-up OIDP scores and used for the meta-analysis. No information was available on the standard deviation for changes and so a default correlation of r = 0.5 was used for this one-month period (only slightly higher than the r = 0.44 implied by McGrath, et al. over 8 weeks using the OHIP) [16].

The study conducted by Bruhn, et al. (2012) was a single blinded (assessors were blinded) randomized controlled trial which evaluated bleaching effectiveness and change in OHRQoL with over-the-counter products and home bleaching on 62 participants who were all over the age of 50 and were randomly assigned with equal probability to control and experimental groups. The experimental group received a whitening strips (14% Hydrogen peroxide) treatment while the control group received no treatment, providing the only non-bleaching controlled trial in the identified studies. The authors used the OHIP-49 questionnaire to measure OHRQoL. There were 28 (53%) female and 25 (47%) male participants who completed the survey after 3 months (85% retention). In relation to tooth colour, a 36.8% improvement in tooth colour was reported over 3 weeks for the experimental group (no p-value provided). Within the experimental group, there was evidence of

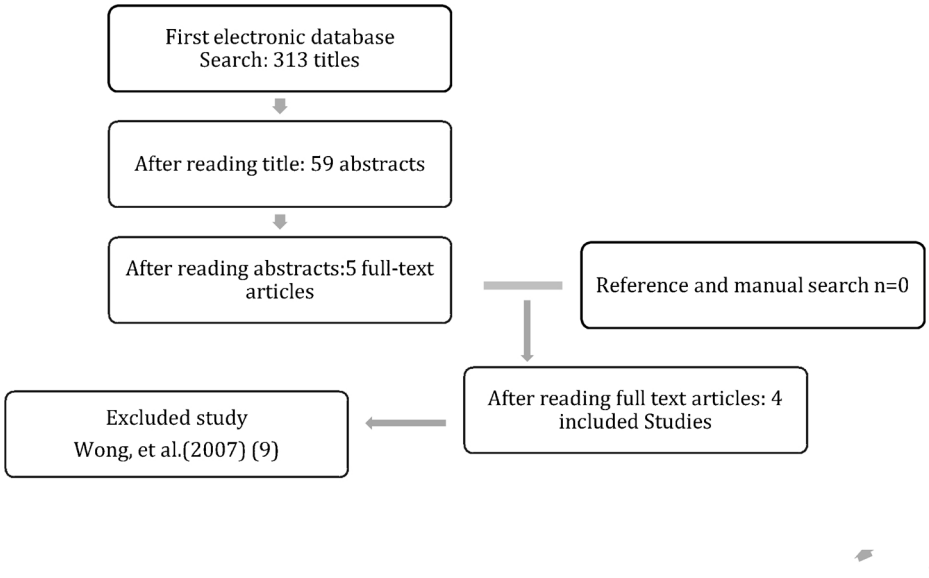

Fig. 2. Selection of studies.

improvement in the handicap subscale (paired *t*-test p = 0.05) and worsening of the physical pain subscale (p = 0.003). There was no evidence of a change in OHIP-49 scores within the treatment group (an increase of 0.96, paired *t*-test p = 0.22). While a control group was available, for the meta-analysis, we used the within-group change for comparability with the other three studies [15]. The effect of bleaching was extracted using the t-statistic for the within-group changes and by pooling the standard deviations from McGrath, et al. and Martin, et al.

The study by McGrath, et al. (2005) evaluated the effectiveness and change in the OHRQoL with over-the-counter products and home bleaching on 87 university students dissatisfied with their tooth colour. The authors used the OHIP-49 questionnaire to measure OHRQoL The mean age of the group was 20.5 years with an age range of 18–30 years. Overall, 63 participants completed the study (19 [30%] Males and 44 [70%] Females) but one was excluded for not completing the questionnaire (71% retention). Over half (n = 32, 52%) of the study participants were satisfied with the tooth whitening effects of the products they used with a further 13% [8] neutral and 36% [22] dissatisfied. There were statistically significant before-after differences in three of the OHIP domain scores: functional limitation (9.32 ± 3.69–7.41 ± 3.69, paired *t*-test on log-transformed data p < 0.001), psychological discomfort (4.44 ± 2.82–3.51 ± 2.84, paired *t*-test on log-transformed data p = 0.006) and in the handicap domain (2.59 ± 2.78 to 1.81 ± 2.42, paired *t*-test on log-transformed data p = 0.047). There was also a non-statistically significant decrease in psychological disability (2.79 ± 2.82 to 2.22 ± 2.72, paired *t*-test p = 0.097). The baseline mean ± SD OHIP-49 score was 31.3 ± 17.8 out of a possible range of 0–196, and with the use of the tooth whitening products there was a mean reduction in OHIP-49 scores of 18% (mean ± SD change 5.52 ± 18.45) which was statistically significant (paired *t*-test on log-transformed data p = 0.046). The improvements overall and for all seven domains were numerically greater amongst those participants who reported being satisfied with the whitening process [13]. For the meta-analysis, the study was again treated as a single group pre-post comparison.

As can be seen in Fig. 3, there was substantial heterogeneity between the four studies in terms of overall OHRQoL (I-squared 82.1%). Two of the studies individually suggested beneficial effects on OHRQoL and one suggested negative effects, with one unclear. Overall, the pooled standardized mean difference was close to zero being 0.04 (95% CI -0.15, 0.24) and the 95% prediction interval for new studies extended from -0.83 to 0.91 suggesting that while within-group effects are likely to be small on average, new studies could plausibly produce large effects in either direction. Removing the one study Meireles, et al., (2014) (16) using OIDP moved the pooled estimate slightly in a positive direction but did not alter the overall interpretation, including heterogeneity with I-squared being 83.3%, except that the prediction interval was much wider (Fig. 4).

According to the selected items from the Cochrane data collection form, two of the studies included McGrath, et al., (2005) and Bruhn, et al., (2012) (13,15) have a very high risk of bias for attrition bias while the studies by Meireles, et al. (2013) and Martin, et al. (2015) have a low risk of bias for all remaining items [14,16]. (Table 2).

As noted above, only one study Meireles, et al., (2014) (16) used the OIDP and the domains for this do not map readily onto the domains for the OHIP. For studies using the OHIP, domain-specific reporting from Bruhn, et al. (2012) (15) was limited, leaving only McGrath, et al. (2005) (13) and Martin, et al. (2015) (14) providing data on individual domains. With only two studies available for meta-analyses of the domain scores, no further analyses were undertaken.

Given only four studies, a funnel plot was not used to investigate publication bias. Furthermore, given only one study used in-office bleaching and the substantial heterogeneity in participants, treatments, OHRQoL, and assessment instruments, no meta-regression comparing treatment modalities was performed.

4. Discussion

This is the first systematic review and meta-analysis investigating vital bleaching of adult teeth and subsequent changes in OHRQoL. Four studies have considered changes in quality of life following vital bleaching and only one of these [15] compared treatment against a non-bleaching comparison group. Three studies [13–15] used at home bleaching regimes and one study [14] compared two different concentration of in-office bleaching agents. To date, no studies have compared in-office and at-home bleaching treatments in terms of their effects on OHRQoL.

All four studies [13–16] showed an increase in tooth colour satisfaction (although this was not statistically tested in McGrath, et al.) and a pattern of improved OHRQoL in the aesthetic domain. However, the pooled result from these studies showed that the bleaching treatments had not provided evidence for overall positive or negative changes in the participants' OHRQoL. At baseline, participants reported an impact on smiling, laughing, and showing teeth without

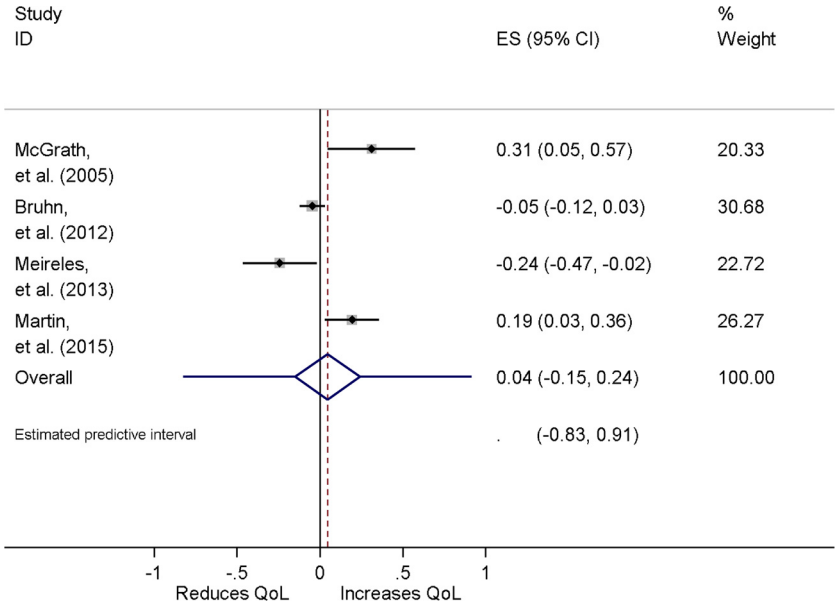

Fig. 3. Meta-analysis of the included studies.

embarrassment; after the bleaching treatment had been provided, fewer participants reported an impact on these same items. There were also results showing worse outcomes for some domains following bleaching with scores for hygiene and physical pain worsening in one study each.

Researchers have reported that physical health has profound quality of life implications. Physical pain associated with dental diseases and disorders, and feelings of embarrassment from unattractive teeth, can decrease social interaction in older adults, thereby decreasing their quality of life [17]. A meta-analysis also concluded that attractive children and adults exhibit more positive behavior and were treated more positively than unattractive children and adults [18]. Similarly, in a cross sectional study of university students, it was concluded that minor difference in dental aesthetics may have a significant effect on perceived OHRQoL [19].

In a study with an older adult population, the vital whitening treatment provided did not improve OHRQoL [15] in isolation or when compared to a control group. The age of participants in the single controlled study was 50 years and over and it has been demonstrated that older individuals are more resilient, and possibly more accepting of

Table 2
Risk of bias table for Cochrane items relevant to single arm studies.

	Incomplete outcome data (attrition bias)	Selective outcome reporting (reporting bias)	Other forms of bias
Martin, et al.	🟢	🟢	🟢
Meirles, et al.	🟢	🟢	🟢
Bruhn, et al.	🔴	🟢	🟢
McGrath, et al.	🔴	🟢	🟢

🟢 Low risk of bias 🔴 High risk of bias

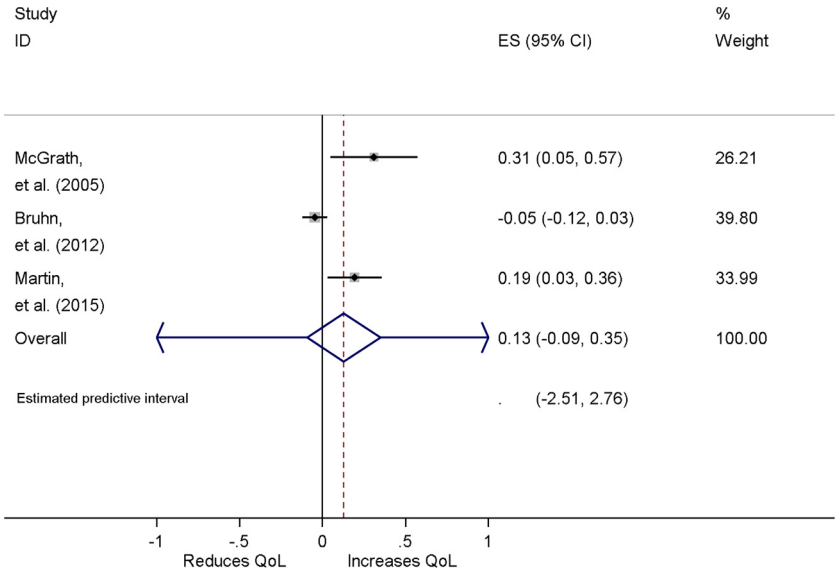

Fig. 4. Meta-analysis of the included studies using OHIP.

their dental appearance than younger people. It has also been reported that older people are less likely to be concerned regarding aesthetics and dental sensibility to hot, cold and sweet stimuli [20]. In contrast, younger individuals are more concerned with their teeth alignment and their teeth colour [21–23], and so they might be more likely to perceive a "positive" impact of the bleaching treatment which was the case for McGrath, et al. (mean age 20.5) and Martin, et al. (mean age 24.5). However, the data from Meireles, et al. showed evidence of lower OHRQoL after bleaching in a younger sample (ages between 18 and 30).

Bleaching has several possible negative impacts (discomfort, pain, difficulty performing oral hygiene activities) with the most common adverse effect reported being tooth sensitivity [24]. After bleaching treatment, subjects have also reported an impact on oral hygiene, meaning that participants had increased difficulty in brushing their teeth. In addition, gingival irritation, another adverse effect reported with tooth bleaching [25] could impair tooth brushing ability. For these reasons, the potential for negative impacts should be recognized when discussing vital bleaching as a treatment option with patients.

The included studies [13–16] used Oral Health Impact Profile (OHIP) and the Oral Impact on Daily Performance (OIDP) questionnaires with some additional questions to measure the change in OHRQoL before and after the bleaching process. The Oral Health Impact Profile (OHIP), a 49-item questionnaire that uses the framework of the 1980 WHO International Classification of Impairments, Disabilities, and Handicaps [29], is one of the most comprehensive measures of oral health related quality of life based on the theoretical conception that oral conditions can produce physical, social and psychological effects that can disable and handicap an individual using seven subscales [26]. Although the Oral Health Impact Profile consists of 49 items (OHIP-49), only two items ask directly about dental aesthetics. To address this, Wong et al., (2007) developed a short form of the OHIP-49 specifically for dental aesthetics (OHIP-aesthetic) with an expert based approach [12]. The authors concluded that OHIP-aesthetic appears to be more appropriate than OHIP-49 and other OHIP forms when it is used to detect changes in dental aesthetics, especially tooth colour.

All four studies [13–16] were very short duration ranging from 3 weeks to 8 weeks and it is unclear whether results might differ with longer-term follow-up. The studies involved a range of different bleaching treatments, with one of the studies using a split-mouth design involving two different bleaching treatments, and it was not possible to identify whether the effects on oral health related quality of life might differ depending on the type of bleaching. It is also possible that individuals participating in these trials could have been subject to the Hawthorne effect, meaning that they might have had a positive response only because they were being studied [30]. We were not able to adjust for placebo or Hawthorne effects through a control group for the studies included in our meta-analysis, as only one of the studies [15] included a non-bleaching comparison group, and it is worth noting that this study did not find evidence of differences between the treated and control groups for overall OHRQoL. Thus, we cannot rule out the possibility that our observed results would also be seen in placebo-treated patients and further research in this area should include control groups, ideally with participants, clinicians, and assessors all blinded as to actual treatment. Some studies did not report sufficient information to include them in the meta-analysis without using default values or values from other studies. The reporting of trials in this area needs to be improved.

The strengths of the present systematic review and meta-analysis include the extensive searching and rigourous data extraction processes used. The literature search was carried out by two individuals with recourse to a third individual to achieve consensus with a similar approach to the data extraction.

Given the paucity of evidence, robust well-designed clinical trials are needed to investigate the focused question: "Does vital bleaching of adult teeth improve an individual's quality of life?" As the effects of bleaching appear to affect domains of OHRQoL differently, researchers should be careful to form hypothesis, and may wish to focus primary analyses, around these domains as well as, or even instead of, overall OHRQoL. Future studies should address the impact in OHRQoL by comparing modalities of bleaching treatments such as in-office and at-home bleaching and for different age groups. Any such trials should have a longer-term follow-up period and OHIP-aesthetic and OIDP questionnaires should be considered to measure the change in the quality of life.

5. Conclusion

Within the limitations of a lack of primary research, it appears that vital bleaching is not associated with changes in overall OHRQoL, although vital bleaching does appear to impact some domains positively (aesthetics) and some negatively (pain and hygiene). These findings support the recommendation that clinicians treat patients with care when providing bleaching treatment so as to obtain the best improvement in aesthetics with minimal adverse side effect.

Declaration of interests

The authors declare that they have no conflict of interest.

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