Comparing Green and White Noise for Reducing Anxiety in Patients During Root Canal Treatment

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Anxiety, Acoustic Stimulation, Noise, Root Canal Therapy

ABSTRACT

Introduction: Anxiety and fear of pain significantly hinder the pursuit of root canal treatments, leading up to 15% of adults to avoid dental care. Since pharmacologic sedation involves risks and typically requires specialist administration, music therapy has demonstrated potential in reducing stress through neurobiological pathways. White noise, known for its static-like sounds, effectively decreases anxiety, while green noise, composed of natural sounds, has shown promise in reducing heart rate and blood pressure during dental procedures. However, their efficacy has never been compared in endodontics.

Aim & Objective: This study aims to compare the effectiveness of Green noise (528 Hz) and White noise (432 Hz) in reducing anxiety and pain during root canal treatment, contributing to evidence-based anxiety management strategies in endodontic practice.

Materials and Methods: Following ethical approval and clinical trial registration, a double-blind study was conducted with 54 patients aged 18-60 with symptomatic irreversible pulpitis in single-rooted teeth. Patients were randomly assigned to 3 groups i.e control (no music), white noise (432 Hz), or green noise (528 Hz) groups. Anxiety levels were assessed using the Corah Dental Anxiety Scale before treatment. Vital signs such as heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded pre- and post-treatment.

Results: ANOVA and paired t-tests revealed that post-operatively, heart rate (HR) decreased across all groups, except for the white noise group, which experienced an increase. Systolic SBP and DBP rose in the control and white noise groups but decreased in the green noise group to 122.45±5.12 (from 138.09±10.41) and to 76.81±5.41 (from 94.22±9.67), respectively. Pre-operatively, HR differed significantly between the control and both noise groups ($p<0.001$). Post-operatively, HR differences were notable between white noise and green noise ($p=0.011$) and between white noise and control ($p=0.011$). The green noise group showed significant changes in HR, SBP, and DBP pre- and post-op ($p<0.001$).

Conclusion: Green noise (528 Hz) effectively reduces anxiety and modulates physiological responses during root canal treatment, offering a non-invasive alternative to pharmacologic sedation.

1. Introduction

Root canal treatment (RCT) is one of the most anxiety-provoking and painful dental procedures, often leading patients to avoid or discontinue necessary endodontic therapies. Patient anxiety and fear of endodontic pain have long posed barriers to seeking necessary root canal treatment (1).

Recent studies estimate that up to 15% of adults avoid dentistry due to high anxiety, with avoidance behaviours being most prevalent for root canal procedures compared to routine care(1). Throughout endodontic procedures, individuals are consistently subjected to auditory inputs, including the metallic tones of tools, the whirring of drills, and the discomforting presence of sharp instruments and obstructive rubber dams. Concerns about breathing difficulties due to changes in saliva control and swallowing management, alongside overhearing discussions among dental staff, amplify these perceptions, particularly for patients with past unpleasant dental encounters (2,3).

While pharmacologic sedation can mitigate treatment fears, systemic drugs risk adverse effects and often require specialist administration (4,5). Attention has therefore shifted to accessible, non-pharmacologic adjuncts to alleviate anxiety during endodontic visits (7). Music therapy has emerged as a simple but powerful intervention leveraging neurobiological pathways to dampen stress and pain signals (8,9).

White noise has been used for a long time to decrease patient anxiety, employing static-like sounds for privacy and sleep (10). Green noise, a variation of white noise utilizing natural sounds at a low frequency, such as waves, flowing rivers, and waterfalls, has also shown promise in reducing heart rate and blood pressure during dental procedures (10,11).

Early evidence links green noise to rapid physiological relaxation effects, although no studies have optimized its use specifically in endodontic settings. This proposed study aims to conduct a timely comparative evaluation of artificial white noise versus green noise in reducing patient anxiety and pain during root canal treatment. Testing the efficacy of green noise for these common procedures would constitute an important step toward accessible, evidence-based anxiety care in endodontic practice.

2. Materials and Methods

Prior to the commencement of the study, ethical approval (SVIEC/ON/Dent/SRP/Nov/23/26) from the institutional review board was obtained, and the trial was registered with the Clinical Trials Registry (CTRI/2024/03/063733 India (CTRI)) to ensure transparency and adherence to ethical standards. Fifty-four patients were recruited based on the study done by Luca Di Nasso et al (12). The study was performed in accordance to the CONSORT 2010 statement.

Selection Criteria

Patients aged between 18 and 60 years, classified as ASA physical status I or II, and diagnosed with symptomatic irreversible pulpitis involving single-rooted maxillary or mandibular teeth, were considered eligible for inclusion. The diagnosis of symptomatic irreversible pulpitis was established based on a comprehensive evaluation, including electric pulp testing, cold testing, and radiographic examination to rule out the presence of periapical changes. Eligible participants were thoroughly informed about the study protocol, and their written informed consent was obtained. Necessary pre-endodontic buildup procedures, involving the placement of composite resin under strict rubber dam isolation, were performed to establish a stable reference point before initiating endodontic intervention. Participants were then randomly allocated to one of three groups using computer-generated randomization to ensure equal distribution and minimize selection bias according to the following inclusion and exclusion criteria.

Inclusion Criteria:

a. Patients ready to sign the consent form.
b. Ability to hear radio or TV easily without the use of a hearing aid.
c. Proficient in speaking and understanding language for effective communication.
d. Patients recommended or indicated for primary endodontic treatment.

Exclusion Criteria:

1. Patients with severe or chronic apical periodontitis, periapical abscess, granuloma, or cyst.
2. Medically compromised patients.
3. Teeth with open apex, root resorption, or any complex root canal anatomy.

4. Pregnant and lactating women.
5. Patients with significant hearing impairment or those using hearing aids.

Investigators' Roles:

- **Principal Investigator:** Performed the root canal treatment.
- **Co-Investigator 1:** Carried out the randomization process and the allocation of the specified music track to the patient.
- **Co-Investigator 2:** Recorded the vital measurements before, during, and after the root canal treatment.

The Principal Investigator and Co-Investigator 2 were blinded, making it a double-blinded study.

Selection of Music:

Two distinct categories of music interventions were employed in the study:

White Noise: Five tracks composed by Stefano Crespan Shantam, namely Lotus, Summer, Signs, White Flower, and Melody were chosen (12). The musical compositions were based on Raga scales & were tuned to 432 Hz, a frequency believed to have therapeutic properties and align with natural human frequencies.

Green Noise: In contrast, five tracks comprising naturalistic sounds, including rain, ocean waves, forest ambiance, thunder, and the resonant tones of Tibetan singing bowls were selected. These tracks were recorded by a semi-free creative collective and tuned to 528 Hz, another frequency purported to have healing potential.

Anxiety Measurement:

In the waiting room, before starting the endodontic treatment, Co-Investigator 1 administered the Corah Dental Anxiety Scale (CDAS) (13) to the participants; the investigator supervised the process of completing the questionnaire. A simplified 5-point scale answering scheme, from 0 to 4, was devised for each question ranging from not anxious to extremely anxious. To obtain the total score for the scale, the scores for each of the 4-item responses were summed, with a total range from 0 to 20. Based on the results of Corah's DAS, the patients were divided into four groups: no anxiety (score < 4), mild (4-8), moderate (9-12), and severe (>12). Patients with a moderate level of anxiety were chosen for the study.

Randomization:

Patients were randomly divided into three groups using computer randomization (www.randomizer.org). Each patient was assigned a number and asked to choose a sealed opaque envelope containing a piece of paper with a group name and its subgroup written on it. According to the text written on the piece of paper, the patients were randomly assigned to one of the three experimental groups.

- **I: Group No Noise (GNN):** No music group
- **II: Group Green noise (GGN)**
- **III: Group White noise (GWN)**

All patients were provided with noise-cancellation headphones (BOAT, India Pvt. Ltd.), and the volume of the tracks was adjusted to a level inaudible to the Principal Investigator (fig.c). Before initiating the root canal treatment, the patients were seated comfortably, and vital signs (SBP, DBP, Heart Rate) were recorded using a digital sphygmomanometer (APOLLO India Pvt. Ltd.) by Co-

Investigator 2 (fig.1a). All steps of the root canal treatment were performed by the Principal Investigator under local anaesthesia (1:200000 Lignocaine with Adrenaline) in a standardized manner. The teeth were isolated using a rubber dam. Before the commencement of treatment, the vitals were recorded (preoperative readings) by Co-Investigator 2 (fig.1b), and at the end of the treatment at one hour, the vitals were recorded again (postoperative readings) by Co-Investigator 2 (fig.1d).

3. Statistical Analysis

Statistical analysis was done with Statistical Package for Social Sciences (IBM SPSS Statistic for Windows, version 21.0. Armonk, NY: IBM Corp.) at 95% CI and 80% power to the study. Kolmogorov-Smirnov and Shapiro-Wilk test was done to check for normal distribution of the data. Descriptive statistics were performed in terms of Mean, and Std Deviation. ANOVA followed by Tukey's post hoc test was applied to compare the Heart rate, Systolic BP, and Diastolic bp between white noise, green noise, and control groups pre- and post-operatively. A paired t-test was applied to compare Pre-Operative and post-operative Heart rates, SBP, and DBP in each group respectively.

Statistical significance was calculated at $p<0.05$ and $p<0.001$ was considered highly significant.

4. Results

A total of 54 patients, from 18-60 years of age, 29 men,25 women, were included in the present study. Descriptive statistical analysis of HR, SBP, and DBP (both pre and post-op) is depicted in terms of mean and standard deviation in Table 1. Post operatively the heart rate was found to be reduced in all the groups except for white noise, in GWN it increased to 78.83±11.50 respectively. Post-operative systolic and diastolic blood pressure increased in the control and GWN group and it decreased in the GGN group to 122.45±5.12 from 138.09±10.41 and 76.81±5.41 from 94.22±9.67 respectively.

Comparison of heart rate between groups preoperatively showed a statistically high significant difference ($p<0.001$) as depicted in Table 2. Pairwise comparison showed there was a statistically high significant difference in the preoperative heart rate when control was compared with GWN and GGN group respectively ($p<0.001$). Between GWN and GGN no statistically significant difference was observed in preoperative heart rate ($p>0.05$).

Post-operatively, there was a statistically high significant difference in the heart rate between Groups respectively ($p<0.001$). There was a statistically significant difference observed in post-operative heart rate between GWN and GGN ($p=0.011$) and between GWN and control GNN ($p=0.011$) respectively. Between control and GGN, there was a statistically high significant difference between GGN and control groups GNN ($p<0.001$) as depicted in Graph 1.

Pre-Operative SBP showed a statistically high significant difference between GWN, GGN, and control GNN respectively ($p<0.001$) according to Table 3. There was a statistically high significant difference in Preoperative SBP when GGN was compared with GWN and control GNN respectively ($p<0.001$). There was statistically no significant difference seen between control GNN and GWN respectively ($p>0.05$).

Post-operatively, no statistically significant difference was observed in SBP between the no noise, white noise, and green noise groups respectively. Pairwise comparison showed no statistically significant difference when GWN compared with GGN and GNN ($p>0.05$). There was no statistically significant difference observed between GGN and control GNN respectively ($p>0.05$) as depicted in Graph 2.

There was a statistically high significant difference observed in the Pre-Op DBP between GWN, GGN, and control respectively as depicted in Table 4. A pairwise comparison shows the statistically significant difference in the Pre op DBP between GWN and GGN ($p=0.001$). There was no statistically significant difference between GWN and control($p>0.05$) whereas a statistically high significant difference was seen between control and GGN respectively($p<0.001$).

There was a statistically high significant difference observed in the Post-Op DBP between GWN, GGN, and control respectively. Pairwise comparison shows a high statistically significant difference in the Post-Op DBP between GWN and GGN ($p<0.001$). There was no statistically significant difference between GWN and control($p>0.05$) whereas a statistically high significant difference was seen between GGN and GWN respectively ($p<0.001$) as depicted in Graph 3.

In white noise, statistically significant difference was seen between Pre-Op and post-op DBP respectively ($p<0.001$) but there was no statistically significant difference observed between Pre-Op and Post-Op HR and SBP respectively($p>0.05$).

In GGN group, there was statistically significant difference observed between Pre-Op and Post-Op HR, DBP and SBP respectively ($p<0.001$) in accordance to Table 5. There was statistically significant difference in the Pre-Op and Post-Op HR and SBP in control group ($p<0.05$) and high statistically significant difference between Pre and Post-Op DBP respectively($p<0.001$).

5. Discussion

This study aimed to analyze the effect of music in controlling anxiety during dental care procedure when employed at 528 Hz (GGN) and 435 Hz (GWN). Results of the present study showed that the clinical perception of anxiety of the participants in the music intervention groups (both GGN and GWN groups) was significantly lower than the control group; and that the subjects exposed to music at 528 Hz (GGN) presented significantly lower anxiety levels than the control GNN group ($p<0.05$) (Table 3 and 4).

Anxiety caused by dental treatment is a complex issue conditioned by personality characteristics, fear of pain, past traumatic dental experiences particularly in childhood, or the influence of anxious relatives (1,2) which manifests as increased anxiety levels before endodontic procedure (19,20,21). However, music has proved to be effective in anxiety control (8-10,12).

In our study, post-operatively, the GWN group (434 Hz) showed an increase in heart rate compared to the preoperative values, while the GGN (528 Hz) exhibited a reduction in heart rate. This finding is in contrast with the study done by *Di Nasso, et al* (12) who studied the impact of music at 432 Hz in patients undergoing endodontic treatment, and have reported a decrease in heart rate following exposure to white noise. It is possible that the prolonged exposure to white noise during the dental procedure may have led to habituation or even increased arousal levels in some individuals, counteracting its potential anxiolytic effects.

On the other hand, the GGN group maintained the heart rate post-operatively, suggesting a sustained calming effect throughout the procedure. The explanation of the effect of music at 528 Hz (GGN) could rely on the study done by *Peter g heper*, who have reported that the human foetus first responds to 500 Hz frequency at 27 weeks, and since green noise is centred around the same frequency it helps in relieving anxiety by directly acting on the autonomic nervous system which reminds us of the womb and promotes relaxation (16).

According to many musicians and music experts, 528 Hz is the frequency closest to natural human rhythms (22). The music used in this study featured nature rhythms and melodies aimed at inducing physical and emotional relaxation in listeners. Its neutral characteristics, devoid of specific emotions, were intended to prevent triggering physiological responses in patients, unlike other musical choices that might evoke such reactions (17,18,24).

Anxiety levels before treatment were assessed using the Corah Dental Anxiety Scale, a widely used tool known for its simplicity and ease of translation (13)

No vasoconstrictors were administered during anaesthesia to avoid influencing cardiovascular parameters. Literature documents dental anxiety and phobia primarily in surgical procedures and among younger patients (19). Limited research has addressed anxiety levels and treatment approaches in adults, despite high demand for sedation in endodontics. Sedation has proven effective in managing irreversible pulpitis (9,23,25).

Furthermore, the systolic and diastolic blood pressure increased in the control and GWN groups, but showed a decreased in the GGN group. The GGN group exhibited significant reductions in both SBP ($p < 0.001$) and DBP ($p < 0.001$) when compared to pre-operative values (table 3 and 4). This finding supports the growing evidence on the positive effects of nature-based auditory stimuli on cardiovascular parameters, potentially due to the restorative properties of natural sounds (10,11,23)

The results of this study highlight the potential benefits of incorporating auditory interventions, particularly nature-based sounds like green noise, in dental settings to promote relaxation and modulate physiological responses during endodontic treatments. However, further research is needed to understand the specific mechanisms underlying these effects and to optimize the application of auditory stimuli in the clinical practice.

6. Conclusion

Within the limitation of the study, it can be concluded that green noise (528 Hz), as an adjunct therapeutic measure, could be a less invasive and more effective alternative to manage patient's anxiety during root canal procedure.

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Flow Charts, Tables and Figures:

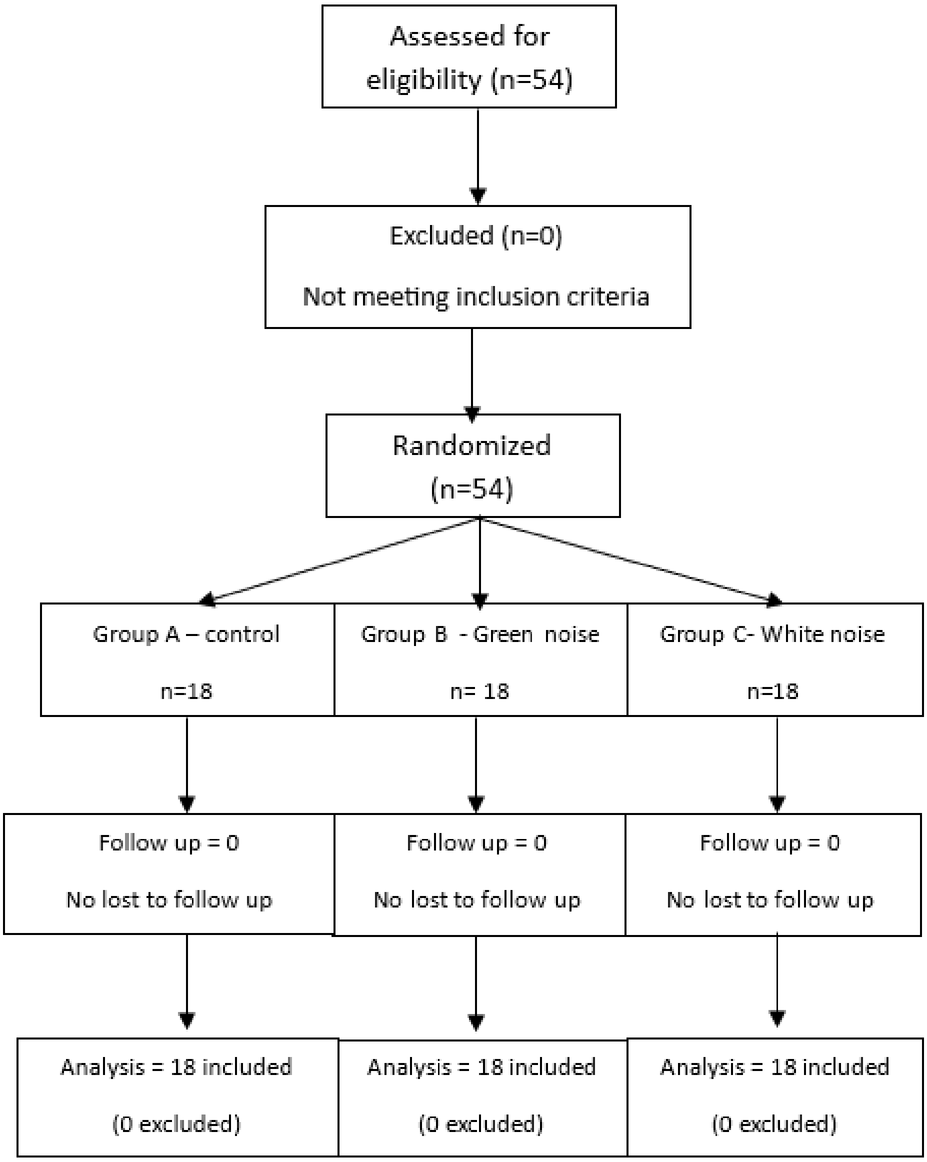


Table 1: Descriptive statistics showing mean Pre op and Post op HR, SBP, DBP for different groups

		HR		SBP		DBP	
		Mean	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Pre-Op	**White Noise**	**76.3333**	**11.7373**	**121.5556**	**14.4679**	**81.4444**	**11.7835**
	Green Noise	**75.6818**	**6.3124**	**138.0909**	**10.4148**	**94.2273**	**9.6704**
	Control	**89.1667**	**7.6945**	**121.7778**	**9.7712**	**80.3333**	**8.9377**
	Total	**80.0690**	**10.5546**	**127.8966**	**13.9821**	**85.9483**	**11.9376**
Post-Op	**White Noise**	**78.8333**	**11.5058**	**124.8333**	**9.3132**	**89.6111**	**10.1003**
	Green Noise	**70.7727**	**6.2635**	**122.4545**	**5.1244**	**76.8182**	**5.4128**
	Control	**85.8889**	**6.9103**	**124.8889**	**12.0825**	**91.4444**	**11.0465**
	Total	**77.9655**	**10.4024**	**123.9483**	**8.9706**	**85.3276**	**11.0983**

Table 2: Comparison of mean Pre op and Post op HR between white noise, green noise, and control groups

Dependent	**(I)**	**(J) Groups**	**Mean Difference**	**Std.**	**P value**	**ANOVA**

Variable	Groups		(I-J)	Error		F value	P-value
Pre-Op HR	White Noise	Green Noise	0.65152	2.7725	0.97	14.222	**<0.001 ***
		Control	-12.83333*	2.9078	**<0.001***		
	Green Noise	White Noise	-0.65152	2.7725	0.97		
		Control	-13.48485*	2.7725	**<0.001***		
	Control	White Noise	12.83333*	2.9078	**<0.001***		
		Green Noise	13.48485*	2.7725	**<0.001***		
Post-Op HR	White Noise	Green Noise	8.06061*	2.6715	**0.011**	16.147	**<0.001 ***
		Control	-7.05556*	2.8019	**0.039**		
	Green Noise	White Noise	-8.06061*	2.6715	**0.011**		
		Control	-15.11616*	2.6715	**<0.001***		
	Control	White Noise	7.05556*	2.8019	**0.039**		
		Green Noise	15.11616*	2.6715	**<0.001***		
*. The mean difference is significant at the 0.05 level.							

Table 3: Comparison of mean Pre op and Post op SBP between white noise, green noise, and control groups

Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P value	ANOVA	
						F value	P-value
Pre-Op SBP	White Noise	Green Noise	-16.53535	3.7013	**<0.001***	13.582	**<0.001***
		Control	-0.22222	3.8819	0.998		
	Green Noise	White Noise	16.53535	3.7013	**<0.001***		
		Control	16.31313	3.7013	**<0.001***		
	Control	White Noise	0.22222	3.8819	0.998		
		Green Noise	-16.31313	3.7013	**<0.001***		
Post Op SBP	White Noise	Green Noise	2.37879	2.8773	0.688	0.483	0.62
		Control	-0.05556	3.0177	1		
	Green Noise	White Noise	-2.37879	2.8773	0.688		
		Control	-2.43434	2.8773	0.676		
	Control	White Noise	0.05556	3.0177	1		
		Green Noise	2.43434	2.8773	0.676		
*. The mean difference is significant at the 0.05 level.							

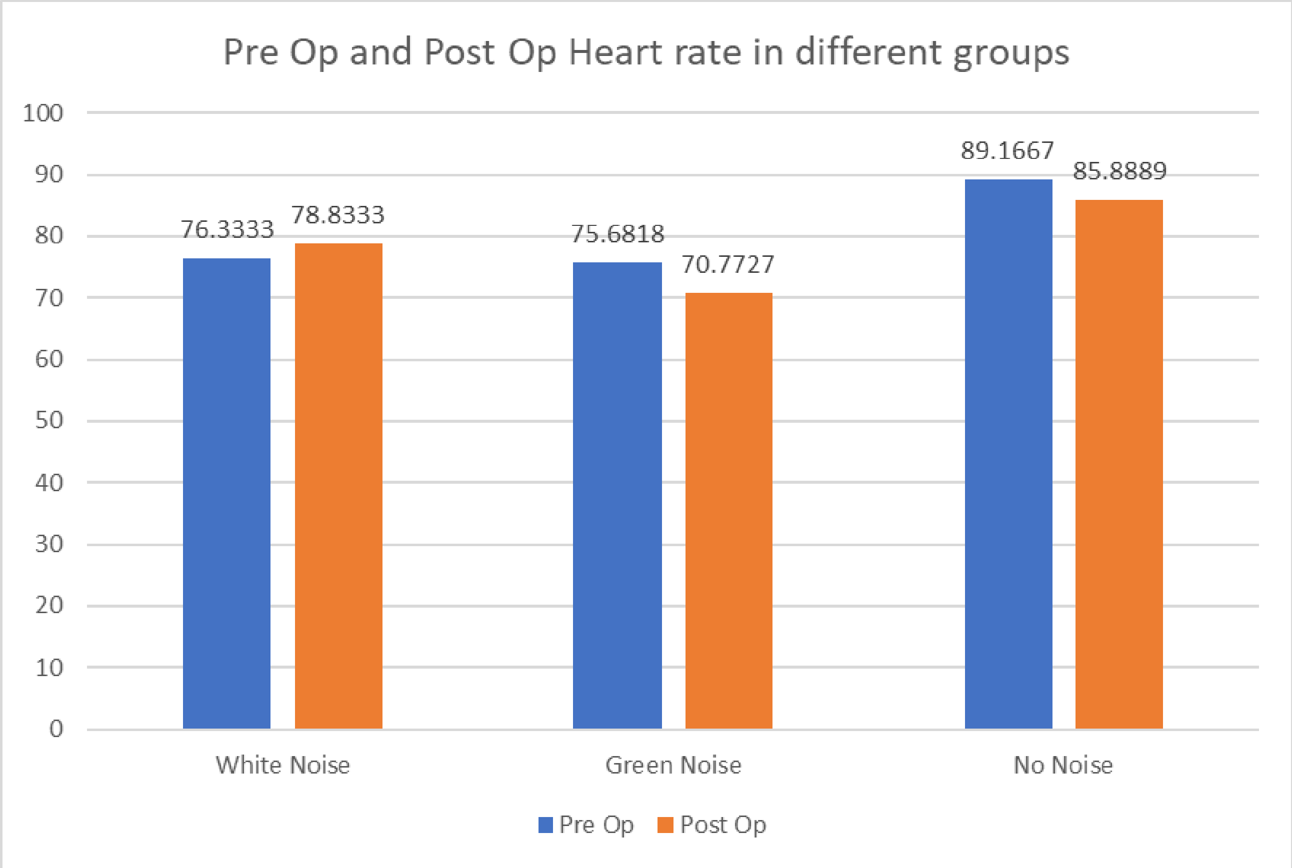
Table 4: -Comparison of mean Pre op and Post op DBP between white noise, green noise, and control groups

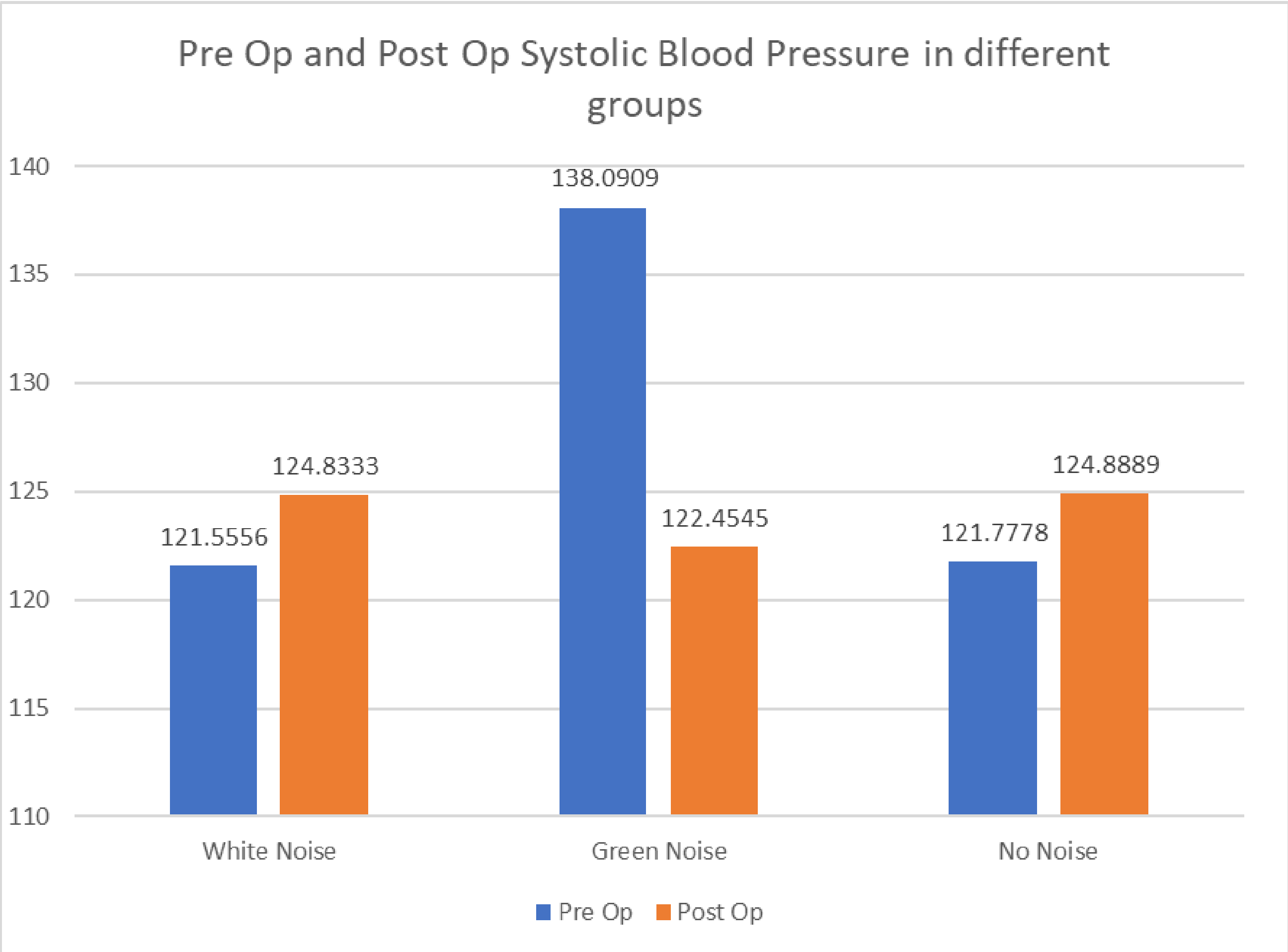
Dependent Variable	(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P value	ANOVA	
						F value	P value
Pre-Op DBP	White Noise	Green Noise	-12.78283	3.23045	**0.001**	11.811	**<0.001***
		Control	1.11111	3.38813	0.943		
	Green	White Noise	12.78283	3.23045	**0.001**		

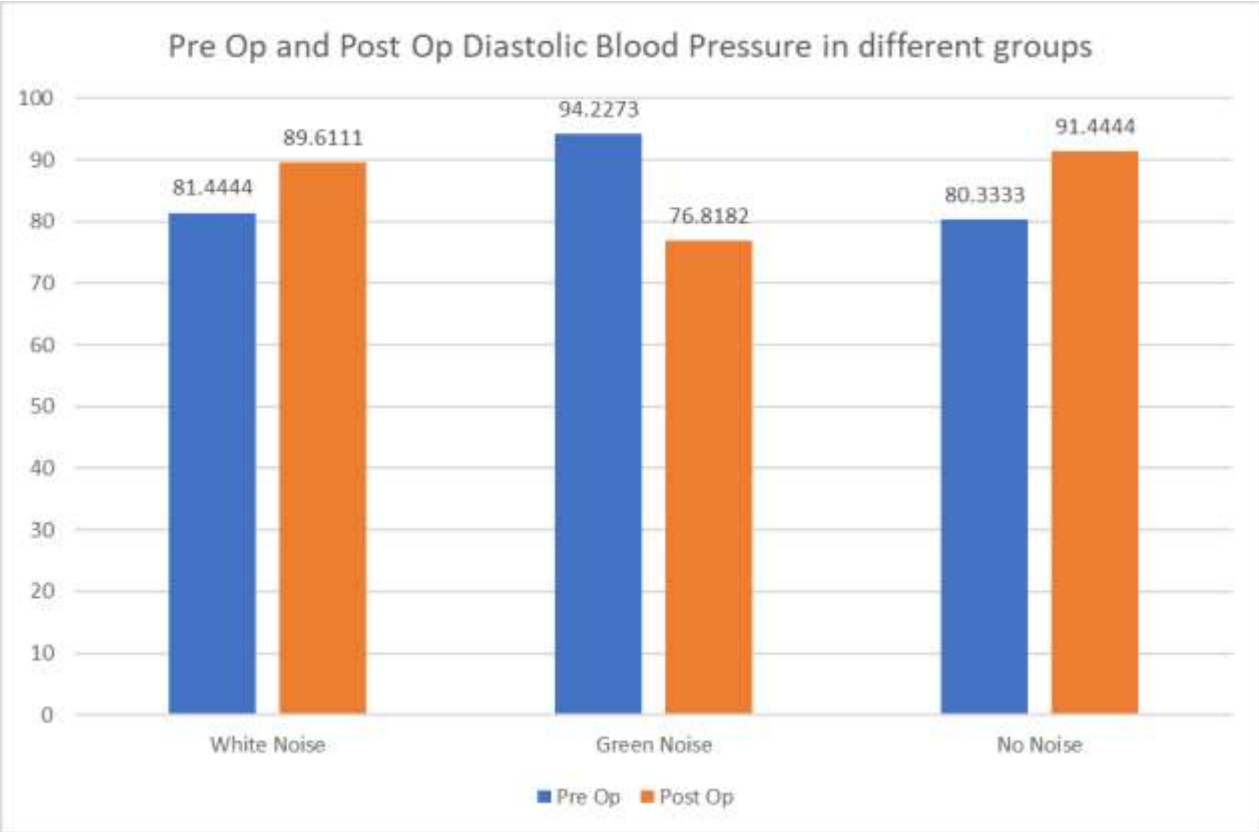
	Noise	Control	13.89394	3.23045	<0.001*		
	Control	White Noise	-1.11111	3.38813	0.943		
		Green Noise	-13.89394	3.23045	<0.001*		
Post-Op DBP	White Noise	Green Noise	12.79293	2.85042	<0.001*	16.142	<0.001*
		Control	-1.83333	2.98954	0.814		
	Green Noise	White Noise	-12.79293	2.85042	<0.001*		
		Control	-14.62626	2.85042	<0.001*		
	Control	White Noise	1.83333	2.98954	0.814		
		Green Noise	14.62626	2.85042	<0.001*		
*. The mean difference is significant at the 0.05 level.							

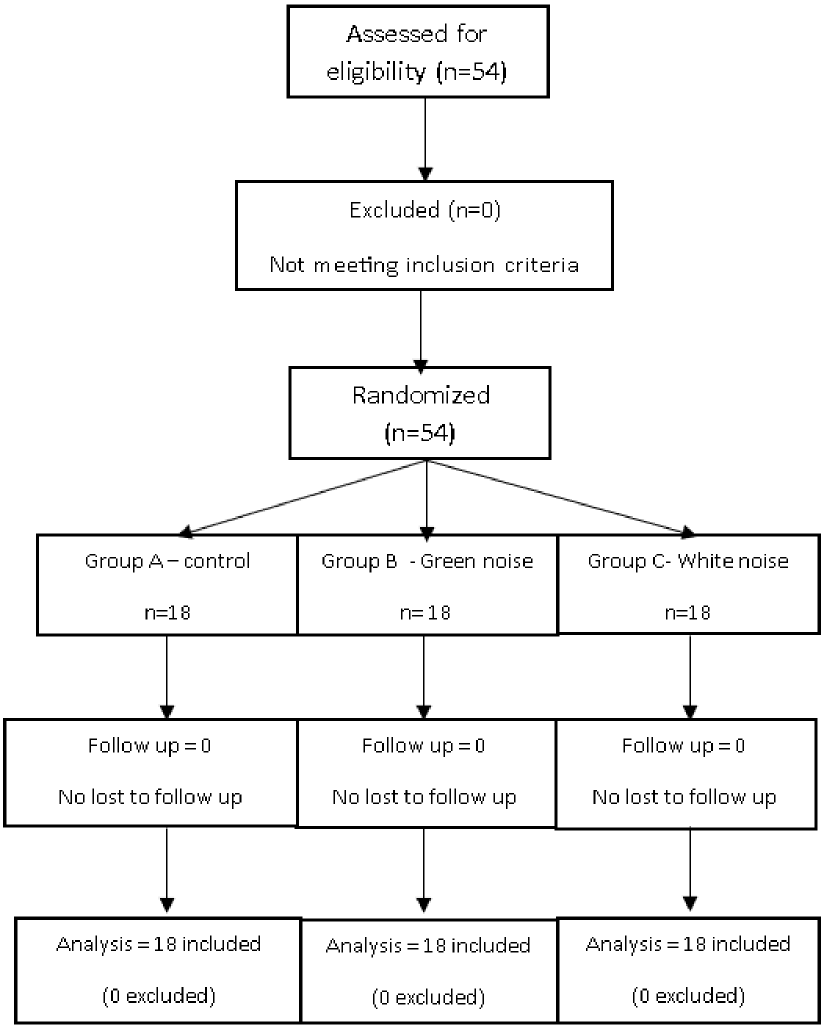
Table 5: -Comparison of Pre op and Post OP HR, SBP and DBP in White Noise, Green Noise and Control Group

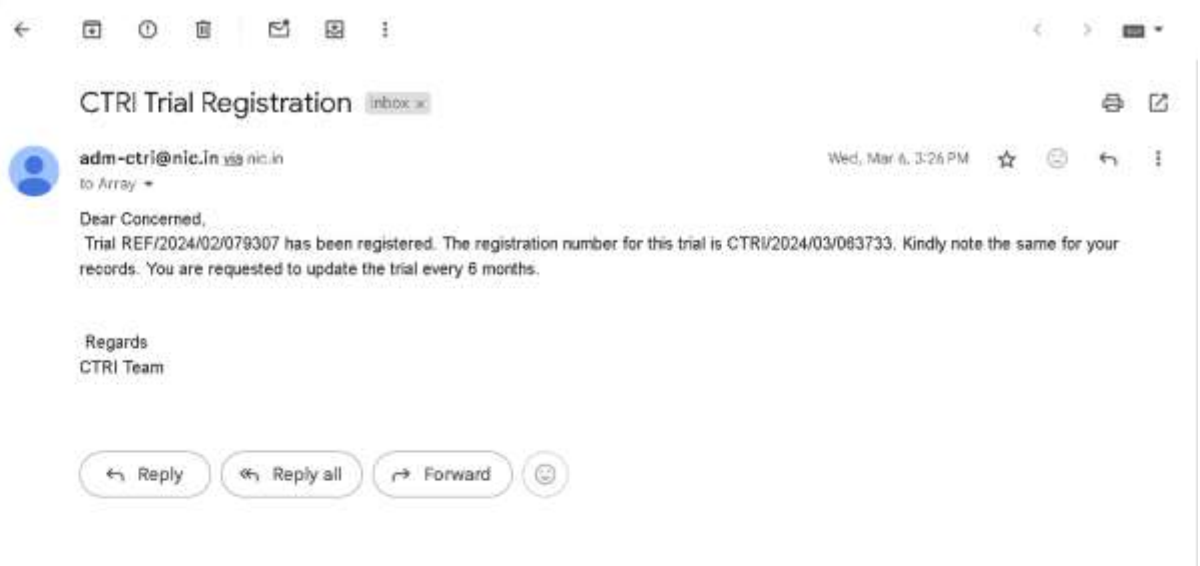
Paired Samples Test						
	White Noise		Green Noise		Control	
	t value	P value	t value	P value	t value	P value
Pre op HR - Post OP HR	-1.702	0.107	5.642	<0.001*	2.92	0.01
Pre op DBP - Post Op DBP	-8.99	<0.001*	7.983	<0.001*	-5.92	<0.001*
Pre-Op SBP - Post Op SBP	-0.949	0.356	6.97	<0.001*	-2.109	0.05


Pre Op and Post Op Heart rate in different groups
100
90
80
70
60
50
40
30
20
10
0
76.3333
78.8333
75.6818
70.7727
89.1667
85.8889
White Noise
Green Noise
No Noise
Pre Op
Post Op


Pre Op and Post Op Systolic Blood Pressure in different groups
140
135
130
125
120
115
110
121.5556
124.8333
138.0909
122.4545
121.7778
124.8889
White Noise
Green Noise
No Noise
Pre Op
Post Op


Pre Op and Post Op Diastolic Blood Pressure in different groups
100
90
80
70
60
50
40
30
20
10
0
81.4444
89.6111
94.2273
76.8182
80.3333
91.4444
White Noise
Green Noise
No Noise
Pre Op
Post Op




CTRI Trial Registration Inbox

adm-ctri@nic.in via nic.in
to Array
Wed, Mar 6, 3:26 PM

Dear Concerned,
Trial REF/2024/02/079307 has been registered. The registration number for this trial is CTRI/2024/03/063733. Kindly note the same for your records. You are requested to update the trial every 6 months.

Regards
CTRI Team

Reply Reply all Forward

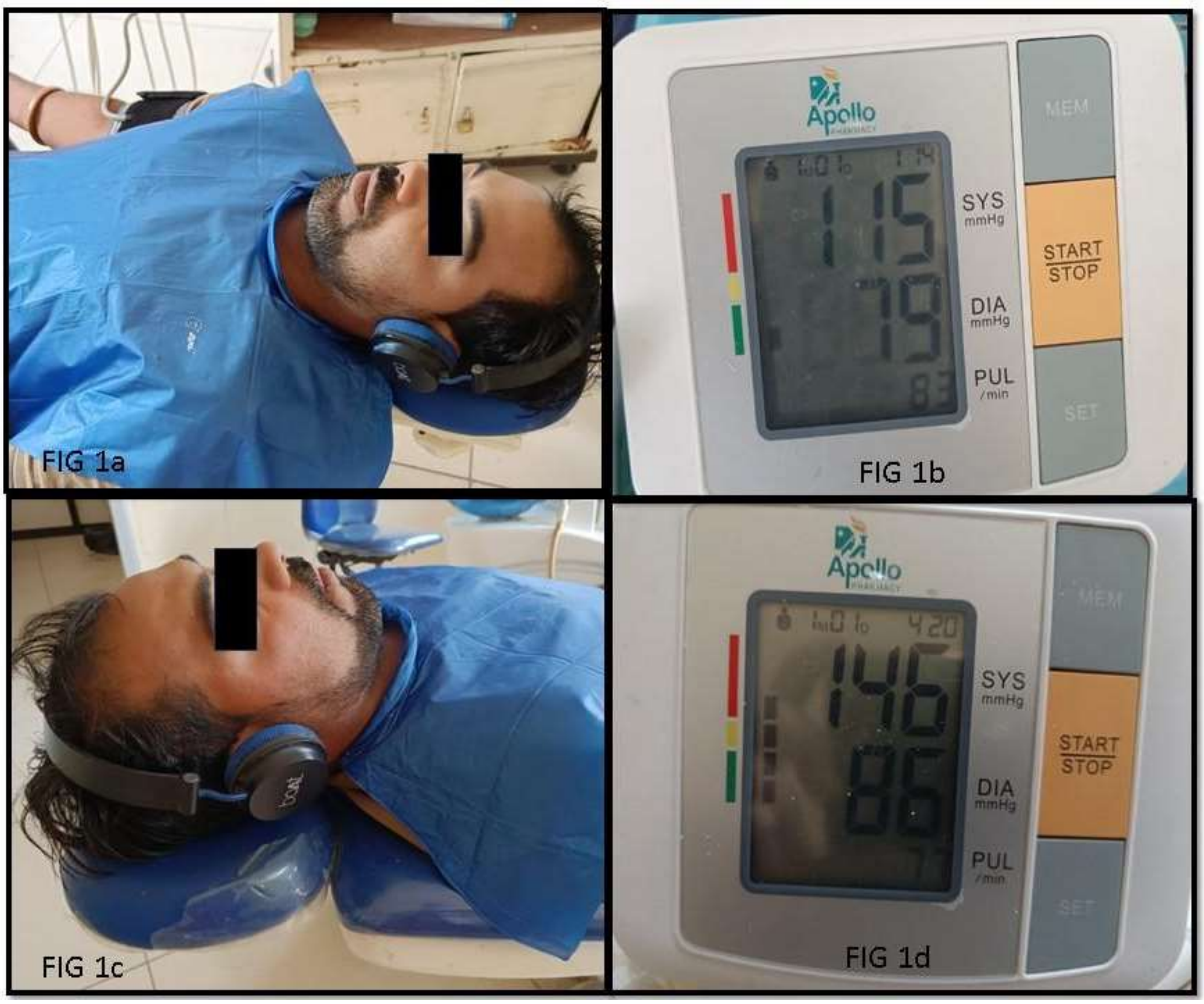


Fig 1a: Measuring blood pressure using digital sphygmomanometer.

Fig 1b: Pre – operative blood pressure reading.

Fig 1c: Patient on audio analgesia therapy.

Fig 1d: Post-operative blood pressure reading.