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REVIEW

The Efficacy of Aromatherapy on Pain and Anxiety During Needle-Related Procedures in Adults: A Systematic Review and Meta-Analysis

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Background: Pain and anxiety resulting from needle-related manipulation are major causes of patient refusal and missed optimal treatment. This study focuses on assessing the effectiveness and benefits of aromatherapy in adult patients undergoing needle-related manipulation for pain and anxiety.

Methods: The researchers conducted detailed searches of a total of five databases, the Cochrane Library, Web of Science, Embase Databases, and Scopus, from the period of the library's construction until November 23, 2024. Inclusion criteria involved adults undergoing needle-related manipulation, aromatherapy as an intervention, and outcome indicators such as pain, anxiety, and satisfaction. And the results were analyzed in subgroups. This study used RevMan 5.4.1 software to analyse the included data.

Results: This meta-analysis and systematic review included a total of 9 studies. A meta-analysis demonstrated that aromatherapy as an intervention significantly reduced pain (MD = −1.82, 95% CI [−2.35, −1.30], $p < 0.00001$) and anxiety (SMD = −0.92, 95% CI [−1.71, −0.14], $p = 0.02$) in adult patients undergoing needle-related invasive procedures compared to placebo and conventional interventions. Subgroup analyses indicated aromatherapy reduced pain during needle procedures for arteriovenous fistulae (AVF) and catheter placement, and alleviated anxiety in AVF patients. Lavender oil effectively reduced both pain and anxiety. The 5-minute duration of action is superior to the 3-minute duration of action. Both inhalation and topical application reduced pain.

Conclusion: This meta-analysis supports aromatherapy for needle-related pain relief and targeted anxiety reduction. However, protocol standardization in future RCTs is needed to address high heterogeneity and methodological limitations.

Keywords: pain, anxiety, needle, puncture procedures, aromatherapy, meta-analysis

Background

Invasive operations are those that require breaking through the surface or mucous membranes of the body and entering the internal environment of the organism to perform.[1] It is a necessary operation for the treatment and diagnosis of various diseases. Although needle-related manipulation is a relatively simple operation in the clinic, it is an almost indispensable operation for patients in the clinic and has an extremely wide audience in the clinic. However, pain and anxiety are often present during needle-related operations.[2,3] This discomfort can lead to treatment refusal, poor compliance, and missed optimal treatment opportunities.[4–6] Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[7] Anxiety,

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characterized by distress and withdrawal behaviors,[8] often intertwines with pain, with anxiety increasing the perception of pain.[6] The ability to reduce pain and anxiety during a medical visit can improve patient satisfaction and the experience of the medical visit.[9] Good pain management reduces the experience of suffering and favours the patient's prognosis.[10] Therefore, reducing pain and anxiety in adult patients during needle-related manipulation is necessary to improve patient satisfaction, reduce pain, and increase attendance.

At present, both pharmacological and non-pharmacological strategies are frequently employed, individually or together, to alleviate pain and anxiety linked to needle procedures in adults.[11,12] Pharmacological approaches to reducing pain and anxiety include local anaesthetics, non-steroidal anti-inflammatory drugs, opioids, and benzodiazepines, among others.[13,14] However, the pharmacological approach has certain side effects and drawbacks.[15] Pharmacological treatments may reduce the sensation of pain, but they do not completely relieve or reduce the patient's anxiety and fear. In addition, pharmacological treatments produce a range of side effects such as drowsiness, addiction, drug dependence, and so on.[16] As a result, alternatives to pharmacological treatments are now being increasingly emphasised in clinical practice.

In recent years, non-pharmacological approaches have been increasingly used and researched in clinical settings. Non-pharmacological treatments can be used alone as a means of reducing pain and anxiety in patients or in combination with pharmacological treatments.[17] Non-pharmacological interventions for alleviating pain and anxiety encompass hypnosis, aromatherapy, virtual reality, and others.[18–20] Aromatherapy is one of the non-pharmacological approaches that has been around for thousands of years. Inhaled essential oils activate the olfactory and other bodily systems, triggering the release of neurotransmitters such as endorphins, which induce feelings of happiness and pain relief.[21,22] Aromatherapy involves utilizing concentrated essential oils derived from herbs, flowers, and other plant components for the purpose of treating various ailments and can be used to alleviate pain and anxiety and is beneficial for the end-of-life care of patients.[23,24] Although some studies have shown that aromatherapy is effective in alleviating various types of pain (such as labor pain, burn pain, and acute pain[25–27]), existing evidence remains inconsistent regarding its specific effectiveness on needle-related pain and anxiety.

The results of studies on the effects of aromatherapy on needle-related pain and anxiety are inconsistent, and there is currently no conclusive meta-analysis evidence to support its effectiveness in a hospital setting. Therefore, the purpose of this study was to assess the efficacy and safety of aromatherapy in reducing pain in adults performing needle-related manipulations. We anticipate that this study will provide valuable findings for patients receiving treatment for pain and anxiety present in needle-related manipulations.

Methods

To ensure the openness and rigor of the study, we strictly adhered to the Preferred Reporting Item Statement for Systematic Assessment and Meta-Analysis Projects (PRISMA-P) guidelines. And the study has been registered with the International Centre for the Registration of Systematic Reviews of Prospective Registrations (Prospero) under the number CRD42024587305.

Study Selection

This study was based on the PICOS[28] framework limiting the inclusion and exclusion criteria for articles.

Inclusion criteria: (1) The study population was adults older than 18 years of age who required needle-related manipulation for treatment during clinical care.(P). (2) The intervention was aromatherapy to relieve pain and anxiety in adult patients during medical procedures related to needling (eg, various intubations, punctures, injections, etc).(I). (3) Patients in the control group received conventional treatment procedures or were given standard of care (SOC).(C). (4) The primary outcome of the study was the level of pain and anxiety associated with needle manipulation. Secondary outcomes included patient satisfaction and adverse reactions. Pain scores were measured using a visual analog scale (VAS) and numerical rating scale (NRS). Anxiety scores were measured using Visual Analogue Anxiety Scale (VAS-A), State-Trait Anxiety Inventory (STAI) and Hamilton Anxiety Rating Scale (HARS).(O).

Exclusion criteria for the study: Non-randomised clinical trials, reviews, conference abstracts, conference proceedings, newspapers, guidelines, responses, other documents, and studies without full text will be excluded. All studies not

in English, studies without full text, and studies reporting incomplete data or for which data extraction was not possible will be excluded. Patients included in the study with audiovisual impairments and psychiatric disorders were excluded.

Search Strategy

A search strategy has been developed based on the Cochrane Manual recommendations for interventions. A comprehensive search of several databases with a cut-off date of November 23, 2024, will be conducted. These include five databases: PubMed, Embase, Web of Science, Scopus, and Cochrane Library. Search formulas will be determined and retrieved by both authors. In addition, we will search other resources, reference lists of grey literature, reference similar articles, etc. The following search strategies were used: (Aromatherapies) or (Aromatherapy) or (Aroma Therapy) or (Aroma Therapies) and (invasive procedure) or (needle*) or (phlebotomy*) or (puncture*) and (pain) or (fear) or (anxiety).

Search Outcomes

Screening of literature was carried out by 2 researchers, and the screened literature was imported into Endnote 21, and duplicate literature removal was carried out. The screening process is divided into two main steps. Firstly, non-compliant literature was removed based on the title and abstract of the literature. Secondly, the full text is then skimmed to determine the final literature to be included. If there was a disagreement between the two researchers in the screening process, it was resolved through discussion.

The study focused on aromatherapy as a treatment to reduce pain and anxiety in adult patients undergoing needle operation. Key findings of the study include: (1) Pain was assessed by visual analogue scale (VAS) and numerical rating scale (NRS). (2) Anxiety was measured using the State Trait Anxiety Inventory (STAI) and the Visual Analogue Anxiety Scale (VAS-A).

Assessment of pain we used the Visual Analogue Scale (VAS) created by Price et al to assess the intensity of the patient's pain.[29] The Numeric Rating Scale (NRS) is an 11-point (NRS-11) or 101-point (NRS-101) scale used to calculate pain and is widely used in clinical settings because it is easy to administer and score.[30]

Created by Spilger in 1970, the State-Trait Anxiety Inventory (STAI) has 40 entries and consists of two sections: first, state anxiety; and second, trait anxiety.[2] The Visual Analogue Scale for Anxiety (VAS-A) is a quick, simple, effective, and reliable tool for assessing anxiety.[31]

Quality Appraisal

Two researchers used the Cochrane Manual for Systematic Assessment (http://www.cochranelibrary.com/) to independently assess potential bias in the literature they included. They are assessing bias in several key areas: generation of randomized sequences of studies, concealment of allocation, blinding procedures for participants and assessors, thoroughness of outcome data, potential for selective reporting, and other sources of bias. Both researchers will assess the literature simultaneously, discussing disagreements as they arise in order to reach consensus. Researchers assessed the quality of evidence for outcomes using the Recommended Assessment, Development, and Evaluation (Levels) framework. Quality will be assessed at three levels: low, medium, and high. Disagreements during the quality assessment process were resolved through discussion.

Extraction of Data

The following data were extracted from the included literature: (1) Firstly, the basic information of the included literature was extracted, including the name of the literature, the authors of the literature, and the year of publication. (2) Characteristics of study participants such as gender and age; patients' knowledge level, country, and ethnicity; and the number of study dropouts and treatment for missing data were recorded. (3) Characteristics of the clinical trial: including sample size, nadir criteria, participant recruitment methods, trial flow, interventions, outcome metrics, assessment time points, and duration of interventions. Data extraction will be done independently by two researchers, and any disagreement during the extraction process will be resolved through discussion, and if not resolved after discussion, it will be decided by a third person. The data to be extracted will be extracted by two researchers and filled in an Excel sheet and compared.

Statistical Analysis

The primary outcome indicators for this study are continuous variable pain scores and anxiety scores. Data included in this study will be meta-analyzed using RevMan 5.4.1 software, with data assessed using mean difference (MD) and standardized mean difference (SMD). Mean difference (MD) will be used if the included data are consistent in assessing the indicators, and standardized mean difference (SMD) will be used to assess the difference between the control and intervention groups if the indicators are not consistent in assessing the indicators. The focus of this analysis was on calculating the mean difference (MD) and standardized mean difference (SMD), as well as 95% confidence intervals (95% CI). For the outcome metrics in the study, we compared not only the direct change values but also the change in the difference between pre-intervention and post-intervention. $P < 0.05$ was considered statistically significant. Statistical heterogeneity was assessed using the I^2 statistic; an I^2 statistic above 50% indicates a high level of heterogeneity using a random-effects model, whereas a statistic below 50% indicates a low level of heterogeneity allowing the use of a fixed-effects model. To determine the source of heterogeneity, a sensitivity analysis of the studies was conducted, excluding one study at a time to determine whether it had an overall effect.

Publication Bias Assessment

Use funnel plots or Egger's test to assess publication bias in the included literature. Visually inspect the funnel chart to assess publication bias. Egger's test uses statistical testing methods to determine publication bias, with $p < 0.05$ indicating the presence of publication bias.

Results

Study Selection

An initial 267 results were identified by searching five databases, of which 105 were left after the Endnote software removed duplicate articles, 15 were left after reading the title and abstract filters, and 15 full-text articles were thoroughly reviewed. Two researchers carefully read the 15 articles to make the decision of literature inclusion. Ultimately, 9 full-text articles were assessed as eligible and met the inclusion criteria. The entire process of the review is illustrated in the PRISMA flowchart (Figure 1).[32–40]

Characteristics of the Studies

Table 1 summarizes the characterization of the included studies. A total of nine studies comprising this systematic evaluation and meta-analysis were analysed on 748 adult patients, with literature published between 2014 and 2024.[32–40] The included studies mainly originated from two countries, Iran and Turkey. Patients participating in these studies will be required to undergo needling-related procedures, including intravenous cannulation, needling into dialysis fistulas, arteriovenous fistula cannulation, insulin injections, and stem cell transplantation. The intervention used in all studies was aromatherapy. In four of the studies the control group was placebo, in four the control group was usual care/blank control, and in one the control group was both placebo and blank control. Most of the studies used a single aroma preparation, lavender oil (n = 6) being the most commonly used, as well as orange-scented essential oils (n = 1), peppermint essential oil (n = 1), and eucalyptus-derived aroma preparations (n = 1), with one study applying a blend of lavender essential oil and sweet almond essential oil (n = 1). Concentrations of essential oils in the included literature ranged from 1% to 100%, and aromatherapy interventions involved inhalation (n = 7) and topical dermal absorption (n = 2), with a dosage range of 2–5 drops of essential oils for inhalation and a dose of 0.3 mL for topical application. Most studies of aromatherapy were applied for 5 minutes. Patients' anxiety levels were assessed using the Visual Analogue Anxiety Scale (n = 2) and the State-Trait Anxiety Scale (n = 5). Patients' pain levels were assessed using the Visual Analogue Pain Scale (n = 7), the Numeric Rating Scale (n = 1), and the Verbal Category Scale (n = 1).

Risk of Bias

The 9 studies included in the meta-analysis were randomized controlled trials.[32–40] Two authors independently critically assessed the included trials using Cochrane's risk of bias assessment tool. Due to the specificity of aromatherapy, it is

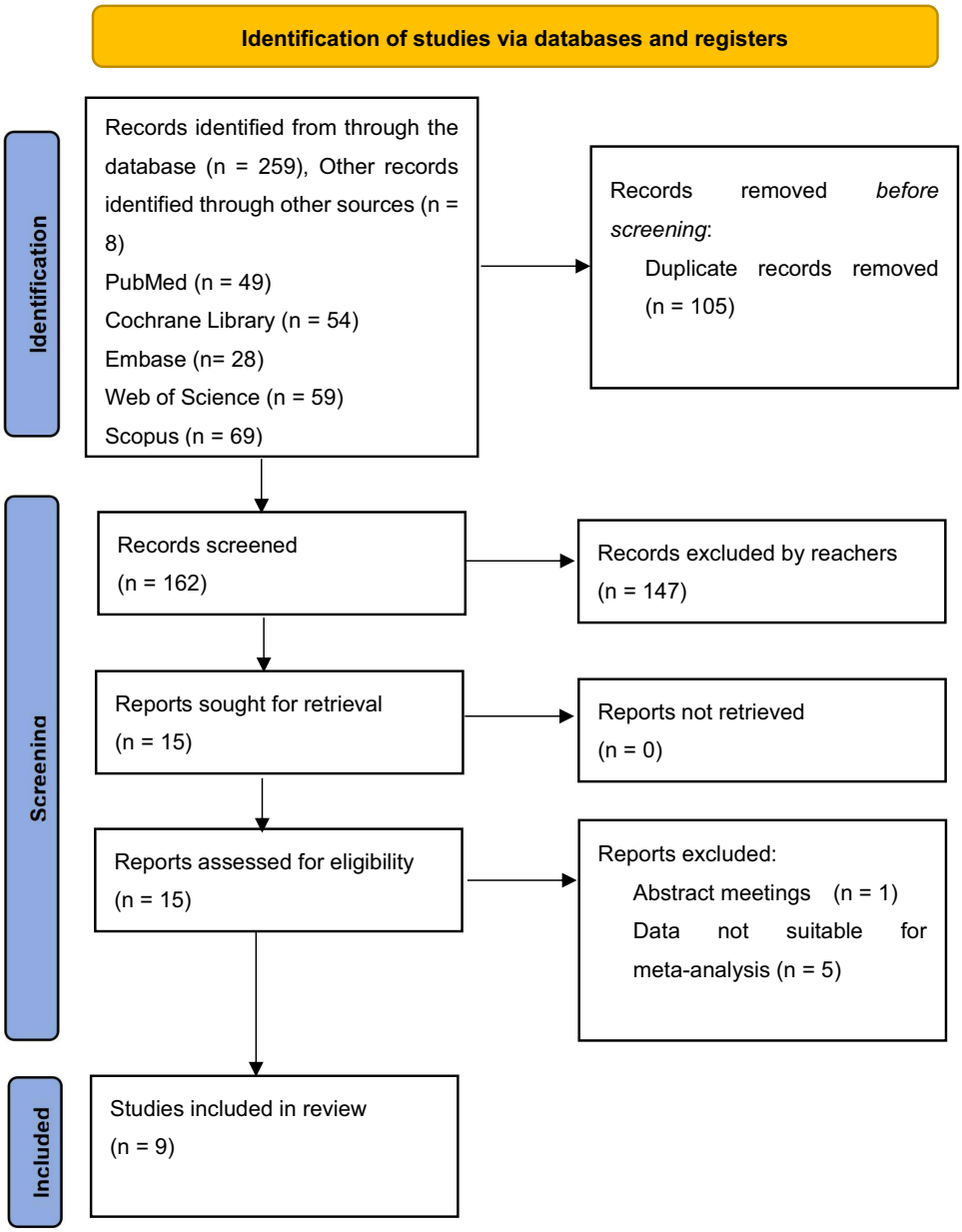

Figure 1 Flowchart of study selection.

difficult to blind the patients and operators involved in the trials, so blinding was performed except in the study by DEMİRAĞ et al.[34] We found that none of the nine included studies indicated a method of allocation concealment, so we were unable to clear confirmation for allocation concealment. Regarding completeness of data reporting, we reviewed the protocols and study designs registered prior to the article and found that all protocols reported results. Figure 2 shows the overall finding of risk of bias for the included studies.

Aromatherapy's Effect on Pain in Needle-Related Operations

Overall Effect of Pain Scores

A total of eight studies[32–35,37–40] (336 patients served as the intervention group and 336 patients participated in the control group) reported patients' pain scores. The overall effect showed that aromatherapy significantly reduced pain levels compared to the control group (MD = −1.82; 95% CI (−2.35, −1.30); $P < 0.00001$); Heterogeneity was high ($P < 0.00001$, $I^2 = 87\%$). Due to the high heterogeneity, a random effects model was used. (Figure 3 and Table 2).

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Table 1 Description of the Characteristics of the 9 Included Studies

study	Study design	Country	Patients	Gender (male/female)	Age(years)	Intervention Group	Control group	Outcomes
Akbari et al 2019[32]	RCT	Iran	Intravenous cannulae patients (heart disease)	I: 24/16 C:24/16	28–65	N=40, Peppermint flavour inhalation, 5mins, 3drops	N=40, distilled water inhalation	NRS, VAS-A
Bagheri–Nesami et al 2013[33]	RCT	Iran	Patients with haemodialysis fistula needling	Not reported	I:60.95±1.93 C:58.06±1.83	N=46, Inhale lavender essential oil, 5mins, 3 drops	N=46, Inhaling a placebo without lavender essence	VAS-P
DEMİRAĞ et al 2022[34]	RCT	Turkey	Diabetics requiring insulin injections	I: 34/26 C:29/31	I:50.91±13.42 C:53.8±13.65	N=60, Topical skin absorption of lavender essential oil, 5mins, 0.3mL	N=60, Inhaling a placebo without lavender essence (placebo group)	VAS-P, VCS
DEMİRAĞ et al 2022[34]	RCT	Turkey	Diabetics requiring insulin injections	I: 34/26 C:31/29	I:50.91±13.42 C:53.8±13.65	N=60, Topical skin absorption of lavender essential oil, 5mins, 0.3mL	N=60, No routine treatment	VAS-P, VCS
Erdal et al 2024[35]	RCT	Turkey	Invasive interventions in patients undergoing haematopoietic stem cell transplantation	I: 24/16 C:20/20	20-≥61	N=40, Inhale orange-scented essential oil, 3 drops	N=40, routine treatment	VAS-P, STAI, sleep duration
Karaman et al 2016[36]	RCT	Turkey	Patients with peripheral venous cannulation	I: 28/23 C:26/24	I:41.51±12.39 C:45.24±10.81	N=51, Inhale lavender essential oil,5mins,2 drops	N=50, Inhalation of pure water	VAS-P, VAS-A, Satisfaction
Mutluay Yayla et al 2018[37]	RCT	Turkey	Patients with implanted central venous catheters	Not reported (63.8% women)	Average age: 53.74±11.49 (26–79)	N=41, Inhale lavender essential oil, 3mins, 3 drops	N=41, routine treatment	VAS-P, STAI-I
Mutluay Yayla et al 2018[37]	RCT	Turkey	Patients with implanted central venous catheters	Not reported (63.8% women)	Average age: 53.74±11.49 (26–79)	N=41, Inhalation of eucalyptus essential oil, 3mins, 3 drops	N=41, routine treatment	VAS-P, STAI-I
Ozen et al 2023[38]	RCT	Turkey	Patients intubated during haemodialysis	I: 8/3 C:8/5	I:63±14.79 C:56.77±13.29	N=13, Inhale lavender and sweet almond oil blend, 3mins, 3 drops	N=11, routine treatment	VAS-P, STAI, HD Comfort Scale
Sahin et al 2021[39]	RCT	Turkey	Patients with arteriovenous fistula puncture during haemodialysis	I: 19/17 C:23/15	I:50.75±18.02 C:53.62±11.03	N=36, Inhalation of essential oils, 5mins, 5 drops	N=38, inhalation placebo	NRS, STAI-S, STAI-T
Tüzün Özdemir et al 2023[40]	RCT	Turkey	Patients intubated with arteriovenous fistulae	I: 13/17 C:17/13	18-≥65	N=30, Inhale lavender essential oil, 5nins, 3 drops	N=30, inhalation placebo	VAS-P
Tüzün Özdemir et al 2023[40]	RCT	Turkey	Patients intubated with arteriovenous fistulae	I: 19/11 C:17/13	18-≥65	N=30, Topical application of lavender essential oil, 5mins, 0.3mL	N=30, inhalation placebo	VAS-P

Abbreviations: VAS-P, Visual analog scale for pain; VAS-A, Visual analog scale for anxiety; STAI, State-Trait Anxiety Inventory; NRS, Numeric rating scale; VCS, Verbal category scale; I, intervention group; C, control group.

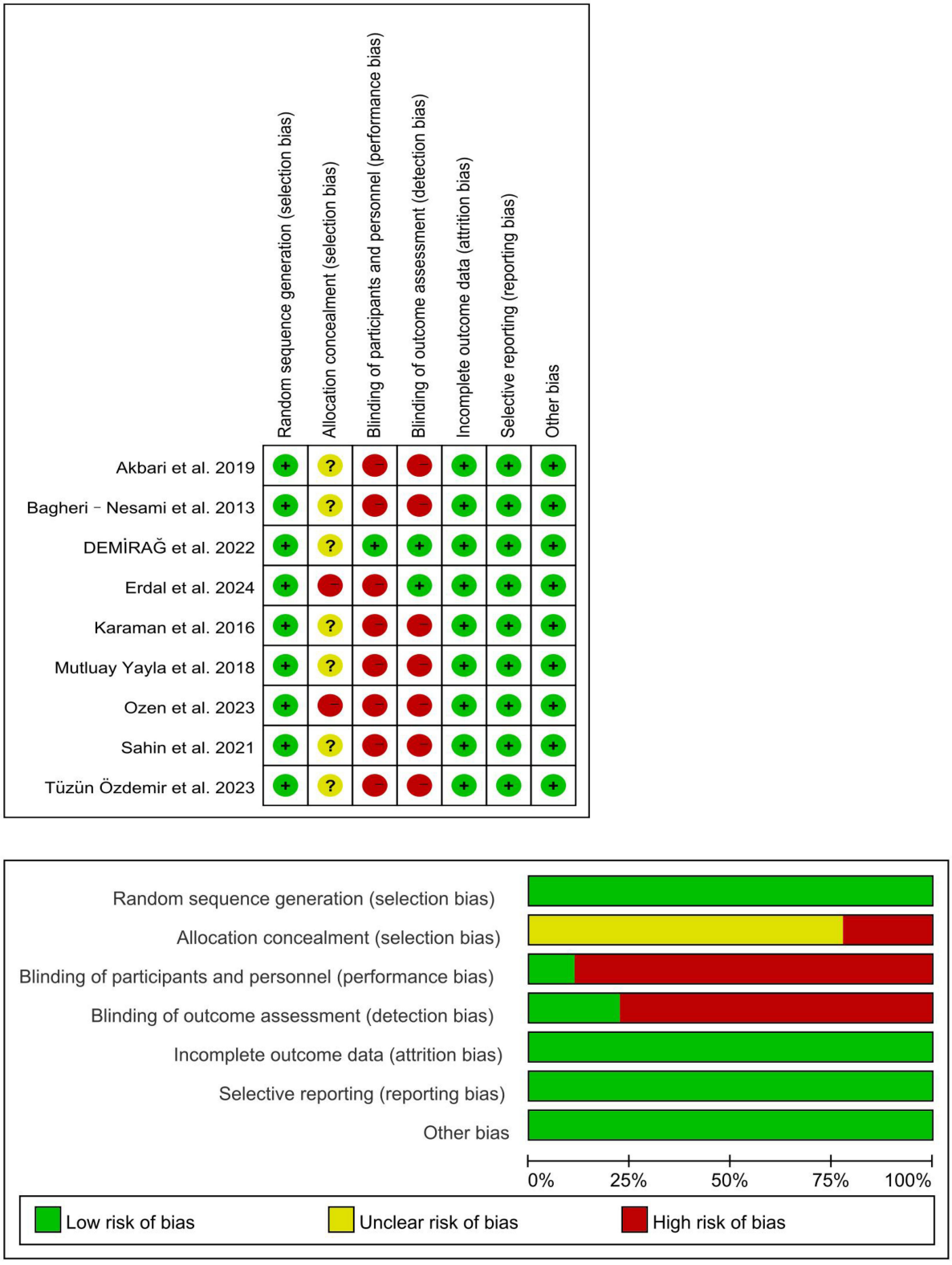

Figure 2 Risk of bias summary of the included studies.

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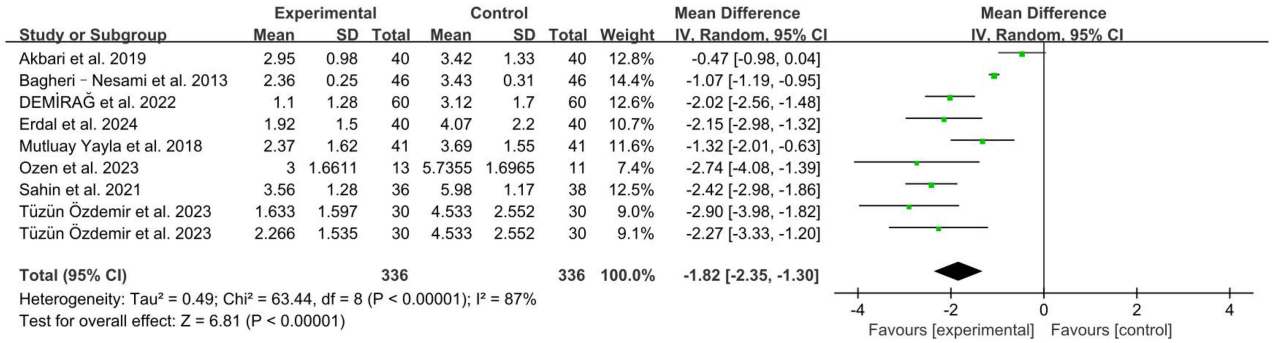


Figure 3 To compare the pain scores of patients in the aromatic and control groups.
Abbreviations: CI, Confidence Interval; SD, Standard Deviation.

Subgroup Analyses by Type of Control Group

5 trials tested the efficacy of inhaled aromatherapy plus usual care versus placebo plus usual care for pain.[32–35,38,39] All trials showed that inhalation aromatherapy plus usual care significantly reduced pain in adult patients undergoing needling

Table 2 Effect Sizes of the Overall and Subgroup Analysis

Title	Number of Trials	Number of Participants	Statistical Method	Effect Size	Overall Effect, p Value	Heterogeneity I^2 Value
1. Overall effect (pain)	8	672	MD (IV, Random, 95% CI)	−1.82 [−2.35, −1.30]	p<0.00001	I^2=87%
1.1 Subgroup analysis by type of control	8					
Placebo control	5	486	MD (IV, Random, 95% CI)	−1.59 [−2.18, −1.01]	p<0.00001	I^2=88%
Routine treatment	4	306	MD (IV, Random, 95% CI)	−1.88 [−2.26, −1.50]	p<0.00001	I^2=35%
1.2 Subgroup analysis of operation types	6					
Arteriovenous fistula-related operations	2	162	MD (IV, Random, 95% CI)	−0.61 [−1.03, −0.19]	P=0.004	I^2=43%
Catheter placement	4	472	MD (IV, Random, 95% CI)	−1.88 [−2.84, −1.03]	p<0.0001	I^2=92%
1.3 Subgroups of essential oil types						
Lavender essential oil	6	512	MD (IV, Random, 95% CI)	−1.99 [−2.61, −1.37]	p<0.00001	I^2=87%
Peppermint essential oil	1	80	MD (IV, Random, 95% CI)	−0.47 [−0.98, −0.04]	P=0.07	NA
Orange scented essential oil	1	82	MD (IV, Random, 95% CI)	0.21 [−0.52, 0.94]	P=0.57	NA
Eucalyptus essential oil	1	80	MD (IV, Random, 95% CI)	−2.15 [−2.98, −1.31]	p<0.00001	NA
1.4 Subgroups of essential oil modes of action	8					
inhalation	7	574	MD (IV, Random, 95% CI)	−1.43 [−1.99, −0.87]	p<0.00001	I^2=88%
Topical application	2	754	MD (IV, Random, 95% CI)	−2.33 [−3.16, −1.51]	p<0.00001	I^2=51%

(*Continued*)

Table 2 (Continued).

Title	Number of Trials	Number of Participants	Statistical Method	Effect Size	Overall Effect, p Value	Heterogeneity I^2 Value
1.5 Subgroups of time of application of essential oils	7					
3 minutes.	2	188	MD (IV, Random, 95% CI)	−1.19 [−2.67, 0.28]	P=0.11	I^2=89%
5 minutes.	5	486	MD (IV, Random, 95% CI)	−1.77 [−2.43, −1.11]	p<0.00001	I^2=91%
2. Overall effect **(anxiety)**	6	515	SMD (IV, Random, 95% CI)	−0.92 [−1.71, −0.13]	P=0.02	I^2=94%
2.1 Subgroup analysis by type of control	6					
Placebo control	3	329	SMD (IV, Random, 95% CI)	−1.43 [−2.85 −0.01]	P=0.05	I^2=97%
Routine treatment	3	268	SMD (IV, Random, 95% CI)	−2.23 [−4.46, 0.00]	P=0.05	I^2=0%
2.2 Subgroup analysis of operation types	5					
Arteriovenous fistula-related operations	2	172	SMD (IV, Random, 95% CI)	−6.52 [−7.11, −5.92]	P<0.00001	I^2=0%
Catheter placement	3	263	SMD (IV, Random, 95% CI)	−0.24 [−0.85, 0.37]	P=0.44	I^2=84%
2.3 Subgroups of essential oil types	6					
Lavender essential oil	3	254	MD (IV, Random, 95% CI)	0.18 [−0.87, 1.24]	P=0.01	I^2=73%
Peppermint essential oil	1	80	MD (IV, Random, 95% CI)	0.18 [−0.26, 0.62]	P=0.42	NA
Orange scented essential oil	1	82	MD (IV, Random, 95% CI)	−0.28 [−0.72, 0.15]	P=0.20	NA
Eucalyptus essential oil	1	80	MD (IV, Random, 95% CI)	−0.29 [−0.73, 0.15]	P=0.20	NA
2.4 Subgroups of time of application of essential oils	4					
3 minutes.	2	106	SMD (IV, Random, 95% CI)	−0.25 [−0.81, 0.31]	P=0.37	I^2=39%
5 minutes.	2	228	SMD (IV, Random, 95% CI)	−1.67 [−3.89, 0.55]	P=0.14	I^2=98%
2.5 Subgroups of different anxiety scales	6					
VAS-A	2	181	MD (IV, Random, 95% CI)	−0.38 [−1.35, 0.59]	P=0.44	I^2=88%
STAI	4	515	MD (IV, Random, 95% CI)	−4.21 [−7.15, −1.26]	P=0.005	I^2=70%

Abbreviations: CI, confidence interval; MD, Mean Deviation; SMD, standardized mean difference; NA, not applicable; VAS-A, Visual analog scale for anxiety; STAI, State-Trait Anxiety Inventory.

operations, and the results of the meta-analyses showed the same results (n = 486, mean difference (MD) −1.59, 95% confidence interval (CI) −2.18 to −1.01, P < 0.00001, I^2 = 88%). 4 studies compared the effectiveness of inhalation aromatherapy combined with usual care compared with usual care alone for pain reduction.[34,35,37,38] All 4 studies showed that aromatherapy was able to reduce pain in patients. The results of the meta-analysis showed the same results (n = 306, mean difference (MD) −1.88, 95% confidence interval (CI) −2.26 to 1.05, P < 0.00001, I^2=35%) (Figure 4 and Table 2).

Subgroup Analysis Based on Type of Operation

There were 2 subgroups based on the type of operation. The forest plot of subgroup analyses is shown in Figure 5. 2 studies[33,37] were catheter insertion, SMD = −0.61, 95% CI (−1.03, −0.19), P = 0.19, I^2 = 43%. 4 studies[33,38–40] were arteriovenous fistula-related puncture, SMD = −1.93, 95% CI (−2.84, −1.03), P < 0.0001, I^2 = 90% (Figure 5 and Table 2).

Subgroup Analysis of Types of Essential Oils

According to the type of essential oil, lavender essential oil[33,34,37–40] (MD = −1.99, 95% CI [−2.61, −1.37], p<0.00001, I^2 = 87%), peppermint essential oil[32] (MD = −0.47, 95% CI [−0.98, −0.04], P = 0.07), and eucalyptus essential oil[37] (MD = 0.21, 95% CI [−0.52, 0.94], P = 0.57), and orange scent essential oil[35] (MD = −2.15, 95% CI [−2.98, −1.32], P < 0.00001). (Figure 6 and Table 2).

Subgroups According to the Mode of Action of Essential Oils

According to the different ways of applying essential oils, the included studies were divided into two main types: inhalation and topical application. Inhalation of essential oils[32,33,35,37–40] (MD = −1.43, 95% CI [−1.99, −0.87], P < 0.00001, I^2 = 88%), topical application of essential oils[34,40] (MD = −2.33, 95% CI [−3.16, −1.51], P < 0.00001, I^2 = 51%). (Figure 7 and Table 2).

Subgroups According to Time of Application of Essential Oils

The included studies were divided into two durations according to the duration of essential oil application: 3 minutes and 5 minutes. 3 minutes[37,38] (MD = −1.19, 95% CI [−2.67, 0.28], P = 0.0002, I^2 = 89%), and 5 minutes[32–34,39,40] (MD = −1.77, 95% CI [−2.43, −1.11], P < 0.00001, I^2 = 91%). (Figure 8 and Table 2).

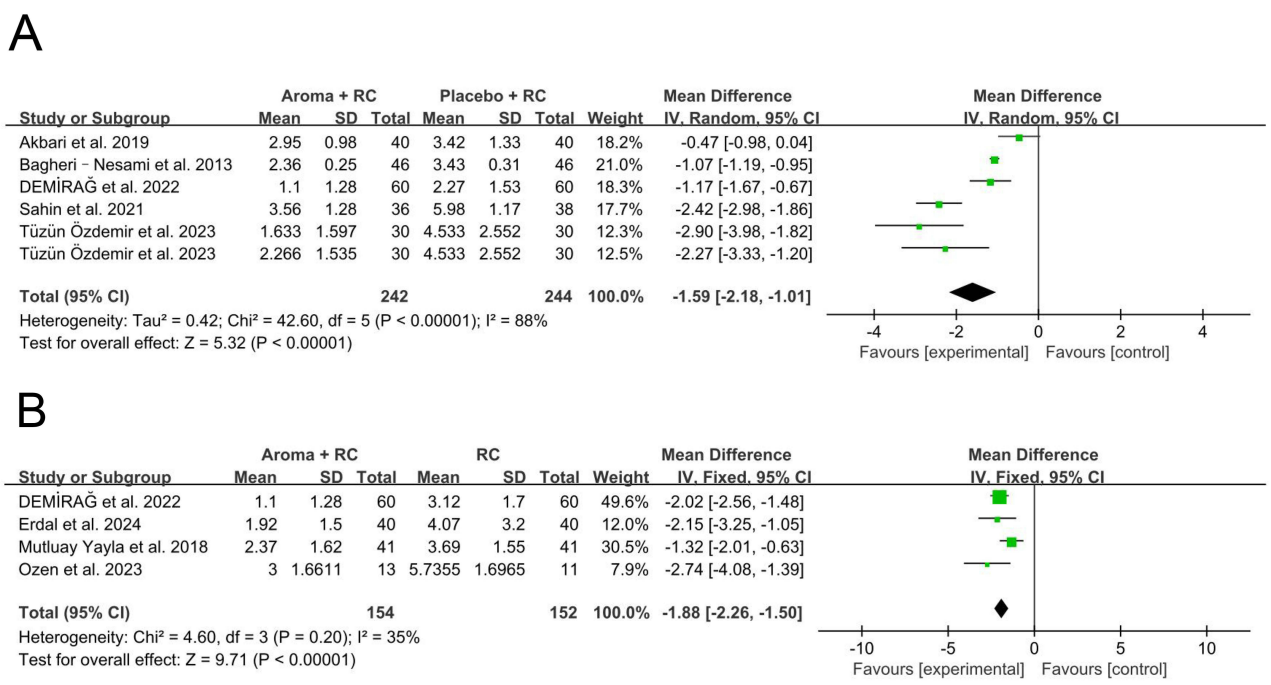


Figure 4 Forest plot of subgroup analysis of pain scores in different control groups. (**A**) Inhalation aromatherapy plus usual care vs placebo plus usual care. **(B)** Inhalation aromatherapy plus usual care vs usual care alone.

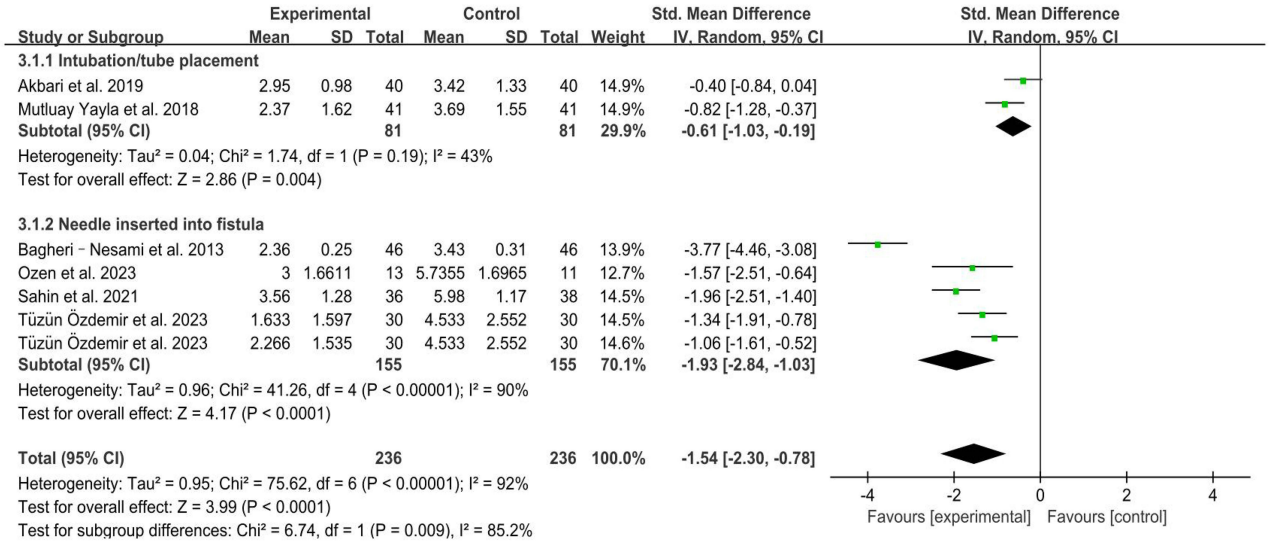


Figure 5 Forest plot of subgroup analyses of pain scores for different types of operations.

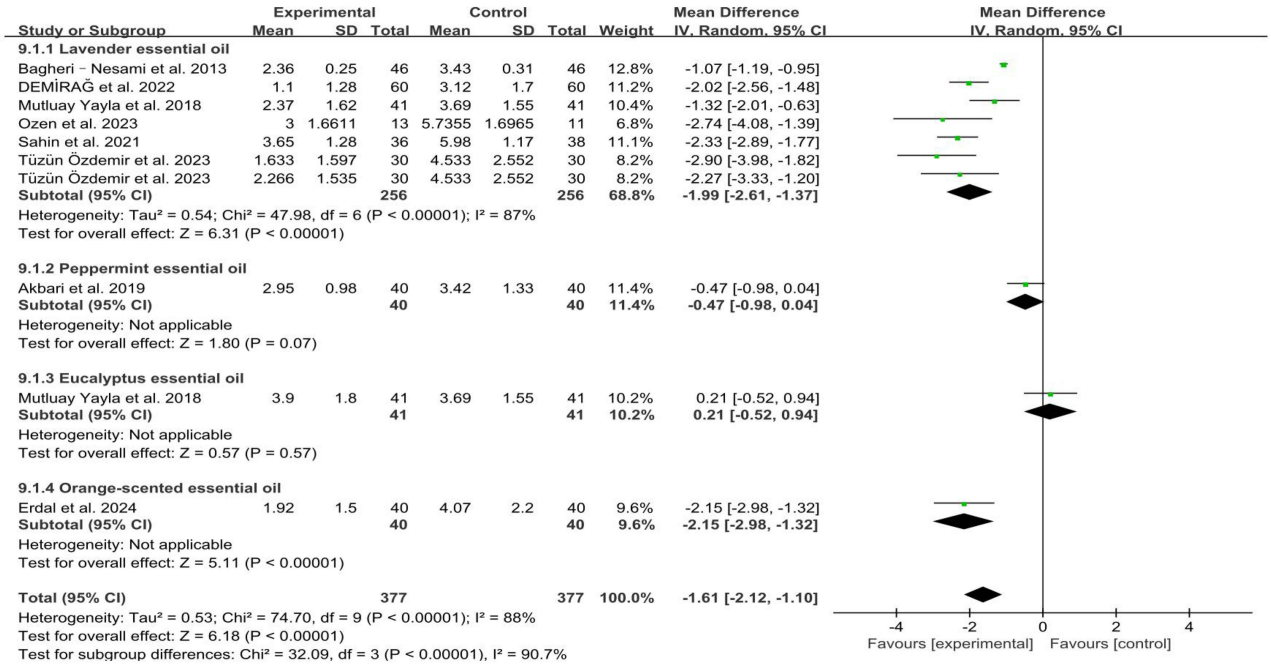


Figure 6 Forest plot for subgroup analysis of pain scores for different essential oil types.

Aromatherapy's Effect on Anxiety in Needle-Related Operations

Overall Effect of Anxiety Scores

A total of six studies (259 patients as an intervention group and 261 patients participating in the control group) reported on patient anxiety.[32,35–39] The overall effect showed that aromatherapy significantly reduced patients' anxiety levels compared to the control group (SMD = −092; 95% CI (−1.71, −0.13); P = 0.02). Heterogeneity was high (P < 0.00001, I^2 = 94%). Due to the high heterogeneity, we used a random effects model. (Figure 9 and Table 2).

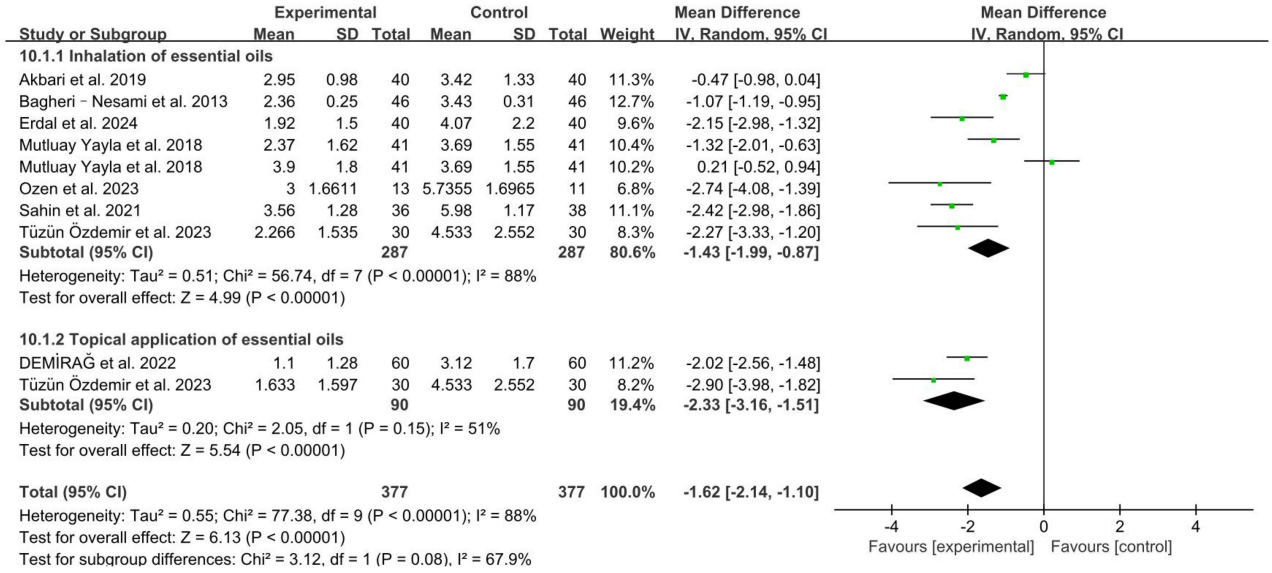


Figure 7 Forest plot of subgroup analyses of pain scores for different application types of essential oils.

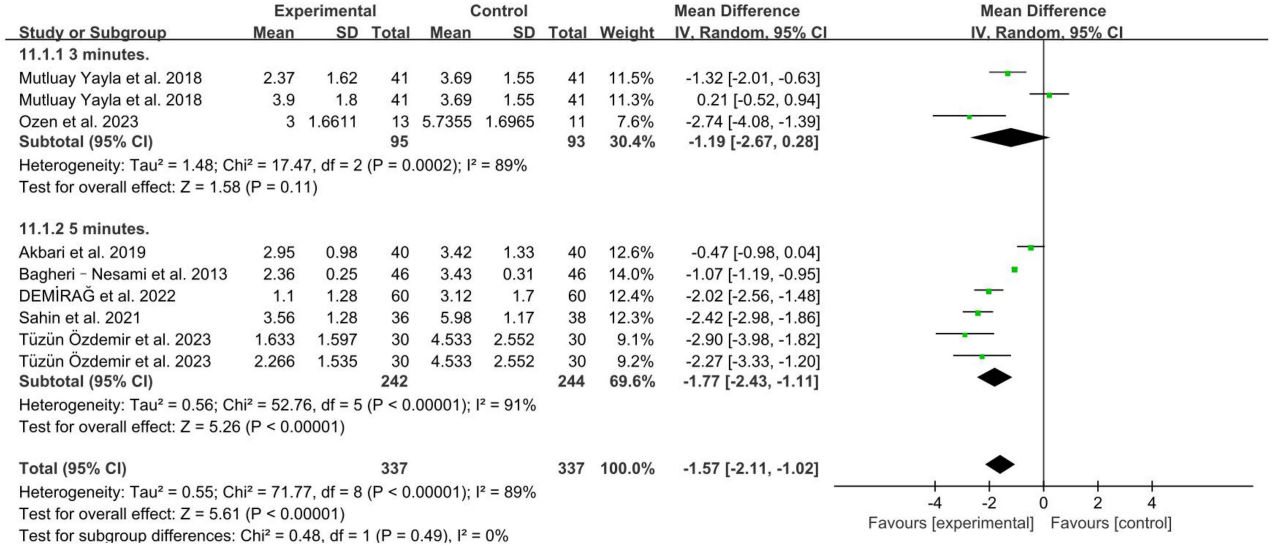


Figure 8 Forest plot of subgroup analyses of pain scores for different application duration.

Subgroup Analyses by Type of Control Group

3 studies tested the efficacy of inhaled aromatherapy plus usual care versus placebo plus usual care on patient anxiety.[32,36,39] The included studies differed in their evaluation metrics, applying SMD. All studies showed that inhalation aromatherapy plus usual care significantly reduced anxiety in adult patients undergoing needle-related operation, and meta-analysis results showed the same results (n = 334, Standardised Mean Difference (SMD) −1.43, 95% Confidence Interval (CI) −2.84 to −0.02, P = 0.05, I^2 = 97%, Figure 10A). 3 trials examined anxiety in inhalation aromatherapy combined with usual care compared with usual care alone.[35,37,38] The pooled results showed that inhalation aromatherapy plus usual care significantly reduced anxiety in patients requiring needle manipulation (n = 268, mean difference (MD) −2.23, 95% CI −4.41 to 0.00, P = 0.05, I^2 = 0%, Figure 10B). (Figure 10 and Table 2).

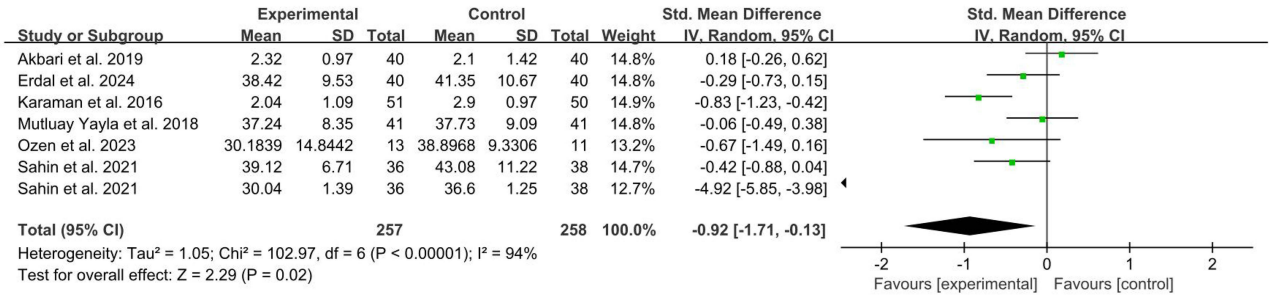
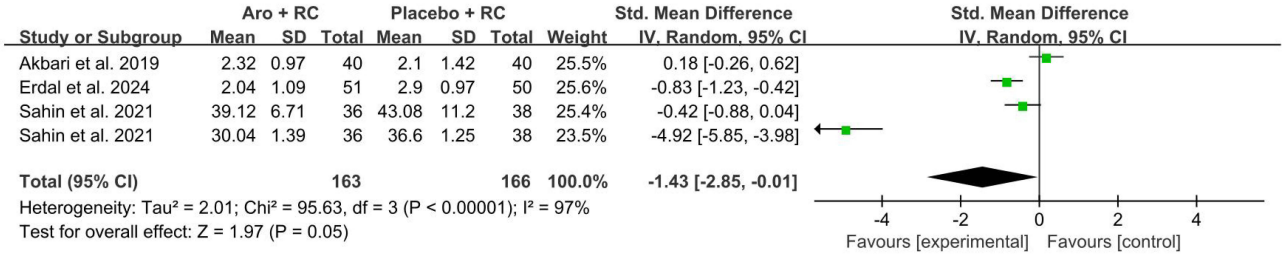


Figure 9 To compare the anxiety scores of patients in the aromatic and control groups.

(A) Inhalation aromatherapy plus usual care vs placebo plus usual care



(B) Inhalation aromatherapy plus usual care vs usual care alone

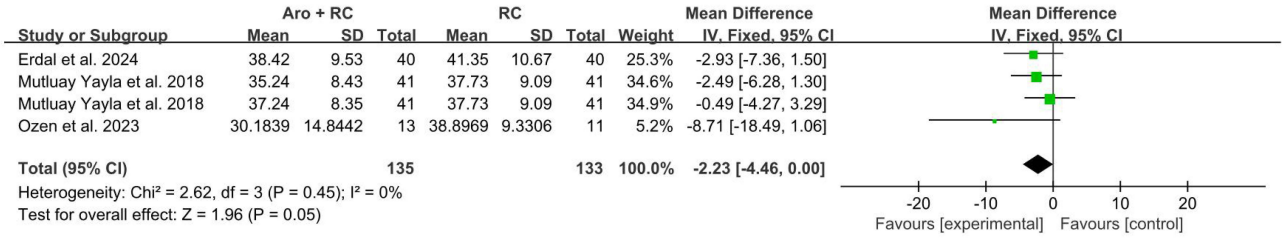


Figure 10 Forest plot of subgroup analysis of anxiety scores in different control groups. (**A**) Inhalation aromatherapy plus usual care vs placebo plus usual care. **(B)** Inhalation aromatherapy plus usual care vs usual care alone.

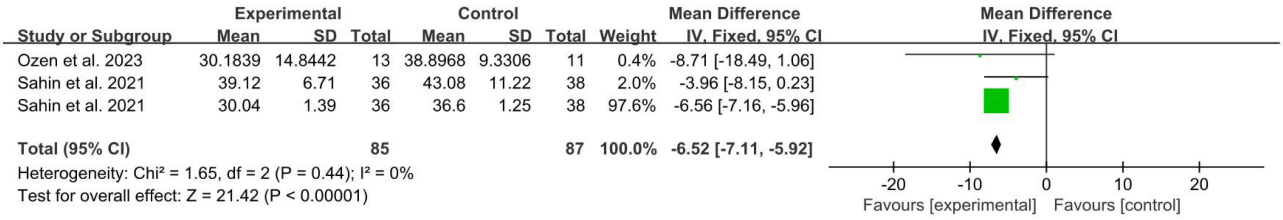
Subgroup Analysis Based on Type of Operation

The studies were divided into 2 subgroups based on the approximate type of operation. A forest plot of the subgroup analyses is shown in Figure 8. The 2 studies[38,39] were for arteriovenous fistula-related punctures, MD = −6.52, 95% CI (−7.11, −5.92), P < 0.00001, I^2 = 0%, respectively (Figure 11A). The 3 studies[32,36,37] were for catheter placement-related punctures, SMD = −0.24,95% CI (−0.85, 0.37), P = 0.44, I^2 = 84% (Figure 11B) (Figure 11 and Table 2).

Subgroup Analysis of Types of Essential Oils

Forest plots of anxiety scores according to the type of essential oil showed that lavender essential oil[37–39] (MD = −4.49, 95% CI [−7.96, −1.02], P = 0.01, I^2 = 73%), peppermint essential oil[32] (MD = 0.22, 95% CI [−0.31, 0.75], P = 0.42), eucalyptus essential oil[37] (MD = −2.49, 95% CI [−6.28, 1.30], P = 0.20) and orange essential oil[35] (MD = −2.93, 95% CI [−7.36, 1.50], P = 0.20). (Figure 12 and Table 2).

(A) Needle manipulation related to arteriovenous fistulae



(B) Needle stick operations related to catheter placement

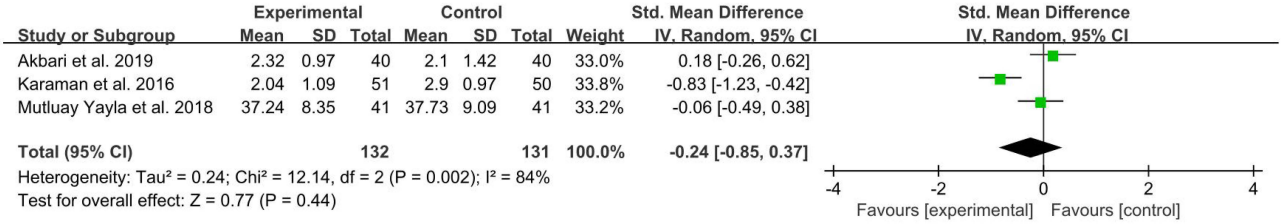


Figure 11 Forest plot of subgroup analyses of anxiety scores for different types of operations. (**A**) Needle manipulation related to arteriovenous fistulae. **(B)**Needle stick operations related to catheter placement.

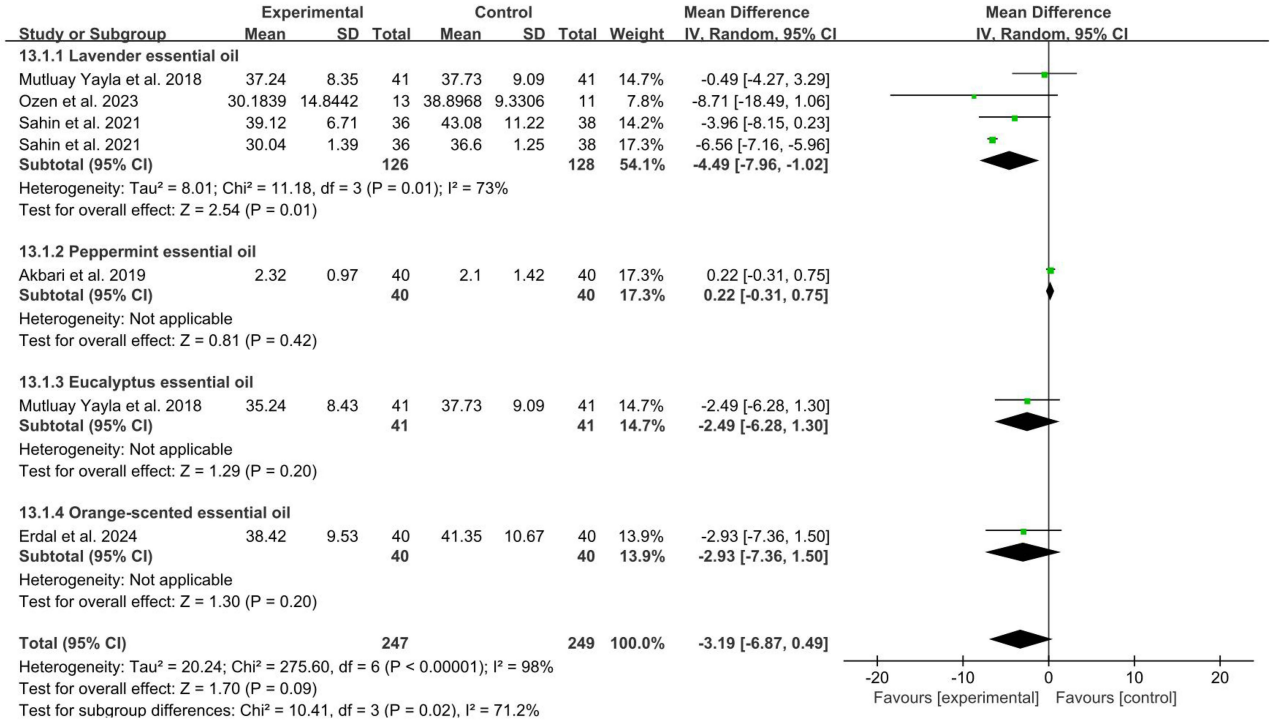


Figure 12 Forest plot for subgroup analysis of anxiety scores for different essential oil types.

Subgroups According to Time of Application of Essential Oils

Forest plots of anxiety scores derived from subgroups based on the duration of action of essential oils showed 3 minutes (SMD = −0.25, 95% CI [−0.81, 0.31], P = 0.37, I^2 = 39%), 5 minutes (SMD = −1.67, 95% CI [−3.89, 0.55], P = 0.14, I^2 =98%). (Figure 13 and Table 2).

Subgroup Analysis of Different Anxiety Scales

Forest plots of anxiety scores in subgroups based on different anxiety rating scales showed that the VAS group (MD = −0.38, 95% CI [−1.35, 0.59], P = 0.44, I^2 = 88%) and the STAI group (MD = −4.21, 95% CI [−7.15, −1.26], P = 0.005, I^2 = 70%). (Figure 14 and Table 2).

Satisfaction and Comfort Level

One study examined patient satisfaction, investigating patient satisfaction between aromatherapy and a distilled water placebo control, and the results were significant, increasing patient satisfaction (P = 0.03).[36] One study reported on patient comfort and the results were significant, indicating that inhalation of lavender increased patient comfort (P < 0.05).[39]

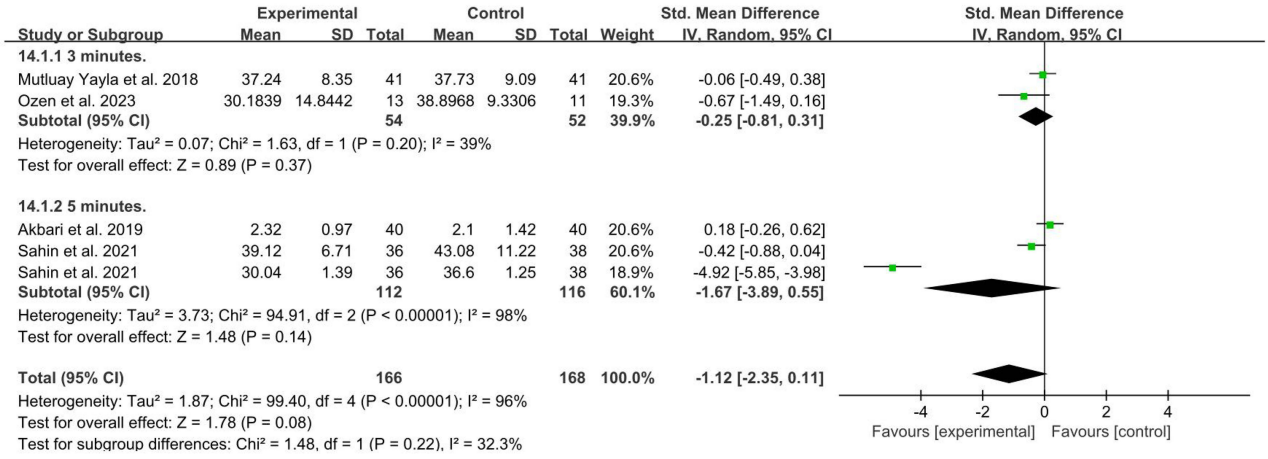


Figure 13 Forest plot of subgroup analyses of anxiety scores for different application duration.

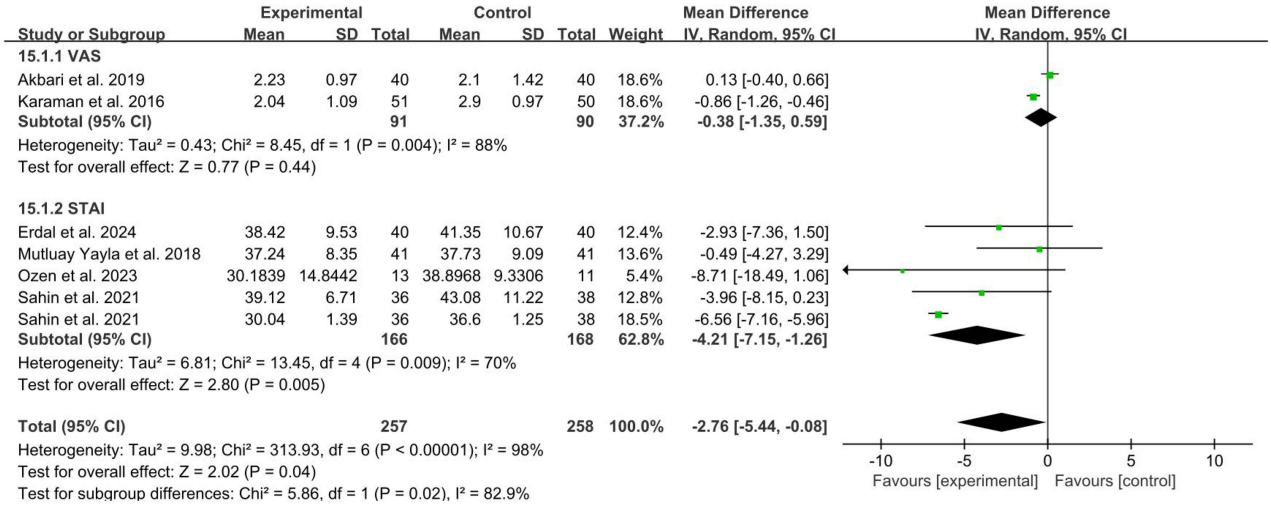


Figure 14 Forest plot of subgroup analysis of anxiety scores under different anxiety scales.

https://doi.org/10.2147/JPR.S533076

Adverse Events and Reactions

The occurrence of adverse events and adverse reactions was not reported in the included studies.

Publication Bias

A funnel plot was constructed, and Egger's test was performed to analyze publication bias. Due to the small number of included studies, the funnel plot results may be biased. Therefore, we also performed Egger's test on the primary outcome measures (pain, anxiety). Egger's test, pain: P=0.118>0.05, anxiety: P=0.070>0.05, indicating no publication bias.

Quality of Evidence

Supplementary Table 1 shows that the quality of evidence for pain scores and anxiety scores was low. Sensitivity analyses of pain and anxiety outcomes in the included studies showed that the overall effect sizes of the analyzed studies remained generally consistent, suggesting that the results of the meta-analyses were reliable.

Discussion

To the best of our knowledge, our meta-analysis is a novel study examining the effectiveness of aromatherapy in reducing pain and anxiety in adult patients undergoing needle-related operation. By evaluating nine randomised controlled trials (involving 748 patients), we found that aromatherapy has the potential to be an influential tool for reducing pain and anxiety in adult patients undergoing needle-related operation in a variety of healthcare settings.[32–40]

To date, needle-related manipulation is an indispensable tool for treatment and diagnosis in the clinical setting and reaches a large audience. Needle-related operations are painful and can cause anxiety and needle phobia in patients. Needle-related anxiety, pain, and discomfort tend to reduce patient compliance, which delays timely diagnosis and treatment of disease. Non-pharmacological therapies are one way to alleviate the painful experience of patients with needling.[41] Aromatherapy is a non-pharmacological treatment, a simple and inexpensive method to reduce anxiety and pain in patients.

Analysis of Results

The results of the study focused on pain scores and anxiety scores, and the overall pooled results showed that aromatherapy reduced pain and anxiety in adult patients undergoing needle procedures. We then conducted a series of subgroup analyses of the included randomized controlled studies. The subgroups were analyzed primarily on the basis of the type of control intervention, the type of manipulation, the type of essential oils, the mode of action of the essential oils, and the duration of action of the essential oils.

Results from 9 randomized controlled trials comprising 748 participants showed that aromatherapy significantly reduces pain in patients undergoing needling-related operations compared to placebo-controlled, usual care. This conclusion is consistent with previous studies that have mentioned that aromatherapy can reduce pain in patients.[42] The mechanism by which aromatherapy reduces pain and increases well-being is that it stimulates the body to produce neurotransmitters.[24]

With regard to the effect on pain, the included studies can be broadly categorized according to the type of operation into catheter placement and operations related to arteriovenous fistula puncture, and the results show that both reduce pain in patients. The results in the subgroup of tube placement showed P=0.04, and the results in the operation related to arteriovenous fistula puncture showed P<0.0001, and the results were all significantly different. However, several of the included studies were not analyzed in subgroups because of the number of studies, and future studies could add relevant studies to verify their validity.

Studies have shown that more than 40 derivatives can be used as aromatic agents for therapeutic purposes, but the most common are lavender, peppermint, chamomile, and eucalyptus.[42] A subgroup analysis showed that lavender essential oil and orange-scented essential oil significantly reduced pain in patients, while peppermint essential oil and eucalyptus essential oil had non-significant results for pain reduction. However, peppermint essential oil and eucalyptus essential oil were included in only one study, and the results for the subgroups may not be robust and need to be validated by including more studies. Based on the results, we can see that the types of essential oils may produce different results.

Essential oils work by inhalation, massage, oral intake, topical application, and more.[43] Depending on the mode of action of the essential oil, the subgroups can be divided into inhalation and topical dermal application. The results

showed that both inhalation and topical application reduced patients' pain, but the included studies were heterogeneous due to inconsistencies in the type of operation. In addition, the included studies had only two methods, inhalation and topical application, and did not discuss both oral and massage modalities. In addition, for the subgroups of duration of action, the intervention time was mainly divided into 3 and 5 minutes based on the inclusion of the study, and the results showed that both durations of action, were able to reduce the pain of the patients.

A series of subgroup analyses have also been conducted on aromatherapy for anxiety reduction. The pathophysiological effects of aromatherapy on anxiety are not yet clear, and most current explanations are that odors stimulate the cerebral cortex to reduce anxiety.[43] Depending on the control group, the effects of aromatherapy were shown to reduce patient anxiety when the control group was placebo; however, the effects of aromatherapy did not differ from usual care when the intervention in the control group was usual care. We consider that the characteristics of the sample may have influenced the insignificant results in this study. We considered the possibility that the characteristics of the sample may have influenced the results of the study. For the subgroup analysis of the results of this study on anxiety, the heterogeneity remained high in the group where the control group was placebo plus routine operations. We considered the different scoring intervals for the different indicators used to assess patients' anxiety, with two studies having the VAS-A as the measurement tool and the other having the STAI-T and STAI-S as the assessment criteria, as well as the different types of disease in the patients, among other things, but the main reason for the difference in the assessment indicators was taken into account. In addition, we should consider whether the relationship between anxiety and pain could be further analysed in a discussion.

Subgroups according to the type of procedure showed that aromatherapy reduced anxiety in patients with arteriovenous fistulae performing needle manipulation, but the results of the effect on anxiety levels in patients with catheter placement were negative. The reasons for this may be: the baseline level of anxiety in patients with catheter placement was high and aromatherapy may not be effective in reducing anxiety in patients, and we believe that virtual reality therapy, massage therapy, and music therapy can be added to aromatherapy; or it may be due to the limited number of included studies and the lack of limited evidence of its effectiveness.

In the subgroup analyses based on the type of essential oil, lavender essential oil was shown to be effective in reducing anxiety in patients. The poor effectiveness of the other essential oils in reducing anxiety in patients may be due to the small number of studies included for each of the three essential oils, which were each included in only one study. In addition, anxiety is also highly correlated with factors such as an individual's personality, but the use of one assessment criterion does not effectively and accurately assess a patient's level of anxiety.

In the duration of action subgroup, the results showed that 5 minutes was more effective than 3 minutes in reducing patients' anxiety. In addition, the analysis based on the subgroup of pain showed that both durations of action reduced patients' pain. We consider 5 minutes to be the optimal duration of action, but trials are needed to validate this prediction.

In subgroups of different anxiety scales, the study results showed that the STAI group was effective in alleviating patients' anxiety, while the VAS-A group showed poor results in alleviating anxiety. The poor results may be related to the small number of studies included and the subjective nature of the VAS-A scoring criteria.

Contradictory results across different studies may stem not only from methodological differences but also from contextual factors. The acceptance of aromatherapy in different cultures and patients' expectations of complementary therapies may significantly influence the observed efficacy. Future studies should clearly document these variables to elucidate their mechanisms of action.

Aromatherapy demonstrates efficacy for pain relief across needle-related procedures (eg, catheter insertion, arteriovenous fistula puncture), though with notable heterogeneity For anxiety reduction, significant benefits are confined to arteriovenous fistula contexts, while evidence regarding catheter insertion remains inconclusive. Given the overall low-quality evidence and methodological limitations, aromatherapy could be explored as a supplementary intervention in specific clinical scenarios. The implementation of clinical measures lies in the introduction of new policies, and appropriate policies should be clinically outlined in the future for this therapeutic option. Transferring the latest evidence on the use of aromatherapy to clinical staff with favourable outcomes. Therefore, future research should use scientifically standardised protocols for aromatherapy interventions to specify the optimal settings of type, concentration, temperature, etc. of aromatic essential oils for different populations. The type of aromatherapy and the setting of data need to be decided by professionals, adjusting to the patient's condition, environment, and mood, among other factors. Relevant

future research could explore the effects of different aromatic essential oil types and the optimal essential oil concentrations to apply to different clinical manoeuvres. In addition, future studies could incorporate assessment metrics such as heart rate, blood pressure, and comfort. We aspire for further development of aromatherapy as it gains traction in the field of needle-related procedures for adult patients. Ultimately, we envision the development of sophisticated biofeedback systems that enable closed-loop management of pain and anxiety, ensuring that patients receive care in a more comfortable and supportive environment.

Aromatherapy may be a method for alleviating pain associated with needle-related procedures and significantly reducing anxiety in arteriovenous fistula puncture scenarios, but its effectiveness in reducing anxiety during catheter insertion procedures remains unclear. Nevertheless, given the generally low quality of the studies examined and the limited evidence available, further well-structured randomised controlled trials are needed to validate our findings.

Analysis of Heterogeneity

We summarised the results for pain and anxiety and found high heterogeneity. Therefore, we conducted a heterogeneity analysis based on differences in the control group intervention methods, surgical types, essential oil types, essential oil application methods, essential oil application times, and anxiety score indicators. Despite extensive subgroup analyses, high heterogeneity persists, indicating unresolved confounding factors beyond conventional stratification. High residual I^2 values reflect genuine clinical diversity rather than methodological flaws, suggesting aromatherapy's effects are context-dependent. This necessitates flexible implementation strategies.

Strengths and Limitations

This meta-analysis and systematic evaluation of ours has several strengths and limitations. Firstly, one of our main strengths was the comprehensive integration and screening of published literature from multiple databases to assess the effectiveness of aromatherapy in reducing pain and anxiety in adult patients undergoing needle-related operation. In addition, we not only analyzed the included studies as a whole but further analyzed them according to the different control groups studied. And the types of included studies were randomized controlled studies with good internal veracity. However, there were some limitations to this study that affected the results to some extent. First, some of the included RCTs did not describe their specific blinded implementation in detail and most of the included trials were single-blinded, which may have affected the reliability of the joint results. Second, the type of needle-related manipulation varied among the included randomised controlled trials, which may have contributed to the observed heterogeneity and thus weakened the robustness of our findings. Third, the number of randomised controlled studies for subgroup analyses was low in some studies, and more randomised controlled studies with large samples are needed in the future to improve the reliability of the results. Fourth, there were differences in measurement tools and data collection time points across the included studies. Given its objectives, the true effect of aroma on the duration of pain and anxiety cannot yet be fully assessed; therefore, it is recommended that future studies include data collection for this variable. Fifth, although our search covered studies from multiple countries, studies from specific regions (such as Turkey and Iran) dominated, limiting the generalizability of the study results across different cultures and healthcare settings. Future studies must prioritize diverse sociocultural settings to establish universal applicability.

Conclusion

This systematic review and meta-analysis suggests that aromatherapy may reduce pain associated with needle-related procedures and alleviate anxiety in some patients. These findings offer promising support for aromatherapy as a complementary, non-pharmacological intervention. However, these conclusions should be interpreted with caution due to variability in study quality, high heterogeneity, and limited sample sizes. Further high-quality randomized controlled trials are essential to confirm these effects and establish standardized clinical protocols for broader implementation.

Abbreviations

RCTs, randomized controlled trials; MD, Mean difference; SMD, Standard Mean difference; CI, confidence interval; NA, not applicable; VAS-P, Visual analog scale for pain; VAS-A, Visual analog scale for anxiety; STAI, State-Trait Anxiety Inventory; NRS, Numeric rating scale; VCS, Verbal category scale; I, intervention group; C, control group.

Data Sharing Statement

All data generated or analysed during this study are included in this paper.

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Author Contributions

Chenxi Sun, Changdong Fei and Ronghua Lin contributed equally to this manuscript as co-first author. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

There are no financial/personal interests or beliefs that could affect their objectivity.

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