BMC Complementary Medicine and Therapies

RESEARCH

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Effect of aromatherapy with lemongrass (Cymbopogon citratus) on the anxiety of patients undergoing scaling and root planning: a randomized clinical trial

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Abstract

Background Anxiety is one of the most common factors that prevent people from going to a dentist. Therefore, finding a solution to better control stress has been an important issue in recent studies. Lemongrass positively affects the prevention of dental anxiety. The literature has shown that aromatherapy may regulate hemodynamic factors in patients. This study investigated the effects of the aroma of lemongrass on anxiety levels and hemodynamic factors during nonsurgical periodontal treatment.

Methods Thirty-eight patients were divided into two groups. First, the patients were asked to complete the Spielberger questionnaire to measure their level of dental anxiety. Blood pressure, heart rate, oxygen saturation, pain and satisfaction with treatment were evaluated. In the case group, nonsurgical periodontal therapy was performed while the patient inhaled the aroma of the lemongrass. Scaling was performed without intervention in the control group. The patients were then asked to complete the questionnaire again, and all the variables mentioned were remeasured.

Results Aromatherapy with lemongrass caused significant reductions in the systolic and diastolic blood pressure values, heart rate, and anxiety scores of patients. On the other hand, the differences in blood oxygen saturation changes, amount of pain and treatment satisfaction were insignificant between the two groups.

Conclusion Inhalation of lemongrass essential oil appears beneficial for reducing anxiety and associated hemodynamic changes. Thus, aromatherapy with lemongrass may alleviate dental patients' anxiety.

Trial registration https://irct.behdasht.gov.ir/ IRCT20230615058492N2, 21/02/2024.

Keywords Aromatherapy, Pain, Dental anxiety, Blood pressure, Oxygen saturation, Heart rate, Cymbopogon, Oils

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Background

Dental anxiety refers to the anxiety that occurs with the idea of visiting a dentist for dental treatment or preventive action [1]. In other words, it refers to a situation in which a person is afraid of an unfortunate incident in dental treatment or some aspects of it [2]. In some studies, dental anxiety has been mentioned as the fifth most common cause of anxiety [1]. In contrast to the progress achieved in various dental techniques, dental anxiety in multiple countries and societies has not decreased over the past 50 years, with a prevalence of 40–75% [3]. The dental environment is a complex situation that can include many stimuli to cause anxiety in patients [4]. Previous negative experiences, vicarious learning from family members who have dental fear, fear of pain and bleeding, the feeling of lack of control during dental treatment and sensory stimuli such as seeing a dental needle or turbine or the smell of substances such as eugenol [1] and even staying in the waiting room [5] are some of the factors that may lead to anxiety in patients. The patient's threat is not necessarily physically present, but the mere idea of an unpleasant situation (such as pain during scaling) can cause worry and anxiety [6]. In addition to the mentioned cases, fear of the unknown is also considered one of the factors causing anxiety in patients [1], and facing a particular type of treatment for the first time and not being familiar with the treatment process can cause anxiety [7, 8].

Anxiety usually increases pain perception, and as a result, patients experience more severe and more prolonged pain during treatment [1]. Patients who suffer from dental anxiety are usually less satisfied with the treatment [9]. These patients typically avoid dental care, which may lead to poor oral hygiene, dental caries, periodontal problems and tooth loss. These patients primarily receive treatment only in emergencies and acute situations requiring more complex and aggressive treatments. This issue in itself causes anxiety, and if not properly managed, it will prevent the acceptance of further treatments in the future [1, 3]. In addition, patients' anxiety can be considered a stress factor for the dental team. This may be due to patients' lack of cooperation, the need to spend more time during treatment to address patients' anxiety, or interpersonal stress caused by working with an anxious person [1, 4]. Therefore, dental anxiety can cause errors in diagnosis and prevent successful treatment [1, 10].

Periodontal treatment is usually associated with high levels of anxiety [2]. Scaling and root planning (SRP), the most common treatment for gingivitis and periodontitis, is generally associated with pain and discomfort. However, pain and discomfort vary among patients [2, 11]. Pain and discomfort during periodontal treatment are the causes of anxiety in patients. Experiencing pain caused by probing can also cause anxiety [2].

Anxiety assessment can be performed in two subjective and objective ways. A variety of questionnaires can be used for mental estimation of dental anxiety, among which are the modified dental anxiety scale (MDAS), Spielberger State-Trait Anxiety Inventory (STAI-S), and visual analog scale (VAS). The objective measurements of anxiety include measurements of the patient's blood pressure and pulse rate and measurements of blood oxygen (pulse oximetry) [1]. Once identified, there is no absolute and one hundred per cent way to manage anxiety in dentistry effectively. Psychotherapy strategies, drug interventions or a combination of these two methods, depending on the characteristics of the patient, his level of anxiety and clinical conditions, can help reduce anxiety. Nonpharmacological methods for reducing anxiety include music therapy, hypnosis, acupuncture, distraction, desensitization, and aromatherapy [7, 12].

In medical interventions, relative analgesia (such as nitrous oxide) or intravenous or oral sedation is used, which is associated with a variety of unwanted side effects, contraindications and risks [12]. Although nonpharmacological strategies have less impact than pharmaceutical interventions, they are often a safe solution for this problem [7, 12]. Among these, aromatherapy is one of the most effective nonpharmacological antianxiety techniques. Aromatherapy involves using essential oils extracted from plants to improve physical and mental health, and it is a simple, safe and inexpensive method that can reduce pain and anxiety [12–14].

In this method, the scent of plant extracts (essential oil aromas) is used to stimulate the sense of smell and affect the limbic system (which is related to heart rate, blood pressure, breathing, memory, emotions and hormonal balance) and the cognitive function or mood of patients is improved [10, 12].

Aromatherapy has been reported as a method for reducing pain and creating a sense of relaxation [10]. Several studies have investigated the effects of aromatherapy with various essential oils, such as orange oil, chamomile oil, lavender oil, and lemongrass oil, on dental anxiety [12, 15]. In a 2021 review and meta-analysis, Purohit et al. reported that aromatherapy effectively reduces dental patients' anxiety levels [10]. A review by Cai et al. in 2020 showed that although aromatherapy can be effective in reducing dental patients' anxiety, due to the possibility of bias in studies and the low quality of evidence, its effectiveness cannot be definitively confirmed in the context of dental anxiety management [16].

Lemongrass (Cymbopogon citratus) is a type of aromatic grass belonging to the Poaceae family and contains various bioactive compounds with broad therapeutic properties. The essential oil of this plant has antibacterial,

antifungal, antioxidant, anti-inflammatory, pain-relieving, and soothing effects, and it is also of great interest because of its many uses in the food industry and traditional medicine. Lemongrass is used as a flavor in food and drinks and a scent in soaps and cosmetics. This plant helps treat chest pain, high blood pressure, diabetes, headache, muscle pain, knee pain and rheumatism, epilepsy, cough and weakness. Studies have shown that inhaling lemongrass essential oil can improve body pain and respiratory system infections and reduce cold and flu symptoms. Lemongrass can prevent the accumulation of bacteria and can also treat periodontitis [17–21].

Costa et al.'s 2011 [22] and Nakavuma et al.'s 2016 [23] study on mice confirmed the safety and non-toxicity of traditional medicine doses of oral lemongrass. A survey by Lulekal et al. 2019 also evaluated skin irritation and acute and subacute toxicity of lemongrass essential oil in mice and rabbits. It is considered relatively safe and non-toxic [23]. Andrade et al. 2023 revealed the protective effect of using Cymbopogon citratus essential oil topically in human skin through a contact model without increasing edema, erythema, blood perfusion and water loss in the epidermal area. This showed not only skin non-toxicity but also a protective effect on human skin against irritants [24].

Studies on the effects of lemongrass aromatherapy on dentistry are very limited. Very few studies are available on children. Radhalakshmi et al. in 2020 concluded that aromatherapy with lemongrass oil could be recommended in routine pediatric dentistry practice for the management of dental anxiety in children [25], but apart from Rajaraman et al.'s study, which investigated the effects of aromatherapy with lemongrass on the level of pain perception and anxiety levels in patients undergoing fixed prosthesis treatment [26], no study has been conducted in the adult patient population.

Owing to the uncertainty of review studies on the effect of aromatherapy on the control of dental anxiety in general and the lack of studies on adult dental patients, specifically candidates for periodontal treatment, and rarely mention the effect of lemongrass in previous studies, the present study was designed to investigate the effect of aromatherapy with lemongrass in reducing the anxiety of adult patients undergoing SRP as the first treatment experience. We hypothesized that lemongrass essential oil would be more effective than the placebo in reducing dental anxiety.

Methods

Study design

This randomized, parallel-design, placebo-controlled and single-blind trial was conducted with the dental faculty of Shahid Sadoughi University of Medical Sciences in Yazd, Iran. The study protocol was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences (IR.SSU.DENTISTRY.REC.1402.044) and conforms to the guidelines of the Declaration of Helsinki. Each participant was given comprehensive instructions on the study's objectives and the procedures to be followed. Informed consent was obtained from all participants. This study was performed by the CONSORT guidelines. The study was also registered in the Iranian Registry of Clinical Trials (IRCT) on 2024-02-21 under the code IRCT20230615058492N2.

Sample size

Since there have been no previous studies on the effects of aromatherapy with lemongrass on the anxiety of adult patients during periodontal treatment, the sample size was calculated via a survey with a methodology very similar to that used in the current study but with a lavender aroma [15]. By estimating the value of the standard deviation of the anxiety score equal to s = 1.6 and to achieve a reduction in anxiety in the intervention group compared with the control group by at least two units, 18 people in each group were needed, including 10% attrition, and 20 people were investigated.

$$n = \frac{(Z_1 - \alpha/2 + Z_1 - \beta)^2 \times 2S^2}{(\bar{x}_1 - \bar{x}_2)^2}$$

Participants

Forty healthy adult patients referred to the periodontics department of Yazd Dental School, who met al.l the inclusion criteria and were candidates for scaling and root planning (SRP) for the first time, were selected. The inclusion criteria were as follows: age between 25 and 50 years; lack of SRP history, no pregnancy; not having systemic problems such as blood pressure, diabetes, or lung problems; not smoking; no history of allergy to a specific medicinal plant; no mood disorders; not having diagnosed anxiety disorders; no history of olfactory disorders; not having allergies or problems such as nasal congestion; loss of sense of smell due to coronavirus; not having diagnosed sinusitis; and not using a tranquillizer or analgesic; and not taking drugs that affect heart rate or blood pressure, such as diuretics and beta blockers. The exclusion criteria were unwillingness to continue smelling lemongrass oil or receiving local anesthesia during SRP. To discover any reaction of increased sensitivity to lemongrass compounds, a patch test (with the concentration used in the study on a circle with a diameter of 3 cm on the elbow fold) was performed for patients [27]. Previously, patients were asked to refrain from wearing perfume/cologne on the day of the appointment and not to eat foods such as sausage, garlic or raw onion for 12 h before treatment. In the case of non-observance of the

aforementioned points before the intervention or sensitivity reaction (such as erythema or itching), the patients were removed from the study and replaced with new patients and replaced with new patients. The flowchart for patient recruitment is shown in Fig. 1.

Randomization

Eligible people were assigned to the intervention and control groups via a table of random numbers generated via Random Allocation Software version 1.0. (Mahmood Saghaei, Iran).

Pre-intervention assessments

Patients were divided into intervention and control groups and matched as much as possible regarding sex distribution, mean age, and education level distribution (stratified randomization).

At the time of the patient's placement in the dental unit and before starting the screening, all patients will be given questionnaires that contain demographic information, and 20 questions from Spielberger's State-Trait Anxiety Inventory-State Scale (STAI-S) will be given to evaluate the baseline anxiety level of the patient. The validity and reliability of the Persian version of this standard questionnaire have been confirmed [28]. Several options were provided for each statement (Likert scale). These options were very low, low, medium, and high, scoring from 1 to 4 (the scoring was reversed for the statements that showed a lack of anxiety). The lowest score of 20 indicates no anxiety, the highest score of 80 indicates maximum anxiety, scores of 21 to 39 indicate mild anxiety, scores of 40 to 59 indicate moderate anxiety, and scores of 60 to 80 indicate severe anxiety [15, 28].

Patients' baseline heart rate and blood oxygen concentration were also measured with a PC-60B1 fingertip pulse oximeter (Shenzhen Creative Industry, China), and systolic and diastolic blood pressure were measured with an M3 Automatic Blood Pressure Monitor (Omron Healthcare, Japan).

Intervention and post-assessments

One hundred per cent pure, non-edible lemongrass essential oil (Narin Gol, Iran) was used for aromatherapy. This product was originally a Moksha India product. Four drops (0.2 ml) of lemongrass essential oil for the case group were diluted in 100 ml of distilled water (according to the manufacturer's instructions). Then, four drops of the diluted essential oil were poured on sterile cotton gauze and applied around the nostrils and on the patient's philtrum. For the control group, four drops of distilled water were used as a placebo to moisten the gauze, and then the gauze was rubbed on the desired

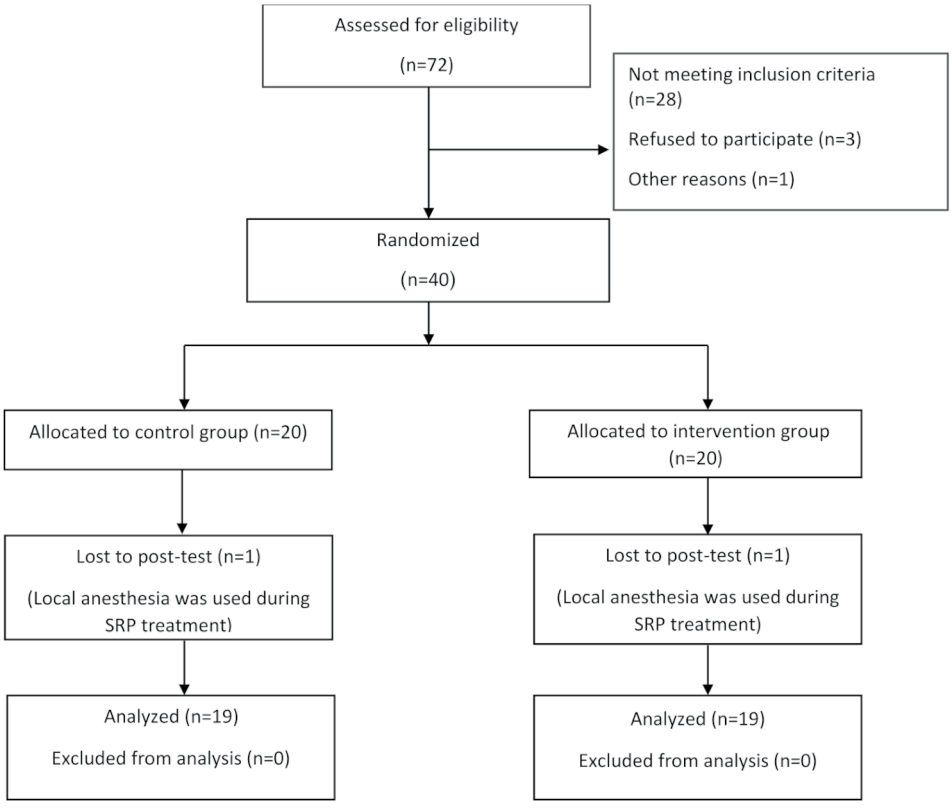

Fig. 1 Flowchart of the study

area of the patient's face. A single last-year dental student performed all SRP treatments for up to 35 min with the help of an ultrasonic scaler model UDS-K (Woodpecker, China). A single periodontist confirmed the quality of the treatment. Aromatherapy continued until the end of SRP by not wiping the patient's face.

In the last third of the treatment time (before the anxiety-causing factor was finished), blood pressure, heart rate, and blood oxygen concentration were re-measured, and the STAI-S questionnaire recorded the anxiety levels of the patients. After the completion of the treatment, a visual analog scale (VAS) ranging from 0 (no pain) to 10 (the most significant amount of pain) was also used to rate the level of pain and discomfort of the patients during the treatment, and two questions expressing the level of patient satisfaction were asked: 1- Please indicate your level of satisfaction with the treatment performed on a scale ranging from 1 to 5 (1 as dissatisfied and five as completely satisfied). 2- Would you like aromatherapy to be used on you again during future dental treatments? (yes, no)

Interim analyses and stopping guidelines

No interim analyses were performed, and no stopping guidelines were established.

Blinding

It was impossible to blind the patient because of the distinct and robust smell of the lemongrass. The person recording the variables at baseline was unaware of how the patients were allocated to the two groups. In the re-evaluation of the variables, due to smelling the scent in the intervention group, blinding was not possible.

Statistical analysis

The Shapiro–Wilk test was used to evaluate the normality distribution of the data, and based on this, the data were found to be normally distributed for systolic blood pressure, diastolic blood pressure, pulse rate, and the STAI anxiety score. In their comparison, the t-test was used. The data were not normally distributed for the other variables (oxygen saturation percentage, pain score and satisfaction score). Thus, the Mann–Whitney test was used for two-by-two comparisons. Spearman's test was used to assess the correlation between variables.

Results

Harms

No patient showed an allergic reaction such as edema, erythema or itching following the patch test. No patients were harmed during the study, and no side effects were reported.

Participant flow and subgroup analysis

A total of 40 patients who were equally divided into two groups participated in this study. Twenty patients were female (50%), and 20 (50%) were male. After the start of the study, two patients (one male from the intervention group and one female from the control group) were excluded from the study because of the use of local anesthesia during SRP treatment, and a total of 38 patients remained. The demographic characteristics of the patients are shown in Table 1. The groups were equalized as much as possible regarding sex and age, and there were no statistically significant differences between the two groups.

The preoperative and postoperative mean values and the differences in these values for each of the variables (systolic blood pressure, blood pressure, diastolic blood pressure, pulse count, and STAI-S anxiety score) are shown in Table 2. The mean postoperative systolic and diastolic blood pressure in the control group significantly increased compared with the preoperative values. The pulse rate decreased significantly in the intervention group after treatment. The STAI-S anxiety score decreased significantly in the intervention group. Blood oxygen saturation did not significantly change in the intervention or control groups.

Table 3 compares the mean/median changes in the variables in the intervention and control groups. Compared with the control, aromatherapy with lemongrass caused significant reductions in the systolic and diastolic blood pressure values, heart rate, and anxiety scores of the patients. On the other hand, the difference in blood oxygen saturation changes was insignificant between the two groups.

Table 1 Patient demographic information and age and sex distributions

Variable		Total (*n*)	Intervention Group		Control Group		*P* value
			n	%	*n*	%	
Sex	Female	20	10	50	10	50	1.000*
	Male	20	10	50	10	50	
Age	-	40	**Mean ± SD**		**Mean ± SD**		0.840**
			37.70 ± 5.904		37.20 ± 9.266		

*Chi-square test

** T Test

Table 2 Intragroup comparisons of variables before and after the intervention

Variables with normal distribution	Group	Pre-operative Mean ± SD	Post-operative Mean ± SD	Pre- and Post-operative Mean Difference	*P*-value*
Systolic Blood Pressure	Intervention	111.00 ± 8.844	109.63 ± 9.599	-1.368 ± 7.274	0.423
	control	116.95 ± 15.472	121.53 ± 16.863	+4.579 ± 8.507	0.031
Diastolic Blood Pressure	Intervention	77.89 ± 6.100	77.05 ± 7.692	-0.842 ± 4.705	0.445
	control	75.74 ± 7.179	80.00 ± 7.032	+4.263 ± 5.321	0.003
Pulse Rate	Intervention	84.21 ± 12.236	78.89 ± 10.027	-5.316 ± 8.446	0.013
	control	75.63 ± 9.776	78.79 ± 11.424	+3.158 ± 10.730	0.216
STAI-S Anxiety Score	Intervention	40.63 ± 9.844	33.74 ± 8.432	-6.895 ± 10.137	0.008
	control	37.21 ± 10.190	39.58 ± 11.992	+2.368 ± 9.382	0.286
Variable with non-normal distribution	**Group**	**Pre-operative Median± IQR**	**Post-operative Median ± IQR**	**Z**	***P*-value****
Oxygen Saturation Percentage	Intervention	97 ± 2	97 ± 2	+0.431	0.666
	control	96 ± 1	97 ± 2	−0.283	0.283

*T-test **Wilcoxon test

Table 3 Intergroup comparisons of changes in variables

Variable	Group	Pre- and Post-operative Difference	*P*-value*
Systolic Blood Pressure	Intervention	-1.368 ± 7.274	0.026
	control	+4.579 ± 8.507	
Diastolic Blood Pressure	Intervention	-0.842 ± 4.705	0.003
	control	+4.263 ± 5.321	
Pulse Rate	Intervention	-5.316 ± 8.446	0.010
	control	+3.158 ± 10.730	
STAI-S Anxiety Score	Intervention	-6.895 ± 10.137	0.006
	control	+2.368 ± 9.382	
Oxygen Saturation Percentage	Intervention	+0.431	0.335
	control	−0.283	

*T test

Table 4 Comparison of the degree of pain during treatment and the level of satisfaction with treatment between the two groups

Variable	Group	Median	IQR	Min	Max	Z	*P*-value*
Degree Of Pain	Intervention	4	5	0	6	0.738	0.470
	control	5	4	0	8		
Level of Satisfaction	Intervention	5	1	4	5	1.094	0.370
	control	5	1	3	5		

*Mann–Whitney test

The Mann–Whitney test revealed no statistically significant difference between the intervention and control groups regarding the amount of pain felt during the treatment or the level of satisfaction (Table 4). 94.7% of the patients in the intervention group (18 out of 19) stated that this method (aromatherapy) would be used in their future dental treatments.

The Spearman correlation coefficient test revealed a significant correlation between the level of pain and the increase in the postoperative anxiety score of the patients in the control group (p value = 0.004). Additionally, as patients' anxiety increased, their level of satisfaction with the treatment decreased significantly (p value = 0.005). In the intervention group, there was also a correlation between pain level, anxiety score and patient satisfaction level, although the correlation was not significant (Table 5).

Discussion

Aromatherapy is a common complementary therapy that uses aromatic essential oils to stimulate the olfactory system for therapeutic purposes. Aromatherapy has long been considered a popular method for treating anxiety, and studies have shown that aromatherapy has positive antianxiety effects on patients with anxiety symptoms and is regarded as a safe intervention [29]. Owing to the therapeutic effects of lemongrass essential oil aroma [18, 19] and considering its overall safety without any systemic, dermal, mucosal or behavioral side effects during animal testing [30] and dermal non-toxicity for human skin [25], the ability of lemongrass aromatherapy to

Table 5 Correlations between pain, anxiety and the level of satisfaction in the two groups

Variable	Group	Correlation with satisfaction	Correlation with Post-operative STAI-S score
Degree Of Pain	Intervention	CC* = -0.211 *P* value = 0.385	CC = 0.297 *P* value = 0.217
	control	CC = -0.522 *P* value = 0.022	CC = 0.631 *P* value = 0.004
Level of Satisfaction	Intervention	---	CC = -0.77 *P* value = 0.755
	control	--	CC = -0.618 *P* value = 0.005

*Correlation coefficient (Spearman's test)

reduce anxiety in patients undergoing scaling and root planning was examined in the present study.

Dental anxiety includes cognitive, behavioral, and physiological components; each measurement technique evaluates one or several [31]. Therefore, to comprehensively examine patient anxiety, this study attempted to use a combination of subjective and physiological anxiety measurement methods. The 20 questions of the State Scale in the State-Trait Anxiety Inventory (STAI-S) questionnaire were used for subjective anxiety measurement. Since anxiety can change blood pressure, heart rate [30], respiratory rate, and consequently, blood oxygen or carbon dioxide saturation [32], a blood pressure monitor and pulse oximeter were used to examine these hemodynamic changes.In the present study, the systolic and diastolic blood pressures in the intervention group decreased after aromatherapy but increased significantly in the control group. In a study by Kamkaen et al. [33], which compared the physiological effects following massage with lemongrass oil and sweet al.mond oil; no significant changes in systolic blood pressure or heart rate were found between the massage groups with lemongrass oil and the control group, but a significant reduction in diastolic blood pressure happened in massage groups than in the control group. The inconsistency in results may be due to different methodologies in the study of Kamkaen et al., such as the one-hour interval between two blood pressure measurements, the use of massage therapy in addition to aromatherapy, or the use of carrier oil combined with lemongrass essential oil (the concentration and potential effects of the carrier are not specified). In a study by Omer et al. [34], A significant decrease in children's blood pressure occurred after lemongrass aromatherapy, consistent with the present study's findings. In this study, aromatherapy was performed for children by inhaling two drops of lemongrass oil placed on sterile gauze for 3 min, both before the procedure of dental anesthesia and extraction of the primary molar. The results of the study by Sari et al. [35] Similar to our study regarding reducing blood pressure in patients, lemongrass aromatherapy was performed along with massage, and all selected samples were from individuals with high blood pressure. According to a review by Silva et al. [36], lemongrass extract and its main component, citral, have antihypertensive effects on animal and human samples. This review suggests that the antihypertensive effects of lemongrass, when consumed orally, may occur through the following mechanisms: (1) vasodilation due to endothelial NO secretion and smooth muscle relaxation (through blockage of calcium channels); (2) central nervous system suppression activity, which causes cardiac depression through the parasympathetic system and reduces anxiety levels; and (3) potentiation of diuresis, which can reduce blood pressure. Additionally, the findings of the study by Law et al. [37] These findings indicate that the antihypertensive properties of lemongrass extract are due to bioactive compounds such as saponins, tannins, flavonoids, alkaloids, and anthraquinones. This study revealed that potassium ions in lemongrass tea regulate blood circulation and lower blood pressure. Unfortunately, the literature does not precisely state how inhaling the essential oil aroma affects blood pressure.

In the present study, the pulse rate in the intervention group decreased significantly after aromatherapy. Regarding the reduction in heart rate, the results of the present study are consistent with the results of the survey conducted by Radhalakshmi et al. [25], which examined the effect of aromatherapy on dental anxiety in children, and the study by Omer et al. [34].

Stress and anxiety during a dental procedure can change the respiratory rate and thus alter blood oxygen saturation, sometimes leading to probable emergencies such as syncope. The normal range for arterial saturation is 95–100% at coastal elevations [38]. Periodontal surgery may be more stressful and traumatic than nonsurgical treatment; however, findings from a study by Padma et al. [32] indicate that nonsurgical periodontal therapy results in a more significant decrease in oxygen saturation levels than surgical periodontal therapy, although both remain within normal physiological limits. The underlying reasons for these findings might be that the surface area affected by surgical periodontal therapy is smaller than that affected by whole-mouth nonsurgical treatment. It is also plausible that patient anxiety decreases with subsequent follow-up in the surgical phase of treatment, unlike in the initial nonsurgical phase. Additionally, subgingival

instrumentation in nonsurgical therapy is likely to cause greater bacteremia than periodontal surgery. Patients undergoing nonsurgical periodontal treatment also experience more significant systemic inflammation perturbations than those undergoing surgical therapy do. As noted by Padma et al., within 24 h, patients receiving nonsurgical periodontal treatment show more pronounced increases in the levels of inflammatory factors such as IL-6 and C-reactive protein than those receiving surgical treatment [32]. In the present study, however, no significant changes were observed in the percentage of blood oxygen saturation; these results were similar to those of the study of Radhalakshmi et al. [25], but a significant increase in the rate of blood oxygen saturation was observed in the study by Omer et al. [34] after lemongrass aromatherapy compared with before treatment.The present study revealed a significant decrease in the STAI-S anxiety score after the intervention. Similar results were reported in the study by Rajaraman et al. [26], which used the STAI-S anxiety score to measure patient anxiety after lemongrass aromatherapy; however, in the mentioned study, the aroma of the lemongrass was used in ambient light with a candle warmer. In the present study, the aroma was not used ambiently to avoid exposing other patients in the treatment environment to the aroma; instead, the patient's nostrils were moistened with diluted lemongrass essential oil via sterile gauze [15]. As noted by Silva et al. [36], citral, the main component of lemongrass oil, is known to undergo transdermal absorption. However, it is still unclear whether this compound or other compounds can be absorbed through the skin as essential oils, as these compounds strengthen the epidermis structure. Therefore, the potential calming effect of lemongrass essential oil through skin absorption has yet to be proven. In the study by Radhalakshmi et al. [25], a significant decrease in children's anxiety scores was observed after exposure to a lemongrass aroma, which is consistent with the results of the present study; despite the different anxiety measurement methods used in the two studies, Radhalakshmi et al. used Venham's picture test. In the mentioned study, aromatherapy with diluted essential oil at a ratio of 1:1 was performed for 15 min using a candle warmer, and the children watched their favorite cartoon along with aromatherapy. The duration of aromatherapy was shorter than that in the present study, but the concentration of the essential oil used was greater. The study by Alvarado-García et al. [39], which examined the effect of reducing general anxiety through lemongrass aromatherapy via the Self-Rating Anxiety Scale (SAS), revealed a significant reduction in anxiety in the aromatherapy group, similar to the findings of the present study. This study performed aromatherapy over eight weeks by inhaling two drops of lemongrass essential oil placed on a cotton ball (10 inhalations per day). The findings of the study by Omer et al. [34], which used the Wong-Baker Anxiety Scale to measure children's anxiety, also revealed a reduction in anxiety scores in the lemongrass aromatherapy group and an increase in anxiety scores in the control group. The results of the present study were consistent with those of the study by Ramadhani [40], although in Ramadhani's study, the subjects performed activities to reduce anxiety (such as inducing positive thinking, exercise, etc.) in addition to aromatherapy, and the anxiety measurement scale was different (COVID-19 Anxiety Scale vs. STAI-S).

To explain the anxiolytic effects of lemongrass essential oil, it should be noted that its main components are terpenes such as citral, followed by myrcene and geraniol, but the major compounds (such as myrcene and citral) are not necessarily responsible for biological activity, and such activity cannot always be attributed to only one constituent from the essential oil; because the compounds in the essential oil can have synergistic effects (e.g., citral and geraniol) [41, 42]. Lemongrass essential oil has anti-anxiety effects similar to those of benzodiazepines, and it exerts these effects, similar to benzodiazepines, through its impact on $GABA_A$ receptors [41, 42]. $GABA_A$ receptors are chloride ion channels activated by GABA and can be modulated by various pharmaceutical agents, including certain aromatic compounds such as terpenoids. These drugs increase the chloride ion flow induced by GABA and cause hyperpolarization of the neuron membrane [39].

As mentioned previously, studies have shown that pain and discomfort during periodontal treatment are the causes of anxiety in patients [2]. In addition to postoperative pain, patient discomfort during nonsurgical periodontal treatment is not significantly different from that during surgical interventions such as modified Widman flaps, flaps with osseous resection or gingivectomy [43]. Therefore, any modification to decrease patient discomfort and pain during nonsurgical therapies is likely as important as surgical methods. In the present study, no significant difference was observed in the pain score reported by the participants using the VAS scale between the intervention and control groups, contrary to the findings of Rajaraman et al. [26], who used the same scale and reported a significant reduction in the pain felt by patients in the intervention group compared with the control group. This inconsistency in results may be due to differences in the method of aroma application, the type of dental treatment in terms of treatment duration, or the use of local anesthesia in the two studies. In the present study, the aromatherapy duration for patients was standardized (35 min). Additionally, local anesthesia was not used for patients receiving dental treatment. Common local anesthetics used in dental treatment include vasoconstrictors. Vasoconstrictors affect the cardiovascular

system, creating an effect similar to that of the sympathetic system, which can itself cause physiological symptoms of anxiety [44]. Additionally, this study eliminated the impact of anxiety reduction due to the completion of dental treatment. Therefore, the secondary examination of anxiety symptoms was performed before the scaling and root planning treatment was wholly terminated. Research conducted by Lorenzetti et al. [45] suggested that lemongrass tea has a peripheral analgesic effect and that myrcene appears to be the most responsible for the analgesic activity of the essential oil of lemongrass. This study revealed that lemongrass essential oil and myrcene exert direct analgesic effects similar to those described for peripheral-acting opioids or dipyrone.

Concerning the desirability of using the aroma among patients, similar to several other studies [33, 36, 39, 46], most patients in this study (94.7%) stated that the lemongrass aroma was pleasant for them and that they would like it to be used in their future dental treatments.

Strengths and limitations of the study

To the best of the authors' knowledge, studies on lemongrass aromatherapy in dentistry for adult patients are very limited; therefore, selecting adult participants is a positive aspect of this study. Not using the aroma in an ambient manner may reduce the aroma concentration over time because of its volatile nature. However, further studies to evaluate and compare different methods of aroma application could help address these ambiguities. The patient and the dentist could sense the presence or absence of the aroma, making blinding practically impossible. Designing future studies as double-blind studies could lead to more reliable conclusions if possible. However, this study maintained randomization and blinding during the statistical analysis. Additionally, for the subjective anxiety assessment in this study, the STAI-S was used to evaluate individuals' anxiety not generally but at the moment and during the anxiety-inducing treatment situation. However, using a scale to measure dental anxiety simultaneously, similar to the study by Karan [47], might have been more beneficial.The inclusion criteria for this study were relatively extensive, and many individuals (including smokers, those with systemic issues, older people, and adolescents) were omitted. Additionally, patients who received anesthesia during scaling were excluded. Therefore, achieving a larger sample size was not easy.

Suggestions

Studies have shown that lemongrass essential oil, even at low concentrations, is effective against gram-positive bacteria that form the oral cavity's dominant population. Moreover, this essential oil is very effective against fungal growth, and its citral content exhibits fungicidal properties. Therefore, lemongrass could be effective as a mouthwash to prevent bacterial accumulation, plaque formation, dental caries, and oral candidiasis. Additionally, since this essential oil has antioxidant and anti-inflammatory properties, it can effectively prevent periodontitis [17]. Moreover, essential lemongrass oil might reduce the oral bacterial load as a mouthwash before periodontal treatment. Therefore, designing such trials in the future is suggested. Additionally, further studies with larger sample sizes could help generalize the conclusions.

Conclusion

Inhalation of lemongrass essential oil appears to be beneficial for reducing anxiety and associated hemodynamic changes. Thus, aromatherapy with lemongrass may alleviate dental patients' anxiety.

Abbreviations

SRP Scaling and root planning
STAI-S Spielberger's State-Trait Anxiety Inventory-State Scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12906-025-04834-w.

Supplementary Material 1

Acknowledgements

The authors sincerely acknowledge all patients who participated in this study.

Author contributions

F.R.M. and M.V. wrote the main manuscript text and V.H. analyzed the data. All authors reviewed the manuscript.

Funding

Shahid Sadoughi University of Medical Sciences supported this study.

Data availability

The datasets analyzed during the current study are not publicly available owing to privacy and ethical concerns but are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Shahid Sadoughi University of Medical Sciences (IR.SSU.DENTISTRY.REC.1402.044) and conforms to the guidelines of the Declaration of Helsinki. Each participant was given comprehensive instructions on the study's objectives and the procedures to be followed and then informed consent was obtained from all participants. This study was performed by the CONSORT guidelines. The study was also registered in the Iranian Registry of Clinical Trials (IRCT) on 2024-02-21 under the code IRCT20230615058492N2.

Consent for publication

Not applicable. The manuscript does not contain individual data.

Competing interests

The authors declare no competing interests.

Received: 11 September 2024 / Accepted: 20 February 2025
Published online: 11 March 2025

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