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Dental fear in adults: a meta-analysis of behavioral interventions

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Abstract – *Objectives:* The aim of this meta-analytic and systematic quantitative approach is to examine the effects of behavioral interventions for dental anxiety and dental phobia. *Methods:* Eighty studies were identified where dental fear treatment with behavioral methods was evaluated. Thirty-eight of 80 met entry criteria and were included in a meta-analysis. *Results:* The calculated effect sizes (ESs) for self-reported anxiety after intervention indicate positive changes in 36 of the 38 studies and no changes in two. The overall ES = 1.8 (95% CI: 1.6, 1.8). The percent of subjects with post-treatment dental visits in the first 6 months post-treatment varied between 50 and 100%. The overall ES for attendance at dental visits, weighted by sample size, is 1.4 (95% CI: 1.3, 1.6). The homogeneity analysis indicates that the studies cannot be adequately described in one ES. The reported percentage of subjects with a dental visit between 6 months and 4 years post-treatment varied from 48 to 100%. The overall weighted ES for visiting the dentist, adjusted for drop-outs in the studies, is 1.2 (95% CI: 0.99, 1.4). *Conclusions:* Despite extensive heterogeneity, changes in self-reported anxiety represent medium to large ESs. Patients signing up for a behavioral intervention for dental fear can be expected to report a significant reduction in their fear, and this effect generally seems to be lasting. Mean long-term attendance (>4 years after treatment) is 77%.

Key words: behavior therapy; cognitive therapy; dental anxiety; meta-analysis; treatment outcome

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Three to five percent of the adult population in western societies suffer from dental phobia, while up to 40% of the adult population have been reported to be fearful of dental treatment (1–4). Kleinknecht (5) concluded that the clearest indicator of fear was the number of dental appointments missed or cancelled. Thus, reliable appearance at the dental clinic is a major behavioral criterion of fear reduction (6, 7). Dental fear may be a condition with effects limited to the dentist's office or may have widespread consequences. Oral health may be compromised (4, 8, 9). Phobics can also experience negative effects in everyday life including compromised social interactions, increased use of medication, and increased time lost from work (10–11).

When dental fear is explicitly treated, psychological therapy with or without adjunctive anxyliotic medications is the typical intervention. Reported psychotherapeutic interventions are mainly behaviorally or cognitively oriented. Most reported treatments include components based on systematic desensitization (SD) (12). SD uses relaxation to counteract and weaken the fear response during gradual exposure. In the dental setting exposure has been performed *in vivo* clinical rehearsals (13–15) or visualized (16, 17). Sometimes video presentations have been used (14, 18, 19). Relaxation can be achieved in a number of ways (20–24). There are also controlled studies of hypnosis (17, 25, 26).

More recently, researchers have attempted to adapt cognitive therapy to the treatment of dental fear (24, 27, 28). These treatments aim to alter and restructure the content of negative cognitions and enhance control over these thoughts. A one-session cognitive treatment of dental phobia has also been

evaluated (27). Sometimes treatment includes therapy components with different theoretical backgrounds that are used in a broad-based package and adapted to individual needs (23, 29). Cognitive reattribution and other educational approaches underlie most of these interventions. There are also educational effects from behavioral treatments that combine components of exposure and clinical rehearsals (14, 18, 30). Education is fundamental to the so-called ''iatrosedative'' technique, (31, 32), and the separate value of informative education has been tested (33). In addition, education constitutes a major part of group therapy (14, 34, 35). However evaluations of separate educational modalities are sparse (34, 35).

We have identified five published reviews of dental fear treatment in adults (36–40). Each covers a limited aspect of the literature. A common conclusion is that approximately 80% of patients treated will be able to receive ordinary dental care as a result of these experimental interventions. It is unclear, nevertheless, if this result can generally be expected when behavioral interventions are used to treat fearful adults outside of study settings.

The aim of this meta-analytic and systematic quantitative approach is to examine the effects of behavioral interventions for dental anxiety and dental phobia for adults. The major questions addressed are: (1) Do behavioral interventions contribute to significant anxiety reduction? (2) Do behavioral interventions result in significantly improved dental attendance in regular dental care? (3) Are the changes lasting?

Methods

Study selection and inclusion criteria

Papers were first identified by using key word and medical subject headings in the databases PubMed and Psychlit covering the period from 1966 to 2001. The search was conducted in November 2001. Two of the authors (G.K. and U.B.) jointly inspected all information extracted from the papers, and decided which studies to include or exclude. A number of different terms (dental fear, dental anxiety, odontophobia, treatment, interventions, etc.) were combined in order to include possible relevant studies. The reference list of each identified paper was then inspected for relevant articles or book chapters. In addition, papers known by the authors but not identified earlier were included. In cases where the authors indicated that the published data were preliminary and the paper was not followed by a subsequent 'final' report, the authors were contacted. In some instances, authors were contacted in order to obtain additional statistical information. Cited, but unpublished theses, were located (41–43).

In order to be included in our analyses, the sample of the study had to be adult subjects with documented high dental fear or avoidance. Also, outcome measures had to include at least self-reported changes in dental fear and preferably include changes in dental behavior/attendance post-treatment. Single-subject designs or studies with insufficient statistical information to permit calculation of effect sizes (ESs) were excluded. Also, studies with group designs intended to explore a specific issue not related to general treatment outcome were excluded. Studies with pharmacological interventions only were excluded. In cases where different papers reported the outcomes on the same group(s) of patients, only one paper was included. In such cases, more than one paper was evaluated in order to yield sufficient statistical information to calculate ESs.

Thirty-eight studies that met the criteria for inclusion were selected from a pool of 80 reports (Table 1) (6, 8, 13, 14, 17, 18, 21, 24, 26–28, 30, 32, 34, 44–67). Appendix A lists studies that were excluded along with the reason for exclusion.

Classification and coding system

Interventions—The studies and their interventions are summarized in Tables 1 and 2. When more than one intervention method (with or without control/comparison group) was reported in the same paper, each was listed separately in the table. Thus, one study citation can include up to three behavioral interventions.

Consistent with earlier reviews (36–40) we have categorized the interventions as *behaviorally oriented approaches* (BM, including applied relaxation, biofeedback, behavior therapy, systematic desensitization, participant modeling, stress inoculation training and hypnosis) and *cognitively oriented approaches* (CT). In addition we have added *educational interventions* (EI). When a study design contained more than one control condition, we compared the behavioral intervention to *one* of the control conditions. We made the choice of which condition to treat as the comparison group from a descending list of priorities first choosing general anesthesia (GA) if present, then intravenous sedaztion (IV), and so on through waiting list (WL),

Table 1. Characteristics of the studies included in the meta-analysis of behavioral treatments of dental fear

	Inclusion						Institutional characteristics			Treatment				Dental avoidance	
Study	Diagnosis	Declines conventional dental care	Anxiety score	Randomized	*n* (male)	Age mean years (range)	Dental fear clinic	Dental clinic	Education/ research	Type	No. of sessions for dental fear treatment	Total *intervention* includes dental treatment	Explicitly aimed at normal dental care	Mean years (SD)	Range (years)
Shaw & Thoresen (64)	No	Yes	No	Yes	36 (9)	30.6			X	BM/AP	Max 10	No	Yes	3.7	Not given
Wroblewski et al. (21)	No	No?	No	Yes?	27 (8)	26 (18–48)			X	BM/WL	6–10	No	No	4	Not given
Corah et al. (22)	No	Yes	No	No	20 (5)	Not given			X	BM	6–10	?	?	Not given	
Gatchel (34)	No	No?	No	Yes	19 (4)	36 (25–56)			X	EI/BM/ WL	6–10	No	No	Not given	
Carlsson et al. (45)	No	Yes	No	No	10 (2)	29.3 (21–39)	X			BM	6–10	Yes	Yes	7.6	1–15
Bernstein & Kleinknecht (6)	No	Yes	No	No	27 (7)	28.2 (19–53)			X	BM[1] / AP	6–10	No	No	Not given	1–10
Berggren & Linde (46)	No	Yes	No	Yes	99 (39)	33 median	X			BM/GA[2]	Mean 5.8 Max 12	Yes	Yes	15 y[3]	Not given
Berggren & Carlsson (18, 29)	No	Yes	No	No	24 (5)	30 median (21–65)	X			BM	6–10	Yes	Yes	10[4]	1–51
Moses & Hollandsworth (35)	No	Yes	No	Yes	24 (4)	Not given			X	EI/BM/ WL	1	No	No	Not given	
Harrison et al. (47)	No	Yes	No	No	11 (1)	27.5 (21–37)	X			BM	6–10	Yes	Yes	8.0 (4.8)	1–17
Gautier et al. (48)	No	Yes	No	No[5]	15 (5)	31.8 (17–51)			X	BM	4	No	No	9.4	Not given
Gatchel (49)	No	Yes	Yes	Yes	20[6]	21+			X	EI/AP	one	No	No	Not given	Not given
Jerremalm et al. (50)	No	Yes	No	Yes	42 (?)[7]	31.6 (21–66)			X	CT/BM[8]	8 (9)[9]	No	Yes	5.8[10]	2–20
Blackwood (42)	No	Not reported	DAS ≥ 13	No	12 (1)	30.8 (21–43)			X	BM[11]	4[12]	No	Yes	1.96	0–7
Berggren (51)	No	Yes	No	Yes	99 (39)[13]	31 median	X			BM/GA	Not given	Yes	Yes	15	Not given
Smith et al. (13)	No	Yes?	No	No	56 (16)	36.6 (22–68)	X			BM	Not given	Yes	No	6.29	1–20
Friedman et al. (32)	No	No	DAS ≥ 16	No	39 (11)	39 (19–59)/? (20–60)		X		EI/WL	One	Yes	Yes[14]	4.2/4.5	Not given
Harrison et al. (52)	No	Yes	No	Yes	32[15] (?)	32.2 (21–50)	X			CT/BM	Mean 6, Max 12	Yes	Yes	12.6	1–35
Hakeberg et al. (53)	No	Yes	No	No	20 (8)	27 (19–37)	X			BM/PM	Not given	Yes	Yes	6	1–14
Ning & Liddell (54)	No	No	DAS ≥ 15	Yes	18 (?)	35.9 (20–56)			X	BM[16]	4	No	Yes	8.29 (9.08)	1–30

Moore et al. (65)	No	Yes	DAS ≥ 15	Yes	143 (56)[17]	37.4 (19–65)/ 36.3 (20–69)	X			BM/WL	6–10?	Yes	Yes	10.4 (7.4)/ 6.4 (6.4)	1–33/ 0–26
Getka & Glass (55)	No	No	DAS ≥ 13	Yes	41 (19)	33.1 (19–51)			X	EI/BM/ CT/WL	6?	No	No	2.5	Not given
Schuurs et al. (56)	No	Yes	DAS ≥ 15	No	55 (?)	Not given	X			BM[18]	6–10?	Yes	Yes	8	2–20
Hakeberg et al. (8)	No	Yes	No	No	21 (8)	27	X			BM/GA[19]	6–10	Yes	Yes	7.3	0–14
Moore & Brodsgaard (57)	No	Yes	DAS ≥ 15	Yes?	143	36.9[20] (19–65)/ 36.8 (23–60)	X			BM[21]/WL	6–10	Yes	Yes	10.5/ 6.6	0–33/ 0–28
Liddell et al. (58)	No	?	No	No?	23 (4)[22]	33.7 (20–56)			X	BM	4	No	Yes	3.43 (3.8)[23]	0–10
de Jongh et al. (27)	No	Yes	DAS ≥ 15	Yes	52 (25)	31.7 (5.4)/ 30.5 (7.6)/ 30.8 (7.7)	X			EI/CT/WL	one	Yes	Yes	6.0 (5.0)	1–27
Hammarstrand et al. (17)	No	Yes	No	Yes	22 (0)[24]	33.4 (22–52)	X			BM/BM2[25]	8	Yes	Yes	9.5	Not given
Moore et al. (26)	No	Yes	DAS ≥ 15	No	76 (31)	39.3 (24–58) / 35.9 (23–60)	X			BM[26]/WL[27]	6–10	Yes	Yes	8.9 (7.3)/ 6.8 (4.3)	1–26/ 1–20
Gitin (43)	Yes	Yes	DBS ≥ 15	No	79 (?)[28]	44.3 (24–62)			X	BM	1	No	Yes	Not given[29]	0–15
Hakeberg et al. (59)	No	Yes	DAS ≥ 13	No?	21 (5)	34.5 (24–53)	X			BM[30]	Max 8	No	Yes	8.6 (7.9)	2–34
Friedman & Wood (60)	No	No[31]	DAS ≥ 16	No	58[32] (13)	46 (19–76)		X		EI/WL	one	Yes	Yes	4.1 (7.0)	Not given
Willumsen (30)	No	Yes	DAS ≥ 15	Yes	41 (?)[33]	32.5/36.4	X		X	CT/BM[34]	10	Yes	Yes	11.7 (8.4)/ 12.7 (8.8)	Not given
Aartman et al. (61)	No	Yes	No	No	280 (113)[35]	33.8 (17–74)	X			BM[36]	6–10	Yes	Yes	6.8 (8.5)[37]	0–30
Berggren et al. (28)	No	Yes	DAS ≥ 13	Yes	112 (30)	31.5/34.1				CT/BM	Max 8	Yes	Yes	10.1 (8.2)	Not given
Thom et al. (62)	Yes	Yes	90 on VAS, Max 100	No	[38]30 (12)	30.4			X	BM/WL[39]	1	No	Yes	2.7 (3.2/ 1.7 (1.1)	Not given
Willumsen et al. (24)	No	Yes	DAS ≥ 15	Yes	41 (?)[40]	32.5/36.4		X	X	CT/BM	10	Yes	Yes	11.7 (8.4)/ 12.7 (8.8)	Not given
Kvale et al. (66)	No	Yes	No	No	70[41] (29)	19+	X			BM	4–15	Yes	Yes	8.2	0–35

[1]Graduated exposure ($n = 6$), symbolic modeling ($n = 7$), participant modeling ($n = 8$) are collapsed (no relevant significant differences given) and compared to attention placebo ($n = 6$). The control condition 'Unaided effort control' ($n = 6$), is not included in the current study.
[2]Patients treated in GA received two sessions of treatment in the specialized clinic before they were referred to community dental care.
[3]Median avoidance = 15 years.
[4]Median.
[5]Matched cross-over design.
[6]The study also included 20 moderately fearful subjects. They are excluded in the current analyses.
[7]Forty-two patients were suitable and included. 37 came for treatment. The initial drop-out is allocated equally to the groups.
[8]Originally four groups are collapsed to two, according to type of intervention.
[9]One session for summarizing.
[10]Seven of the patients attended dental treatment fairly regularly.
[11]Two modes of BM are reported. Due to no relevant significant group differences, groups are collapsed.
[12]Each session lasts 2 h.

[13]These are the same subjects as reported in Ref. (85). Data reported on follow-up are unique for the current paper.
[14]The treatment is delivered by the dentist that will provide the regular care.
[15]Of totally 42 potentially eligible patients, only 32 were included. Two dropped out before treatment was initiated. These two patients are treated as drop-outs.
[16]Eighteen were included. Twelve received two different modes of BM with no significant group outcome differences.
[17]143 patients were eligible, but eight dropped out before treatment started.
[18]The study is a follow-up of a selected group of successfully treated dental fear patients.
[19]The study includes a PM control group, $n = 8$.
[20]Calculated from information given.
[21]Includes both individually treated patients, and patients treated in groups.
[22]Twenty-six successfully treated patients were intended included in the follow-up, and 23 agreed. The number of patients originally included in the program is not given.
[23]Computed based on raw data given in the paper.
[24]The study includes a WL control group without sufficient presented data, and is thus treated as pre–post-treatment study.
[25]Hypnosis.
[26]Hypnosis.
[27]The paper also includes two additional treatment modes. These are, however, reported in Ref. (57).
[28]40 patients that agreed to come, but did not show up, are not included in the attrition.
[29]Seven patients report to have been to the dentist within the year before treatment.
[30]Self-reported anxiety scores pre–post-treatment is not given separately for the two modes of treatment (cognitive oriented and behavioral therapy) and the intervention is classified as BM.
[31]29 of the subjects could attend dental care prior to the treatment.
[32]Only 54 patients are actually included in the study.
[33]Sex is given in percentages. 43% vs. 30% were men.
[34]The study includes an additional condition with nitrous oxide.
[35]Total n is given as 280.
[36]The patients received a combination of BM alone or in combination with NO, or IVS. Some of the patients received GA, but were excluded from analyses. Unclear group assignments and no statistical differences between groups in outcome variables justify a collapse across groups.
[37]Dental avoidance was evaluated in $n = 82$.
[38]Among 91 eligible patients, 41 dropped out. The study also includes a pre-medication group $n = 20$.
[39]The study also includes a pre-medication group, $n = 20$.
[40]The study includes a condition with nitrous oxide.
[41]Potentially eligible patients were $n = 100$.

premedication (PM), nitrous oxide (NO), and attention placebo (AP) conditions. Some papers report multiple experiments within the same study: these comparisons of different interventions were analyzed separately. Multiple comparisons are indicated in Table 2.

We recorded whether dental treatment was an integral part of the intervention, and whether general dentistry outside a specialized university or fear clinic was an explicit end-point. Also, we classified each study as conducted within a specialized fear clinic, in a general dental setting, or within a primarily educational or research setting.

Outcome variables—The studies were coded for two independent outcome measures: changes in self-reported dental anxiety, and dental attendance in a private practice or community clinic outside of the dental anxiety treatment setting. Attendance measures were grouped into less than 6 months, 6 months to 4 years after the intervention, and longer-term. The definition of dental attendance varies between studies. Not all studies included sufficient information on all outcomes.

Drop-out, attrition—Not all studies reported drop-outs from treatment. This represents a substantial challenge to assessing the effectiveness of treatment as ESs are strongly impacted by sample size. Also, the definition of a drop-out varies between studies. In order to address this dilemma of unaccountable discrepancies between the number of eligible patients and the number who completed treatment, we have reported the post-treatment attendance ESs both with and without attrition.

Statistical procedures

Estimation of effect size—ES for self-reported dental fear was calculated by subtracting the mean of the control group from the mean of the treated group at post-treatment and dividing by the pooled standard deviation of the two groups. The pooled standard deviations were used because they provide a more precise estimate of population variance than the standard deviation of either the experimental or control conditions (67). For single-group pre–post-studies, ES was calculated based on the subtracted mean pre–post-treatment divided by the pooled standard deviations. When means and standard deviations were not provided ES was estimated from appropriate F, t, or P-values. When relevant outcome measures were reported as *non-significant*, the ES was considered to be 0. The DSTAT program was used to calculate the ESs (68).

A positive ES indicates a reduction in self-reported dental fear from pre- to post-intervention or a difference in the proportion of subjects who had a dental visit after behavioral treatment. ESs represent standardized z scores that can be interpreted as the distance, in standard deviation units, between the mean value in the intervention group and a similar value in the control group. An ES of zero indicates the same average level of a given outcome in both groups. An ES of 1 implies that the average level of outcome (e.g. dental fear) in the control group was one standard deviation greater than the average level on the same measure in the treatment group.

Dental attendance was treated as a dichotomous outcome at each period. ES was calculated based on the proportions of subjects in each group with a dental visit after treatment. Studies with single-group pre–post-designs were treated analogous to two-way chi-square tests. An ES of zero indicates that 50% of the group went to the dentist after treatment and a negative ES indicates that less than 50% went to the dentist. The proportion of subjects with dental visits in the intervention group is reported together with the ES. To prevent the calculated ESs from being distorted by the results from small-sample treatment groups, each was weighted by sample size.

Homogeneity analysis—Homogeneity tests (69, 70) were conducted to check whether observed ES estimated a single population value differing only by sampling error or represented a real difference among studies along with sampling error. If the distribution of ESs is homogenous the weighted mean and confidence interval can be interpreted as estimating a single-population ES. If the distribution of the observed ESs is heterogeneous, there are real differences among the ESs. In the latter case, a breakdown of the ESs is warranted in order to identify meaningful factors behind these differences.

Results

Study characteristics

The most common inclusion criterion is refusing conventional dental care (28/38 studies). Mean dental avoidance varies from less than 2 to nearly 13 years. Only three of the studies included a formal diagnosis of dental phobia at entry (30, 42, 61). The majority of the patients are women. Mean age is typically between mid-twenties to mid-thirties.

Table 2. Changes in self-reported dental anxiety and dental attendance post-treatment in the studies included in the meta-analysis (BM = behavior modification; CT = cognitive interventions; EI = educational interventions; AP = attention placebo; GA = general anesthesia; WL = waiting list; PM = premedication, NO = nitrous oxide) When more than one intervention method (with or without control/comparison group) was reported in the same paper, each was listed separately in the table. Thus, one study citation can include up to three behavioral interventions

		Self-reported dental anxiety						Dental attendance						
			Completion/drop out						Post-treatment		Follow-up from approx. 6 months to 4 years		Long-term follow-up	
	Inter-vention	Design[1] (control)	*n*	% drop-out	Post treat-ment (ES)	Follow up from approx. 6 months to 4 years (ES)	Long term follow-up (ES)	Design (control)	ES/(%) based on reported sample	ES/(%) included drop-out	ES (%) based on reported sample	ES (%) included drop-out	ES (%) based on reported sample	ES (%) included drop-out
Shaw & Thoresen (64)	BM/AP	Yes	27/9[2]	0.0	0.92*			Yes	1.08* (61)	1.08* (61)				
Wroblewski et al. (21)	BM/WL	Yes	18/9[3]	12.9	0.0[4]			Yes	0.84 ns (50)	0.83 ns (33)				
Corah et al. (44)	BM	No	20	Not given	3.06*				Not given					
Gatchel (34)	BM/WL	Yes	8/6	0.0	0.79 ns[5]			Yes	1.31* (88)	1.31* (88)				
	EI/WL	Yes	5/6	0.0	0.79 ns			Yes	1.69* (100)	1.69* (100)				
Carlsson et al. (45)	BM	No	10	0.0	3.21*			No	13.47* (100)	13.47* (100)				
Bernstein & Kleinknecht (6)	BM/AP[6]		21/6	Not given	No data			Yes			0.25 ns (76)	Not given		
Berggren & Linde (46)	BM/GA[7]	Yes	50/49	8.3/ 27.2	0.86*			Yes	0.40* (92)	0.40* (92)	0.33 n.s (69)	0.33 ns (69)		
Berggren (51)	BM/GA	Yes	50/49[8]	12.1/ 18.4		0.70*		Yes			0.62* (93)	0.56* (82)		
Berggren & Carlsson (18, 29)	BM	No	24	12.5	2.48*			No	3.70* (88)	3.70* (88)				
Moses & Hollandsworth (35)	BM/WL	Yes	12/6	0.0	0.97 ns			Yes	2.54* (83)	2.54* (83)				
	EI/WL	Yes	6/6	0.0	1.0 ns			Yes	0.91 ns (33)	0.91 ns (33)				
Harrison et al. (47)	BM	No	11	0.0	3.08*			No	2.64* (91)	2.64* (91)				
Gautier et al. (48)	BM	No	14	7.1	1.87*			No			0.46 ns (62)	0.34 ns (59)		
Gatchel (49)	EI/AP	Not possible to calculate	10/10	0.0				Yes	0.00 (50%)	0.00 (50%)				

Jerremalm et al. (50)	BM	No	18	29.2[9]	0.97*			No[10]			4.59* (96)	0.48[11] ns (62)		
	CT		19	19.1	1.48*						4.59* (96)	0.48 ns (62)		
Blackwood (42)	BM	No	12	0.0	2.97*			No	2.66* (91)	2.66* (91)				
Smith et al. (13)	BM	No	56	18.4	1.60*			No	1.64* (82)	0.44 ns (61)[12]				
Friedman et al. (32)	EI/WL	Yes	23/16	Not given	1.27*				Not given					
Harrison et al. (52)	BM[13]	No	16	11.7	1.42*			No	3.51* (93)	1.66* (82)				
	CT	No	16	17.6	1.49*			No	0.23 ns (56)	0.12 ns (53)				
Hakeberg et al. (53)	BM/PM	Yes	10/10	40.1/20.2	1.27*		0.00[14]	Yes					0.98* (100)	0.19 ns (69)
Ning & Liddell (54)	BM	No	12[15]	33.3	1.69*	1.69*		No	13.09* (100)	0.69 ns (67)				
Moore et al. (65)	BM/WL	Yes	68/75	12.1/0.0	2.62*	3.23*		No	1.93* (85)	1.14* (75)[16]	3.33* (93)	0.67* (66)[17]		
Getka & Glass (55)	CT/WL	Yes	11/10	18.2/10.1	1.78*	0.99			Not given					
	BM/WL	Yes	10/10	10.2/10.2	1.80*	0.99			Not given					
	EI/WL	Yes	10/10	20.1/10.3	0.00	0.00			Not given					
Schuurs et al. (56)	BM	No	55[18]	38.2		1.34*		No			1.13* (75)	−0.62*[19] (35)		
Hakeberg et al. (8)	BM/GA[20]	No	12/9	10.0[21]			1.15*[22]	Yes					1.5* (91)	1.08* (81)
Moore & Brodsgaard (57)	Individual	Yes	68/45	12.2/0.0[23]	3.74*[24]	2.75*		No	2.31* (88)	Not given	2.31* (88)	1.33* (78)		
	Group	Yes	30/45	20.2/0.0	3.58*	3.24*		No	1.45* (80)	Not given	0.48 ns (62)	0.00 (50)		
Liddell et al. (58)	BM	No	23[25]	11.5			1.04*	No					0.79 ns (69)[26]	0.47 ns (62)
de Jongh et al. (27)	CT[27]	No	15	Not given	1.18*	2.27*[28]		No			0.97 ns[29] (73)			
	EI	No	14	Not given	0.05 ns	2.21*		No			0.55 ns (64)			
Hammarstrand et al. (17)	BM[30]	No	11	27.1	1.50*			No	2.03* (88)	0.55 ns (64)				
	BM2[31]	No	11	54.2	1.18 ns			No	0.49 ns (80)	−0.51 ns (36)				
Moore et al. (26)	BM[32]	Yes	25/51	12[33]/0.0	3.14*[34]	2.04*		No	2.26* (88)	2.26* (88)	−0.07 ns (48)[35]	−0.07 ns (48)		
Gitin (43)	BM	No	22[36]	43.5[37]	1.08*			No	0.001 ns (69)	−0.58* (54)[38]				
Hakeberg et al. (59)	BM[39]	No	21	0.0	1.08				Not given					
Friedman & Wood (60)	EI/WL	Yes	38/20	Not given	0.21 ns				Not given					
Willumsen et al. (24)	BM	No	21[40]	4.6	4.62*			No	18.9* (100)	3.97* (95)				
	CT	No	21	4.6	2.64*			No	18.6* (100)	3.98* (95)				
Willumsen (30)	BM[41]	No	20	4.6		3.40*		No			13.50* (100)	3.97* (95)		
	CT	No	21	4.6		2.14*		No			3.96* (95)	2.76* (91)		
Aartman et al. (61)	BM[42,43]	Insufficient data	280[44]	19.1				No			0.49* (62)[45]	−0.19 ns (45)		
Berggren et al. (28)	BM	No	54	33.3	3.08 *			No	2.46* (89)	0.36 ns (59)				
	CT	No	58	17.2	2.57*			No	2.63* (90)	1.08* (74)				
Thom et al. (62)	BM/PM	No	30[46]	20.1	2.71*[47]			Yes			1.40* (70)	1.40* (70)		
Kvale (66)	BM	No	100	30.2[48]	2.82*	1.60*		No	13.91* (100)	0.86* (70)	0.53* (63)	−0.55* (36)		

[1]If the study is not listed as 'controlled', a one-group pre–post-design applies.
[2]Two kinds of behavioral interventions are collapsed due to no significant differences.
[3]Eighteen persons were randomized to one of two BM interventions. No significant groups differences related to treatment mode allows for collapsing of groups.
[4]There were no significant group differences in pre-post dental anxiety.
[5]Effect sizes are based on *F*-values. Since no significant effects of treatment mode were presented, the same effect size is given for both interventions.
[6]Graduated exposure ($n = 6$), symbolic modeling ($n = 7$). Participant modeling ($n = 8$) are collapsed (no relevant significant differences given) and compared to attention placebo, $n = 6$. The control condition 'unaided effort control, $n = 6$ is not included.

[7]The patients in the GA group received adjusted conventional dental treatment after being treated in full narcosis.
[8]These are the same subjects as reported in Ref. (85). Data reported from follow-up are unique for the current paper.
[9]Forty-two patients were suitable and included. 37 came for treatment. The initial drop-out is allocated evenly to each group.
[10]Since the study only includes two modes of behavior intervention, the groups are treated as single-group pre–post-design.
[11]Forty-two patients were included. 26 had been to the dentist at follow-up. No differences related to mode of intervention are reported.
[12]Thirty-four of 56 patients returned, and were able to be treated within the specialized clinic.
[13]Two patients were drop-out before allocation to treatment. They are treated as one drop-out from each group.
[14]Reported as ns difference between groups.
[15]Eighteen patients were included.
[16]The figure is based on the original 68 patients included in treatment, and nine reported failures.
[17]Forty-five of the originally 68 included patients received dental treatment at follow-up.
[18]The study is a follow-up of a selected group of successfully treated dental fear patients.
[19]Nineteen of fifty-five patients received dental care at FU.
[20]The study also includes a group that receives pre-medication ($n = 8$) This group is not included in the current study.
[21]37 patients were originally allocated to the study. 29 completed treatment. Three could not be reached at FU. These are included in the attrition, and allocated equally to the groups.
[22]Ten years follow-up.
[23]Attrition given here is pre–post-treatment. Attrition from post- to follow up is not included in this figure.
[24]Effect sizes are based on post-dental treatment scores.
[25]Twenty six successfully treated patients were included in the follow-up (but only 23 reported on). The number of patients originally included in the program is not given.
[26]No data given regarding attrition from pre- to post treatment.
[27]Self-reported dental anxiety is not reported for the WL ($n = 23$).
[28]Between intervention and FU patients were receiving dental care in a clinic specialized on dental fear.
[29]Between the intervention and follow-up the patients were treated in a specialized clinic for dental fear.
[30]The study includes a WL control group without sufficient presented data, and is thus treated as pre–post-treatment study.
[31]The intervention is hypnosis.
[32]The behavioral intervention is hypnosis. The paper also included two additional treatment modes. These are, however, reported in Ref. (57).
[33]The drop-out between post-treatment and follow-up is an additional 10 patients. total drop-out is thus 52%.
[34]The effect size is based on DAS scores post the dental treatment.
[35]Among the 12 patients with dental attendance at follow-up, four sees dentists that specialize in hypnotic treatment.
[36]The figure refers to the number of patients with data.
[37]40 patients that agreed to come, but that did not show up, is not included in the attrition.
[38]If patients that show up for interview (and were included) but did not receive treatment are included in the attrition, the dental attendance post-treatment is 39%. Among these, seven has also been to the dentist within a year before treatment.
[39]Two slightly different behavioral interventions were employed. Data relevant for the current study are not reported separately for the two interventions.
[40]A total of three patients are drop-outs from a sample of 64. The drop-out are allocated to each group.
[41]Only data from 1 year follow-up are presented from the thesis.
[42]Parts of the current sample is reported in Artman (109).
[43]The patients received a combination of BM alone or in combination with NO or IVS. Patients that received GA are excluded from the analyses. Unclear group assignments and no statistical significant differences between groups in outcome variables justify a collapse across groups.
[44]Total n given is 280. Patients with IV sedation are not included in analyses.
[45]Dental attendance was evaluated in $n = 131$.
[46]91 patients were eligible for inclusion. 41 did not complete. Only five of these were included in the BM and these are included in the drop-out calculations. The study includes 'no treatment control group' ($n = 10$) and pre-medication group ($n = 20$). Statistics presented does not allow for pre–post-comparisons within groups on this measure.
[47]FU 2 months after completed treatment.
[48]70 patients completed treatment. The attrition between post-treatment and follow-up was an additional 18.6%.

Seventeen of the 38 studies were performed within four specialized clinics for treating dental fear and include self-referred or health-professional referred subjects for dental anxiety treatment. Eleven studies originated from one specialized clinic (Göteborg). Among the remaining 21 studies, 17 are primarily based on a Ph.D. thesis, which implies that patients were specifically recruited for that purpose. Two studies, both by the same author, were conducted within a setting of ordinary dental care.

Characteristics of the interventions

In 16 of the 38 studies, patients were randomly assigned to a treatment condition. In four cases the assignment procedure was not specified (see Table 1). In nine cases, the randomization includes a true control group. When this is the case the non-behavioral intervention serves as a long-term control in only four studies. These four represent two different samples and are from a single institution.

Thirty-four of 38 studies include behavior modification (Table 2). Most studies use a mixed intervention package. Fourteen of the 34 studies that include behavior modification, use BM as part of a package. Seven of the packages include an educational intervention (EI) and seven of the packages include cognitive restructuring (CT). Twenty-two of the 38 studies include dental treatment as part of an intervention. Twenty-nine of the 38 studies use receiving conventional dental care as the primary end-point of treatment.

Outcomes

Self-reported dental anxiety—The overall ES for the self-reported dental anxiety interventions was 1.78 (95%CI: 1.67, 1.89) in the 35 separate interventions where the data allowed an estimate. The ESs for self-reported anxiety indicate positive outcomes in 33 and no change in two (Table 2). In eight cases, the confidence intervals (CI) indicate a slight negative change that cannot be ruled out. The ESs vary substantially (Table 2).

Significant heterogeneity among the studies was seen ($Q = 333.812$, d.f. $= 40$; $P < 0.0000$). This suggests that the sample cannot adequately be within a single effect size. Even when the largest outlier was removed, the heterogeneity persisted. In order to investigate whether ESs derived from controlled studies differed from single-group pre–post-designs, a homogeneity analysis was performed on the controlled studies alone (ES = 1.59, 95%CI: 1.42,1.77; $Q = 186.97$, d.f. $= 16$, $P = 0.000$). This analysis still indicated that the sample is not adequately described with a single ES.

Dental attendance post-treatment—ESs and percentages of subjects with dental visits post-treatment are given in Table 2. Thirteen of the studies could be classified as controlled when this outcome measure was assessed. Five of the 13 were conducted in a specialized dental fear clinic (Göteborg), partially on the same sample of patients, but with different periods of follow-up.

The overall ES, weighted by sample size, is 1.4 (95% CI: 1.27, 1.58). Reported percentages of post-treatment attendance within 6 months varied between 33% and 100%, with a mean attendance of 79.5%. In eight of 30 cases where visits were measured, the CI implies the possibility of negative ESs, indicating no treatment effect. The analysis indicates that the studies cannot be adequately described in a single ES as a result of heterogeneity ($Q = 585$, d.f. $= 29$, $P < 0.00$). When attrition is considered, the overall ES is reduced to 0.76 (95% CI: 0.61, 0.92). In 12 of 27 cases where attrition (number of subjects enrolled did not match the number on whom the investigators reported results) is provided, the CI indicates a possibility for negative ESs, again indicating no documented treatment effect. Since the number of controlled studies is so limited, contrast analyses between controlled and single-group outcome studies were not conducted. Note, however, that in the two controlled studies within a specialized dental fear clinic, one ES was 0.62 while the other was essentially zero (47, 52).

The overall ES was 1.17 (95%CI: 0.99, 1.35) for dental visits between 6 months and 4 years. The proportion of subjects with visits varied from 48 to 100% post-intervention. The criteria for regular dental attendance varied across studies. When attrition was considered it varied from 36 to 93%, with a mean proportion of subjects with at least one dental visit of 76.9% in this interval. In six of 14 cases where this outcome could be studied, the individual CI indicates the possibility of a negative ES. There is considerable heterogeneity within the sample ($Q = 295.98$, d.f. $= 13$, $P < 0.00$). The overall ES when attrition is taken into consideration is 0.46 (95% CI: 0.31, 0.62). In eight of the 14 cases the CI indicates the possibility of a negative ES. As most were single-sample post-intervention studies, contrast analyses were not warranted.

Because few studies addressed longer-term attendance it was not possible to calculate an ES. The percentage of subjects with dental attendance

after 4 years varies from 69 to 100% when attrition is not included. It is reduced to 62–81% when attrition is considered.

Discussion

Previously published reviews on the effect of behavioral interventions for dental fear and dental phobia have concluded that approximately 80% of the patients will seek conventional dental care after treatment, and that there is evidence that this effect is lasting (38, 40). The current meta-analysis, including 38 studies from a potential pool of 80 papers, clearly challenges this estimate. The most obvious feature of the studies included in the current analysis is the heterogeneity despite the use of reasonably strict inclusion criteria (71, 72). This heterogenity is reflected in sampling procedures, population characteristics, design, reported attrition, outcome measures, and effect sizes.

It is a common finding in meta-analyses that studies with pretest–post-test designs yield substantially larger ESs, especially on self-report measures, than comparison-control group designs (71). Despite this, studies that could not be classified as having a comparison control group were included in this analysis. The main reason for this is that inclusion of studies based on within-subject designs allowed for a much broader, and thus more representative, review of the research literature. Also, potential bias in favor of studies based on within-subject designs would be detected by homogeneity analyses. Despite significant heterogeneity, all studies reported reductions in self-reported anxiety, and all calculated ESs indicated positive clinical changes. Thus, it seems reasonable to infer that the heterogeneity primarily refers to some underlying differences in sampling that do not seriously reduce the validity of the reported changes.

It is striking that few of the 80 studies on psychological interventions for dental fear fulfill the basic criteria for randomized controlled trials. Even in many of the 38 studies included in the current meta-analysis, subjects were entered without a formal diagnosis or the investigators failed to use a commonly accepted end-point. This means that there was neither a common standard across the studies for estimating the magnitude of the dental fear nor a standard end-point. It is well known that patients suffering from dental fear actually may endure dental treatment intermittently, most often in acute pain, and also that some patients may suffer from severe dental fear without being phobic. Most studies included patients that have not avoided dental care. Thus, the lack of detailed behavioral data for estimating anxiety pre-intervention seriously confounds outcome estimates. Some studies include a behavioral test for evaluating anxiety in the dental situation before and after treatment (43).

A less distinct picture emerges regarding dental attendance post-treatment. Several of the controlled studies performed on patients with severe dental anxiety seeking care at a specialized clinic found the condition treatable and the change lasting (51, 53). These studies were performed by a single group of researchers. The majority of the comparable studies, although with weaker designs, report higher drop-out rates as well as lower proportions of subjects with dental visits post-treatment. Also, a general concern in meta-analyses is publication bias where negative studies may not have been reported thus inflating both anxiety and post-treatment attendance effects (73).

Thus, most of the studies evaluated demonstrated anxiety reduction with *behavioral* treatments, and none reported a worsening of the condition. However, the heterogeneity of the intervention packages did not allow for quantitative comparisons between modes of behavioral treatment. This meta-analysis demonstrates that well-designed randomized clinical trials of behavioral interventions for dental fear are warranted.

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Appendix

Studies of behavioral interventions for dental fear that were evaluated but excluded from the meta-analysis

Study	Insufficient statistical data	Not severe enough dental anxiety	Too few subjects/ preliminary	Reported elsewhere
Gale & Ayer (6)	X			
Molin & Seeman (74)	X			X
McAmmond et al. (20)		X		
Klepac (75)		X		
Horan et al. (76)		X		
Mathews & Rezin (77)		X		
Beck et al. (78)		X		
Miller et al. (79)		X		
Corah et al. (80)		X		
Bernstein (81)				X
Kleinknecht & Bernstein (82)	X		X	
Lamb & Strand (83)		X		
Bosmajian (41)		X		
Bar-Gil et al. (84)	X		X	
Wardle (33)		X		
Berggren (85)				X
Kleinhauz et al. (86)	X		X	
Kroeger (87)	X		X	
Berggren & Carlsson (7)				X
Makkes et al. (88)	X			
Weinstein et al. (89)	X		X	
Kroeger & Smith (90)	X			
Moore (91)	X		X	
Friedman & Wexler (92)	X		X	
Smith et al. (93)	X	X		
Moore et al. (14)				X
Robertson et al. (94)		X		
Hakeberg (95)				X
Soh (96)		X		
Kleinhauz et al. (97)	X			
Hakeberg & Berggren (98)				X
Carpenter et al. (99)		X		
Coldwell et al. (19)			X	
Smyth (100)	X		X	
Winick (101)		X		
Johren et al. (102)				X
Kulich et al. (103)	X			
Vassend et al. (104)				X
Hoffman et al. (105)			X	
Garcia-Palacios et al. (106)			X	
Hoffman et al. (107)			X	
Wilson & Davies (108)		X	X	