

Comparing binaural beats and 432 Hz music for reduction of preoperative anxiety in root canal patients: a randomized controlled trial

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Abstract

Objective: To compare the effectiveness of binaural beats and 432Hz music in decreasing preoperative dental anxiety among adult patients undergoing root canal procedure.

Method: The double-blind, randomised controlled trial was conducted from October 2023 to March 2024 at the Department of Operative Dentistry and Endodontics, Dr Ishrat-ul-Ebad Khan Institute of Oral Health Sciences, Dow University of Health Sciences, Karachi, and comprised adult patients undergoing root canal procedure who were randomised into three groups. Group A listened to 432Hz music, group B listened to binaural beats, and control group C listened to white noise. All the patients and the outcome assessors were kept blinded to the randomisation. The Visual Analogue Scale for Anxiety was used to measure anxiety levels before and after the administration of local anaesthesia and 10 minutes after listening to the sounds. The endodontic therapy was done as usual. Data was analysed using SPSS 26.

Results: Of the 99 participants, 64(64.6%) were females and 35(35.4%) were males with overall mean age 28.06 ± 7.36 years. All the groups had 33(33.3%) subjects. Intragroup improvement in preoperative anxiety was significant in both interventional groups compared to the baseline value and the control group ($p < 0.05$). No significant difference was found between the interventional groups ($p > 0.05$).

Conclusion: Binaural beats and 432Hz music were found to be highly and equally effective for decreasing preoperative dental anxiety in adult patients undergoing endodontic treatment.

Clinical Trial Registration Link: <https://clinicaltrials.gov> RCT No. (NCT06349200).

Key Words: Dental anxiety, 432 Hz music, Root canal treatment, Binaural beats, White noise.
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Introduction

Anxiety and fear of dentists among patients are universally recognised phenomena that are also very common.¹ This fear and anxiety related to dentists and dental treatments are both vital reasons for avoiding dental visits.² The term "dental anxiety" does not have a proper definition in the literature, but it incorporates a wide array of sentiments ranging from light uneasiness to severe dental phobia or anxiety,^{3,4} and can be described as a patient-specific reaction to a stimulus in dental treatment that is not known, vague, or absent at the time.⁵ Patients undergoing root canal treatments are constantly exposed to drill noises and sharp instruments that cause a lot of fear among patients.⁶ Patients' perceptions about root canal therapy procedures, such as anaesthetic injection, drillings and rotary instrumentation can lead to an overall increase in anxiety and fear.⁷

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Several techniques are in use nowadays to reduce dental anxiety among the patients.⁴ There is a growing preference for non-invasive, non-pharmacological methods that effectively reduce fear and anxiety in patients, avoiding medication side effects and the discomfort of invasive techniques.⁵ In 1959, Gardner and Licklider introduced auditory analgesia, a way of using sound to alleviate pain during medical procedures like dental treatments, without medication.^{5,8}

Binaural sounds were first described in 1939.⁵ The phenomenon occurs when two constant-intensity sounds with different frequencies are independently presented to each ear. The resulting sound identified in the mind is a single tone with a frequency equal to the difference between the frequencies of the original sounds. Depending on the difference in the frequencies, various brainwaves would be produced, causing improved cerebral and behavioural reactions. This procedure is termed "brainwave entrainment." This method has proven to be effective in alleviating moderate anxiety.^{4,5,9}

Music of 432Hz frequency has been suggested by many musicians as being closest to the usual human frequency. This also has the advantage of being 'neutral' and free

from feelings to avoid triggering any unwanted physiological responses in the patients.⁵

Several studies have reported the effectiveness of binaural beats as an anxiety reduction modality in patients undergoing impacted molar surgeries,¹⁰ whereas other studies have reported 432Hz music to be a successful dental anxiety reduction modality,¹¹ but none of them have compared their effectiveness for anxiety reduction before root canal procedures.

The current study was planned to address the gap in literature by comparing the effectiveness of binaural beats and 432Hz music in the reduction of preoperative dental anxiety among adult patients undergoing root canal procedure.

Patients and Methods

The double-blind randomised controlled trial (RCT) was conducted from October 2023 to March 2024 at the Department of Operative Dentistry and Endodontics, Dr Ishrat-ul-Ebad Khan Institute of Oral Health Sciences (DIKIOHS), Dow University of Health Sciences (DUHS), Karachi. After approval from DUHS ethics review board, the trial was registered with the international trial registry Clinical Trials.gov identifier <https://clinicaltrials.gov> (NCT06349200). The study complied with the requirements of the Consolidated Standards of Reporting Trials (CONSORT) criteria.¹² The sample size was estimated using Power Analysis and Sample Size (PASS) software (2021)¹³ with power 80% and a significance level (alpha) of 0.05 using one-way analysis of variance (ANOVA) while keeping mean Visual Analogue Scale (VAS) score 3.54 ± 1.742 in binaural beats group, 2.94 ± 2.09 in music group, and 4.55 ± 3.014 in control group for preoperative anxiety at second measurement.⁴ The sample was raised using probability, simple random sampling technique.

Those included were patients of either gender aged 18-45 years who were appointed for endodontic treatment for both maxillary and mandibular teeth that had no history of preoperative pain or teeth with pulpal necrosis (determined by no response on vitality tests) without symptomatic apical periodontitis. Those who required emergency dental treatment, who had a history of systemic, endocrine and mental illnesses, or were taking antidepressants, and those who had any hearing impairment were excluded, and so were pregnant and lactating women.

After taking written informed consent, the participants were randomised into 432Hz music group A, binaural beats group B, and control group C using the lottery method. All the patients and the outcome assessors were

kept blinded to the randomisation.

The Visual Analogue Scale for Anxiety (VAS-A)^{4,10} was used to assess preoperative dental anxiety prior to the administration of local anaesthesia (LA). VAS-A consisted of a 100mm horizontal line on paper, with "no anxiety" marked on the left side and "worst anxiety imaginable" on the right. The patients were asked to mark their level of anxiety on the line.

Following LA administration, a second assessment of anxiety level was conducted using VAS-A. Wireless headphones were used for listening to the interventional sounds (Figure 1). Subsequently, group A listened to music tuned to 432Hz ("Summer", a song by Stefano Crespan Shantam) via wireless headphones for 10 minutes. Group B used wireless headphones to listen for 10 minutes binaural beats played at 220Hz in the right ear and 212Hz in the left ear. The frequencies were produced by the mobile application BrainWaves Binaural Beats (MynioTech Apps, Brazil). Group C listened to white noise for 10 minutes using wireless headphones. After 10 minutes, the headphones were removed in all the groups, and VAS-A was used to record the third measurement of anxiety level in the groups.

For the 10-minute duration of the intervention, the patients experienced silence without distractions or



Figure-1: A patient listening to the interventional sound for 10 minutes before root canal treatment.

conversation. Noise cancelling headphones blocked background noise. The patients were instructed not to close their eyes to preserve natural brain waves. Subsequently, routine endodontic therapy was conducted.

Data was analysed using SPSS 26. Frequencies and percentages were calculated for qualitative variables, while mean \pm standard deviation were calculated for quantitative variables. Normality of quantitative variables was assessed using Shapiro-Wilk's test of normality. Quantitative data follow normal distribution. One-way repeated measure ANOVA test was applied to assess the difference of VAS-A values across the groups. Paired t-test was used to see the pairwise differences of VAS-A in different groups. $P \leq 0.05$ was considered significant.

Results

Of the 99 participants, 64(64.6%) were females and 35(35.4%) were males with overall mean age 28.06 ± 7.36 years. All the groups had 33(33.3%) subjects (Figure 2).

Improvement in preoperative anxiety was significant in both the interventional groups compared to the control group ($p < 0.05$). No significant difference was found between the interventional groups ($p > 0.05$). (Table 1).

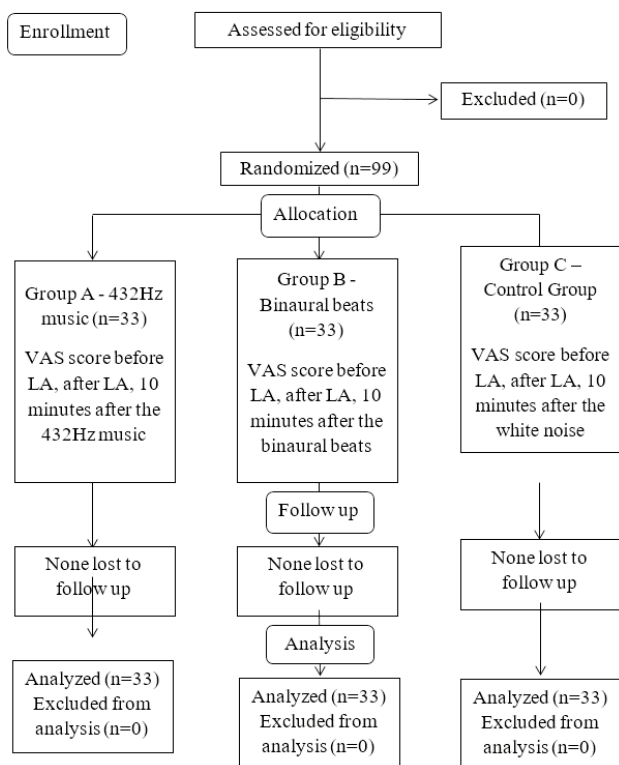


Figure-2: Consolidated standards of reporting trials (CONSORT) flow chart.

Table-1: Intergroup comparison of audio intervention.

S. No.	Time of anxiety measurement	Group A Mean \pm SD	Group B Mean \pm SD	Group C Mean \pm SD	P value
1.	Before LA administration	67.03 \pm 11.46	62.58 \pm 11.90	58.64 \pm 10.36	
2.	After LA administration	74.61 \pm 11.45	70.85 \pm 11.01	62.82 \pm 10.30	<0.001
3.	10 minutes after music intervention	22.27 \pm 7.91	21.85 \pm 6.90	62.82 \pm 10.30	

LA: Local anaesthesia, SD: Standard deviation.

Intragroup comparison showed that both the interventional groups showed significant reduction in anxiety scores across all stages ($p < 0.001$). In contrast, group C had minimal changes, with no significant reduction in anxiety score post-intervention (Table 2).

Table-2: Intragroup comparison of sound intervention.

S. No.	Groups	Before LA administration – After LA administration Absolute Mean difference (P value)	Before LA administration – 10 minutes after the intervention Absolute Mean difference (P value)	After LA administration – 10 minutes after the intervention Absolute Mean difference (P value)
1.	Group A	7.58 (<0.001)	44.76 (<0.001)	52.37 (<0.001)
2.	Group B	8.27 (<0.001)	40.73 (<0.001)	49 (<0.001)
3.	Group C	4.18 (<0.001)	4.18 (<0.001)	0 (NS)

LA: Local anaesthesia, NS: Not significant.

Discussion

The current study found that both 432Hz music and binaural beats were highly effective in decreasing preoperative dental anxiety among adult patients undergoing root canal treatment. Despite a lot of modern advancements in dentistry, dental anxiety remains a common problem among children and adults.¹⁴ The prevalence of dental anxiety and fear ranges from 4.2% to 50% in the literature.¹⁵ As reported in the literature, dental anxiety in relation to poor oral hygiene has a vicious cycle. Patients with severe dental anxiety tend to avoid going to the dentists and have poor oral hygiene; the embarrassment and guilt of having bad oral health give them even more anxiety.^{14,15} Dentists also find these anxious patients less cooperative and difficult to treat.¹⁶

Dental anxiety is a state of apprehension and loss of control, often accompanied by a sense of impending harm during dental procedures.¹⁶ There is no single effective means of reducing dental anxiety all around the world.¹⁰ While drugs and sedatives are highly effective in reducing anxiety,⁴ their invasive nature and potential side-effects can be avoided through non-pharmacological methods.⁵ Audiovisual and audio have

been used as effective non-pharmacological means of reducing dental anxiety. Daoker et al. conducted a study comparing audiovisual and audio interventions in patients undergoing root canal treatment. Both methods effectively reduced anxiety, with audiovisual intervention showing superior efficacy.³

Music, a well-established anxiety reducer, is highly effective and also alleviates pain by triggering cerebral endorphin release. Additionally, it distracts patients from both pain and anxiety-inducing stimuli.³ In the current study, binaural beats and music tuned to 432Hz, known for their anxiety-reducing properties, were selected.

Binaural beats, introduced in the 19th century, involve presenting slightly different frequency sounds to each ear simultaneously. Proven effective in reducing anxiety before various procedures, such as Caesarean section,¹⁷ cystoscopies¹⁸ and coronary artery bypass grafting,¹⁹ they were used in the current study without accompanying music for 10 minutes, a duration known to be most effective in reducing dental anxiety.^{4,10} Previous studies have found these sounds to be effective in reducing preoperative anxiety in both children for various dental treatments⁵ and adults for impacted third molar surgeries.^{4,10,20} However, no prior research, to our knowledge, specifically investigated binaural beats for reducing preoperative anxiety in endodontic patients, both locally and internationally.

The current study employed 432Hz music as an intervention, known for its close alignment with the natural human frequency and its ability to induce physical and emotional relaxation.⁶ The findings were parallel those of Aravena et al., who used 432Hz music to reduce dental anxiety during extractions, showing significant reductions in cortisol levels and dental anxiety.¹¹ Similarly, Nasso et al.⁶ and Daoker et al.³ demonstrated the high effectiveness of 432Hz music in reducing dental anxiety during root canal treatment.

In the current study, VAS-A was used to record the measurements of dental anxiety due to its ease of understanding by the patients, and its validity.^{4,10}

To the best of our knowledge, the current study is the first, both locally and internationally, to compare the effectiveness of binaural beats and 432Hz music in reducing preoperative anxiety in root canal patients. To overcome limitations in previous studies, the current study employed a placebo sound in the control group, ensuring double-blinding to minimise biases. Additionally, interventions were standardised, and noise cancelling headphones were used to block background

noises to overcome any confounding factors.

However, the current study has limitations as well. First, it relied solely on subjective measurements of dental anxiety, which may not accurately reflect patients' true anxiety levels. Future studies should include objective measurements of vital parameters. Additionally, the study was conducted in a university hospital setting, which may not offer the same level of calm and privacy as a private clinic. Future research could also explore using multi-layered binaural beats and shorter intervention durations to assess the effectiveness of these sounds.

Conclusion

Music tuned to 432Hz and binaural beats were effective non-pharmacological methods for alleviating preoperative dental anxiety among patients undergoing endodontic treatment compared to the control group.

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Conflict of Interest: None.

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AUTHORS' CONTRIBUTIONS:

HZ: Concept, design, data acquisition, analysis, interpretation, drafting and agreement to be accountable for all aspects of the work.
SA: Drafting and revision.

FURQ: Final approval.

NF: Design and drafting.

YSA: Data acquisition, analysis and interpretation.