Article

Effects of Cognitive Behavioural Therapy and Mindfulness-Based Interventions Combined With Structured Care on Executive Function, Emotion Regulation, and Impulsive Behaviour During Dental Treatment in Children With Attention-Deficit/Hyperactivity Disorder

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Abstract

Background: Children with attention-deficit/hyperactivity disorder (ADHD) experience difficulties with executive functions, emotional regulation and impulse control in medical institutions, and dental clinics can be particularly challenging environments. This study aimed to systematically evaluate the effects of cognitive behavioural therapy (CBT) combined with mindfulness-based interventions (MBIs) under structured care in children with ADHD on the following outcomes: executive function (Behavior Rating Inventory of Executive Function, Second Edition [BRIEF-2] and Conners Comprehensive Behavior Rating Scales, Third Edition [Conners-3]), emotion regulation (parent-reported Emotion Regulation Checklist [ERC]), impulsive behaviour during dental treatment (Frankl Behavior Rating Scale [FBRS] and Children's Fear Survey Schedule-Dental Subscale [CFSS-DS]), core ADHD symptoms (Swanson, Nolan, and Pelham Rating Scale, Fourth Edition [SNAP-IV]), and parental stress (Parenting Stress Index, Fourth Edition [PSI-4]).

Methods: This single-centre retrospective cohort study included 115 children with ADHD who received dental treatment between March 2021 and June 2025. Patients were divided into a combined therapy group (CBT + MBI + structured care, n = 58) and a control group (routine dental behavioural guidance, n = 57) according to the treatment plan documented in routine clinical records. Outcomes were assessed at baseline and at 4, 8, and 12 weeks after treatment. The co-primary outcomes were the BRIEF-2 and Conners-3 scores. A Bonferroni-adjusted two-sided α level of 0.025 was used for these outcomes. Secondary outcomes included ERC, FBRS, CFSS-DS, SNAP-IV, and PSI-4 scores.

Results: Both co-primary outcomes met the multiplicity-adjusted significance threshold at week 12. Compared with the control group, the combined therapy group had lower BRIEF-2 scores (61.1 $\pm$ 4.8 vs. 70.5 $\pm$ 5.2; mean difference (MD) = −9.4, 95% confidence interval (CI): −11.3 to −7.6) and lower Conners-3 scores (57.8 $\pm$ 4.1 vs. 69.0 $\pm$ 4.4; MD = −11.2, 95% CI: −12.8 to −9.6; both $p < 0.001$), with lower scores indicating fewer executive-function and attention difficulties. Secondary outcomes showed higher ERC emotion-regulation and FBRS cooperation scores and lower ERC lability/negativity, CFSS-DS dental-fear, SNAP-IV symptom, and PSI-4 parenting-stress scores (all $p \leq 0.002$), except for the prevalence of dental fear ($p = 0.053$). Covariate-adjusted and sensitivity analyses were consistent with the primary findings.

Conclusions: In this single-centre retrospective co-

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hort study, CBT combined with MBI under structured care was associated with better 12-week executive-function/attention, symptom, emotion-regulation, dental-cooperation, and parental-stress outcomes than routine guidance. The protocol may provide a structured management option for children with ADHD who have difficulty cooperating with dental care; however, causal effects and the contribution of each component cannot be established and require confirmation in prospective studies.

Keywords

attention deficit disorder with hyperactivity; cognitive behavioral therapy; mindfulness; executive function; anxiety

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder in children. A 2023 global meta-analysis of 61 cross-sectional studies reported that the global ADHD prevalence among children and adolescents was about 8.0% (95% confidence interval [CI]: 6.0%–10.0%), with a male-to-female ratio of approximately 3:1 [1]. The disorder has the following typical features: persistent inattention, hyperactivity and impulsivity; as well as all kinds of impairments in executive functions, such as reduced inhibitory control, diminished working memory, reduced cognitive flexibility, and deficiencies in planning and organisation [2]. Executive function deficits are likely to affect children's learning and social ability and lead to various coping difficulties in other parts of life; given that dental treatment settings have multiple sensory stimuli, these problems are probably more severe [3,4].

During dental treatment, children with ADHD may exhibit impulsivity, distractibility, difficulty following instructions, and reduced cooperative behaviours, which can interrupt dental procedures [5]. These behaviours may reflect three interconnected dimensions: executive dysfunction, emotional dysregulation, and heightened physiological stress responses (e.g., increased salivary cortisol) [6]. Therefore, effective strategies need to be developed for the management of impulsive behaviours in children with ADHD during dental treatment.

Cognitive behavioural therapy (CBT) is a non-pharmacological treatment for children with ADHD that has received strong research support. It aims to address deficits in executive functions through approaches such as cognitive restructuring, self-monitoring and behaviour modification reinforcement [7,8]. Mindfulness-based interventions (MBIs) reduce both emotional reactivity and physiological stress by cultivating emotional awareness and reducing automatic emotional responses [9,10]. At the level of mechanism, the two treatments work together to offer specific cognitive-regulation strategies in CBT and establish an awareness system for the application of these strategies in MBI [11].

Based on the above rationale, the present study used a retrospective cohort design and multiple outcome measures. Using the electronic medical record system and nursing records of Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, data were retrospectively collected from 115 children with ADHD who received dental treatment between 2021 and 2025. Based on the treatment regimens documented in contemporaneous records, patients were divided into a combined therapy group (CBT + MBI + structured care) and a control group (routine dental behavioural guidance). Seven standardised instruments were used to compare outcomes related to executive function/attention, ADHD symptoms, emotion regulation, dental behaviour and fear, and parental stress. The study was designed to compare outcomes between the two treatment pathways and did not undertake exploratory correlation or mediation analyses.

Materials and Methods

Study Design and Ethics

This single-centre retrospective cohort study was conducted between March 2021 and June 2025 in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement. The research institution is Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, and the Department of Paediatric Dentistry serves as the project-initiating department. All data were retrieved retrospectively from the hospital's electronic medical record system and nursing records; the researchers did not participate in the implementation of the original treatment plans but performed a retrospective analysis of previously collected clinical data. This study has been approved by the Medical Ethics Committee of Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine with an Approval No. of SH9H-2026-T288-2; the review method was expedited review. As this study is a retrospective analysis of medical records based on the available clinical data, and all patient information has been anonymised and de-identified, the Ethics Committee has granted an exemption from the requirement for informed consent. All the above

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procedures have been carried out in accordance with the relevant provisions of the Declaration of Helsinki (2013 Revision) and the Measures for Ethical Review of Biomedical Research Involving Humans.

Study Subjects

Inclusion criteria: (1) Diagnosed with ADHD according to Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)/Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR) criteria and classified as combined, predominantly inattentive, or predominantly hyperactive-impulsive presentation by a qualified clinician [12]; (2) Aged 5–16 years, consistent with ADHD diagnostic guidelines for children and adolescents [12]; (3) Received dental treatment at this institution and completed a full 12-week treatment/follow-up period; (4) Baseline data were available for all seven assessment scales, and at least one follow-up assessment was available; remaining missing follow-up values were handled by multiple imputation; (5) Medical records are fully traceable, and research data have been anonymised and de-identified.

Exclusion Criteria: (1) Severe organic neurological disorders (e.g., epilepsy or cerebral palsy); (2) Comorbid autism spectrum disorder or intellectual disability, defined by documented clinical diagnosis and/or standardised intelligence quotient (IQ) <70 with impaired adaptive functioning [13]; (3) Receiving other systemic psychological or behavioural therapies concurrently; (4) Use of systemic glucocorticoids or other medications that could substantially affect behavioural or emotional assessment during the observation period; (5) Insufficient information to determine treatment exposure or the primary outcomes.

Group allocation was based on the treatment pathway documented in contemporaneous electronic medical and nursing records and was not determined by the investigators or by a fixed calendar sequence. In routine practice, the treating dentist assessed ADHD-related symptoms, previous dental cooperation, anticipated treatment needs, and the family's ability to attend a 12-week programme, and then discussed the available options with the parents. Children received CBT + MBI + structured care when this protocol was clinically recommended, accepted by the family, and feasible in terms of trained staff and appointment availability; otherwise, routine dental behavioural guidance was provided. Therefore, clinical judgement, parental preference, expected adherence, and resource availability may have influenced exposure assignment and introduced selection bias or confounding by indication. All consecutive eligible children treated between March 2021 and June 2025 were screened, and 115 children were included (58 in the combined therapy group and 57 in the control group).

Family socioeconomic status was classified from documented annual household income using prespecified institutional cut-offs: low, <RMB 100,000; middle, RMB 100,000–299,999; and high, ≥RMB 300,000 (1 CNY = 0.14 USD).

Because major clinical guidelines primarily address children aged ≥4 years and diagnostic differentiation is more challenging in very young preschool-aged children, this study set the lower age limit at 5 years [12,14]. This criterion was intended to improve diagnostic reliability and reduce misclassification with developmental delay, separation anxiety, autism spectrum disorder, and other neurodevelopmental conditions.

Treatment Protocols

Combined Therapy Group (CBT + MBI + Structured Care)

During the study period, CBT, MBI, and structured care had been routinely implemented in clinical practice for children with ADHD undergoing dental treatment, based on previous evidence [8–11,15]. The documented clinical protocol was as follows:

(1) CBT: All patients received the same manualised protocol, with treatment delivered once a week for 12 weeks, each session lasting 50 minutes. The protocol consisted of three periods: (a) Foundation period (Weeks 1–4): ADHD psychoeducation, the "Red−Yellow−Green" emotional traffic light recognition system, and individualised emotion–behaviour chain journaling; (b) Skill-building period (Weeks 5–9): A "stop–think–act" three-step cognitive coping framework, Socratic questioning to challenge automatic thoughts, role-playing of dental visit scenarios (≥3 sessions), and a token economy system for immediate reinforcement; and (c) Generalisation period (Weeks 10–12): Transferring skills to real dental situations, creating "challenge situation coping cards", and concurrent parent training. The protocol was locally manualised and informed by established CBT and behavioural-management principles [8,16]; the sequence and materials were institution-specific.

(2) MBI: All patients participated in MBI training sessions for 30 minutes twice a week over 12 weeks. The protocol consisted of four modules: (a) Respiratory anchoring (Weeks 1–3): A 4−4−4 diaphragmatic breathing technique combined with visual biofeedback guidance; (b) Body awareness (Weeks 4−6): A modified body scan (8−10

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minutes) plus a "sensation detective game"; (c) Emotional awareness (Weeks 7−9): "Weather Bottle" emotion visualisation, imagery-based desensitisation in a dental setting, and loving-kindness meditation; and (d) Daily integration (Weeks 10−12): Standardised pre-consultation mindfulness preparation (5−8 minutes of diaphragmatic breathing and body scanning before entering the consultation room) and a daily 3-minute morning homework assignment. The locally adapted modules were informed by child-focused mindfulness programmes and reviews [9–11]; the sequence and materials were institution-specific.

(3) Structured care: The structured care components were supported by literature emphasising the role of nurses in ADHD assessment, psychoeducation, behavioural monitoring, and follow-up management [15]. It was delivered by paediatric primary nurses who had received special training ($\geq$16 hours), with a nurse-to-patient ratio of 1:5. The specific components were as follows: (a) Environmental optimisation: waiting area light $\leq$300 lux, background noise $<$50 dB, provision of sensory integration toys, and vibration-assisted chair backs; (b) Parental psychoeducation: the parental psychoeducation program (60 minutes once every two weeks for a total of six sessions) to educate parents about ADHD, behavioural management techniques, and home-based supervision of MBI; (c) Closed-loop behavioural observation: standardised behavioural observation checklists were used, and electronic notifications were sent to the attending physician within 24 hours; and (d) Extended follow-up: monthly telephone follow-ups for three months after discharge, with proactive follow-up triggered if the adherence rate fell below 50%.

Control Group

The control group received routine dental behavioural guidance, including regular outpatient follow-up every 4 weeks, Tell-Show-Do guidance during dental examination or treatment, verbal reassurance, positive reinforcement, and general oral-health education for parents. No manualised CBT, MBI, structured nursing protocol, closed-loop behavioural monitoring, extended telephone follow-up, or standardised home-based training materials were provided.

Outcomes and Assessment Tools

The outcomes covered executive function/attention, core ADHD symptoms, emotion regulation, dental behaviour/fear, and parental stress. Assessments were completed at baseline and at 4, 8, and 12 weeks after treatment. The co-primary outcomes were executive function and attention-related difficulties, assessed using the Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2) and the Conners Comprehensive Behavior Rating Scales, Third Edition (Conners-3), respectively. Secondary outcomes included core ADHD symptoms, emotion regulation, dental behaviour and fear, and parental stress. The assessment tools were as follows:

(1) BRIEF-2: The BRIEF-2, developed by Gioia *et al*. [17], was used to assess everyday executive function in young children and adolescents [18]. The BRIEF-2 parent version contains 63 items and nine clinical scales: Inhibit, Self-Monitor, Shift, Emotional Control, Initiate, Working Memory, Plan/Organise, Task-Monitor, and Organisation of Materials. These scales can be combined to form three composite indices: the Behavioural Regulation Index (BRI), the Emotional Regulation Index (ERI) and the Cognitive Regulation Index (CRI). Standardised T-scores are used for scoring (mean = 50, standard deviation = 10), with T-score of $\geq$65 indicating clinically significant executive function deficits.

(2) Conners-3: The Conners-3, developed by Conners [19], are widely used rating scales for assessing ADHD-related symptoms and behavioural difficulties. The Conners-3 includes parent, teacher and self-report versions. The scale uses T-score standardisation with a mean of 50 and a standard deviation of 10. A T-score of $\geq$65 is considered clinically elevated. The four main subscales are inattention, hyperactivity-impulsivity, learning difficulties and executive functions. The Conners-3 has good reliability and validity, and it is used widely in clinical diagnosis, evaluation of treatment response and other research on therapy.

(3) Swanson, Nolan and Pelham Rating Scale, Fourth Edition (SNAP-IV): The SNAP-IV, developed by Swanson *et al*. [20], is a widely used measure of the main symptoms of ADHD based on the symptom criteria of the DSM. The 18-item parent version of SNAP-IV was used in this study, including two DSM-based symptom domains: inattention (9 items) and hyperactivity-impulsivity (9 items). Each item is scored from 0 to 3 (0 = Never; 3 = Very Often), yielding a total score of 0−54. The SNAP-IV was used as a continuous measure of ADHD symptom severity and treatment response rather than as an independent diagnostic or screening cutoff. Higher scores indicated more severe ADHD-related symptoms. ADHD diagnosis and eligibility were determined according to DSM-5 criteria and clinical assessment. The SNAP-IV has good sensitivity to changes in symptoms. This study did not include the additional supplementary items present in the extended version of SNAP-IV.

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(4) Emotion Regulation Checklist (ERC): The ERC, developed by Shields and Cicchetti, was used to assess children's emotion regulation through parent or caregiver report. The checklist contains 24 items and the two subscales: Emotion Regulation (8 items) and Lability/Negativity subscale (16 items). A 4-point Likert scale is used (1 = Almost Never; 4 = Almost Always). Higher score in the Emotion Regulation subscale indicate better emotional regulation, whereas lower scores in the Lability/Negativity subscale indicate better emotional stability. Recent studies supported the ERC as a brief multidimensional measure of emotional dysregulation, although its factor structure may vary across samples [21].

(5) The Frankl Behavior Rating Scale (FBRS): The FBRS is a widely used to assess children's behaviours during dental visits [22]. It classifies children's behaviours into four levels: Level 1, definitely negative; Level 2, negative; Level 3, positive; and Level 4, definitely positive. Standardised training for raters was performed before assessment, and inter-rater reliability was acceptable (intraclass correlation coefficient [ICC] = 0.82).

(6) Children's Fear Survey Schedule-Dental Subscale (CFSS-DS): CFSS-DS is a screening instrument for dental fear in children, comprising 15 items (each scored from 1 to 5, with a total score of 15−75). A score of ≥38 is considered to have clinical dental fear. The scale was reported to be correlated with the Modified Child Dental Anxiety Scale (MCDAS) (rho = 0.60, $p < 0.001$) [23]. During dental visit, children aged ≥6 years completed the assessment by self-report, whereas assessments for children aged <6 years were completed with assistance from a nurse.

(7) Parenting Stress Index, Fourth Edition, Short Form (PSI-4 Short Form): This instrument has 36 items (rated on a 5-point Likert scale) and a total score range of 36−180. A score at or above the 90th percentile is considered clinically significant [24]. The three subscales are parental distress (PD), parent-child dysfunctional interaction (P-CDI) and difficult child (DC). PSI-4 can also be considered as a supportive indicator in assessing ADHD treatment; a bilateral positive correlation between a reduction in parental stress and improved behaviour in children was reported [25].

Statistics Analysis

SPSS 26.0 (IBM Corp., Armonk, NY, USA) was used to conduct statistics analysis. Normality was assessed with the Shapiro–Wilk test. Normally distributed continuous variables are presented as mean ± standard deviation and were compared using independent-samples *t* tests; non-normally distributed variables are presented as median (interquartile range) and were compared using the Mann–Whitney U test. Categorical variables are presented as counts (%) and were compared using the χ^2 test or Fisher's exact test. Repeated-measures analysis of variance (ANOVA) assessed group, time, and group × time effects, with Bonferroni correction for post-hoc comparisons. For the two co-primary outcomes, a Bonferroni-adjusted two-sided α of 0.025 was used; secondary outcomes were considered supportive and were interpreted with multiplicity in mind. Unadjusted linear regression models included treatment group only; adjusted multiple linear regression models additionally included age, sex, ADHD subtype, medication use, ADHD duration, previous dental visits, residence, family socioeconomic status, and the corresponding baseline outcome. Treatment group was coded 1 for combined therapy and 0 for control, so β represents the between-group mean difference at week 12 rather than a correlation coefficient. Missing follow-up data were handled by multiple imputation in the primary analysis. Robustness was assessed by repeating the adjusted models after last-observation-carried-forward (LOCF) imputation and comparing the direction, magnitude, and statistical significance of the estimates. No correlation, mediation, or exploratory pathway analyses were performed. All other tests were two-sided, with $p < 0.05$ considered statistically significant.

Results

Baseline Characteristics

Table 1 provides a systematic comparison of demographic, clinical, and baseline outcome variables. No statistically significant differences were observed in the measured variables (all $p > 0.05$). Because non-significant tests do not exclude clinically relevant imbalance or unmeasured confounding, covariate-adjusted analyses were also performed. Three children had partial follow-up scale data for non-medical reasons; these values were handled by multiple imputation, with last observation carried forward used only in sensitivity analysis. Fig. 1 shows the age-group and sex distributions.

Executive Function and Attention Outcomes

BRIEF-2 and Conners-3 Scores

Both co-primary outcomes showed significant group, time, and group × time effects and met the Bonferroni-adjusted significance threshold ($p < 0.025$). At week 12, the combined therapy group had lower BRIEF-2 scores

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Table 1. Baseline demographic, clinical, and outcome characteristics of the two groups.

Characteristic	Combined therapy group (n = 58)	Control group (n = 57)	Statistic	*p* value
Age (years, mean ± SD)	8.6 ± 2.9	8.1 ± 2.5	$t = 1.08$	0.282
Male/female (cases)	45/13	42/15	$\chi^2 = 0.32$	0.573
ADHD subtype (combined/inattentive/hyperactive-impulsive)	28/20/10	26/16/15	$\chi^2 = 1.21$	0.546
ADHD medication use (yes/no)	28/30	23/34	$\chi^2 = 0.89$	0.345
ADHD duration (years, mean ± SD)	3.0 ± 1.6	2.6 ± 1.2	$t = 1.52$	0.131
Previous dental visits (median)	2 (1–5)	2 (1–4)	Z = 0.71	0.478
Family socioeconomic status (low/middle/high)	16/30/12	17/26/14	$\chi^2 = 1.05$	0.592
Residence (local/non-local), cases	27/31	25/32	$\chi^2 = 0.08$	0.772
BRIEF-2 Global Executive Composite T-score	74.8 ± 5.6	74.3 ± 5.4	$t = 0.49$	0.627
Conners-3 Attention Index T-score	71.6 ± 4.8	71.3 ± 4.6	$t = 0.34$	0.733
SNAP-IV total score	34.6 ± 6.8	34.2 ± 6.5	$t = 0.32$	0.748
ERC emotion-regulation score	18.2 ± 3.4	18.5 ± 3.3	$t = -0.48$	0.632
ERC lability/negativity score	48.5 ± 6.8	48.1 ± 6.5	$t = 0.32$	0.748
CFSS-DS total score	28.6 ± 6.4	28.2 ± 6.1	$t = 0.34$	0.732
Dental fear, cases (%)	12 (20.7)	11 (19.3)	Fisher's exact	1.000
FBRS score	2.1 ± 0.6	2.0 ± 0.5	$t = 0.97$	0.334
Dental cooperation (FBRS ≥3), cases (%)	24 (41.4)	22 (38.6)	$\chi^2 = 0.09$	0.761
PSI-4 total score	112.4 ± 18.3	111.8 ± 17.9	$t = 0.18$	0.859

Note: Data are presented as mean ± SD, median (interquartile range), or cases (%). Baseline outcome measures were included to show measured pre-treatment comparability. ADHD, attention-deficit/hyperactivity disorder; BRIEF-2, Behavior Rating Inventory of Executive Function, Second Edition; CFSS-DS, Children's Fear Survey Schedule-Dental Subscale; FBRS, Frankl Behavior Rating Scale; ERC, Emotion Regulation Checklist; PSI-4, Parenting Stress Index, Fourth Edition; SD, standard deviation; SNAP-IV, Swanson, Nolan, and Pelham Rating Scale, Fourth Edition.

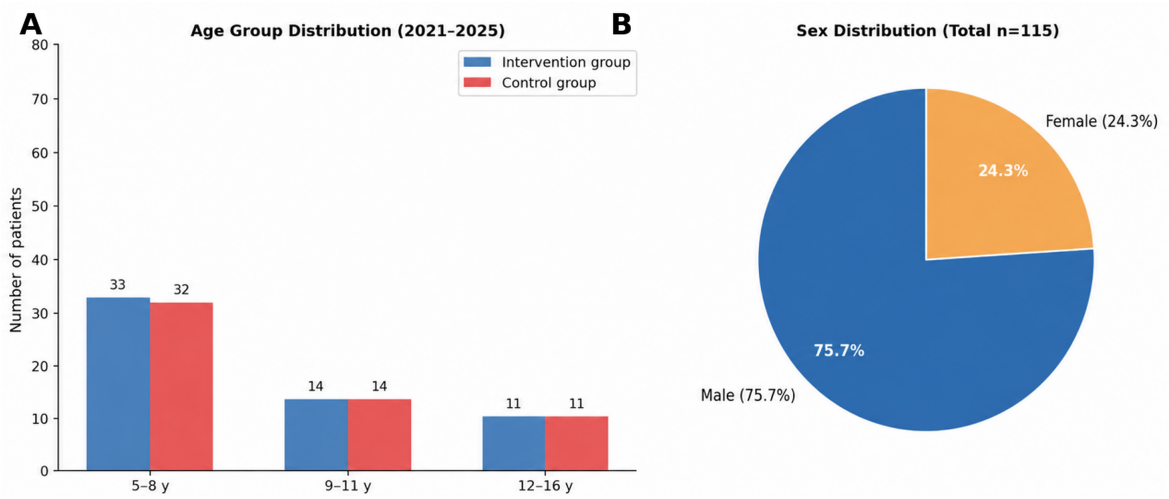


Fig. 1. Baseline demographic characteristics of study participants. (A) age-group distribution by treatment group. (B) sex distribution in the full cohort.

(61.1 ± 4.8 vs. 70.5 ± 5.2; MD = −9.4, 95% CI: −11.3 to −7.6; Cohen's d = 1.88; $p < 0.001$) and lower Conners-3 scores (57.8 ± 4.1 vs. 69.0 ± 4.4; MD = −11.2, 95% CI: −12.8 to −9.6; Cohen's d = 2.64; $p < 0.001$) than the control group. The combined therapy group improved by 13.7 points on BRIEF-2 from baseline, whereas the control group improved by 3.8 points. Table 2 presents the repeated measurements; Fig. 2A shows clinical-scale scores, and Fig. 2B shows the magnitude of improvement.

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Table 2. Comparison of BRIEF-2 and Conners-3 scores for the two groups at different times.

Time point/Effect	Combined therapy group BRIEF-2	Control group BRIEF-2	Combined therapy group Conners-3	Control group Conners-3
Baseline	74.8 ± 5.6	74.3 ± 5.4	71.6 ± 4.8	71.3 ± 4.6
4 weeks	70.3 ± 5.4	72.8 ± 5.5	67.9 ± 4.6	70.5 ± 4.7
8 weeks	65.5 ± 5.0	71.4 ± 5.3	62.7 ± 4.3	69.8 ± 4.5
12 weeks	61.1 ± 4.8	70.5 ± 5.2	57.8 ± 4.1	69.0 ± 4.4
Group effect	$F = 53.42$, $p < 0.001$, partial $\eta^2 = 0.32$	—	$F = 71.65$, $p < 0.001$, partial $\eta^2 = 0.39$	—
Time effect	$F = 146.28$, $p < 0.001$, partial $\eta^2 = 0.56$	—	$F = 178.94$, $p < 0.001$, partial $\eta^2 = 0.61$	—
Group × time effect	$F = 21.36$, $p < 0.001$, partial $\eta^2 = 0.16$	—	$F = 19.84$, $p < 0.001$, partial $\eta^2 = 0.15$	—

Note: Data are presented as mean ± SD. Repeated-measures ANOVA was used to assess group, time, and group × time effects. Bonferroni-adjusted between-group post hoc comparisons were: BRIEF-2, week 4 MD = −2.5 (95% CI −4.5 to −0.5), p_adj = 0.046; week 8 MD = −5.9 (95% CI −7.8 to −4.0), p_adj < 0.001; week 12 MD = −9.4 (95% CI −11.3 to −7.6), p_adj < 0.001; Conners-3, week 4 MD = −2.6 (95% CI −4.3 to −0.9), p_adj = 0.010; week 8 MD = −7.1 (95% CI −8.7 to −5.5), p_adj < 0.001; and week 12 MD = −11.2 (95% CI −12.8 to −9.6), p_adj < 0.001. BRIEF-2, Behavior Rating Inventory of Executive Function, Second Edition; MD, mean difference; ANOVA, analysis of variance; CI, confidence interval.

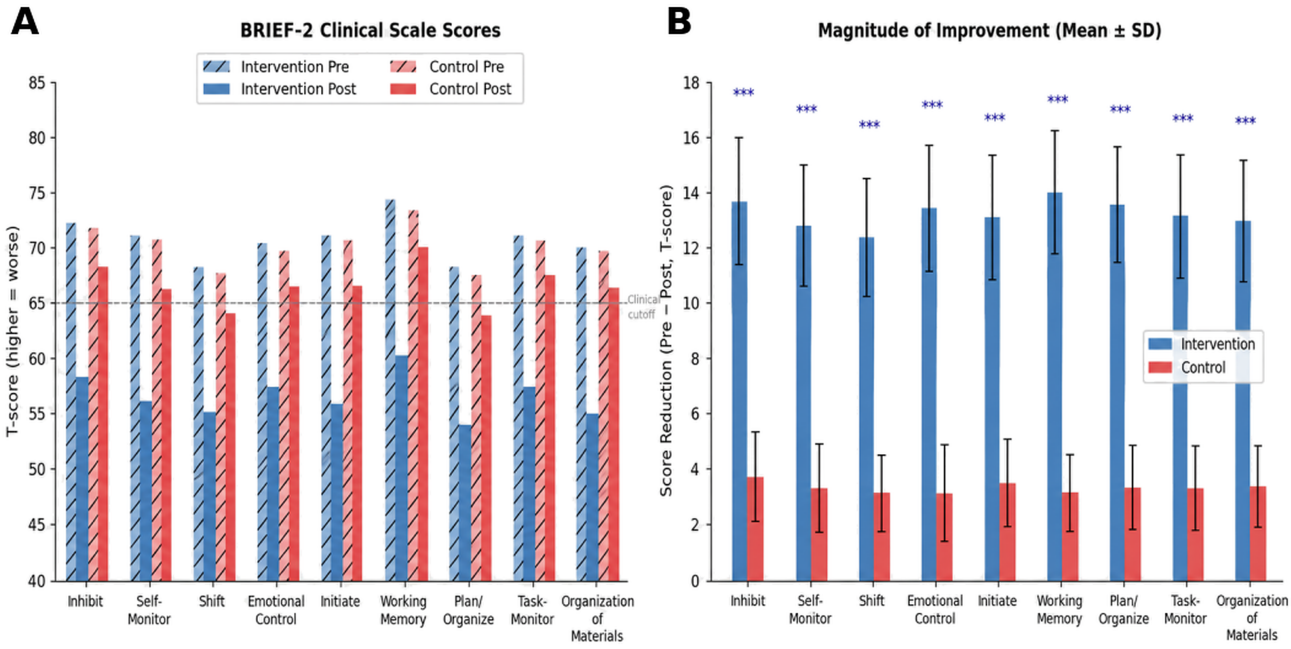


Fig. 2. BRIEF-2 outcomes. (A) baseline and week-12 clinical-scale T-scores in the two groups. (B) magnitude of score reduction from baseline to week 12. Note: Lower BRIEF-2 T-scores indicate better executive function. Error bars in Figure 2B represent standard deviations; asterisks denote between-group differences: ***$p < 0.001$. BRIEF-2, Behavior Rating Inventory of Executive Function, Second Edition.

Core Symptoms of ADHD: SNAP-IV Scores

At week 12, the combined therapy group had lower SNAP-IV total scores than the control group (22.5 ± 5.4 vs. 30.6 ± 6.1; $t = 7.54$, $p < 0.001$). The inattention, hyperactivity/impulsivity, and item-mean scores were also lower (all $p < 0.001$) (Table 3).

Emotion Regulation: ERC Scores

At week 12, the between-group mean difference in the ERC emotion-regulation score was 4.8 points (25.6 ± 3.1 vs. 20.8 ± 3.2; 95% CI 3.6 to 6.0; $p < 0.001$), whereas the mean difference in the lability/negativity score was −11.2 points (32.4 ± 5.2 vs. 43.6 ± 6.0; 95% CI −13.3 to −9.1; $p < 0.001$). Table 4 presents the baseline and week-12 values, and Fig. 3A shows the lability/negativity trajectory.

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Table 3. Baseline and week-12 SNAP-IV scores in the two groups.

SNAP-IV subscale	Combined therapy group baseline	Combined therapy group 12 weeks	Control group baseline	Control group 12 weeks	*t* value	*p* (between groups)
Inattention (0–27 points, 9 items)	17.2 ± 3.7	11.3 ± 3.0	17.0 ± 3.5	15.2 ± 3.4	6.52	<0.001
Hyperactivity/impulsivity (0–27 points, 9 items)	17.4 ± 3.6	11.2 ± 2.9	17.2 ± 3.4	15.4 ± 3.2	7.37	<0.001
SNAP-IV total score (0–54 points)	34.6 ± 6.8	22.5 ± 5.4	34.2 ± 6.5	30.6 ± 6.1	7.54	<0.001
Item mean score (total score ÷ 18)	1.92 ± 0.38	1.25 ± 0.30	1.90 ± 0.36	1.70 ± 0.34	7.52	<0.001

Note: Data are presented as mean ± SD. SNAP-IV item mean score = total score ÷ 18 and was used only to describe symptom severity, not as an independent diagnostic cutoff. The reported *t* values and *p* values compare the two groups at week 12; baseline values are provided to show pre-treatment status. SD, standard deviation; SNAP-IV, Swanson, Nolan, and Pelham Rating Scale, Fourth Edition.

Table 4. Baseline and week-12 ERC subscale scores in the two groups.

ERC subscale	Combined therapy group baseline	Combined therapy group 12 weeks	Control group baseline	Control group 12 weeks	*t* value	*p* value
Emotion regulation subscale (increase)	18.2 ± 3.4	25.6 ± 3.1	18.5 ± 3.3	20.8 ± 3.2	8.17	<0.001
Lability/Negativity subscale (decrease)	48.5 ± 6.8	32.4 ± 5.2	48.1 ± 6.5	43.6 ± 6.0	10.69	<0.001

Note: Data are presented as mean ± SD. The reported *t* values and *p* values compare the two groups at week 12; baseline values are provided to show pre-treatment status. SD, standard deviation; ERC, Emotion Regulation Checklist.

Dental Impulsive Behaviour and Dental Fear: FBRS and CFSS-DS Scores

At week 12, compared with the control group, the combined therapy group had significantly higher FBRS scores (3.5 ± 0.5 vs. 2.6 ± 0.6; $t = 8.73$, $p < 0.001$), a significantly higher dental cooperation rate [46/58 (79.3%) vs. 29/57 (50.9%); $\chi^2 = 10.25$, $p = 0.001$] and significantly lower CFSS-DS scores (18.3 ± 5.1 vs. 24.8 ± 5.8; $t = 6.38$, $p < 0.001$). Dental-fear prevalence was numerically lower in the combined therapy group than in the control group [2/58 (3.4%) vs. 8/57 (14.0%)], but the difference was not statistically significant ($p = 0.053$). Fig. 3B shows the FBRS trajectory, and Table 5 presents the baseline and week-12 comparisons.

Family Functioning: Parental Stress Index (PSI-4)

At week 12, the PSI-4 total score was lower in the combined therapy group than in the control group (92.1 ± 16.8 vs. 107.2 ± 17.4; $t = 4.73$, $p < 0.001$). Similar between-group differences were observed for PD (34.9 ± 6.9 vs. 39.2 ± 7.4; $t = 3.22$, $p = 0.002$), parent-child dysfunctional interaction (29.6 ± 6.5 vs. 33.5 ± 6.8; $t = 3.14$, $p = 0.002$), and DC scores (27.6 ± 6.8 vs. 34.5 ± 7.2; $t = 5.28$, $p < 0.001$). These findings suggest that the combined protocol was associated with lower parental stress at 12 weeks. Details are shown in Table 6.

Descriptive Summary of Structured Care Adherence

In the combined therapy group, structured care adherence was descriptively summarised according to documented attendance and completion records. Across the study period, the proportion of children with full adherence ranged from 55.0% to 72.0%, whereas the proportion of non-adherence ranged from 6.0% to 16.0% (Fig. 4). These findings indicate that structured care was generally feasible and acceptable in routine clinical practice.

Adjusted and Sensitivity Analyses

Adjusted estimates were consistent with the unadjusted findings after controlling for age, sex, ADHD subtype, medication use, ADHD duration, previous dental visits, residence, family socioeconomic status, and the corresponding baseline outcome. Combined therapy was associated with lower BRIEF-2 ($\beta = -9.62$, 95% CI: −11.48 to −7.76), Conners-3 ($\beta = -10.94$, 95% CI: −12.52 to −9.36), SNAP-IV total ($\beta = -7.72$, 95% CI: −9.78 to −5.66), ERC

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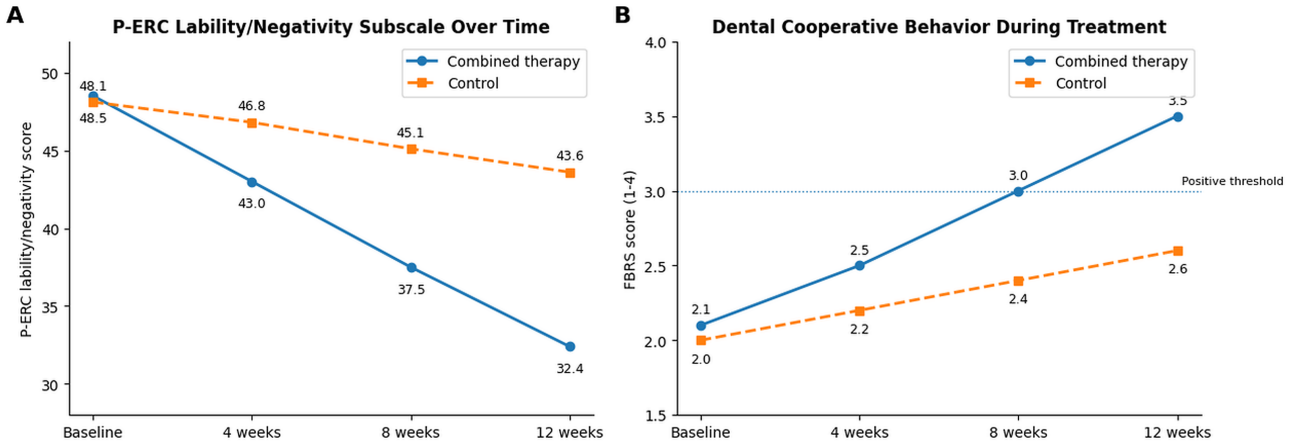


Fig. 3. Emotion regulation and dental cooperation across time. (A) ERC lability/negativity scores. (B) FBRS dental-cooperation scores. Note: Lower ERC lability/negativity scores indicate better emotional stability, whereas higher FBRS scores indicate better dental cooperation. The horizontal line in Figure 3B marks the FBRS threshold of 3 for positive cooperation. ERC, Emotion Regulation Checklist; FBRS, Frankl Behavior Rating Scale.

Table 5. Baseline and week-12 dental behaviour and dental-fear indicators in the two groups.

Indicator	Combined therapy group baseline	Combined therapy group 12 weeks	Control group baseline	Control group 12 weeks	Statistic	*p* value
CFSS-DS total score	28.6 ± 6.4	18.3 ± 5.1	28.2 ± 6.1	24.8 ± 5.8	$t = 6.38$	<0.001
Prevalence of dental fear [cases (%)]	12 (20.7)	2 (3.4)	11 (19.3)	8 (14.0)	Fisher's exact test	0.053
FBRS score (1–4 points)	2.1 ± 0.6	3.5 ± 0.5	2.0 ± 0.5	2.6 ± 0.6	$t = 8.73$	<0.001
Dental cooperation rate (FBRS ≥3 points) [cases (%)]	24 (41.4)	46 (79.3)	22 (38.6)	29 (50.9)	$\chi^2 = 10.25$	0.001

Note: Data are presented as mean ± SD or cases (%). The reported test statistics and *p* values compare the two groups at week 12; baseline values are provided to show pre-treatment status. CFSS-DS, Children's Fear Survey Schedule-Dental Subscale; FBRS, Frankl Behavior Rating Scale.

lability/negativity ($\beta = -10.87$, 95% CI: −12.89 to −8.85), CFSS-DS ($\beta = -6.21$, 95% CI: −8.18 to −4.24), and PSI-4 total scores ($\beta = -14.36$, 95% CI: −20.33 to −8.39), and with higher ERC emotion-regulation ($\beta = 4.55$, 95% CI: 3.42 to 5.68) and FBRS scores ($\beta = 0.84$, 95% CI: 0.65 to 1.03) (all $p < 0.001$). Sensitivity analyses using last observation carried forward produced no material change in direction or significance. Unadjusted, adjusted, and LOCF sensitivity estimates are presented in Table 7; all sensitivity estimates retained the same direction and statistical significance as the primary analysis.

Discussion

Interpretation of the Main Findings

This study found that CBT and MBI delivered with structured care were associated with greater 12-week improvement than routine dental behavioural guidance across executive function/attention, core ADHD symptoms, emotion regulation, dental cooperation, dental fear, and parental stress. The two co-primary outcomes showed consistent group × time effects and remained significant after multiplicity adjustment and covariate adjustment. Because the intervention was delivered as one package, the findings support the combined protocol as a whole rather than any single component.

The BRIEF-2 and Conners-3 findings provide com-

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Table 6. Baseline and week-12 PSI-4 scores in the two groups.

PSI-4 subscale	Combined therapy group baseline	Combined therapy group 12 weeks	Control group baseline	Control group 12 weeks	*t* value	*p* value
Parental distress (PD)	41.2 ± 7.8	34.9 ± 6.9	40.8 ± 7.6	39.2 ± 7.4	3.22	0.002
Parent-child dysfunctional interaction (P-CDI)	34.8 ± 7.2	29.6 ± 6.5	34.6 ± 7.0	33.5 ± 6.8	3.14	0.002
Difficult child (DC)	36.4 ± 8.1	27.6 ± 6.8	36.4 ± 7.8	34.5 ± 7.2	5.28	<0.001
PSI-4 total score	112.4 ± 18.3	92.1 ± 16.8	111.8 ± 17.9	107.2 ± 17.4	4.73	<0.001

Note: Data are presented as mean ± SD. The reported *t* values and *p* values compare the two groups at week 12; baseline values are provided to show pre-treatment status. PSI-4, Parenting Stress Index, Fourth Edition.



Fig. 4. Descriptive distribution of structured care adherence during the study period. Note: Figure 4 shows the yearly distribution of structured care adherence in the combined therapy group.

plementary information: BRIEF-2 reflects executive-function difficulties in daily life, whereas Conners-3 captures attention-related difficulties. Their concordant improvements are consistent with evidence that structured behavioural and cognitive training can improve executive-function-related outcomes in children with ADHD [26,27]. The reductions in SNAP-IV inattention and hyperactivity/impulsivity scores further suggests broader symptom improvement. A plausible explanation is that repeated cognitive coping practice, immediate behavioural reinforcement, and mindfulness-based attention exercises may have helped children pause, follow instructions, and sustain goal-directed behaviour during dental treatment; however, the present data did not directly test these mechanisms [28,29].

Emotion regulation, dental fear, and observable cooperation improved in parallel. Higher ERC emotion-regulation scores, lower lability/negativity and CFSS-DS scores, and higher FBRS scores are clinically coherent because children who are better prepared to recognise and manage distress may be more able to tolerate dental stimuli and complete procedures. Previous work supports cognitive-behavioural approaches for dental anxiety and non-pharmacological behaviour guidance in paediatric dentistry [30,31]. Nevertheless, no correlation or mediation analysis were performed, so these findings should be interpreted as concurrent changes rather than evidence that improved emotion regulation caused better cooperation.

Parental stress also decreased, particularly in the

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Table 7. Unadjusted, adjusted, and sensitivity analyses of week-12 continuous outcomes.

Outcomes	Unadjusted β (95% CI)	Adjusted β (95% CI)	LOCF sensitivity β (95% CI)
BRIEF-2	–9.40 (–11.23 to –7.57)	–9.62 (–11.48 to –7.76)	–9.51 (–11.36 to –7.66)
Conners-3	–11.20 (–12.76 to –9.64)	–10.94 (–12.52 to –9.36)	–10.86 (–12.43 to –9.29)
SNAP-IV total	–8.10 (–10.21 to –5.99)	–7.72 (–9.78 to –5.66)	–7.60 (–9.63 to –5.57)
ERC emotion regulation	4.80 (3.65 to 5.95)	4.55 (3.42 to 5.68)	4.47 (3.35 to 5.59)
ERC lability/negativity	–11.20 (–13.25 to –9.15)	–10.87 (–12.89 to –8.85)	–10.73 (–12.73 to –8.73)
CFSS-DS	–6.50 (–8.50 to –4.50)	–6.21 (–8.18 to –4.24)	–6.12 (–8.07 to –4.17)
FBRS	0.90 (0.70 to 1.10)	0.84 (0.65 to 1.03)	0.82 (0.63 to 1.01)
PSI-4 total	–15.10 (–21.35 to –8.85)	–14.36 (–20.33 to –8.39)	–14.08 (–20.01 to –8.15)

Note: β values are between-group mean differences at week 12 (combined therapy minus control). Adjusted models included the prespecified covariates and the corresponding baseline outcome. All $p < 0.001$. LOCF, last observation carried forward; CI, confidence interval; BRIEF-2, Behavior Rating Inventory of Executive Function, Second Edition; SNAP-IV, Swanson, Nolan, and Pelham Rating Scale, Fourth Edition; ERC, Emotion Regulation Checklist; CFSS-DS, Children's Fear Survey Schedule-Dental Subscale; FBRS, Frankl Behavior Rating Scale; PSI-4, Parenting Stress Index, Fourth Edition.

difficult-child and parental-distress domains. This may reflect fewer treatment-related behavioural difficulties and greater parental confidence in managing symptoms at home. Parenting stress is closely linked to the burden of caring for children with ADHD [32], and mindfulness-based parent programmes may provide additional support [33]. In this study, however, parent and child outcomes were assessed mainly by rating scales and were not modelled as a causal feedback pathway.

In addition, structured care may have improved implementation by standardising the environment, parent education, behavioural observation, and follow-up. The adherence distribution suggests that the protocol was feasible for many families in routine practice, however, adherence was analysed descriptively and cannot be interpreted as an independent efficacy factor. Clinically, the combined pathway may be most relevant for children with ADHD who repeatedly struggle with dental cooperation and whose families can participate in a structured 12-week programme. The required staffing, visit frequency, and family commitment should be considered before wider implementation.

Overall, the consistency of the primary, secondary, adjusted, and sensitivity analyses strengthens the observed association. At the same time, treatment choice was influenced by clinical judgement, parental preference, expected adherence, and resource availability. These factors may have selected more motivated families into the combined group and limit causal interpretation despite measured baseline comparability.

Limitations of this Study

This study has several limitations. First, the single-centre retrospective design and non-random treatment selection create risks of selection bias, confounding by indication, and residual confounding; parental motivation, clinician preference, and programme availability were not fully quantifiable. Second, CBT, MBI, and structured care were delivered together, so their independent contributions and interactions cannot be separated. Third, no correlation or mediation analyses were performed, and mechanistic interpretations therefore remain tentative. Fourth, follow-up period was limited to 12 weeks, preventing assessment of durability and long-term dental outcomes. Fifth, several outcomes were parent-reported, which may introduce reporting bias and shared-method variance, although FBRS provided direct behavioural observation. Finally, neurophysiological measures were unavailable. Prospective multicentre studies with randomisation or carefully designed comparative groups, longer follow-up, objective outcomes, and component-specific analyses are needed.

Conclusions

In this retrospective cohort study, CBT and MBI combined with structured care were associated with better 12-week executive-function/attention, ADHD symptom, emotion-regulation, dental-cooperation, dental-fear, and parental-stress outcomes than routine guidance. The findings support the combined pathway as a potentially useful option for children with ADHD who have difficulty cooperating with dental care, but causality and the independent contribution of each component remain uncertain.

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Availability of Data and Materials

All experimental data included in this study can be obtained by contacting the corresponding author if needed.

Author Contributions

MJW contributed to study design, data analysis and manuscript writing. JYG was responsible for the implementation of nursing interventions and data quality control. RX performed data extraction. YTL completed follow-up assessment and scale entry. YFJ conducted data analysis. WJY participated in writing—review & editing, resources provision and validation. All authors critically revised the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study has been approved by the Medical Ethics Committee of Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, and is listed as Approval No.: SH9H-2026-T288-2; the review method was expedited review. As this study was a retrospective analysis of medical records based on the available clinical data, and all patient information has been anonymised and de-identified, the Ethics Committee has granted an exemption from the requirement for informed consent. All the above procedures have been carried out in accordance with the relevant provisions of the Declaration of Helsinki (2013 Revision) and the Measures for Ethical Review of Biomedical Research Involving Humans.

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Conflict of Interest

No conflicts of interest for this article.

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