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The effects of lavender aromatherapy on stress and pain perception in children during dental treatment: A randomized clinical trial

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A B S T R A C T

Background and purpose: Reducing dental anxiety is a major aspect of childmanagement in dental visits. This crossover randomized clinical trial was designed to determine the effect of lavender aromatherapy on anxiety level during dental treatment and pain perception during dental injection in children.

Materials and methods: Twenty-four children aged 7-9 years received restorative treatment with lavender aromatherapy in the intervention session and without aroma in the control session. Salivary cortisol and pulse rate were measured to evaluate child's anxiety level and the Face Rating Scale (FRS) was used for assessing the pain perception during injection in both visits.

Results: The treatment effect on salivary cortisol, pulse rate, and FRS score was -8.01 ± 0.92 nmol/l, -11.17 ± 1.28 (in minutes), and -2.00 ± 0.41 respectively, which was statistically significant ($P < 0.001$).

Conclusion: Lavender aromatherapy can decrease dental anxiety and experienced pain in dental setting.

1. Introduction

Dental anxiety can lead to avoidance of necessary dental care, which in turn negatively affects oral health. The control of dental anxiety is the major aspect of child management in dental visits [1]. Dental anxiety develops mostly in childhood and adolescence. Low to moderate dental anxiety has been reported in approximately half of the children, and high levels of dental anxiety have been reported in about 10%–20% of children [2]. Moreover, more pain sensitivity is observed in anxious patients, and it is the primary reason for uncooperative behavior in dental treatment. To achieve oral and dental health through regular visits to the dentist, it is essential to help patients overcome the anxiety and fear [3]. Several anxiety-provoking factors are present in a dental setting including smells (eugenol, cut dentine), sounds (screaming patients, drilling), sights (blood, needles), sensation (high-frequency vibration), and gag-inducing procedures [4]. Many pharmacological and non-pharmacological therapies such as music therapy, different forms of cognitive-behavioral therapy (CBT), hypnotherapy, nitrous oxide sedation, benzodiazepine premedication, and laser therapy have been applied to control the pain during dental injection as well as dental anxiety [5–8].

Recently, aromatherapy (application of fragrant volatile essential oils for therapeutic targets) has been propounded as a complementary approach in medical [9–12] and dental settings [13–16]. The concept of the therapeutic use of aromatic essential oils is supported by this method that can produce a positive physiological effect through the sense of smell. Aromatherapy can induce relaxation and relieve anxiety symptoms in an inexpensive, simple way [13]. The aroma of lavender essential oil may lead to improved mood, decreased anxiety, and increased sedation due to parasympathetic stimulation of the autonomic nervous system [17].

There is controversy about the anxiolytic effect of aromatherapy in several researches [13,18,19]. Most of the studies in dentistry assessed the anxiolytic effect of different aromas on patients by using questionnaires and in the waiting room [13,14,20,21]. There are only few studies investigating the effect of aromatherapy with different essential oils on dental anxiety in children during dental treatment. Recently, Arslan et al. have demonstrated the calming effect of lavender aromatherapy on children during tooth extraction [22]. Jafarzadeh et al. revealed that orange aromatherapy can help decrease the child's anxiety while receiving fissure sealant therapy [15]. Pradopo et al. showed the positive effect of pandan (*Pandanus amaryllifolius*) aromatherapy on reducing the child anxiety during fissure sealant treatment. However, Pradopo et al. suggested that the combination of relaxing music and pandan aromatherapy could be more effective in anxiety management than just aromatherapy [16].

Some studies have shown that lavender aromatherapy may be effective in reducing the pain following needle insertion in either healthy volunteers or hemodialysis adult patients [9,23]. Lavender aromatherapy has also been reported as a beneficial choice for managing

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the pain severity of intravenous catheter insertion in the preschool children [24]. However, there was only one study evaluating the effect of lavender essential oil on pain perception during dental treatment including local anesthesia and tooth extraction [22]. Therefore, we designed a crossover randomized controlled clinical trial to evaluate the effect of aromatherapy with lavender essential oil on salivary cortisol and pulse rate, as indicators of the child's anxiety during stress-induced dental treatments including anesthetic injection and drilling. Pain perception during dental injection was also assessed.

2. Materials and methods

2.1. Sample and sampling method

Considering the salivary cortisol as the primary outcome, the sample size was calculated based on a previous study in which mean ± SD in the control and intervention groups were 14.84 ± 2.94 (nmol/lit) and 12.51 ± 1.34 (nmol/lit) respectively [15]. The adequate sample size for a parallel study was determined to be 15 persons in each group, considering $\alpha = 0.05$ and power = 80%. Since the maximum sample size for a crossover design is half of the parallel sample size, it would be enough to recruit eight patients for each group [25]. The final sample size was considered 12 patients in each group to compensate for the potential dropouts. A total of 24 children aged 7–9 years were selected according to the following inclusion criteria among patients attending the Pediatric Dental Clinic of Shiraz in 2019. Twenty four participants were assigned into two groups using two block randomization by a dental assistant. They were randomized to one of the two study treatments for the first treatment session, and then assigned to the alternate treatment for the second treatment visit. Two-block randomization was completed by recording the two possible treatment orders (6 of A-B, 6 of B-A) for the first 12 people to start the study on small pieces of paper. These pieces of paper were folded in half identically, placed in a small box, and randomly drawn from the box without replacement. Once the first set was drawn, all pieces of paper were returned to the box and the procedure was repeated to determine the order of the next 12 participants.

A form containing children's socio-demographic characteristics and medical information was given to the parents to complete. The inclusion criteria for participants were as follows: healthy children aged 7–9 years old, patients exhibiting Frank's behavior rating grade III or IV, and children having decayed lower second primary molars bilaterally, which need a class I restorative treatment. The exclusion criteria consisted of: patients with previous dental visits, children with the common cold, children with a history of allergy, children who currently use any medication, and patients with any history of dental pain.

2.2. Measurement instruments

To measure the anxiety of children in this study, the salivary cortisol level and pulse rate were evaluated as primary and secondary responses, respectively. The salivary cortisol level was detected using a commercial ELISA kit (Cortisol saliva ELISA, Diametra, Italy). The salivary cortisol was measured before and at the end of each dental visit, while the pulse rate was evaluated before and during the treatment (after the dental injection). Pulse rate was measured using a finger-base type pulse oximeter (Beurer, Ulm, Germany) by a trained nurse.

The Face Rating Scale (FRS) was used to determine patients' experienced pain in a subjective way. The FRS is a horizontal line with six faces from a happy face for "no pain" to a crying face for "extreme pain", scoring from 0 to 10. The children were asked to mark the point that represented their perceived pain intensity, and the score was recorded by the nurse.

2.3. Intervention procedures

All patients were treated twice at about 9 a.m. with a one-week interval. In order to control the changes in salivary cortisol related to drinks and foods, the participants were asked to refrain from drinking or eating anything for 30 min before sample collection. The first group consisted of 12 children (7 girls and 5 boys) with a mean age of 7.83 ± 0.83 years, who were treated without lavender aroma in the first session (control) and with lavender aroma in the second visit (intervention). The second group consisted of six girls and six boys, with a mean age of 8.00 ± 0.85 years, who received the treatment with lavender aroma in the first appointment (intervention) and without lavender aroma in the second appointment (control). In each session, first, the dental assistant separated the child from his/her parents and carried him/her to a room. After 5 min, the nurse recorded the pulse rate using a finger type pulse oximeter (Beurer, Ulm, Germany) and collected the unstimulated saliva by guiding the child to expectorate directly into the plastic vial, which was numbered as the first sample. The children were asked not to move their hand while the finger pulse oximeter was attached to their left index finger. Then, the child was taken to the isolated room, which was 12 m^2 in size. A Humidifier (Zyklusmed, Germany) was used to diffuse the essential oil while it was out of patients' sight. Two drops of pure lavender (*Lavandula angustifolia*) essential oil (Tisserand Aromatherapy, Newtown Road, Hove, Sussex, UK) was poured in 100 ml water in the humidifier and diffused in the air 30 min before the patient's arrival in aromatherapy days. For the control group, the plain water (without lavender oil) was used and applied in the same manner.

Before transitioning to a control session, the room was ventilated to completely remove the lavender scent. A routine restorative treatment was performed in both sessions by a pediatric dentistry resident including the local anesthetic injection after topical application of anesthetic gel, cavity preparation, and caries removal using high and low-speed dental handpieces followed by composite filling. The injection site was dried by cotton gauze. A cotton tip applicator with 20% benzocaine gel (Master-Dent, Dentonics Inc., USA) was applied and left in place for 1 min. The inferior alveolar nerve block was performed using a 27-gauge needle (tgJect, London, United Kingdom). Following aspiration, 1.8 ml of 2% lidocaine with 1:100,000 epinephrine (Xylocaine, Dentsply Pharmaceutical, York, PA) was deposited over a 1-min time period. After the injection, the FRS was used to determine the patient's experienced pain as a subjective way and the score was recorded by the nurse. Pulse rate was also recorded after the injection as the second record. At the end of the treatment, the second saliva sample was collected. In the other visit, the samples were taken following the same procedure. Thus, in the second session, the third and fourth saliva samples were collected. Also, the third and fourth pulse rates, and the second FRS scores were recorded. By collecting four saliva samples of each child, a total of 96 samples were obtained. The samples were sent to the laboratory at the end of each appointment. The saliva samples were centrifuged and stored frozen at −20 °C until adequate samples were ready for analysis.

2.4. Data analysis

In this study, the carryover and treatment effects were tested based on the crossover design. A paired *t*-test was applied using the NCSS statistical analysis package (NCSS 11.0 Statistical Software (2016). NCSS, LLC. Kaysville, Utah, USA.). A P-value of less than 0.05 was considered as the level of significance.

2.5. Ethical considerations

The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences, and the trial was registered at the Iranian Registry of Clinical Trials (www.irct.ir, registration number: IRCT20190119042406N1). A written informed consent was obtained from the parents before enrolment of the children in the study.

3. Results

There was no statistically significant difference in age between the two groups ($P = 0.633$). Also, there was no statistically significant difference in the number of girls and boys in this study ($P = 0.68$). As presented in Table 1, the main outcome of this study was obtained by calculating the difference of salivary cortisol means between treatment with lavender aroma and without it, which was statistically significant ($P = 0.00064$). Similarly, the other outcome of this study was achieved by calculating the difference of pulse rate means between the intervention and control visits, which was statistically significant ($P = 0.00043$).

As shown in Table 2, the effect of lavender aromatherapy on the pain perception during dental injection was assessed by the FRS in both sessions which was statistically significant ($P = 0.00083$). The carry-over effect was not statistically significant for the pulse rate, salivary cortisol level, and FRS scores (P = 0.65, 0.18 and 0.83, respectively). It declared that the wash-out period of one week was long enough to eliminate any potential carry-over effect. Table 3 presented that the changes in salivary cortisol level, pulse rate, and FRS score in the intervention visit were not affected by gender.

4. Discussion

The findings showed that aromatherapy with lavender essential oil can significantly result in reduced pulse rate and salivary cortisol level in children during dental treatment. The results also found the effectiveness of lavender aromatherapy on the reduction of pain perception during dental injection; therefore, it could be considered as a method for stress and pain control in dental settings in children.

Several studies have reported the anxiolytic effect of aromatherapy with different essential oils in medical settings [9,10,12,23,26]. It has been shown that lavender aromatherapy may be an efficient therapeutic option for managing the pain following needle insertion in either healthy volunteers or hemodialysis patients [9,23]. Karaman et al. introduced the lavender aromatherapy as a beneficial choice for managing anxiety and pain during peripheral venous access placement [12]. Cho et al. showed the effectiveness of aromatherapy with the oil blend of lavender, roman chamomile, and neroli in reducing the anxiety, improving the sleep, and stabilizing the blood pressure of patients undergoing cardiac stent insertion [10].

As it was mentioned before, the studies evaluating the effect of aromatherapy with different essential oils on dental anxiety are few. Most of them are in agreement with the results of the current study, showing the positive effect of aromatherapy with different essential oils on reducing dental anxiety. The majority of these researches, however, evaluated the anxiety of adult patients by using questionnaires in the waiting room and not during the dental treatment [13,14,20,21]. It is not known whether the reduced anxiety in the waiting room caused by aromatherapy still lasts during the dental procedure. Jafarzadeh et al. and Pradopo et al. revealed that the child anxiety could be reduced while receiving fissure sealant therapy by using orange and pandan aromatherapy, respectively [15,16]. Arslan et al. reported that the lavender oil inhalation can result in decreased anxiety during tooth extraction in children [22].

In contrast to the results of the current study, Nord and Belew indicated that the use of ginger and lavender essential oils could not significantly provide comfort to the children in a perianesthesia setting [27]. Since in their study the parents performed the FLACC (faces, legs, activity, cry, and consolability) assessments without any training, the reliability of their reports is questionable. Moreover, heterogeneity of the samples was the other limitations of their study [27]. In a double-blind, placebo-controlled trial, Ndao et al. demonstrated that inhalation aromatherapy with bergamot essential oil was not effective in reducing nausea, anxiety, or pain in children and adolescents 5–21 years of age undergoing stem cell infusion. Using the same amount of essential oil or placebo for all participants with various diagnoses and treatment histories may have affected the results of their study [28].

Toet et al. showed that neither apple nor orange odor was effective in reducing anticipatory anxiety in patients waiting in large dental clinics. The outcome may have been affected by additional distraction sources, such as great noises and crowding [20]. Holm and Fitzmaurice stated that music significantly decreased the anxiety of adults accompanying children to a pediatric emergency department, while orange aromatherapy did not result in a significant anxiety reduction. As they mentioned, this outcome might be due to the inadequate application of aromatherapy or decreased potency of aromatherapy due to the hospital air circulating system [29].

In the present study, the FRS score revealed that the inhalation of lavender aroma could significantly decrease pain perception related to the needle insertion and local anesthetic injection in children. Similar to our study, Arslan et al. showed the effect of lavender inhalation on decreasing the pain intensity during tooth extraction [22]. Moreover, Bikmoradi et al. found the significant differences in pain scores of preschool children who were given aromatherapy with lavender essential oil during intravenous catheter insertion [24]. However, Soltani et al. found that lavender had no significant effect on the reduction of pain intensity following tonsillectomy in pediatric patients, which may be due to the use of analgesic agents in the case and control groups that might have masked the effect of lavender aroma [30].

Based on the results of this study, the treatment effect of lavender was not affected by gender. There was no significant difference in the mean changes of the salivary cortisol level, pulse rate, and FRS scores between boys and girls. Pradopo et al. also reported no gender influence on dental anxiety decrement of pandan leaves aromatherapy on pediatric patients [16]. However, Lehrner et al. indicated that there was more anxiety reduction in women exposed to orange odor while waiting in the dental office, which might be due to the greater olfactory sensitivity in females [21]. Moreover, the mean age of male participants was higher than female in their study [21]. It has been reported in another study that aging not only decreases the sensory function in both genders but also it weakens the sensory function even more strongly in male

Table 1
Mean, standard deviation (SD), mean difference, and treatment effect on the salivary cortisol level (nmol/lit) and pulse rate (per minute) by group and visit.

Variable	Group	Visit	Sample size	Before treatment Mean ± SD	After treatment Mean ± SD	Mean difference Mean ± SD (intragroup)[a]	Treatment effect Mean ± SE[b]	95.0% Confidence limit	P-value
Salivary cortisol	1	Control	12	20.16 ± 9.47	16.76 ± 7.05	−3.40 ± 5.45	−8.01 ± 0.92	−9.92 to −6.10	0.00064
		Intervention	12	18.41 ± 7.60	9.84 ± 4.75	−8.57 ± 3.99			
	2	Intervention	12	27.78 ± 7.62	13.97 ± 4.00	−13.81 ± 6.10			
		Control	12	23.65 ± 9.11	20.69 ± 6.92	−2.96 ± 3.52			
Pulse rate	1	Control	12	107.42 ± 7.44	109.33 ± 8.42	1.92 ± 5.14	−11.17 ± 1.28	−13.83 to −8.50	0.00043
		Intervention	12	106.58 ± 8.60	94.92 ± 9.33	−11.67 ± 5.48			
	2	Intervention	12	112.50 ± 8.53	104.08 ± 8.27	−8.42 ± 6.05			
		Control	12	109.33 ± 7.27	109.67 ± 6.80	0.33 ± 5.12			

[a] Mean difference in values before and after the treatment (intragroup).
[b] Standard error.

Table 2
Mean, standard deviation (SD), and treatment effect on the FRS score by group and visit.

Variable	Group	Visit	Sample size	Mean ± SD	Treatment effect Mean ± SE[b]	95.0% Confidence limit	P-value
FRS[a] score	1	Control	12	4.00 ± 2.70	−2.00 ± 0.41	−2.84 to −1.16	0.00083
		Intervention	12	1.17 ± 1.59			
	2	Intervention	12	2.17 ± 1.99			
		Control	12	3.33 ± 2.15			

[a] FRS: Face Rating Scale.
[b] Standard error.

Table 3
Mean and standard deviation (SD) of changes in the salivary cortisol level, pulse rate, and FRS score in the intervention visit by gender.

Variable	Mean (SD)		P-value
	Female	Male	
Changes in the salivary cortisol	−3.81 ± 2.45	−4.34 ± 1.55	0.54
Changes in the pulse rate	−10.61 ± 6.47	−9.36 ± 5.33	0.61
[a] FRS score	2.00 ± 2.16	1.27 ± 1.34	0.34

[a] FRS: Face Rating Scale.

[31].

Aromatherapy is assumed to have therapeutic effects due to both physiological effects of the inhaled volatile compounds and the psychological effects of the odor. The psychological effect acts via the sense of smell or olfactory system which, in turn, may cause a physiological effect [32]. The physiological effects are considered to act through the limbic system, particularly the hippocampus and amygdala [32]. Nevertheless, the detailed cellular mechanism of action is undetermined; it has been proposed that lavender may increase the activity of gamma-aminobutyric acid in the amygdala in a similar way to benzodiazepines [33]. On the other hand, some studies have found that the inhibition of acetylcholine release and alteration of ion channel function at the neuromuscular junction could be induced by linalool, which is one of the main components of lavender oil that acts as a sedative [34]. Also, linalyl acetate, another main constituent of lavender oil, has narcotic actions [35].

The safety of long-term use of lavender oil aroma inhalation is unknown, particularly concerning toxicity or sensitization [26]. Lavender may induce a stimulating effect rather than a calming effect when used in large amounts [27]. Some studies have shown that contact dermatitis might be seen following lavender exposure [32]. Nevertheless, lavender oil is one of the safest essential oils with a broad therapeutic action [23].

Arslan et al. revealed the positive analgesic and anxiolytic effects of lavender aromatherapy on 6 to 12 year-old children undergoing tooth extraction. Blood pressure and pulse rate were the psychological indicators of anxiety in their study [22]. However, a crossover randomized block design (RBD) was employed in the current study. Furthermore, the salivary cortisol and pulse rate were measured for child anxiety assessment during dental restorative treatment including injection and drilling with both high and low-speed handpieces, which are the most powerful anxiety-provoking stimulus [3]. On the other hand, Arslan et al. poured two drops of lavender essential oil on med patches and asked the patients to inhale for 3 min prior to the interventions [22]. More studies could be designed in order to discover whether this method would be effective for anxiety reduction in longer treatment procedures such as tooth restoration and pulp therapy. Jafarzadeh et al. reported the anxiolytic effect of orange essential oil on the salivary cortisol level and pulse rate for evaluating the child's anxiety level during a noninvasive procedure (fissure sealant). They, however, collected the unstimulated saliva by placing an absorbent cotton pellet which may cause some errors in cortisol measurement [15]. In this study, we decided to collect the saliva samples by asking the child to expectorate directly into the plastic vials, since it has been reported that the use of cotton-based materials to collect the saliva can be a source of systematic and unsystematic errors in measurements [36]. Therefore, further investigations could be performed on evaluating the effect of orange or other aromas during anxiety-provoking dental procedures. The results of the current study might have been influenced by individual's age and scent preferences.

In the present study, gas chromatography was not performed for determining the main components of the lavender essential oil. Another limitation of this study was the lack of a control odor; hence it is possible that lavender scent might have simply masked odors in the dental clinic. This is while the smell of the dental office (such as eugenol) may play an important role in developing dental anxiety and fear [4]. Therefore, some part of the anxiolytic effect of lavender scent could be due to masking of dentistry-related odors rather than its therapeutic effect. Although the narrow age range of 7–9 years was considered as inclusion criteria in our study, it is suggested to use the accurate amount of essential oil regarding age or weight in future studies.

5. Conclusion

Based on the results of this crossover randomized clinical trial, the reduction in the salivary cortisol level and pulse rate showed that the use of lavender aroma in dental settings can be effective in reducing the child's anxiety. Lavender aroma can also decrease pain perception during local anesthetic injection in children. Further research using a nontherapeutic odor as the placebo is needed to assess the therapeutic effect of lavender. It is also suggested to evaluate the effect of other therapeutic aromas especially during more anxiety-induced dental treatments.

Declaration of competing interest

The authors declare that they have no conflict of interest.

CRediT authorship contribution statement

Faezeh Ghaderi: Conceptualization, Methodology, Writing - review & editing. **Neda Solhjou:** Data curation, Formal analysis, Writing - original draft, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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