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Effectivity of Binaural Beats in reduction of anxiety during dental treatment in pediatric patients

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Abstract
Context: *Over the years, audio analgesia has been gaining popularity as a method of distraction amongst pediatric patients. The present study deals with binaural beats i.e an auditory illusion perceived when two different pure-tone sine waves with less than a 40 Hz difference between them, are presented to a listener dichotically. Depending on the differences between the frequencies, the brainwaves are generated causing effects corresponding to the type of wave.*
Aim: *To evaluate the effectiveness of binaural beats in reduction of anxiety in apprehensive paediatric patients in order to achieve the objective of minimizing requirement of other behaviour management techniques and time for dental treatment procedures.*
Material & Method*: 30 apprehensive, co-operative and non co-operative3-10 year old patients were subjected to binaural beats imposed upon soft music by means of wireless over-the-ear headphones. Pre-Operative, Intra-Operative and Post-Operative sets of Visual Facial Anxiety Scale and Pulse rate were recorded.*
Results: *Binaural beats were effective in reduction of anxiety within 10 minutes in 86.67% of the cases. 93.33% of the cases responded positively to binaural beats by the time of termination of treatment procedure.*
Conclusion: *Binaural Beats can be used effectively as a non-invasive treatment modality to reduce anxiety in apprehensive paediatric patients*
Key Words: *audio analgesia, binaural beats, anxiety, relaxation, distraction.*

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I. Introduction

The young child's emotional and behavioural response to the stress of dental visit is a matter of serious concern to paediatric dentists[1]. Odontophobia and dental anxiety contribute significantly to avoidance of dental care[2]. Management of children in dental clinic is relatively challenging when compared with adults. Paediatric patients are often subjected to procedures that can cause anxiety and pain. Although newer techniques are presently available, such as general anaesthesia and sedatives, non-pharmacological and non-invasive management techniques are always preferred[3].Distraction with audios and videos is a simple and effective technique that focuses children's attention away from noxious stimuli [4].Based on this principle, audioanalgesia can be used to diminish the fear and anxiety of the patients at the time of local anaesthesia (LA) administration and extraction [5]. Audioanalgesia is the relief of pain using audio means without anypharmacological agents while doing painful medical procedures such as dental treatments. It was first introduced by Gardner and Licklider in 1959 [6].

Binaural beats, first described by Dove in 1939, occur when two sounds with steady intensities but different frequencies are presented separately, one to each ear [7].The resulting perception is of a single tone with afrequency that is halfway between the two carrier tones and that waxes and wanes in amplitudes at a rate equal to the difference between them requiringacollective action of both ears [8]. For example, when the 344 Hz tone is presented to the left ear and the 340 Hz tone to the right, a beat of 4 Hz is perceived in the brain[9].It can arousephysical, cognitive, emotional, and behavioural responses[10]. These binaural beats, particularly, theta wave[11], unlike previous studies pertaining to audio analgesia that were dependant primarily on distraction[12], form the basis of this study which was conducted to understand the clinical effects of binaural beats on paediatric patients during dental treatment procedure which ranged from as minor as a fluoride application to major ones like extraction of teeth.

II. Materials And Methods

Inclusion Criteria:

- The study sample included 30 patients belonging to the age group of 3-10 years
- Patients showing signs of any degree of anxiety– mild, moderate or severe.

Exclusion Criteria:

- Patients with a history of any medical condition were excluded from the study.
- Extremely non-cooperative patients refusing to wear the headphones throughout the procedure were eliminated from the study.

Patient's parents/guardians were explained about the procedure and allowed to listen to the audio that was going to be presented to the patient following which consent was obtained from the patient's parent/guardian as well as the patient. Patients were asked to mark the face on Visual Facial Anxiety Scale(VFAS) they could most relate to before the commencement of treatment procedure(V_1). Also, Pulse Oximeter(PO) reading of the patient by means of his right thumb was obtained pre-operatively(PO_1).

The patients were then presented with binaural beats of frequencies 344 Hz and 340 Hz in the left and right ears respectively superimposed on soft, relaxing music (to utilize their synergistic effect) by means of over-the-ear headphones and the treatment procedure was started thereafter. In case of patients that felt uncomfortable wearing over-the-head headphones due to smaller skull size or other reasons, in-the-ear type of earphones were used.

Another set of VFAS (V_2).and Pulse oximeter (PO_2) reading was obtained 10 minutes following the commencement of the treatment procedure and the treatment procedure was, then, resumed. After the completion of the treatment procedure, a final set of VFAS and Pulse oximeter (PO_3) reading was recorded following which the administration of beats was terminated and the headphones were removed.

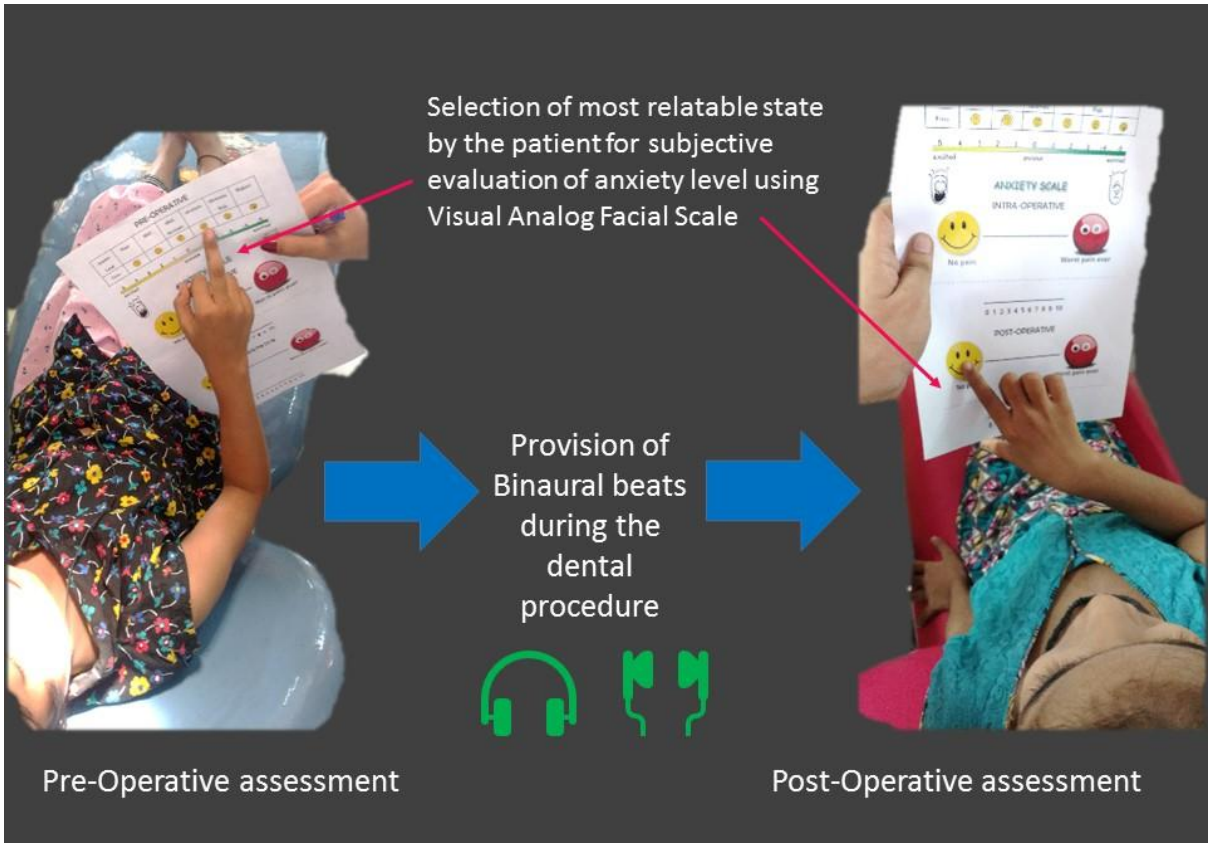


Figure 1: Subjective evaluation of the patients before and after treatment using VFAS scale

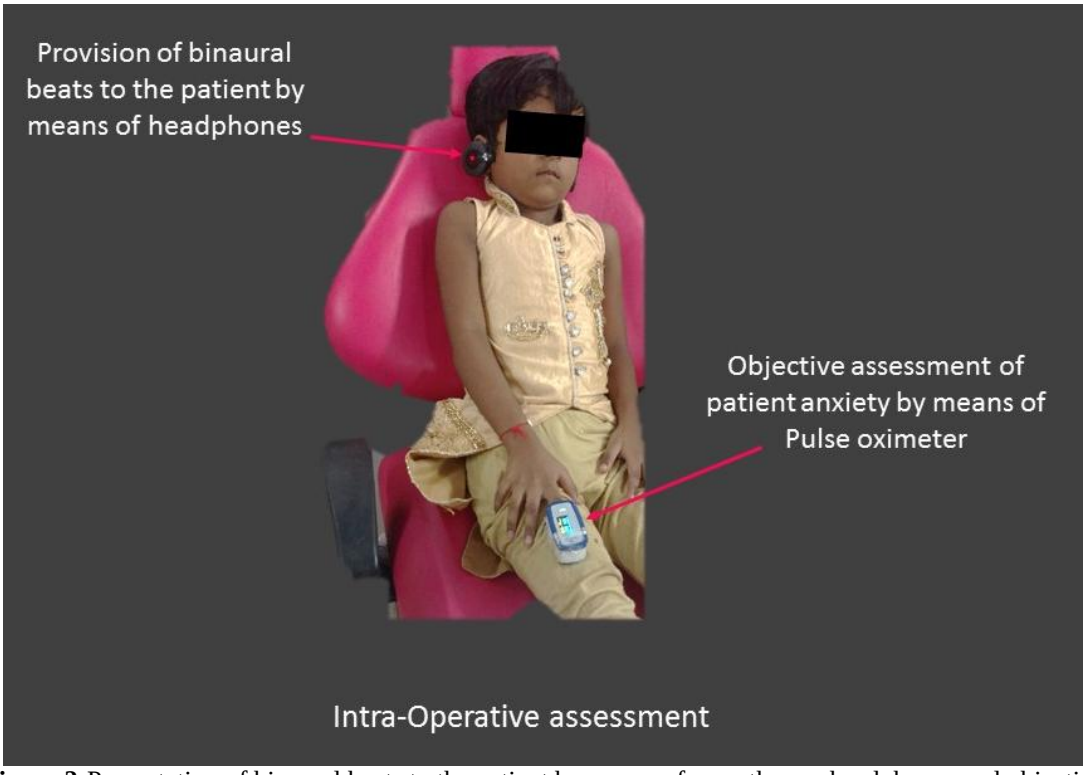
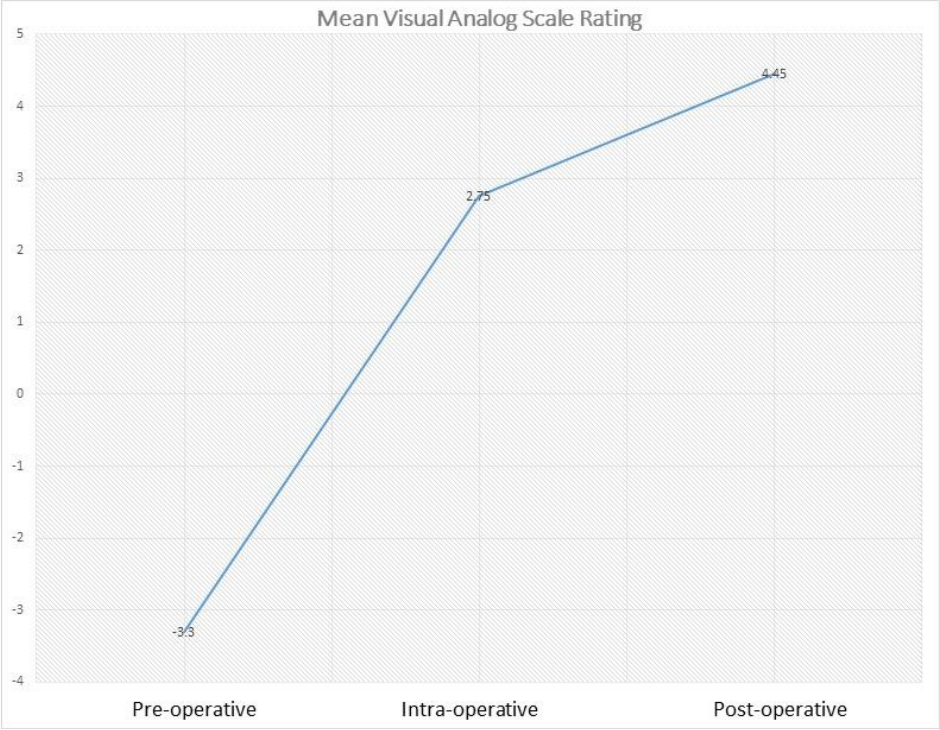


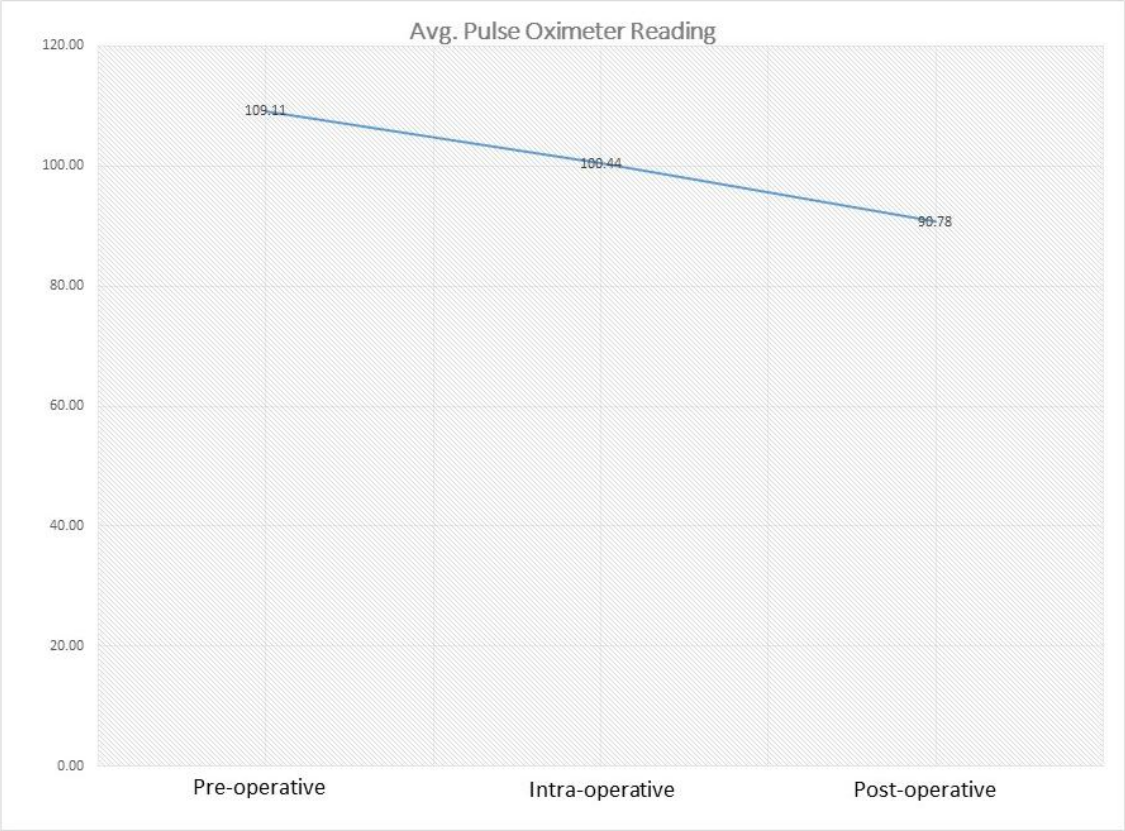
Figure 2: Presentation of binaural beats to the patient by means of over-the-ear headphones and objective assessment using Pulse Oximeter

III. Results

Statistical analysis of data and plotting the corresponding graphs of the mean VFAS and mean PO readings revealed a sharp transition from negative to positive in the mean VFAS rating (Graph 1) and a gradual decline in mean PO readings (Graph 2) from the pre-operative assessment to post-operative assessment of the patient.



Graph 1illustrates the steep improvement in the Mean VFAS scale rating



Graph 2illustrates the change in Pulse Oximeter Reading

The criteria required for binaural beats to be considered effective in each case was defined as:
The patient should give a more positive rating on the VFAS than that given on the previous assessment (V1/V2)

The Pulse oximeter reading should be lower as compared to that obtained in the previous assessment (PO1/PO2)

At the stage of intraoperative assessment, 87% of the cases satisfied the criteria, thus, indicating that binaural beats were effective in these cases.Assessment of the cases after the termination of procedure yielded successful results in a significant 94% of the cases.

The most significant change observed was marked improvement seen in cases who were difficult to manage (most negative initial value on VFAS) with other behavioural management techniques within 5-7 minutes, from crying loudly to calmly accepting the treatment giving positive intra- and post-operative VFAS scores. Also, it was observed that gag reflex was significantly reduced in cases of fluoride application even in hypersensitive patients.

IV. Discussion

It has been established by various studies that audio analgesia affects pain tolerance and not the pain threshold[13,14]. A number of theories pertaining to the action of binaural beats or, in general, audio analgesia have been put forth by many researchers including the gate control theory. The binaural beats are able to alter the functional connectivity between the brain region and have been reported to have significant brainwave entrainment effects[15]. This brainwave entrainment achieved due to theta wave stimulation could possibly lead to the release of the hormone endorphin which would result in the clinical effect of relaxation of the patients. According to report by Mountcastle[16], pain-evoked neural and activity is suppressed by auditory stimuli in the posterior group nuclei o the thalamus and in the cerebral cortex.

Nonpharmacological approaches,such as modelling, voice control, tell show do, desensitization also play a vital role before the application of more invasive methods in behaviour management [1].Altogether, nonpharmacological methods instilla positive dental experience in the child's mind and modify theiroutlook toward dentistry. Various types of music, such as live music [17],familiar songs, upbeat and calm sounds can be used [18].

August[19] postulated that the hypnoanesthesia achieved by audio analgesia results from directing the attention of the patient away from pain response towards a pleasant abstract entity." Mood is a temporary,

conscious state of mind or predominant feeling [20]. Mood states are often reliant upon external factors. Several studies have sought to modulate mood states by binaural-beat stimulation [21,22]. Anxiety on the other hand are of two types. State anxiety is a momentary increase in anxiety levels associated to an event or situation. Trait anxiety, however, is a persistently heightened level of anxiety which is a personal characteristic [23].

In acoustics, a beat is an intrusion pattern between two sounds of slightlydifferent frequencies, perceived as a periodic variation in volume whose rate is the difference of the two frequencies [21]. A binaural beat is an auditory illusion perceived when two different pure-tone sine waves, both with frequencies lower than 1500 Hz, with less than a 40 Hz difference between them, are presented to a listener dichoticallyi.eone through each ear[24]

The auditory signal from each ear is directed ipsilaterally along the ascending auditory pathway to the auditory cortex. However, at the brainstem, auditory signals from both sides are passed to the superior olivary complex [25], the first nucleus in the ascending auditory pathway receiving bilateral auditory signals. The binaural beat is instinctively generated with a frequency equaling the difference of the frequencies of the two tones. The binaural beat is then led to the auditory cortex in phase-locked manner described by the response of the inferior colliculus – a part of the ascending auditory pathway – as a binaural beat [26].

The brain gets induced to oscillate at the rate of binaural beat frequency once the auditory areas are signalled by the primary auditory cortex, which can be illustrated by EEG rhythms. This phenomenon is called entrainment of neural oscillation [27]. These neural activities are entrained due to the frequency of the binaural beat, which is known as a frequency-following response[28]. Usually, spectral elements of EEG signals can be divided into five frequency bands[29]:

i. Delta waves: Binaural beats in the delta pattern operate at a frequency of 0.2-3 Hz with links to a dreamless sleep.
ii. Theta waves: Practitioners set binaural beats in the theta pattern to a frequency of 3-8 Hz.
iii. Alpha waves: Binaural beats in the alpha pattern are at a frequency of 8–12 Hz and may incite relaxation.
iv. Beta waves: Binaural beats in the beta pattern are at a frequency of 12–27 Hz. These waves improve concentration and awarenessbut may also amplify anxiety at higher frequencies.
v. Gamma waves: This frequency pattern accounts for a range of 27 and up Hz.

For the effect of binaural beats to take effect, the beats had to be presented dichotically to the patient for at least 3 minutes as a brief exposure to noise does not result in significant alteration in the pain threshold or tolerance as inferred by the clinical findings of Camp et al. [30]. Prolonged exposures to the beats are tolerated relatively safely[31] without causing any measurable permanent change in hearing, thus, making audio analgesia a relatively safer non-invasive modality to achieve relaxation and analgesia in pediatric patients. However, if a patient complains of tinnitus for a time period greater than 20 minutes following a noise exposure, or of vertigo during the exposure, the exposure should be terminated[32].

V. Conclusion

Use of 'binaural beats' is a novel method which has demonstrated an adequate level of patient compliance with a minimum requirement of equipment. Owing to their entrainment effects on the brain to release certain hormones like endorphin and dopamine, binaural beats may rightly be termed as 'digital drugs' allaying their anxiety and relaxing the patients. Binaural beats can efficiently serve as a safer and effective method for the behaviour management of pediatric patients. Like every other technique, this too has its drawbacks, none of which are insurmountable, and with the correct training equipment, it has the potential to be a viable and sustainable mainstay in the field of sedation. It is possible that combined with visual and/or vibratory relaxing stimuli or any other type of distraction methods, binaural beats could have an even greater scope in reducing patient apprehensiveness more effectively.

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