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Original Research Article

Efficacy of binaural beats in the treatment of TMJ disorders: A randomized control trial

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Abstract

Introduction: Binaural beats are a type of auditory stimulation where two slightly different frequencies are played in each ear, and the brain perceives a "third" frequency, known as the binaural beat. These beats are thought to influence brainwave activity through a phenomenon called brainwave entrainment, where brainwaves synchronize to the frequency of the binaural beats. When used intentionally, binaural beats may help reduce anxiety by promoting relaxation and altering brainwave patterns. The effects of the binaural beats, intervention may include improved focus, memory, anxiety, analgesia, and meditation. It has been demonstrated to be effective in reducing both acute and chronic pain.
Objective: To ascertain whether using binaural beats in addition to conventional ultrasound therapy can successfully reduce dentistry students TMD symptoms.
Materials and Methods: This randomised control study was conducted in the Department of Oral medicine and radiology in ITS Dental College, Ghaziabad from June 2024 to Aug 2024. Twenty young dental students, ages 18 to 25, were chosen for this pilot trial; ten were placed in the experimental (Binaural beats + USG therapy) group and ten in the control (USG therapy) group. The following selection criteria were applied while choosing the participants: The study included individuals with TMJ pain, stiffness, or related symptoms. Patients who used analgesics for TMJ pain recently, had a history of underlying systemic disease, or had pain with an odontogenic origin were excluded from the study. Binaural beats in experimental group were delivered with the help of headphones at frequencies of 400 Hz and 412 Hz in the left and right ears, respectively. The Hamilton Anxiety Rating Scale and the pre-validated TMJ Pain questionnaire were used to measure the patients' pain and anxiety before beginning of the treatment. And once the treatment was over, the same questionnaires were completed.
Results: The pilot study consisted of 20 participants (10 in each group) and had a mean age of 23.56 years and were comprised of 2 males and 8 females in the control group and 1 male and 9 females in the case group. In the Wilcoxon Signed Ranks Test, the experimental group had statistically significant p values for anxiety ($P < 0.02$), however, there was a discernible but statistically insignificant decrease in other signs and symptoms. Using the Mann-Whitney U test to compare the two groups, a statistically significant difference was found in the anxious mood parameter values between the experimental and control groups.
Conclusion: In patients with TMJ dysfunction, binaural beats were more successful in lowering anxiety. As a result, they work well as a non-pharmacological, non-invasive behaviour management tool. However, research continues to focus on its potential to reduce pain.

Keywords: Audio analgesia, Anxiety, Pain, Distraction, USG

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1. Introduction

Temporomandibular disorders (TMD) cause aberrant, partial, or compromised temporomandibular joint function that leads to a variety of illnesses affecting the temporomandibular joint (TMJ), masticatory muscles, and occlusion. Common symptoms of these disorders include discomfort, restricted movement, muscular tenderness, and intermittent joint noises.[1] Although there are several contributing causes to TMD, the relative importance of each etiological factor is still up for debate. A variety of behavioural and psychosocial characteristics are prevalent in TMD patients, and psychological stress is a significant cause. Stress is a state of pressure, either physiological or psychological, brought on by various factors. In such situations, stress levels are higher due to socioeconomic factors, changes in lifestyle, competitive workloads, and emotional disturbances.[2]

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As dental school offers both theoretical and clinical challenges, it is often known that dental students experience a stressful environment. Extended periods of stress can negatively impact students' health, which could lower their output at work or make it more difficult for them to study. Prolonged stress can also make it harder for students to interact with patients, impair their productivity, and cause them to lose their personal touch, all of which can have a detrimental effect on their academic achievement.[3]

The number of surgical treatments performed for TMDs rose dramatically in 2010, but has since drastically decreased because there is insufficient data on arthrocentesis as a treatment for TMDs. Bio-psychosocial models have been applied recently. This paradigm incorporates pharmaceutical, psychological, and physical treatments.[4] Such noteworthy non-pharmaceutical intervention is the use of Binaural beats (BB). Numerous scientific investigations have exhibited the efficacy of a non-pharmacologic approach, such as the Binaural Beats (BB) intervention, in mitigating pain and anxiety levels across diverse therapeutic contexts.[5]

The BB is an easy method that Gerald Oster originally detailed.[6] It entails playing two sounds that are comparable in frequency over the two channels of a stereo headset. The difference between the two initial frequencies causes the waves to interfere at the level of the central nervous system, creating a composite signal. Without any prior training, the theta range (4–7 Hz) beta band induces a brain state that resembles the benefits of meditation. The BB intervention may affect analgesia, meditation, anxiety, memory, and focus. Its efficacy in mitigating both acute and chronic pain has been established.[7,8] Our goal in this randomized controlled experiment is to determine whether binaural beats, in addition to traditional ultrasound therapy, can effectively lessen the symptoms of TMD in dental students.

2. Materials and Methods

The present randomised controlled study was conducted in the Department of Oral medicine and Radiology in ITS Dental College, Ghaziabad from June 2024 to Aug 2024. The I.T.S Institutional Ethics Committee granted ethical approval under protocol number ITSCDSR/IIEC/RP/2024/050. The study was registered with the Clinical Trials Registry of India (CTRI) under the number CTRI/2024/08/071985. As it was a pilot study sample size was determined using a thumb rule by Birkett and Day (1994) the final sample size included 10 individuals in each group.

2.1. Inclusion and Exclusion criteria

Participants, who ranged in age from 18 to 25 with TMJ pain, stiffness, or related symptoms were included. Patients who used analgesics for TMJ pain recently, had a history of underlying systemic disease, or had pain with an odontogenic origin were excluded from the study.

Using random allocation software, all 20 participants were randomly assigned to two groups: an experimental group and a control group, each with 10 individuals. This was done to assure standardization. The experimental group received treatment with both ultrasound therapy and binaural auditory beats, while the control group's participants received simply ultrasound therapy without any music intervention.

2.2. Intervention for control and experimental group was given for 5 days only.

Ultrasound therapy was given at an intensity of 2.4 W and frequency of 3MHz for 10 minutes for 3 days in both the groups using Electroson -709 machine with consecutive 5 days of Binaural beats for 5 minutes in the experimental group. An assistant with training gave the subjects beats using over-the-ear headphones while the lead investigator was blinded. The first group (control group) of participants did not receive any music intervention; instead, they were given over-the-ear headphones to conceal their identities from the lead researcher.

Prior to starting treatment, the patients' pain and anxiety were assessed using the Hamilton Anxiety Rating Scale[9] and the pre-validated TMJ Pain questionnaire. And same Questionnaires were filled on the 5th day after completion of the treatment. Every participant in the study gave their informed consent.

2.2.1. Presentation of binaural beats (BB)

With over-the-ear headphones connected to the mobile device, the subjects in the binaural auditory beat group listened to gentle, calming music overlaid with beats at frequencies of 400 Hz and 412 Hz in the left and right ears, respectively for 5 minutes continuously (**Figure 1**). This was done to take advantage of their synergistic effect. The software utilized in the prior experiments, Brain Waves Binaural Beats from MynioTech Apps in Santa Catarina, Brazil, provided the frequencies.

The ultrasound therapy was given at an intensity of 2.4 W and frequency of 3MHz for 10 minutes for 3 days in both the groups using Electroson -709 machine.

2.2.2. Statistical assessment

The Statistical Package for the Social Sciences (SPSS) (SPSS v26.0, International Business Machines Corporation) was used to do the statistical analysis. A t-test was used to perform an inter-group comparison of the demographic data (**Table 1**). The Chi-square test was used to compare variable category frequencies between groups. When the Shapiro-Wilk test was performed to determine if numerical data was normal, it was found that the data did not follow a normal curve; as a result, non-parametric tests were employed for comparisons. To compare the parameters between the two groups, the Mann-Whitney U test was run. The Wilcoxon Signed rank test was utilized for the intra-group comparison. $P < 0.05$ was deemed statistically significant for all statistical

tests, maintaining α error at 5% and β error at 20%, providing 80% power for the investigation.

3. Results

The pilot study consisted of 20 participants (10 in each group) and had a mean age of 23.56 years and were comprised up of 3 males and 17 girls. Control group was comprised of 8 females and 2 males, whereas 9 females and 1 male make up the experimental group.

A statistically significant difference was observed in the anxious mood parameter values between the experimental group and the control group when the two groups were compared using the Wilcoxon signed-rank test. (**Table 2**) Other values across the groups showed a statistically non-significant difference. According to these results, there was a statistically significant decrease in anxiety levels in the experimental group as compared to the control group. **Table 4** shows Comparison of post intervention changes between case and control group. Post-treatment, both groups showed significant improvements in various symptoms. The case group had stronger improvements in psychological variable like anxious mood. Both groups showed significantly improved in TMJ pain indicating overall intervention effectiveness.

Figure 1: Presentation of binaural beats with headphones.

Table 1: Gender Distribution in both the groups

Group Gender Crosstabulation					
			Gender		Total
			Male	Female	
Group	Case Group	Count	1	9	10
		% within Group	10.0%	90.0%	100.0%
	Control Group	Count	2	8	10
		% within Group	20.0%	80.0%	100.0%
Total		Count	3	17	20
		% within Group	15.0%	85.0%	100.0%

Table 2: Comparison of pre- and post-intervention changes in case and control groups

Group	Variable	Mean pre(SD)	Mean post(SD)	p- value
Case Group	Anxious Mood	1.50 (0.85)	1.00 (0.67)	0.025
	TMJ Pain	1.70 (0.68)	0.50 (0.53)	0.006
	TMJ Noises	1.50 (0.97)	0.60 (0.52)	0.024
	Headaches	1.40 (0.84)	0.80 (0.63)	0.014
	Jaw Function	1.30 (0.82)	0.60 (0.97)	0.038
Control Group	Anxious Mood	1.50 (0.53)	1.10 (0.32)	0.046
	TMJ Pain	2.10 (0.57)	1.20 (0.42)	0.007
	TMJ Noises	1.50 (0.85)	0.60 (0.52)	0.030
	Headaches	2.20 (1.03)	1.10 (1.10)	0.015
	Jaw Function	2.40 (2.72)	0.80 (1.32)	0.027

Table 3: Wilcoxon Signed Ranks Test Intra group comparison

Group		Anxious mood post - Anxious mood pre	TMJ pain post - Tmj pain pre	TMJ noises post - Tmj noises pre	Headaches post - headaches pre	Jaw function post - jaw function pre
Case Group	Z	-2.762[a]	-2.762[a]	-2.251[a]	-2.449[a]	-2.070[a]
	P value	.006	.006	.024	.014	.038
Control Group	Z	-2.714[a]	-2.714[a]	-2.165[a]	-2.428[a]	-2.214[a]
	P value	.007	.007	.030	.015	.027

Table 4: Comparison of post intervention changes between case and control group

Variable	Case group Mean (SD)	Control group Mean (SD)	Case Group P value	Control Group P value
Anxious Mood	1.00 (0.67)	1.10 (0.32)	0.002	0.046
TMJ Pain	0.50 (0.53)	1.20 (0.42)	0.006	0.007
TMJ Noises	0.60 (0.52)	0.60 (0.52)	0.024	0.030
Headaches	0.80 (0.63)	1.10 (1.10)	0.014	0.015
Jaw Function	0.60 (0.97)	0.80 (1.32)	0.038	0.027

4. Discussion

The use of music therapy as a nonpharmacological anxiolytic intervention is gradually becoming more widespread among medical practitioners. It has proven useful for its relaxing effects and easing anxiety by affecting the limbic system of the brain and providing the release of endorphin and enkephalin, which causes a reduction in dental anxiety. Music also activates the parasympathetic nervous system and causes a decrease in physiological findings such as blood pressure, pulse, and respiration, and reducing dental anxiety. Similar to music, binaural beats are useful in alleviating anxiety.

The concept of binaural beats is only valid when two sinusoidal waves of sounds with nearly identical frequencies are presented to either of the ears separately. The exchange of sound is ensured by the olivary body, the auditory center that processes sound in association with the cochlear and colliculus inferior nuclei. Once the two signals connect in the brain, the difference in their frequency manifests itself as a unified, third signal that is different from the original waves altogether, called "binaural integration." The purpose of this randomized controlled study is to ascertain whether using binaural beats in addition to conventional ultrasound therapy can successfully reduce dentistry students' TMD symptoms.

To our knowledge, no study has been published related to the management of TMD with binaural beats. Numerous research works have documented the psychological and physiological impacts of binaural beats. For instance, managing persistent pain, enhancing attentiveness, lowering ante-operative anxiety, and enhancing sleep quality. A randomized control trial conducted by Isik BK, et al[10] assessed effectiveness of the binaural beats in reducing preoperative anxiety in dentistry. They emphasized that binaural beats could be effective to reduce preoperative anxiety in dentistry. The results showed significant differences in the experimental and control group's pre-operative dental anxiety levels and the results are compatible with the literature. The use of binaural beats has been shown to have an antianxiety effect in dental settings, reducing preoperative anxiety in patients having a third molar extracted and in paediatric dental patients.[11,12] However, this effect was also observed in the current study pertaining to TMJ disorders, where stress was identified as a contributing factor.

A randomized control trial conducted by Bhuvanesh Nitin Bhusari et al[13] in 2022 also showed a significant decrease of anxiety levels during restorative treatment in children aged 6-12 years after using binaural beats. Another study done by Dimple Padawe et al[12] in year 2023 also showed reduction of pre- and intraoperative dental anxiety in paediatric patients. Therefore, they can be used satisfactorily as a nonpharmacological and non-invasive behaviour management aid. Patient acceptance, efficiency, ease of availability, and feasibility are some of their additional advantages. Another RCT showed Binaural tone music and patient choice music can be suitable alternatives to pharmacological therapies for perioperative anxiolysis done by Markandey Prasad et al[14] in year 2022. Randomized Control Trial done by Alia El ALY et al[15] in year 2021, also showed the positive effect of alpha binaural beat music on orthodontic pain after initial archwire placement toward the end of the first week of treatment.

5. Strengths

Non-Invasive and Safe, easily assessable via different applications, reduction in pain and anxiety.

6. Future Recommendations

Binaural beats can be introduced as a supplementary tool in cognitive-behavioral therapy (CBT) or other treatments having pain and anxiety.

Use binaural beats as part of pre-session relaxation to help patients enter a receptive mental state or as homework to extend therapeutic benefit.

Study the application in situational anxiety, such as pre-surgery stress, exam anxiety, or public speaking fear.

7. Limitations

The study included small sample size, which may limit the generalizability of the result. There was also lack of prior research studies on this topic. It was not possible to control the compliance of the patients in listening to the music as requested, which may have influenced the results. The duration of the exposure of the binaural beat may have been too short (5 minutes), and longer exposure could have improved results, although patient compliance could then be reduced. Lastly, the lack of blinding of the clinician and statistician may have introduced some bias.

8. Conclusion

Due to their capacity to synchronize brainwaves, binaural beats are unquestionably beneficial in lowering dental anxiety. Their usefulness in lowering anxiety for TMJ condition is also supported by our research. In terms of frequency and duration of use, their role in pain relief is still subject to debate and requires a meticulously planned, standardized approach in large sample size.

9. Source of Funding

None.

10. Conflict of Interest

None.

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