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SCENTSATIONAL SMILES: THE IMPACT OF AROMATHERAPY ON ALLEVIATING DENTAL ANXIETY IN CHILDREN

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ABSTRACT

The Dealing with dental anxiety in children is the most problematic responsibilities for pedodontists. Essential oils had been used for reducing dental anxiety in adults; this study is to understand their effects on children. Aromatherapy is considered as potent, safe, and non-pharmacological way, especially for children who go through dental procedure under local anesthesia. The aim of this study was to compare the effect of Rosemary versus Lemongrass essential oils on dental anxiety levels and vital signs of children during dental anesthesia and extraction of lower primary molar. Forty-five children, 4 to 7 years, who had a minimum of one mandibular primary molar with deep caries indicated for extraction were selected. Patients were divided, randomly, into three groups (15 each): Group I (control group): with no interference before dental procedures, Group II (Rosemary group): children inhaled three drops of rosemary oil for 3 minutes, Group III (Lemongrass group): children inhaled two drops of lemongrass oil, for 3 minutes (both before the procedure of dental anesthesia and extraction of primary molar). Wong Baker Scale and the physiological measures of the children were recorded for each child by measuring (pulse rate, oxygen saturation, and blood pressure) before, during and after dental procedures. There was statistically significant difference between the three groups in the mean scores of Wong Baker scale, pulse rate, oxygen saturation, and blood pressure. Rosemary oil produced significant reduction of dental anxiety in all treated children. Rosemary oil can be recommended in routine dental practice for reducing dental anxiety in children.

KEYWORDS: Dental anxiety; children; Essential oil; Rosemary; Lemongrass

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INTRODUCTION

One of the major problems for many children in visiting pediatric dentists is fear of pain and anxiety. The actual definition of dental anxiety is the unusual distress of visiting the dentist for prophylactic care and treatment, with unjustified nervousness over dental procedures. It may also include physical, mental and communication results [1]. Dental fear and anxiety (DFA) frequency range from 5% to 20% in different countries, reaching the extent of dental phobia and severe DFA. All these causes make the child uncooperative during the dental visit. Not only does it render the dental visit stressful to the child, but also it concerns the lives of dental specialists. More time is required in addition to the tense atmosphere that probably renders the performance of the dental personnel [2-4]. Pain management in children is, characteristically, neglected due to the lack of knowledge of the physical effects. As an example of tension, insecurities, loneliness, and fright, bad mood states are the consequences of exposing children to pain. Not only all the previous but also the creation of damaging effects on children and their parents as suspicion and mistrust. The mental and emotional circumstances of the children impact their central nervous system, which leads to an increase in the heart rate, blood pressure, and respiratory rate. Furthermore, the fright of pain results in elevated anxiety stages, leading to more troublesome encounters upon dental visits and non-cooperation issues of the children [5,6]. Managing dental anxiety in children is one of the most challenging responsibilities for pediatric dentists. These days different interference modalities have been approached, and medicinal or non-medicinal methods have been introduced to conquer the concern of children's dental anxiety. Some of the modalities employed to overrule anxiety in children include hypnosis, behavior supervision and audio-visual distraction. As soon as all the above-mentioned methods are declared unsuccessful, sedation and general anesthesia are unavoidable in children with severely unwilling attitudes [7,8]. General anesthesia or conscious sedation is used in children with dental anxiety cases. Still, such techniques are costly, might have some hazards, and cannot be applied to kids with allergies, in addition to the required tools and knowledge. Thus, these techniques cannot be consistently used on every patient receiving dental care. Therefore, searching for a better appropriate, non-medicinal, substitute treatment to decrease pain and anxiety in children should be of primary significance [9,10]. Aromatherapy is considered one of the potent non-pharmacologic ways; it has been taken into consideration due to its reasonability and especially for children, who are supposed to go through any dental procedure under local anesthesia as it is considered safe. Aromatherapy is the consumption of essential oils to lessen emotional and physiological distress. It is the kind of medicine that is considered complimentary, after which the unstable oil of plants is consumed to encourage the standard of physiological, psychological, and spiritual well-being [11-14]. The oil that is extracted from plants, also known as volatile oils, ethereal oils, or aetherole, is what is known as an essential oil. Steam or the distillation method is typically used to extract essential oils. In addition to these two methods, essential oils can also be extracted via cold pressing, expression, solvent extraction, absolute oil extraction, or absolute oil extraction [15]. This method provides evidence for the theory t hat common oils can elicit pharmacological and physiological effects through the olfactory system. Observations indicate that orange oil increases parasympathetic nervous system activity by 12% and decreases sympathetic activity by 16%. Aroma therapists endorsed using orange essential oil as a tranquillizer for this reason [16]. Few researchers have investigated the effect of aromatherapy on dental anxiety. Among others, lavender, bergamot oil, and apple scents have been studied primarily among adults. According to a study that examined the effect of gender and ethnicity on the preferences and attitudes of children, the odor and flavor preferences of youngsters differ significantly from those of adults. Therefore, children are more inclined to accept essential oils they enjoy [17,18]. Lemongrass provides one of the most often-used essential oils in the medical and dental professions. Lemongrass, also known as *Cymbopogon citratus*, is a grass-like culinary herb from the family Poaceae. It has a light citrus flavor. It is a fragrant treasury of vital nutrients that provides a variety of health advantages. It possesses antimicrobial, antibacterial, and antifungal effects. In the medical area, Lemongrass provides treatment for stomach issues, sleeplessness, respiratory diseases, fever, pains, infections, and rheumatism. The antioxidant activity of Lemongrass protects against antibiotic-resistant Staphylococcus aureus and promotes optimal cholesterol levels, cellular health, neurological system, skin health, and immunity. In the dentistry industry, Lemongrass aids in the removal of microorganisms from the oral cavity and prevents tooth and gum problems. It has antioxidant qualities that aid in treating and preventing periodontitis [19]. Radhalakshmi et al., [20] researched the effectiveness of Lemongrass oil in lowering children's dental anxiety. Forty youngsters between the ages of 8 and 11 who were having their first dental appointment were randomly allocated into two groups. This consisted of a control group and an experimental group exposed to a candle warmer with regular water and Lemongrass oil. For both groups, a psychometric and objective evaluation of anxiety was conducted using "Venham's image test" and a "pulse oximeter". This study showed that the experimental group had lower mean scores on Venham's picture scale (VPS) and heart rate after exposure. This research suggests that paediatric dentists should routinely employ aromatherapy using Lemongrass oil to help calm their anxious young patients. There are three different types of Rosemary (Rosmarinus officinalis Linn), but only the green form is employed for its therapeutic benefits. The bitter principle, resin, tannic acid, and volatile oil in this plant are particularly plentiful. Bornyl acetate, borneol, and other esters are the active components. Its oil has been shown to have a significant effect on the digestive tract, easing gastrointestinal distress such as bloating, gas, and indigestion. It's a tonic for the liver and gallbladder. Moreover, oil has a beneficial effect on the cardiovascular system. It stabilizes blood pressure and slows the development of atherosclerosis. Formerly, it was used to alleviate rheumatic discomfort, which worsens in the winter owing to cold [21]. Rosemary's stimulating effects on the neurological system are effective in cases of hysteria and paralysis. Due to its free radical scavenging activity, aromatherapy has the potential to improve cognitive function, particularly in Alzheimer's disease patients, according to the results of the most recent human experiments [22-24]. Atsumi and Tonosaki, 2007 [23] investigated to determine the total salivary free radical scavenging activity (FRSA), which reduces oxidative stress. After inhaling lavender and Rosemary essential oils, which are extensively used in aromatherapy, saliva has this activity. Several salivary physiologically active chemicals, including cortisol, secretory IgA, and -amylase activity, were observed to be linked with aroma-induced FRSA. Twenty-two healthy participants inhaled aromas for 5 minutes, and their saliva was promptly collected. 1,1-diphenyl-2-picrylhydrazyl was utilized to determine FRSA. Stimulation with low concentrations (1000 times dilution) of lavender or high concentrations (10 times dilution) of Rosemary enhanced the FRSA levels. In contrast, stimulation with lavender and Rosemary lowered cortisol levels. There was a substantial inverse connection between FRSA readings and cortisol levels at each Rosemary stimulation concentration. There were no substantial alterations in sIgA or -amylase. These results demonstrate that lavender and Rosemary increase the FRSA and reduce cortisol, which protects the body from oxidative stress.

This research aimed to assess the effects of inhaling Rosemary and Lemongrass essential oils on children's dental anxiety by measuring Wong Baker Scale by measuring Wong Baker Scale and vital signs by measuring pulse rate, oxygen saturation and blood pressure during the administration of anesthesia and the extraction of a lower primary molar in a dental clinic.

MATERIALS AND METHODS

The present study was carried out after the approval of the Research Ethics Committee (REC) No: 455/2022, Faculty of Dentistry, Suez Canal University. That was in full accordance with the World Medical Association Declaration of Helsinki (version 2008) and with The ClinicalTrial.gov ID: NCT06068777.

MATERIALS

TABLE (1) Materials' name, equipment's and Manufacturer that was used in the study:

Name of materials	Manufacturer
Lemongrass essential oil	Black Lotus
Rosemary essential oil	Black Lotus
Local anesthesia Articane %4 with epinephrine 1:100,00	Artinibsa, Inibsa, Barcelona, Spain.
Pulse oximeter	Granzia, Pulsox, Italy.
Sphygmomanometer	Granzia, Pulsox, Italy.

METHODS

Study setting

The participants in this randomized controlled clinical trial were 45 children between the ages of 4 and 7 years who needed to have at least one lower primary molar indicated for extraction. The patients were gathered from the Suez Canal University School of Dentistry's outpatient clinic of Pediatric Dentistry Department. Before any treatments were performed, the children and their parents or legal guardians were told of the research and gave their permission in a written informed consent.

Patient Selection

The participating children were chosen based on the inclusion criteria listed below [25].

Apparently, healthy patients.

Both girls and boys were included.

Patients with Frankl Behavior Rating Scale, categories 2, 3 and 4.

Patients who needed extraction of at least one mandibular primary molar.

Parents who agreed to contribute to the study.

Randomization, allocation concealment and blinding

This study included 45 children recruited and allocated randomly to three groups according to Simple randomization. It was computer generated by the Research Randomizer software program (https://www. randomizer.org/). An independent person (the author S.A.W) put randomization codes in sequentially numbered, secured, opaque wrappers to ensure covert distribution into the three groups, the author (S.A.W) used 45 different numbered cards; I, II and III (fifteen each). Cards were put in a big envelope for the children to pick a card from them, the numbers resemble the following groups:

- **Group I** (control group): included 15 children with no prior intervention before the anesthesia and extraction procedures of a primary molar.

Group II (Rosemary group): included 15 children who were asked to inhale three drops of Rosemary oil, from a gauze, for 3 minutes before the anesthesia and extraction procedures of a primary molar [25].

- **Group III** (Lemongrass group): included 15 children who were asked to inhale three drops of Lemongrass oil, from a gauze, for three minutes before the anesthesia and extraction procedures of a primary molar.

Before the operating period, the author (Y.S.H) measured anxiety using the Wong Baker Scale and measured the children's anxiety (vital signs) by recording pulse rate and oxygen saturation using pulse oximeter, and blood pressure using a sphygmomanometer.

Pedodontist, the author (S.M.O), performed clinical diagnosis and dental procedures. The author (S.A.W) hid the cotton with or without essential oil in closed envelopes and coded them as A, B or C. At the time of application, the cotton was prepared according to the random codes as follows: Group I (A): empty cotton, Group II (B): cotton prepared with 3 drops of Rosemary &Group III (C): cotton prepared with 3 drops of Lemongrass oil.

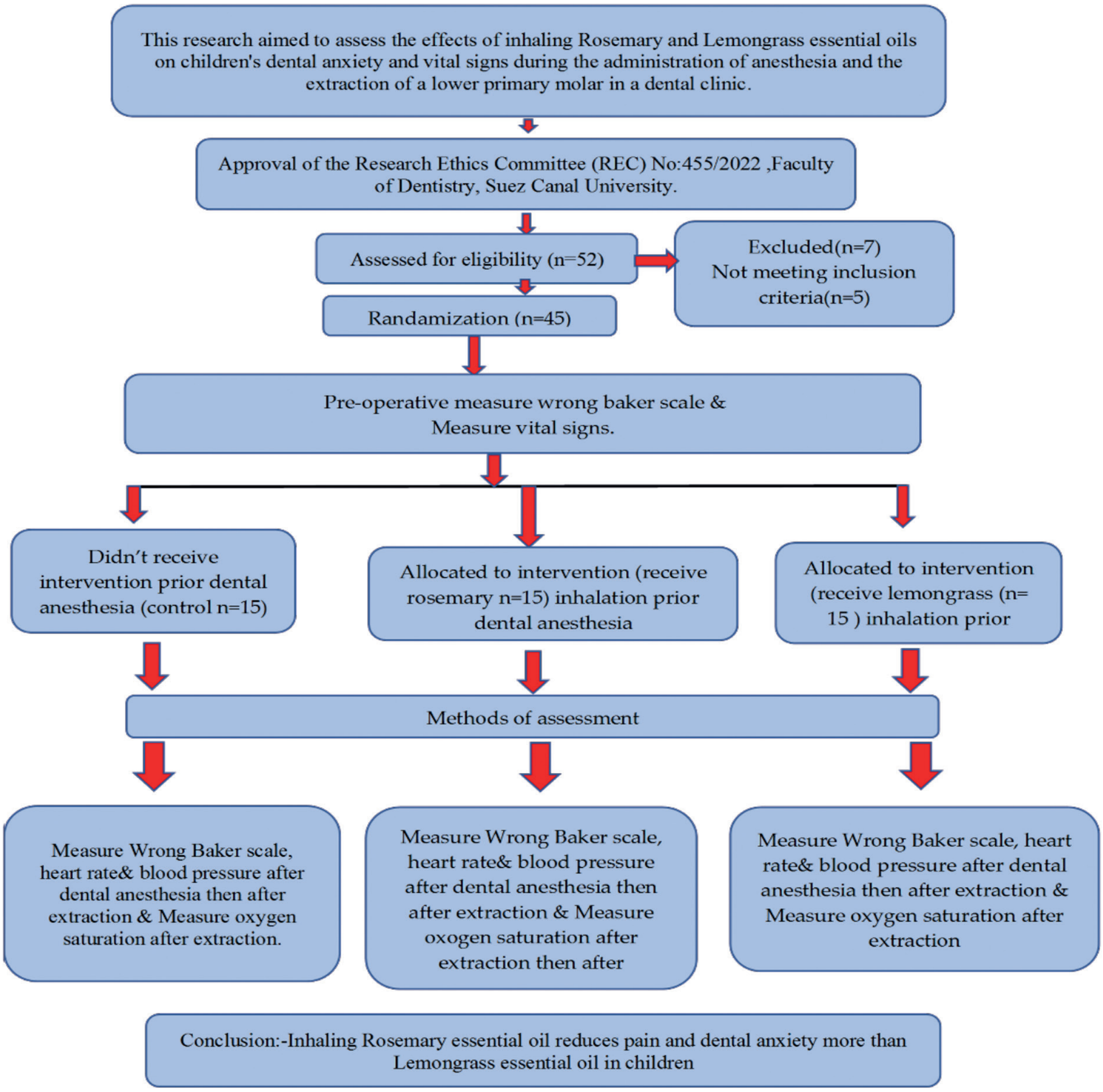

Fig (1) patient's flowchart

Each cotton was packed into their corresponding patient through the author (S.A.W). Therefore, the operator (Author S.M.O) was blinded to the type of oil and the group of the patient. The patients were also blinded to the oil intervention (double-blinded).

Study Procedures and Evaluation Methods: The same pediatric dentist (S.M.O) operated all children included in the study to minimize differences due to operator variability.

Based on group allocation, each child in group II (Rosemary group) and III (Lemongrass group) was asked to inhale three drops from a gauze of the specified essential oil before dental anesthesia in a separate room for three minutes, with no skin contact.

The physiological measure of the children's anxiety in the operatory period was evaluated and recorded by measuring pulse rate and oxygen saturation, using pulse oximeter, and measuring blood pressure, using a sphygmomanometer.

All parameters were recorded by the author (Y.S.H) as follow:

Regarding anxiety, it was recorded at three different times, in all 3 groups:

Using a subjective scale to record self- pain by the Wong-Baker Scale (figure 1).

T0 Base line prior to any dental procedure (before inhalation).

T1 After the anesthesia (after inhalation).

T2 After the extraction procedure of a primary molar (after inhalation).

Regarding the vital signs, heart rate and blood pressure were recorded, at three different times (T0, T1, T2) while oxygen saturation recorded two times (T0, T1) for the three groups as follows:

T0 Base line prior to any dental procedure (before inhalation).

T1 After the anesthesia (after inhalation).

T2 After the extraction procedure of a primary molar (after inhalation).

After finishing all the procedures, the patient was rewarded and sent home.

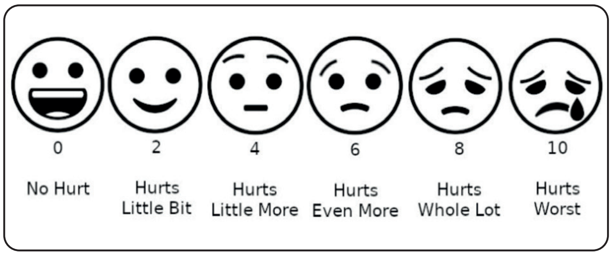

Fig. (2). Wong Baker Scale.

Statistical plan

a. Sample Size Calculation for Study:

The present study is performed to explore and compare the effect of Rosemary versus Lemongrass essential oils Lemongrass oil (A0, A1, A2) on anxiety levels and vital signs of children during dental anesthesia and extraction of lower primary molar in a dental office. To compare between the three groups; one-way analysis of variance or corresponding statistical analysis is proposed. A minimum total sample size of 45 samples will be sufficient to detect the effect size of 0.48 according and a power (1-β=0.80) of 80% at a significance probability level of p<0.05 and partial eta squared of 0.19. According to sample size calculations each treatment group (A0, A1, A2) would be represented by a minimum of 15 children as shown in tables 1 and 2. The sample size was calculated according to G*Power software version 3.1.9.6. (Cohen, 1988, Faul et al., 2007, 2013) 26-28.

Where;

f: is the effect size; $\alpha = 0.05$;

$\beta = 0.15$;

Power= $1 - \beta = 0.85$

$$f = \frac{\sigma_\mu}{\sigma}$$

$$\sigma_\mu^2 = \frac{\sum_{i=1}^{k} n_i (\mu_i - \mu)^2}{N}$$

b. Statistical Analysis:

All data were collected, tabulated, and statistically analyzed. The Chi-square test was used to test the significance of the association between categorical variables. To compare the mean difference between groups, an independent samples-t test was used for two groups, and one-way analysis of variance (ANOVA) repeated measures were used for more than 2 groups. The significance level was set as P value≤0.05 significant. Statistical analysis was performed using SPSS version 26 [29].

RESULTS

Results of the current study were collected for the clinical evaluation of the effect of inhaling Rosemary or Lemongrass essential oils on dental anxiety using the Wong Backer scale and vital signs by measuring the systolic blood pressure, diastolic blood pressure, heart rate and Oxygen Level in, children during dental extraction procedures of lower primary molars.

Wong Baker Scale of children was evaluated in the three different groups (I, II, and III), including control, Rosemary, and Lemongrass groups and presented in Figures (3-5).

According to repeated measures ANOVA, the overall effect of groups (I, II, and III) and Time of measurements (T0, T1, T2) and their interaction revealed a highly significant difference in Wong Baker Scale. The overall Wong Baker Scale presented as the average of all time points in each group showed an average of 3.56±1.27, 2.62±1.11, and 3.24±1.23 in control, Rosemary, and Lemongrass groups with a highly significant (p<0.001***) difference between groups as revealed by Freidman's test; respectively Figures (3-5).

In group I (control group), the Wong Baker Scale increased significantly (p<0.001***) from pre-operative (2.67±0.98), after anesthesia (4.40±1.12) to after extraction (3.60±1.12), with a significant increase in after extraction Wong Baker Scale by 35.0% from pre-operative.

However, in the group II (Rosemary group), where children were asked to inhale two drops of Rosemary oil, the Wong Baker Scale showed an average(±SD) of 3.87±1.41, 3.20±1.01, 2.67±0.98, and in pre-operative, after anesthesia and after the extraction; respectively. The Wong Baker Scale significantly decreased after extraction by -44.44% from pre-operative.

In group III (Lemongrass group), where children were asked to inhale two drops of Lemongrass oil, the Wong Baker Scale of the third group recorded an average (±SD) of 3.87±1.41, 3.20±1.01, and 2.67±0.98 pre-operative, after anesthesia, and after the extraction; respectively. The Wong Baker Scale significantly decreased by -31.03% from pre-operative to after extraction. From the previous results, group II included children who inhaled drops of Rosemary oil, showed the highest significant decrease (-44.44%) from pre-operative, followed by Lemongrass oil with -31.03% decrease compared to increased Wong Baker Scale in the control group (35.0%).

The detailed Wong Baker Scale presented as frequency (n, %) was represented in Table (2), with a significant difference between time points as revealed by Freidman's test and a significant difference between the three groups as revealed by Kruskal-Wallis test.

The significant increase in Wong Baker Scale in groups II and III treated with Rosemary and Lemongrass was also confirmed using simple linear regression and regression trend line presented in figures 5 (A-C).

Systolic Pressure

The systolic blood pressure was evaluated in the control, Rosemary, and lemon groups ((I, II, and III). According to repeated measures ANOVA, the overall effect of groups (I, II, and III) and time of measurements (T_0, T_1, T_2) and their interaction revealed a highly significant difference in systolic blood pressure.

TABLE (2) Bar chart of the Wong Baker Scale in the three different groups including (control, Rosemary, and Lemongrass groups at two time points preoperative and after extraction.

Group	Score	Pre-operative	After anes-thesia	After Extrac-tion	Overall	Freidman's test
G1 control	**1**	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	<0.001***
	2	10 (66.67%)	1 (6.67%)	4 (26.67%)	15 (33.33%)	
	3	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	4	5 (33.33%)	10 (66.67%)	10 (66.67%)	25 (55.56%)	
	5	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	6	0 (0.00%)	4 (26.67%)	1 (6.67%)	5 (11.11%)	
	Chi-square	**>0.05 ns**	**0.015 ***	**0.015 ***		
G2 rosmary	**1**	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	<0.001***
	2	5 (33.33%)	13 (86.67%)	15 (100.00%)	33 (73.33%)	
	3	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	4	8 (53.33%)	2 (13.33%)	0 (0.00%)	10 (22.22%)	
	5	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	6	2 (13.33%)	0 (0.00%)	0 (0.00%)	2 (4.44%)	
	Chi-square	**>0.05 ns**	**>0.05 ns**	**0.005 ****		
G3 Lemon-grass	**1**	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0.006**
	2	4 (26.67%)	6 (40.00%)	10 (66.67%)	20 (44.44%)	
	3	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	4	8 (53.33%)	9 (60.00%)	5 (33.33%)	22 (48.89%)	
	5	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	
	6	3 (20.00%)	0 (0.00%)	0 (0.00%)	3 (6.67%)	
	Chi-square	**>0.05 ns**	**>0.05 ns**	**>0.05 ns**		
Kruskal-Wallis		0.037*	<0.001***	<0.001***	<0.001***	
Repeated measures ANOVA						
Corrected model		< 0.001***				
Group		0.013 *				
Time		0.001***				
Group x Time		< 0.001***				

, **, ***: significant at p<0.05, 0.01, 0.001; ns: non-significant at p>0.05

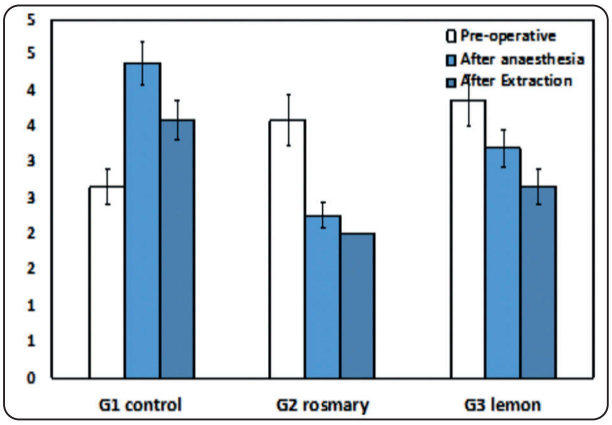

Fig. (3) Bar chart of the Wong Baker Scale in the three groups (I, II, III), including control, Rosemary, and Lemongrass groups, at three time points pre-operative, after anesthesia and after extraction.

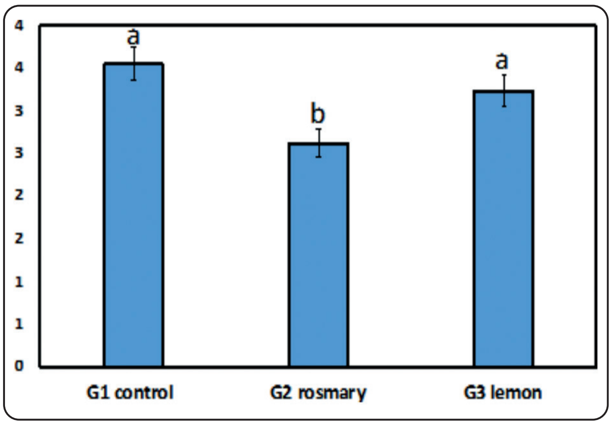

Fig. (4) Bar chart of the Wong Baker Scale in the total of the three different groups (I, II, and III) including control, Rosemary, and Lemongrass groups.

The overall systolic blood pressure presented as the average of all time points in each group showed an average of 115.13±7.01, 110.38±5.92, and 111.07±6.21 mmHg in control, Rosemary and Lemongrass groups with a highly significant difference between groups; respectively Figures (6-8).

Regarding group I (control group), the systolic blood pressure increased significantly ($p<0.001$***) from pre-operative (112.93±7.46 mmHg) to after anesthesia (116.80±7.05 mmHg) and after extraction (115.67±6.37 mmHg).

However, in group II (Rosemary group) showed highly significant difference between time points. The systolic blood pressure showed an average (±SD) of 114.93±5.84, 109.13±4.53, and 107.07±4.45 mmHg in pre-operative, after anesthesia, and after extraction; respectively. The systolic blood pressure significantly decreased by -6.84% from pre-operative to after extraction.

In group III (Lemongrass group) the systolic blood pressure recorded an average (±SD) of 112.87±6.20, 111.47±6.28, and 108.87±5.89 mmHg in pre-operative, after anesthesia, and after extraction; respectively. The systolic blood pressure significantly decreased by -3.54% from pre-operative to after extraction.

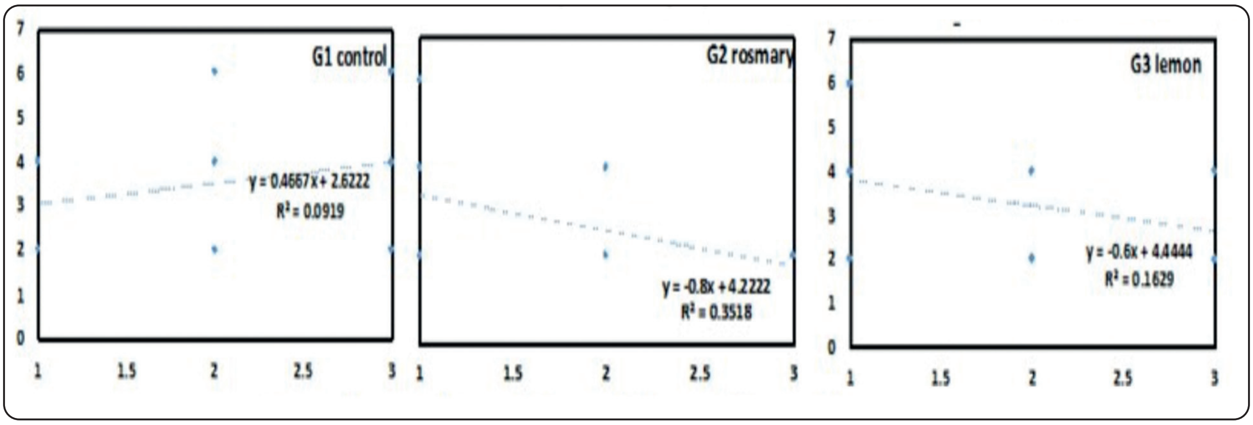

Fig. (5) Linear regression trend line showing the relationship between time of investigation and Wong Baker scale in the three different groups (I, II, III), including (I) control, (II) Rosemary, and (III) Lemongrass groups.

From the previous results, group II showed the highest significant decrease (-6.83%) from pre-operative, followed by Lemongrass oil with (-3.54%) decrease. The significant decrease in systolic blood pressure was also confirmed using simple linear regression and regression trendline presented in figures (8 A-C).

2- Diastolic blood pressure

The diastolic blood pressure was evaluated in the three different groups (I, II, and III), including control, Rosemary, and lemon groups and presented in Figures (9-11). According to repeated measures ANOVA, the overall effect of groups (I, II, and III) and time of measurements (T_0, T_1, T_2) and their interaction revealed a highly significant difference in diastolic blood pressure.

The overall diastolic blood pressure presented as the average of all time points in each group showed an average of 85.16±3.18, 77.67±4.14, and 75.62±3.70 mmHg in control, Rosemary, and Lemongrass groups with a highly significant (p<0.001**) difference between groups as revealed by one way ANOVA; respectively and Figures (9, 10).

Regarding the control group, the diastolic blood pressure increased significantly (*p*<0.001**) from pre-operative (84.40±3.42 mmHg) to after anesthesia (85.87±3.14 mmHg) and after extraction

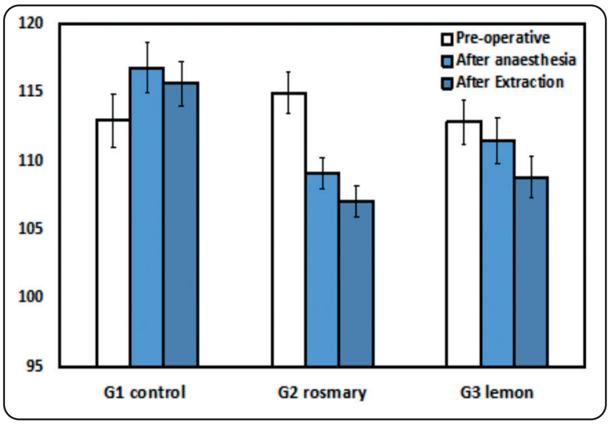

Fig. (6) Bar chart of Systolic pressure (mmHg) showing the three different groups (I, II, and III), including control, Rosemary, and Lemon groups.

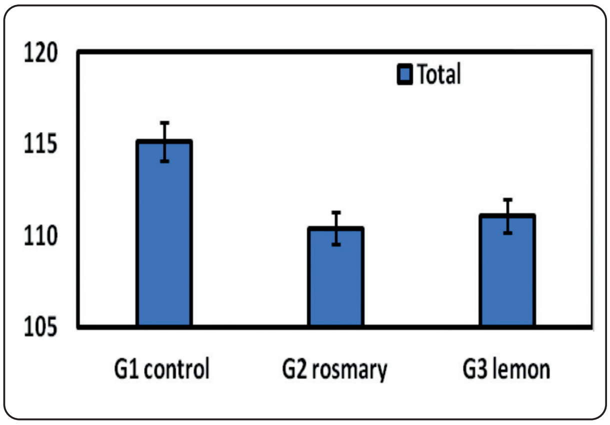

Fig. (7) Bar chart of Systolic pressure (mmHg) showing the total of the three different groups (control, Rosemary, and lemon)

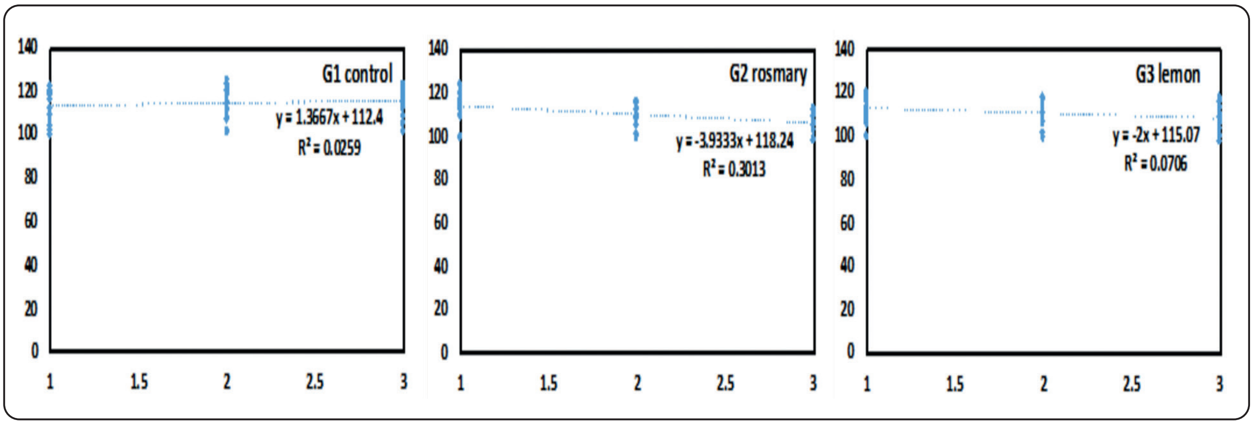

Fig. (8) Linear regression trendline showing the relationship between time of investigation and Systolic pressure (mmHg) at the three different groups (I, II, and III), including (I) control, (II) Rosemary, and (III) Lemon groups.

(85.20±3.03 mmHg), with a significant increase in after extraction diastolic blood pressure by 0.95% from pre-operative.

However, in the group II, where children were asked to inhale two drops of Rosemary oil, the diastolic blood pressure showed an average (±SD) of 80.20±4.20, 77.20±3.59, and 75.60±3.42 mmHg in pre-operative, after anesthesia, and after the extraction; respectively. The diastolic blood pressure significantly decreased after extraction by -5.74% from pre-operative.

In group (III), diastolic blood pressure in the third group recorded an average (±SD) of 76.73±4.11, 75.60±3.58, 74.53±3.27 mmHg. In pre-operative, after anesthesia, and after the extraction, respectively. The diastolic blood pressure significantly decreased by -2.87% from pre-operative to after extraction.

From the previous results, group II showed the highest significant decrease (-5.74%) from pre-operative, followed by Lemongrass oil with -2.874% decrease. The significant decrease in diastolic blood pressure was also confirmed using simple linear regression and regression trendline (Figure 11 A-C).

3-Heart Rate

The heart rate of children was evaluated in the three different groups (I, II, and III), including control, Rosemary, and Lemongrass groups and presented in and Figures (12-14).

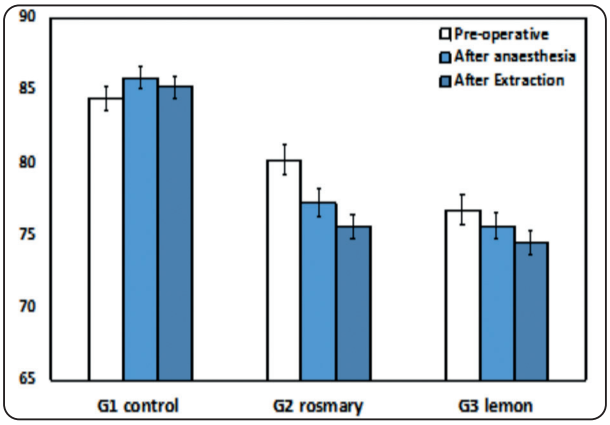

Fig. (9) Bar chat of the diastolic pressure (mmHg) showing the three different groups (I, II, and III), including (control, Rosemary, and Lemongrass) groups respectively at three different time points (T0, T1, and T2).

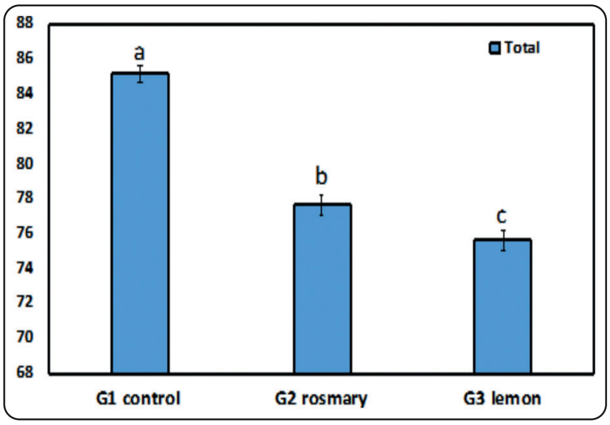

Fig. (10) Bar chat of the diastolic pressure (mmHg) shows the total of three groups (I, II, and III), including (control, Rosemary, and Lemongrass) groups respectively.

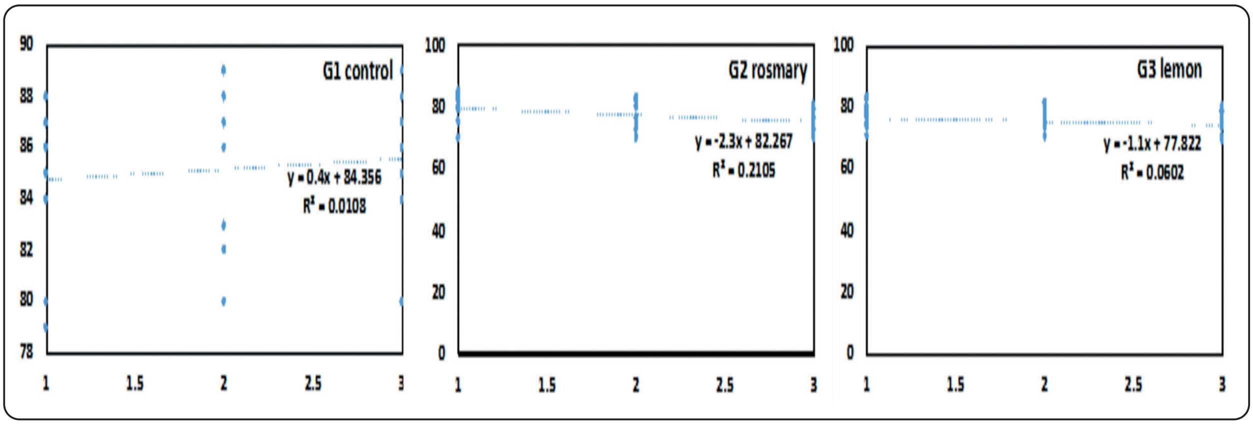

Fig. (11) Linear regression trend line showing the relationship between time of investigation and diastolic pressure (mmHg) at different groups (I) control, (II) Rosemary, and (III) Lemongrass groups.

According to repeated measures ANOVA, the overall effect of groups (I, II, and III) and Time of measurements (T_0, T_1, T_2) and their interaction revealed a highly significant difference in heart rate.

The overall heart rate presented as the average of all time points in each group showed an average of 119.73±4.21, 110.53±8.18, and 113.51±6.48 in control, Rosemary, and Lemongrass groups with a highly significant ($p<0.001$***) difference between groups as revealed by one way ANOVA; respectively Figures (12, 13).

Regarding the control group, the heart rate increased significantly ($p<0.001$***) from pre-operative (118.87±4.82) to after anesthesia (120.53±3.83) and after extraction (119.80±4.04), with a significant increase in after-extraction heart rate by 0.79% from pre-operative.

However, in group II, the heart rate showed an average(±SD) of 113.80±8.16, 110.20±7.57, and 107.60±8.09 in pre-operative, after anesthesia, and after extraction; respectively. The heart rate significantly decreased after extraction by 5.45% from pre-operative.

Group (III), the heart rate in the third group recorded an average (±SD) of 116.00±6.16, 113.53±6.17, and 111.00±6.52 pre-operative. In after anesthesia, and after the extraction; respectively. The heart rate significantly decreased by -4.31% from pre-operative to after extraction.

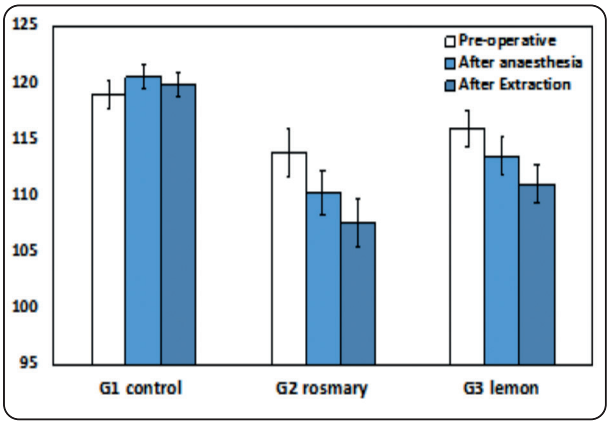

Fig. (12) Bar chart of the heart rate showing the three different groups including control, Rosemary, and Lemongrass groups at three different time points (T0, T1, and T2).

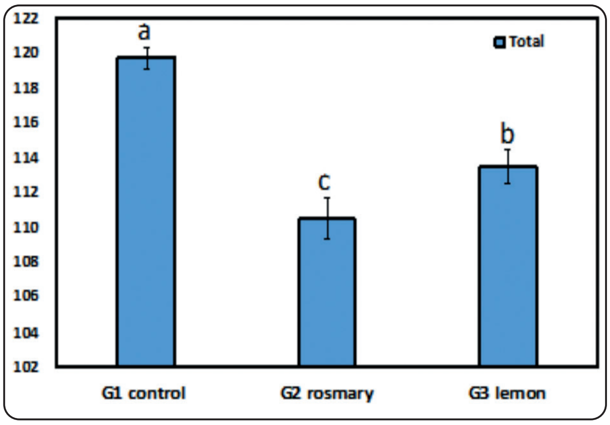

Fig. (13) Bar chart of the heart rate shows the total of three groups (I, II, and III), including control, Rosemary, and Lemongrass groups.

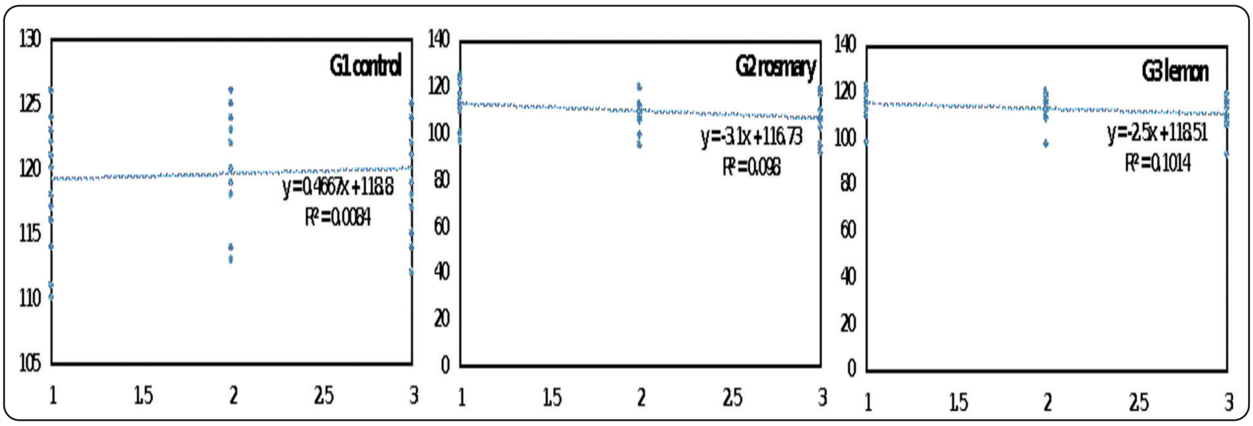

Fig. (14) Linear regression trendline showing the relationship between time of investigation and heart rate in (I) control, (II) Rosemary, and (III) Lemongrass groups.

From the previous results, group II showed the highest significant decrease (-5.45%) from pre-operative, followed by Lemongrass oil with a -4.31% decrease. The significant decrease in heart rate was also confirmed using simple linear regression and regression trendline presented in figures (14 A-C).

4- Oxygen Level

The oxygen level of children was evaluated in the three different groups (I, II, and III), including control, Rosemary, and lemongrass groups and presented in Figures (15-17). According to repeated measures ANOVA, the overall effect of groups (I, II, and III) and time of measurements (T_0, T_2) and their interaction revealed a highly significant difference in oxygen level.

The overall oxygen level presented as the average of all time points in each group showed an average of 97.47±1.04, 98.00±0.95, and 97.97±0.85 in control, Rosemary, and lemongrass groups with a highly significant ($p<0.001$***) difference between groups as revealed by one-way ANOVA; respectively Figures (15-17).

Regarding the control group, the oxygen level decreased significantly (p=0.010***) from pre-operative (98.00±0.93) to after extraction (96.93±0.88), with a significant decrease in after extraction heart rate by -1.09% from pre-operative. However, in group II, the oxygen showed an average (±SD) of 97.60±0.91, and 98.40±0.83, and in pre-operative and after the extraction; respectively. The oxygen level significantly increased after extraction by 0.82% from pre-operative.

In group (III), the oxygen level recorded an average (±SD) of 97.60±0.83 and 98.33±0.72 pre-operative and after the extraction; respectively. The oxygen significantly increased by 0.75% from pre-operative to after extraction.

From the previous results, (group II) Rosemary oil with the highest significant increase (0.82%) from pre-operative, followed by Lemongrass oil with a 0.75% increase compared to the decreased oxygen level in the control group (-1.09%).

The significant increase in oxygen level in groups II and III treated with Rosemary and Lemongrass were also confirmed using simple linear regression and regression trend line presented in figures (17A-C).

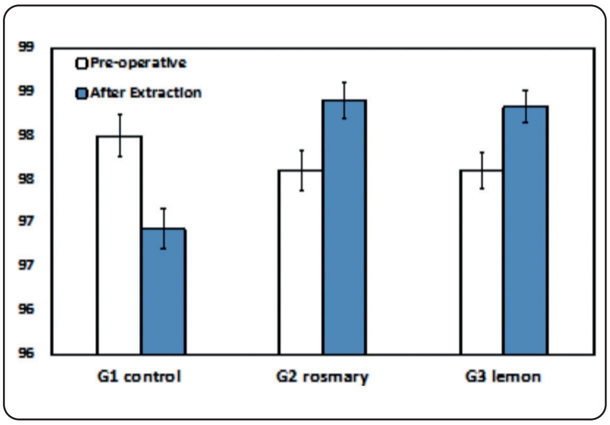

Fig. (15) Bar chart the oxygen level in the three groups (I, II, and III), including control, Rosemary, and Lemongrass groups at two time points pre-operative and after extraction.

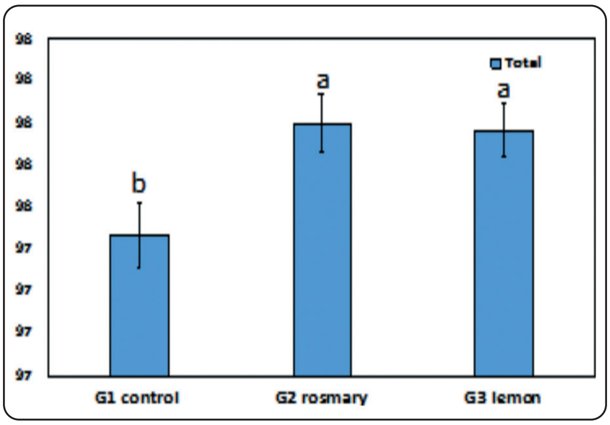

Fig. (16) Bar chart of the oxygen level in the three different groups (I, II, and III), including control, Rosemary, and Lemongrass groups.

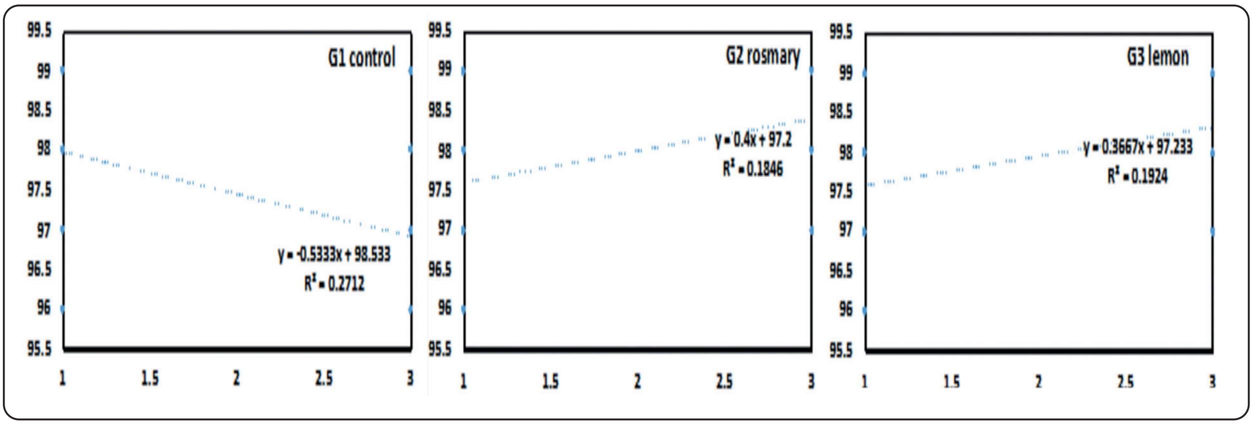

Fig. (17) Linear regression trend line showing the relationship between time of investigation and heart rate in the three different groups including (I) control, (II) Rosemary, and (III) Lemongrass.

DISCUSSION

In pediatric dentistry, the administration of local anesthetic is the most common intrusive technique, causing youngsters to experience oral anxiety and panic [30]. Anxious and fearful children experience the pain of a higher amount and extended duration [31]. Hence, to attain this goal, several behavior management methods, both non-pharmacological and pharmacological, have been used [32]. Pharmaceutical anxiolytic medications, such as benzodiazepines, have been correlated to unpleasant sedative and withdrawal effects; the danger of addiction is a further adverse impact [33-34]. The current research's main emphasis is to decrease children's anxiety and pain. Thus, aromatherapy was used as a non-invasive and inexpensive method. Aromatherapy oils are perfumed, volatile liquid substances detached from plants using steam or pressure. They have been positively stated to alleviate generalized anxiety and pain [35].

All practitioners should obtain a comprehensive allergy-focused clinical history and refrain from administering aromatherapy to patients with relevant sensitivities. Furthermore, it should be highlighted that a few of the included research had limitations [10, 36, 37, 38], stating that participants with allergies were left out as one of the eligibility criteria for study recruitment.

This study explored and compared the effect of Rosemary versus Lemongrass essential oils on children's anxiety levels and vital signs during the administration of dental anesthesia and extraction of a lower primary molar in the dental office. First-visit children, aged between (4 to 7) years, were selected to obtain a homogenous sample and to easily assess anxiety level and pain, using a sphygmomanometer, pulse oximeter and Wong-Baker scale in all groups. This, disagreed with (Kamalapuram and Rekhalakshmi., [39], who used lavender oil prior to dental anesthesia in children and assessed pain by self-report scale, while Jonnalagadda et al., [40] used Venhams scale and pulse oximeter for measuring pain and anxiety levels in (8-11) aged children who inhaled Lemongrass before dental procedures.

In the current study, Patients were asked to inhale two drops of each oil, from a gauze, for 3 minutes before the procedure of extraction of a lower primary molar, according to different treatment modalities, for standardization of the amount and time of administration of each type of essential oil according to Arslan et al., [25] who used two drops of lavender essential oil on the gauze for 3 minutes to test the efficacy of aromatherapy in reducing anxiety and pain associated with local anesthesia administration. In addition, the candle warmer with essential oil (Lemongrass mixed with water in a 1:1

ratio was put and activated half an hour before the first kid patient's arrival to reduce dental anxiety [40].

On the other hand, the use of Lavender and orange essential oils in the waiting area of a dentist's office has been evaluated for their favorable effect on anxiety and increased mood in two types of inhalations, nebulizer and inhaler [39]. In the current study, either Rosemary or Lemongrass essential oils were inhaled in an operatory room just before the extraction procedure, contrary to Jonnalagadda et al., [40], who used Lemongrass essential oil in adjunct with cartoon videos to decrease anxiety levels in children awaiting different dental procedures in the dental office.

This study revealed that group II (Rosemary oil) had decreased systolic blood pressure and heart rate from pre-operative to post-extraction, followed by the group I (Lemongrass oil). This may be due to the presence of luteolin, phenolic acid, diterpenes, triterpenes, tannins, and resins in the Rosemary plant. These substances affect different regions of the central nervous system [41]. In addition, Rosemary is abundant in flavonoids, which serve as ligands for central nervous system receptors that may also penetrate the blood-brain barrier, may behave like benzodiazepines, and operate as a positive and allosteric regulator to improve GABA actions on GABA receptors. Behavioral investigations on anxious behavior, sedation, and seizures in animal models led to the formation of this concept [42].

This study's results concurred with those of Jonnalagadda et al., [40], who found that the anxiety decrease owing to aromatherapy with Lemongrass essential oil was considerable compared to the anxiety level seen in the control group. This is because Lemongrass essential oil includes neroli, which is often employed in aromatherapy to treat persistent depression. It is believed that inhaling the perfume of neroli essential oil transmits messages to the region of the brain (limbic system) that regulates emotions, which in turn changes the neurological system, resulting in reduced stress and improved mood [43]. When scented oils are inhaled, the volatile molecules attach to olfactory receptors, producing an electrical signal that reaches the brain. Consequently, aromatherapy reduces the pulse rate, as demonstrated by the present investigation.

From the current results, group II (Rosemary oil) showed the highest significant decrease in diastolic blood pressure (-5.74%) when compared pre-operatively, followed by group III (Lemongrass oil) with a (-2.874%) decrease. These findings agree with Premkumar et al., [44], who found that the lavender aromatherapy demonstrated a greater reduction in diastolic blood pressure and dental anxiety compared to Rosemary. Also, stress and anxiety alter the respiratory rate and thereby alter oxygen saturation in the blood [37]. Hence, a pulse oximeter was used to monitor these alterations. Results of the present study showed; a significantly high increase in oxygen saturation from pre-operative to post-extraction. Group II (Rosemary oil) group showed the highest increase, followed by group III (Lemongrass oil) compared to the decreased oxygen level in group I (control group). These results disagreed with Jonnalagadda Radhalakshmi et al, 2018 [40], who found no significant difference in oxygen saturation after using Lemongrass oil inhalation in a conditioning room before dental procedures.

From the results of the present study, group II (Rosemary oil) showed the highest significant decrease in Wong-Baker scale from pre-operative, followed by group III (Lemongrass oil) compared to the increased Wong-Baker scale in group I (control group). These results are in line with Abhishek et al.,[45], who investigated patient dental anxiety levels using Mean State-Trait Anxiety Inventory/ Modified Dental Anxiety Scale (STAI/MDAS) scores, which are reliable and sensitive measures of dental anxiety among the commonly used anxiety tools and, they concluded that there is a significant reduction in patient dental anxiety levels upon using aromatherapy.

CONCLUSIONS

Rosemary essential oil or Lemongrass essential oil can be inhaled before any painful dental practice to reduce dental anxiety in children. Both Rosemary and Lemongrass essential oil can be used as new non-medicinal interference modalities for decreasing pain and dental anxiety in children. Inhaling Rosemary essential oil reduces pain and dental anxiety more than Lemongrass essential oil in children.

Supplementary Materials:

Author Contributions: Conceptualization, S.M.O., methodology, S.M.O and Y.S.H., software, S.A.W. S.M.O., and Y.S.H.; validation, S.M.O formal analysis, S.M.O and Y.S.H.; investigation, S.M.O, Y.S.H. and S.A.W.; resources, S.M.O and Y.S.H.; data curation Y.S.H.; writing—original draft preparation, S.M.O., and Y.S.H.; writing—review and editing, S.A.W., S.M.O., and Y.S.H.; visualization, X.X.; funding acquisition, Y.S.H., S.M.O, S.A.W. All authors have read and agreed to the published version of the manuscript.

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