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Effect of Combined Stress Ball and Lavender Aromatherapy on Cannulation-Related Anxiety in Hemodialysis Patients: A Randomized Controlled Trial

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ABSTRACT

Objective: This study aimed to evaluate the effect of combined stress-ball squeezing and lavender aromatherapy on arteriovenous fistula cannulation-related anxiety among maintenance hemodialysis patients.

Methods and Materials: A prospective, parallel-group, single-blind randomized controlled trial was conducted in two dialysis centers between December 2025 and February 2026. Eighty hemodialysis patients were randomized to intervention (n = 42) or control (n = 38) groups using dialysis-day cluster allocation. After eight dropouts, 72 participants completed the study and were analyzed per protocol, with 36 patients in each group. The intervention group received lavender oil inhalation and stress-ball squeezing during AVF cannulation across six sessions, while the control group received conventional care. Anxiety was measured immediately before and two minutes after cannulation using the Visual Analogue Scale for Anxiety. Data were analyzed using Mann–Whitney U, Friedman, and related non-parametric tests, with rank-biserial correlation as effect size.

Findings: Baseline sociodemographic and clinical characteristics were comparable between groups. By Session 6, median pre-cannulation anxiety was lower in the intervention group than the control group, 3.3 versus 4.3, respectively, with a between-group difference of 1.0, $p < .001$, 95% CI [0.81, 1.19], rank-biserial correlation = .82. Median post-cannulation anxiety was also lower in the intervention group, 2.6 versus 4.0, with a between-group difference of 1.4, $p < .001$, 95% CI [1.15, 1.65], rank-biserial correlation = .86. No intervention-related adverse events were reported.

Conclusion: Combined stress-ball squeezing and lavender aromatherapy safely reduced cannulation-related anxiety in hemodialysis patients.

Keywords: Hemodialysis, Cannulation Anxiety, Stress Ball, Lavender Aromatherapy, Randomized Controlled Trial.

Introduction

Hemodialysis is the most common renal replacement therapy for end-stage renal disease worldwide, making reliable long-term vascular access typically an arteriovenous fistula (AVF) essential (Al-Waeli & Hattab, 2026). Anxiety is a clinically important comorbidity in chronic illness and is especially common in chronic kidney disease, where it can worsen symptom burden, coping, and quality of life (Huang et al., 2021; Stein & Craske, 2017). In hemodialysis units, repeated invasive procedures intensify distress, and AVF cannulation is frequently identified as a major trigger of acute procedure-related anxiety (Ibrahim et al., 2022).

While much research has focused on cannulation pain, needle-related anxiety independently worsens the procedural experience and may persist despite repeated exposure to treatment (Duncanson et al., 2023; Ng et al., 2015). Focusing specifically on anxiety is crucial because anticipatory worry directly exacerbates sympathetic arousal, complicates the cannulation process, and reduces overall treatment tolerance. Consequently, effective, ongoing supportive strategies are required to manage this psychological burden over time.

Because AVF cannulation is repeated regularly, brief chairside interventions that do not disrupt workflow are particularly valuable; therefore, non-pharmacological approaches are often preferred due to their low cost, acceptability, and feasibility (Alzaatreh & Abdalrahim, 2020). This is especially relevant in Iraqi hemodialysis settings, where practical, easily implemented interventions are needed to overcome the distress and uncertainty associated with repeated care encounters (Jassem & Al-Ashour, 2023).

Active distraction, such as using a stress ball, is a practical option supported by evidence that attentional engagement can reduce procedural distress (Moont et al., 2010). This effect is conceptually grounded in the gate control theory. While traditionally applied to pain, the non-noxious tactile stimulation from squeezing a stress ball competes with nociceptive input at the spinal dorsal horn, effectively reducing ascending sensory threat signals. Crucially, this attenuation of perceived threat directly mitigates the central nervous system arousal and anticipatory anxiety associated with the needle insertion.

Concurrently, lavender (Lavandula) aromatherapy has shown anxiolytic potential in hemodialysis, with inhalation associated with reduced anxiety and improved sleep quality (Şentürk & Kartın, 2018). Experimental and pharmacologic findings support plausible anxiety-modulating mechanisms through central nervous system targets (López et al., 2017; Schuwald et al., 2013). However, the evidence is not entirely uniform; for instance, some trials have reported no significant anxiolytic effect of lavender oil in hemodialysis patients (Bagheri-Nesami et al., 2017). This inconsistency suggests that a single unimodal intervention may not always be sufficiently potent, highlighting the need for combined approaches.

Managing procedural distress through non-pharmacological methods is gaining traction in acute and chronic care settings. For instance, the use of aromatherapy has been shown to successfully alleviate acute procedural discomfort during invasive vascular procedures (AL-Mussawi & Baqer, 2024). Similarly, within hemodialysis care, applying physical and sensory-based interventions has proven effective in mitigating the specific distress associated with AVF needle insertion (Al-Waeli & Hattab, 2026). Building on these principles, combining a stress ball with lavender aromatherapy presents a novel, dual-pathway intervention model. However, despite the growing evidence supporting individual complementary strategies, the specific clinical effect of combining active tactile distraction (stress ball) with olfactory relaxation (lavender) on AVF cannulation-related anxiety remains under-investigated, representing a clear research gap.

Therefore, this trial was designed to fill this gap. The primary aim of this study is to evaluate the effect of combined stress ball squeezing and lavender aromatherapy on AVF cannulation-related anxiety in maintenance hemodialysis patients. The primary hypothesis is that hemodialysis patients receiving the combined intervention will experience significantly lower pre- and post-cannulation anxiety across repeated sessions compared to patients receiving conventional care.

Methods and Materials

Study design and setting

We conducted a prospective, parallel-group, cluster-allocated randomized controlled trial to determine the effect of stress ball squeezing and lavender oil on anxiety during arteriovenous fistula (AVF) cannulation in maintenance hemodialysis patients. Due to the physically recognizable nature of the intervention (olfactory and tactile stimuli), participant and provider blinding was not feasible; therefore, a rigorous single-blind approach was utilized wherein only the data analyst was blinded to group allocation. The study was conducted at Al-Fallujah Teaching Hospital Dialysis Center and Al-Amiriya Dialysis Center between December 2025 and February 2026. A detailed flow diagram indicating enrollment, allocation, follow-up, and analysis (Figure 1).

Sample and participants

The study enrolled maintenance hemodialysis patients undergoing routine AVF cannulation. Inclusion criteria included: age ≥18 years; clinically stable on thrice-weekly hemodialysis via a functioning AVF; ability to provide consent and reliably report anxiety; ability to squeeze a stress ball; and no scent-aggravated respiratory conditions. Exclusion criteria involved active access-site complications, severe cognitive limitations, and recent use of sedatives or anxiolytics. While excluding patients using anxiolytics may slightly reduce generalizability to the most highly anxious hemodialysis populations, it was a necessary methodological step to prevent pharmacological confounding of the primary acute anxiety outcome.

Sampling and randomization

Proportional stratified sampling was used to recruit eligible patients, ensuring each center contributed a quota proportional to its patient volume. Because dialysis units operate in open halls with fixed schedules, individual randomization would risk severe cross-contamination of the lavender scent and expectancy bias among control patients. Therefore, randomization was conducted at the dialysis-day cluster level. Patients scheduled for Saturday–Monday–Wednesday and those for Sunday–Tuesday–Thursday formed two natural clusters. These clusters were randomly allocated to either the intervention or control arm via an opaque-envelope draw by an independent nurse not involved in outcome assessment, ensuring cluster-level allocation concealment.

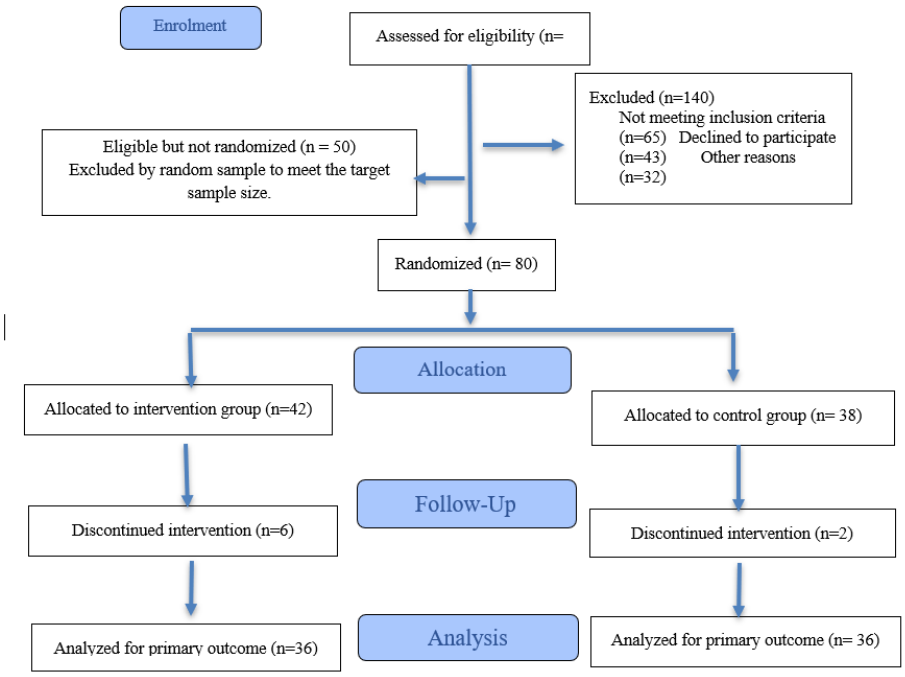

Figure 1

CONSORT Flow Diagram

Sample size

The minimum sample size was calculated using G*Power (version 3.1.9). The expected standardized mean difference (Cohen's d = 0.71) was explicitly derived from pooled effect sizes reported in previous randomized trials evaluating lavender and tactile distraction for cannulation distress in hemodialysis (e.g., (Şahin et al., 2021; Tosun et al., 2025). Using a two-tailed independent-samples comparison (α = 0.05, power = 0.80, allocation ratio 1:1), the required size was 64 participants. Accounting for an anticipated 20% attrition rate, the final recruitment target was set at 80 participants.

Instruments

Sociodemographic and Clinical Data

This section collects baseline sociodemographic information (age, sex, marital status, education, occupation, residence [urban/rural], smoking status and cigarettes/day if applicable, alcohol use, and anthropometric measures: height, weight, and BMI). It also records baseline clinical characteristics, including medical history (e.g., hypertension, diabetes, heart disease, other conditions), surgical history (e.g., appendectomy, nephrectomy, parathyroidectomy, other surgeries), medication history (e.g., antihypertensives, analgesics, antipsychotics, other drugs), and vascular access related data (fistula site and age, hemodialysis duration, access side, and dialysis shift).

visual analogue scale for Anxiety (VAS-A)

Anxiety was measured using the Visual Analogue Scale for Anxiety (VAS-A), a 10-cm line anchored by "No anxiety" and "Worst possible anxiety". The anchors were linguistically validated and culturally adapted for Iraqi Arabic speakers. While the VAS-A is a single-item tool with limited psychometric depth compared to multi-item questionnaires, it was deliberately selected because it is highly sensitive for rapid, repeated chairside screening and minimizes assessment burden during acute procedural stress without causing patient fatigue.

Data collection

Following ethical approval and informed consent, baseline anxiety was recorded. The control group received conventional care, operationally defined as standard skin preparation and routine verbal instructions by the nursing staff, without any structured physical distraction or olfactory stimuli. In the experimental group, a standardized lavender protocol was applied to maintain consistency across sessions. Lavender essential oil diluted with sweet almond oil (1:10) was administered via inhalation. Exactly two drops were applied to a sterile gauze held 5 cm from the patient's nose. This localized application, combined with the cluster-day randomization in a ventilated hall, effectively prevented ambient scent contamination and protected staff behavior and control patients from expectancy effects. Concurrently, participants squeezed a standardized soft stress ball using the hand contralateral to the AVF. Interventions commenced five minutes before needle insertion and concluded upon procedure completion. Outcome timing was highly specific: anxiety was measured immediately pre-cannulation and exactly two minutes post-cannulation. The two-minute post-cannulation mark was strategically justified to capture the acute, residual peak of penetration-related emotional arousal before habituation or general treatment fatigue occurred. Assessments were consistently repeated across six sessions.

Data Analysis

Data analysis was performed using SPSS (version 26.0). Because some participants discontinued the intervention, a completer-only (per-protocol) analysis strategy was employed, analyzing only the data of the 72 participants who completed all six sessions. Missing data from dropouts were excluded. Baseline comparability between the clustered groups was assessed using independent t-tests and Chi-square/Fisher's exact tests. To account for the dependency of correlated observations created by repeated assessments across the six sessions, non-parametric equivalents for repeated measures were utilized. The Mann–Whitney U test was used for between-group comparisons at specific time points, with the Rank-Biserial Correlation calculated to report effect sizes for the primary outcomes. The Friedman test was employed to assess within-group session variance over time. When evaluating within-subject reductions across the multiple sessions, the Bonferroni correction was formally applied to adjust the alpha level for multiple pairwise comparisons (comparing Session 6 against Sessions 1-5) to prevent Type I error inflation. Results were considered statistically significant at α = 0.05 (two-tailed).

Ethical considerations

The study proposal was reviewed and approved by the relevant academic and administrative bodies at the University of Baghdad, College of Nursing, and official permissions were obtained to conduct the study at Al-Amiriya Dialysis Center (Al-Amiriya General Hospital) and Al-Fallujah Dialysis Center (Al-Fallujah Teaching Hospital) under the Al-Anbar Health Directorate. Ethical approval was granted by the Research Ethics Committee (Approval No. 40, 25/11/2025). The trial was registered in the Chinese Clinical Trials Registry (ChiCTR2500114232; 09/12/2025). Written informed consent was obtained from all participants before enrollment. Participation was voluntary, and participants could withdraw at any time without penalty or any effect on their care.

Findings and Results

A total of 80 hemodialysis patients were initially randomized. Following post-randomization exclusions due to discontinued intervention, 8 patients dropped out (6 in the intervention group and 2 in the control group). The final per-protocol analysis included 72 participants (36 in each group). This attrition did not severely disrupt the overall baseline comparability; however, marginal, non-significant imbalances were observed regarding diabetes prevalence and AVF age between the two groups (Table 1 and Table 2).

Table 1

Distribution of sociodemographic characteristics of hemodialysis patients by group.

Variable	Intervention (n=36)	Control (n=36)	p
Age (years)	48.11 ± 10.09	49.22 ± 10.15	0.643
Sex			0.336
Female	17 (47.2%)	12 (33.3%)	
Male	19 (52.8%)	24 (66.7%)	
Marital status			0.659
Divorced	4 (11.1%)	4 (11.1%)	
Married	24 (66.7%)	22 (61.1%)	
Separated	1 (2.8%)	1 (2.8%)	
Single	4 (11.1%)	8 (22.2%)	
Widowed	3 (8.3%)	1 (2.8%)	
Education level			0.070
Illiterate	5 (13.9%)	8 (22.2%)	
Intermediate	9 (25.0%)	2 (5.6%)	
Primary	7 (19.4%)	9 (25.0%)	
Reads & writes	4 (11.1%)	8 (22.2%)	
Secondary	10 (27.8%)	5 (13.9%)	
University	1 (2.8%)	4 (11.1%)	
Occupation			0.882
Government employee	15 (41.7%)	18 (50.0%)	
Homemaker	5 (13.9%)	5 (13.9%)	
Private sector employee	13 (36.1%)	10 (27.8%)	
Retired	3 (8.3%)	3 (8.3%)	
Residence			0.330
Rural	16 (44.4%)	11 (30.6%)	
Urban	20 (55.6%)	25 (69.4%)	
Smoker			1.000
No	27 (75.0%)	26 (72.2%)	
Yes	9 (25.0%)	10 (27.8%)	
Cigarettes/day			0.767
<10	4 (11.1%)	6 (16.7%)	
>10	5 (13.9%)	4 (11.1%)	
-	27 (75.0%)	26 (72.2%)	
Alcohol			0.115
No	36 (100.0%)	32 (88.9%)	
Yes	0 (0.0%)	4 (11.1%)	

Note. Values are presented as mean ± SD for continuous variables and n (%) for categorical variables. P values for continuous variables were calculated using an independent-samples t-test. P values for categorical variables were calculated using the chi-square test or Fisher's exact test, as appropriate.

Table 1 shows that 72 participants were equally allocated to the intervention and control groups (n = 36 each). The groups were comparable in baseline sociodemographic characteristics: mean age was 48.11 ± 10.09 vs. 49.22 ± 10.15 years (p = 0.643), and sex distribution did not differ significantly (p = 0.336). Marital status (predominantly married) was similar between groups (p = 0.659), and education level revealed no significant difference, but it came close (p = 0.070). The same was true for occupation and residence (p = 0.882 and 0.330, respectively). Alcohol use was rare (p = 0.115), and there was no significant difference in cigarette consumption or smoking status across groups (p = 1.000 and p = 0.767). Baseline characteristics were generally equal between groups.

Table 2

Distribution of clinical characteristics of hemodialysis patients by group.

Variable	Intervention (n=36)	Control (n=36)	p
Height (cm)	165.19 ± 8.68	164.86 ± 8.42	0.869
Weight	74.33 ± 10.26	75.56 ± 13.78	0.671
BMI	27.52 ± 5.20	28.05 ± 6.02	0.691
AVF age (months)	39.67 ± 14.02	45.19 ± 13.41	0.092
Dialysis duration (months)	85.89 ± 27.68	89.06 ± 22.79	0.598
Hypertension			0.814
No	18 (50.0%)	17 (47.2%)	
Yes	18 (50.0%)	19 (52.8%)	
Diabetes			0.077
No	28 (77.8%)	21 (58.3%)	
Yes	8 (22.2%)	15 (41.7%)	
Heart disease			1.000
No	33 (91.7%)	32 (88.9%)	
Yes	3 (8.3%)	4 (11.1%)	
Other disease			0.478
No	33 (91.7%)	30 (83.3%)	
Yes	3 (8.3%)	6 (16.7%)	
Appendectomy			0.710
No	31 (86.1%)	33 (91.7%)	
Yes	5 (13.9%)	3 (8.3%)	
Nephrectomy			0.614
No	33 (91.7%)	35 (97.2%)	
Yes	3 (8.3%)	1 (2.8%)	
Parathyroidectomy			0.493
No	36 (100.0%)	34 (94.4%)	
Yes	0 (0.0%)	2 (5.6%)	
Other surgery			0.357
No	32 (88.9%)	35 (97.2%)	
Yes	4 (11.1%)	1 (2.8%)	
Antihypertensive meds			1.000
No	15 (41.7%)	15 (41.7%)	
Yes	21 (58.3%)	21 (58.3%)	
Analgesics			0.586
No	28 (77.8%)	26 (72.2%)	
Yes	8 (22.2%)	10 (27.8%)	
Antipsychotics			0.493
No	34 (94.4%)	36 (100.0%)	
Yes	2 (5.6%)	0 (0.0%)	
Other medication			0.384
No	30 (83.3%)	27 (75.0%)	
Yes	6 (16.7%)	9 (25.0%)	
AVF site			0.405
Brachiocephalic	29 (80.6%)	26 (72.2%)	
Radiocephalic	7 (19.4%)	10 (27.8%)	
Access side			0.155
Left	13 (36.1%)	19 (52.8%)	
Right	23 (63.9%)	17 (47.2%)	

Note. Values are presented as mean ± SD for continuous variables and n (%) for categorical variables. P values for continuous variables were calculated using an independent-samples t-test. P values for categorical variables were calculated using the chi-square test or Fisher's exact test, as appropriate.

As shown in Table 2, baseline clinical characteristics were comparable between the intervention and control groups (n = 36 each). Anthropometric measures did not differ significantly (height p = 0.869; weight p = 0.671; BMI p = 0.691). Dialysis-related variables were also similar, including AVF age (p = 0.092) and dialysis duration (p = 0.598). The prevalence of comorbidities (hypertension p = 0.814; diabetes p = 0.077; heart disease p = 1.000; other diseases p = 0.478), prior surgical history (all p > 0.05), and medication use (all p > 0.05) showed no significant between-group differences. Vascular access characteristics were likewise comparable (AVF site p = 0.405; access side p = 0.155). Overall, all baseline comparisons were non-significant, indicating balanced clinical characteristics between groups.

Primary Outcome: Cannulation-Related Anxiety

To appropriately evaluate the primary outcome, the analysis focused on the between-group differences across the repeated sessions rather than relying on pooled total medians, distinguishing the true intervention effect from natural habituation. While both groups exhibited progressive reductions in anxiety over time suggesting some degree of routine habituation to repeated needle insertions in the control group the magnitude of this reduction was significantly greater in the intervention group.

For pre-cannulation anxiety, the intervention group experienced a substantial decrease from Session 1 to Session 6, which was significantly lower compared to the control group's trajectory. By Session 6, the median pre-cannulation anxiety was 3.3 in the intervention group versus 4.3 in the control group (Between-group difference = 1.0; p < 0.001, 95% CI for the difference [0.81, 1.19], large effect size: Rank-Biserial Correlation = 0.82) (Table 3).

Similarly, post-cannulation anxiety scores demonstrated a more pronounced and statistically significant decline in the intervention group relative to the control group. By the final session, the median post-cannulation anxiety was 2.6 in the intervention group versus 4.0 in the control group (Between-group difference = 1.4; p < 0.001, 95% CI for the difference [1.15, 1.65], large effect size: Rank-Biserial Correlation = 0.86) (Table 4).

Table 3

Pre-cannulation anxiety scores across six sessions by study group (median [min–max]).

Session	Intervention Median (min–max)	Control Median (min–max)	p-value (Between group)
Session 1	5.0 (4.3-5.7) a	4.9 (4.3-5.5) a	0.412
Session 2	4.6 (4.0-5.5) b	4.8 (4.3-5.5) b	0.045
Session 3	4.3 (3.6-5.2) c	4.7 (4.1-5.4) c	< 0.01
Session 4	4.0 (3.2-4.8) d	4.5 (4.0-5.3) d	< 0.01
Session 5	3.7 (2.9-4.5) e	4.5 (3.9-5.2) e	< 0.001
Session 6	3.3 (2.6-4.2) f	4.3 (3.7-5.0) f	< 0.001

Note: The "Total" column has been intentionally removed to focus on session-by-session randomized comparisons. Different superscript letters (^{a}, ^{b}, ^{c}, ^{d}, ^{e}, ^{f}) indicate statistically significant within-group differences between the respective session and Session 6 based on post-hoc pairwise comparisons (p < 0.001)

Table 4

Post-cannulation anxiety scores across six sessions by study group (median [min–max]).

Session	Intervention Median (min–max)	Control Median (min–max)	p-value (Between-group)
Session 1	4.2 (3.4-5.1) a	4.7 (4.1-5.4) a	0.038
Session 2	3.8 (3.2-4.8) b	4.5 (4.0-5.3) b	< 0.01
Session 3	3.5 (2.7-4.5) c	4.5 (3.8-5.2) c	< 0.001
Session 4	3.2 (2.3-4.2) d	4.3 (3.7-5.1) d	< 0.001
Session 5	2.9 (2.1-4.0) e	4.2 (3.7-5.0) e	< 0.001
Session 6	2.6 (1.7-3.5) f	4.0 (3.4-4.7) f	< 0.001

Note: The "Total" column has been omitted to accurately reflect time-variant effects. Different superscript letters (^{a}, ^{b}, ^{c}, ^{d}, ^{e}, ^{f}) denote statistically significant within-group reductions when compared to the final Session 6 (p < 0.001).

Adverse Events

Throughout the six study sessions, no adverse events, allergic reactions, respiratory distress, or physical discomforts related to the lavender aromatherapy or stress-ball squeezing were reported by any participants in the intervention group.

Discussion and Conclusion

The primary finding of this cluster-randomized trial suggests that a combined chairside intervention comprising stress-ball distraction and lavender aromatherapy may provide additional reductions in AVF cannulation-related anxiety compared to conventional care. While both groups exhibited a progressive decline in anxiety across the six sessions likely reflecting natural habituation and psychological adaptation to repeated needle insertions the intervention group demonstrated a more pronounced and statistically greater reduction in both pre- and post-cannulation anxiety.

Regarding the demographic and clinical profile, the sample predominantly consisted of middle-aged adults with a higher proportion of males, tightly aligning with the recognized demographic patterns of end-stage renal disease among Iraqi hemodialysis populations (Al‐Jubouri et al., 2024). Expectedly, hypertension and diabetes mellitus were the most prevalent comorbidities, reflecting the primary leading etiologies of chronic kidney disease locally (Hermis & Abed, 2021). Although baseline characteristics were generally comparable, the cluster-allocation design introduced marginal, non-significant imbalances in variables such as diabetes prevalence and AVF age (Tables 1 and 2). These clinical factors, alongside sex and dialysis duration, could theoretically interact with the intervention's efficacy. For instance, diabetic neuropathy might alter tactile perception and grip efficacy during stress-ball use, and prolonged dialysis vintage might influence baseline habituation levels. While this study was not adequately powered to formally test these subgroup interactions, the fundamental baseline comparability ensures that the overall reductions in anxiety can be reliably attributed to the intervention, though these variables represent important areas for future predictive modeling.

In the context of Iraqi hemodialysis settings, managing patient distress has historically involved various multidimensional approaches. Previous local studies have emphasized the importance of spiritual well-being and spiritual coping strategies to help patients adapt to chronic renal failure (Al-Khaqani & Al-Fayyadh, 2024). Furthermore, other local efforts have focused on improving patients' health literacy through structured educational programs regarding vascular access care (Hussein & Ahmed, 2020; Mohammed, 2016). While these educational and spiritual interventions are highly valuable for long-term adaptation, they may not provide immediate relief during the acute phase of needle insertion. Our study uniquely focuses on the acute anxiety pathway, offering a non-pharmacological, immediate sensory adjunct directly at the chairside.

Our observations align with several trials reporting the independent benefits of active tactile distraction (Ozen et al., 2023; Şahin et al., 2021; Tosun et al., 2025) and olfactory relaxation (Şahin et al., 2021; Şentürk & Kartın, 2018). However, the literature is not uniformly supportive. For instance, Bagheri-Nesami et al. (2017) found no significant anxiolytic effect of lavender oil in hemodialysis patients. This inconsistency may stem from variations in lavender concentration, application duration, or, critically, expectancy effects. Because the scent of lavender is easily recognizable, it serves as a potent sensory cue that can trigger placebo or expectancy-driven anxiety relief, an effect our unblinded design could not completely isolate. We hypothesize that the combined intervention operates through complementary pathways: active cognitive-motor distraction via the stress ball and passive olfactory relaxation via lavender inhalation. However, these mechanistic claims remain speculative, as our study did not measure intermediate physiological variables (e.g., sympathetic tone or cortisol levels) to confirm this synergy.

Limitation

Several limitations must be acknowledged when interpreting these findings. First, the cluster-style allocation reduces statistical efficiency compared to individual randomization and was not explicitly adjusted for using multilevel modeling. Second, while we successfully blinded the statistical analyst to minimize detection bias, blinding the participants and care providers was methodologically impossible due to the physically recognizable scent of lavender. This inherent nature of olfactory interventions introduces a potential expectancy bias. Third, anxiety was assessed solely using

a single-item tool (VAS-A), which restricts the comprehensive psychometric evaluation of the patients' distress. Fourth, the sample size lacked adequate statistical power to perform subgroup analyses evaluating how variables like diabetes status, sex, or dialysis duration might interact with the intervention's efficacy. Finally, the short follow-up period (six sessions) and the restriction to two centers limit the ability to confirm the long-term sustainability and broader generalizability of these findings.

Conclusion

In conclusion, the combined use of a stress ball and lavender aromatherapy serves as a feasible, low-cost, and safe adjunct that may alleviate AVF cannulation-related anxiety beyond the natural habituation observed with routine care. While this dual sensory approach offers a promising non-pharmacological tool for hemodialysis nurses, the findings should be interpreted with caution. The precise magnitude of the effect and the hypothesized underlying mechanisms require further validation due to the study's methodological constraints. Future, adequately powered trials utilizing rigorous randomization models, comprehensive anxiety inventories, and objective physiological markers are essential to substantiate these preliminary results and explore how individual patient characteristics such as diabetes status or dialysis vintage might influence the intervention's efficacy.

Acknowledgments

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Declaration of Helsinki, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contributed to this study.

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