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Can Binaural Beat Music Be Useful as a Method to Reduce Dental Patients' Anxiety?

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ABSTRACT

Background: One of the main issues in dentistry and a barrier to offering dental treatment is anxiety. The usage of music is one of the nonmedical ways to reduce anxiety. Binaural beat technology is used as a music treatment technique. The goal of this study wasto determine whether employing binaural beat technology during and after dental appointments can help patients feel less anxiety and pain.

Methods: In this clinical trial, 80 patients who were candidates for mandibular wisdom tooth surgery (in 2 test and control groups) were examined. In the control group, after the injection of anaesthesia and before surgery, they waited for 10 minutes and during this time no intervention was done. In the test group, thought, after the injection of anaesthesia, the patients were asked to listen to binaural beat music with headphones for 10 minutes. The level of anxiety of the patients before and after the intervention was checked with the Spielberger State-Trait Anxiety Inventory and finally the data were entered into SPSS version 21 software.

Results: The score of overt anxiety ($P = .524$) and covert anxiety ($P = .118$) before the start of the study was not significant between the 2 groups, but overt anxiety ($P = .001$) and covert anxiety ($P = .000$) after the intervention in the test group decreased significantly.

Conclusions: The research showed that the use of binaural beat music has significantly reduced the level of overt and covert anxiety in patients and can be used as an alternative nonpharmacologic method to reduce anxiety.

Introduction

Oral and dental health is an important element of general health, but receiving dental treatment is generally considered uncomfortable and upsetting for patients.[1] Dental procedures can be uncomfortable and painful, and many patients worry about discomfort during and after dental treatment. Anxiety is one of the biggest issues in dentistry and mitgates the

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delivery of dental care.[2,3] According to epidemiologic research, 20% to 30% of people experience dread and anxiety before receiving dental care.[4] According to reports, dental anxiety affects 14.9% of adults in Australia, 12.5% in Canada, 12.6% in Russia, and 29% in Saudi Arabia.[5,6]

Some persons with dental phobia only visit the dentist if there is an urgent issue.[7] The sound of dental equipment, concerns about the lack of sterility of the instruments, and concerns about the dentist's insufficient knowledge of the treatment are amongst the elements that amplify this fear and anxiety.[8,9] The patient has more pain during and after dental procedures due to severe anxiety, which also increases the likelihood of mental health complications and emergencies like syncope in patients, hinders regular visits, and lowers quality of life.[10] Additionally, anxiety-related changes in blood pressure and heart rate can produce tremors, restlessness, vasovagal syndrome, and hyperventilation in those who already have cardiac issues and high blood pressure. The patient may experience myocardial ischaemia, arrhythmia, heart attack, and even stroke as a result of these changes.[11]

One of the nonmedicinal methods of reducing anxiety is relaxation induced by music. Music therapy is a supportive treatment. It can help patients with a variety of physical, mental, emotional, and social problems, the most significant of which are pain, anxiety, sadness, and communication problems.[12] Patients of every age, from infants to the elderly, can be treated with music therapy services.[13] Music interventions influence the patient's physiologic and mental states, including their level of postoperative anxiety, as well as their heart rate and blood pressure.[14] Binaural beat technology is used as one music treatment technique. Oster[15] initially described this method in the 19th century.

In order to create a binaural beat, 2 pure sine tones must be delivered to each ear separately, with a stable intensity but a slight difference in their frequencies. This results in the perception of a misleading tone with a frequency equal to the average of the 2 tones and an oscillation amplitude equal to the difference between 2 songs, which is thought to be an auditory illusion. In order to reduce patients' anxiety, this procedure stimulates brain waves.[16] For example, when 2 songs with frequencies of 400 and 410 Hz are presented separately, they are heard as one song with a frequency of 405 Hz and an oscillation amplitude of 10 Hz.[17] Tones must have a frequency of less than 1500 Hz in order to be audible, and the difference in frequency between any 2 tones must be less than 30 Hz in order to be interpreted as a single song. Some of the benefits of using these sounds include lowering anxiety, improving focus and attention, easing stress, promoting relaxation, boosting good mood, enhancing creativity, and alleviating pain.[18]

This technology has been used to cure chronic pain, improve sleep quality, increase alertness, treat children with developmental disabilities, alleviate alcoholic depression, and reduce preoperative anxiety, according to numerous studies.[19,20] Based on the findings of a meta-analysis study by Garcia-Argibay et al[21] on the impact of binaural beat technology on anxiety and pain perception, listening to music both before and during stressful tasks had more positive benefits than undertaking the tasks themselves. The impact of binaural beat technology on anxiety reduction in various patient groups was examined by Ölçücü et al,[22] Parodi et al,[23] Yusim et al,[24] Wiwatwongwana et al,[14] and Padmanabhan et al[20]; patients included those undergoing cytoscopy, cesarean section, treatment of anxiety symptoms, cataract surgery, and general anaesthesia for surgery, respectively. The efficacy of binaural beat strategy on lowering anxiety before dental procedures was evaluated Menziletoglu et al[25] and Isik et al,[26] but both utilised the visual analog scale (VAS) scale, which is less trustworthy than questionnaires with multiple questions. Due to the limited number of studies on the use of this technology in dentistry and the potential benefits of its use in clinical experience, this research focused on the effect of applying binaural beat technology on dental patients' levels of anxiety during and after dental appointments.

Methods

The present study is a double-blind clinical trial. The present study was registered in the clinical trial centre of Iran (IRCT20220824055789N1). The current study's ethics code is IR.MAZUMS.REC.1400.11731. The study population comprised patients referred to the dental clinic of Mazandaran University of Medical Sciences for mandibular wisdom tooth surgery from 10 September to 19 October 2022. Based on the following sample size calculation formula and the findings of the Isik et al study,[26] with an alpha of 0.05 and a power of 90%, the sample size was determined to be 80 patients (40 patients in each group).

$\mu 1 = 3.59$

$\mathrm{SD1} = 2.23 \quad n = 2\dfrac{\left(z1-\dfrac{\alpha}{2}+z1-\beta\right)^2\left(\sigma_1^2+\sigma_2^2\right)}{\left(\mu_1-\mu_2\right)^2}$

$\mu 2 = 5.39$

$\mathrm{SD2} = 2.65$

Patients having complete informed consent and written consent forms who were between 18 and 60 years old and in good overall health were included in the trial. The study eliminated patients who were taking psychiatric medication, had hearing issues, had epilepsy, or did not desire to continue or participate in the study.[26,27] According to the established parameters for inclusion and exclusion, individuals belonging to the selected cohort were incorporated into the investigation through the employment of a census approach, with the aim of attaining the specified sample size of 80 participants.

By using block randomisation (block size of 4), the patients were split into 2 groups: experimental and control. The patients received a thorough explanation of the research procedure before the study began, and their written consent was obtained. The potential for tooth or gum pain during and after the dental surgery was mentioned to the patients. The Spielberger State-Trait Anxiety Inventory (STAI) overt and covert anxiety questionnaire was then used to assess the level of anxiety in both the control and experimental group patients prior to the start of therapy.[27]

In the control group, the patients' degree of anxiety was initially assessed after local anaesthetic was administered, and the patients had to wait for 10 minutes. Nothing was

done, no distracting background noises were played, and the patient was no longer informed about the progress of the dental surgery during this time. The patients' anxiety levels were assessed once more after 10 minutes (the second time in the control group).

In the experimental group, the patient received a local anaesthetic injection and then was asked to wear headphones (Beats, model x) for 10 minutes whilst listening to instrumental music. For this, frequencies of 200 Hz and 209.3 Hz were applied to the left and right ears, respectively.[26] On an iPhone 8 smartphone, these frequencies are produced using the Brain Waves Binaural Beats program. The music's volume might be adjusted at the patient's discretion. The binaural beat music used was frequency-only and devoid of any ambient sound or other calming sounds like the sound of the ocean or falling rain. After 10 minutes of listening to this music, the patient's headphones were taken off and they underwent another stress test (the second time in the experimental group).

All patients were instructed to keep their eyes open throughout the waiting period before the treatment began because doing so would alter brain waves and bias the results. The remainder of the treatment was then administered as usual. All the aforementioned clinical measures of managing treatment and executing the procedures prior to the surgical intervention were conducted by a trained dentist (RR) in order to mitigate the possibility of interpersonal errors. Furthermore, all dental extractions were executed by an oral and maxillofacial surgeon who was a coauthor (AP).

STAI questionnaire

The STAI overt and covert anxiety questionnaire includes separate self-report scales to measure overt and covert anxiety. Twenty items make up the overt anxiety scale (form Y-1 of STAI), which evaluates a person's feelings "at this moment and at the time of responding." Twenty items on the covert anxiety scale (form Y-2 of STAI) measure people's daily and general emotions. Each of the 2 scales took educated persons roughly 6 minutes to complete. Each scale took 10 minutes to complete for people with lower education levels or emotional distress. The patients were informed that their answers would be kept confidential so that they could answer honestly.[28] Behdani et al[29] have demonstrated the questionnaire's validity; they stated that the averages of overt and covert anxiety and finally the total anxiety at 2 levels of 0.95 and 0.99 were calculated separately, and the results of the confidence calculation were significant at 95% and 99%. In addition, this questionnaire's reliability has been estimated to be 87%. In pilot research, Roohy et al[27] and Rabiee et al[30] determined the reliability of the STAI to be 89% and 90%, respectively.

Scoring system for the questionnaires

Patients had to select the option that best represented the strength of their feelings for each statement whilst responding to the overt anxiety scale by choosing from a range of options. These options include:

1 = not at all, 2 = somewhat, 3 = moderately so, 4 = very much so

Table 1 – Interpretation of questionnaire scores.

Overt anxiety	Covert anxiety scale
20–31: mild	20–31: mild
32–42: moderate to low	32–42: moderate to low
43–52: moderate to high	43–52: moderate to high
53–62: relatively severe	53–62: relatively severe
63–72: severe	63–72: severe
73–80: very severe	73–80: very severe

In response to a 4-option scale on the covert anxiety scale, the patients selected the response that best described their common and dominant mood as follows:

1 = almost never, 2 = sometimes, 3 = often, 4 = almost always

Based on the response, a weight between 1 and 4 was given to each of the STAI's items. Ten items from the overt anxiety scale and 11 statements from the covert anxiety scale each received a score of 4, indicating a high presence of anxiety. A high rank for each of the other questions, which comprised 9 statements measuring covert anxiety and 10 statements measuring overt anxiety, showed the lack of anxiety. The scoring weights were reversed for expressions that show lack of anxiety; in other words, the scores of the answers for these sentences were weighted, rather than ranging from 1 to 2, 3, and 4, as 4 to 3, 2, and 1.

Expressions that indicate the absence of anxiety and were weighted inversely during scoring are:

Overt anxiety scale: 1, 2, 5, 8, 10, 11, 15, 16, 19, 20

Covert anxiety scale: 21, 23, 26, 27, 30, 33, 34, 36, 39

The total scores of the 20 items on each scale were summed in order to determine the individual's score on each of the 2 scales. The results of the 2 scales measuring overt and covert anxiety therefore ranged from 20 to 80. Results are presented in Table 1[31]:

Statistical analyses

The data were entered into the statistical software SPSS version 21. The normal distribution of the data was measured by the Shapiro–Wilk test. Independent *t* test, paired *t* test, and Mann–Whitney and Wilcoxon tests were used. *P* values smaller than .05 were considered significant.

Results

In this investigation, 2 groups of 40 patients each—the control group and the experimental group—were studied. In the experimental group, the average age was 34.74 ± 11.34 years, whilst it was 35.37 ± 8.92 in the control group. Between the 2 groups, there was no noticeable difference in age ($P = .348$; Table 2). Additionally, there was no significant gender difference in either the experimental or control groups ($P = .257$; Table 2).

The Mann–Whitney statistical test was used to compare the STAI test scores at the beginning of the study between the experimental and control groups. The findings demonstrated that there was no significant difference between the 2 groups' levels of overt ($P = .524$) and covert ($P = .118$) anxiety

Table 2 – Comparison of the participants' demographics between the experimental and control groups.

	Age, y							Gender	
	18–20	21–30	31–40	41–50	51–60	Mean ± SD	Range	Male	Female
Experimental group	4 (10%)	12 (30%)	19 (47.5%)	4 (10%)	1 (2.5%)	34.74±11.34	18–52	18 (45%)	22 (55%)
Control group	6 (15%)	13 (32.5%)	15 (37.5%)	4 (10%)	2 (5%)	35.37±8.92	19–58	21 (52.5%)	19 (47.5%)
P value	.348[a]							.257[b]	

[a] Mann–Whitney test.
[b] Chi-square test.

Table 3 – Comparing the degree of overt and covert anxiety in 2 groups before and after the intervention.

	Type of anxiety	Experimental group (Mean ± SD)	Control group (Mean ± SD)	*P* value[a]
Before intervention	Overt	41.79 ± 6.30	40.35 ± 5.32	.524
	Covert	44.35 ± 7.59	46.38 ± 12.39	.118
After intervention	Overt	35.74 ± 8.42	41.65 ± 4.77	.001*
	Covert	39.25 ± 6.61	47.53 ± 11.05	.000*

[a] Mann–Whitney test.
* Significance.

prior to intervention (Table 3). The experimental group used binaural beat technology, and the average score for overt and covert anxiety was determined using the STAI exam. The control group's anxiety level was recalculated after 10 minutes of no intervention. The means of the 2 control and experimental groups were compared. The experimental group's average score for overt (*P* = .001) and covert (*P* = .000) anxiety was significantly lower than that of the control group (Table 3).

Discussion

There is currently no known approach for specifically lowering patient anxiety during dental procedures. Sedative medications are frequently used to reduce anxiety. But, lately, there has been a lot of interest in nonpharmacologic approaches. Today's professionals frequently employ music as a nonmedical intervention. Studies have revealed that the usage of music has a good impact on patients' emotions and has been linked to reductions in anxiety.[32,33] Binaural beat technology is used as one music treatment technique. The first mention of this technique dates back to the 19th century, according to Oster's[15] paper.

According to the findings of the current study, the case group's mean score for overt and covert anxiety was significantly lower than that of the control group, which is consistent with the findings of the study by Ölçücü et al.[22] Ölçücü et al[22] included 159 males undergoing cystoscopy and the removal of ureteral stents. According to the STAI index, the 2 case groups in Ölçücü's study—those who used binaural beat music and those who listened to classical music—had much lower levels of anxiety than the control group.

The outcomes of a study by Isik et al[26] agreed with those of the present study. This study had 30 patients in each of the case and control groups, and the average age of the participants was younger than in our study. In the Isik et al[26] study, the average level of patient anxiety after 2 VAS scale measurements (before and after intervention) did not change in the control group, but it decreased significantly in the experimental group. Also, in the current study, the average anxiety of patients utilising the STAI questionnaire was notably lower in the case group (*P* = .001).

One of the advantages of listening to music is that it reduces anxiety. Earlier research has demonstrated how binaural music can ease preoperative anxiety before anaesthesia or anaesthetic injection.[20] In a 2022 investigation, 2 techniques, including binaural music and talking with the patient, were utilised to examine the impact of binaural music on preoperative anxiety in patients undergoing vascular bypass surgery.[34] Each case group and control group had 28 patients. There was a significant difference between 2 study groups; the average anxiety as indicated by the STAI questionnaire was 48.2 ± 6.7 in the case group and 52.9 ± 5.5 in the control group. In the current study, the mean overt anxiety scores in the case and control groups were 35.74 ± 8.42 and 41.65 ± 4.77, respectively. Additionally, the mean covert anxiety score in the case group was 39.25 ± 6.61 and in the control group was 47.53 ± 11.05. According to both anxiety factors, the control group experienced much more anxiety than the case group. The considerable difference is consistent with the research results from Ghouri et al.[34]

People's experiences of pain and anxiety and their hopes for pain relief all have an impact on how intense their pain and anxiety are. In other words, different physical, physiologic, and psychocultural elements are also implicated in this issue. The case group in the current study scored significantly lower on covert and overt anxiety than the control group. However, difference of these variables between groups was not significant prior to the intervention. In this regard, the effect of classical music and binaural beat music was examined in the study by Chairinkam et al,[35] which involved 134 students. The results showed that the comparison between binaural beat music and the control group was statistically significant. In the binaural beat music group, 100% of the patients experienced a decrease in anxiety, which was statistically significant (*P* = .04).

Results from a study that contrasted with the current study were reported. Le Scouarnec's[36] study, which looked at patients'

levels of anxiety after 4 weeks of listening to binaural beat music, found that although their levels of anxiety decreased after using the music, the difference was not statistically significant, which is in contrast to the findings of our study. It is possible that different patient treatments led to different results. The variation in the review period can be another factor.

In 2021, Menziletoglu et al[25] applied this technology to the practice of dentistry. Before performing surgery to remove impacted wisdom teeth, they compared the influence of music with a 432 Hz frequency on lowering dental anxiety with that of music with binaural beats. The findings revealed that the anxiety reduction rate in the 2 test groups was considerable (music recipients). They pioneered the use of music as an all-natural remedy for dental anxiety.[25] Another study in the field of dentistry, Isik et al[26] evaluated the effectiveness of binaural music in minimising anxiety prior to wisdom teeth extraction. According to their findings, the degree of anxiety in the control group remained same in 2 assessments (before and during the intervention), but it lessened considerably in the experimental group.[26] These studies in the same field supported the findings of the current study and arrived at the same conclusions, despite that they utilised a VAS scale to measure anxiety.

It is simple and inexpensive to utilise music and binaural beats on a phone or tablet to help patients feel less anxious. These techniques have no negative side effects. The use of binaural music technology in dental offices to reduce the anxiety of patients undergoing dental treatment may therefore be advised based on the results of the present study and in light of the study's objectives.

One of the limitations of the present study was that it was conducted in a small community of patients and it may not be possible to extrapolate the findings to other populations. Moreover, in the current investigation, we gave the patient the option of altering the music's volume, which may have resulted in unintended changes to the outcomes. It is recommended that further research in this topic be done on more patients, with various frequencies to determine the best frequency of binaural beat music. In order to avoid any unwanted modifications and changes in the outcomes, the music volume should also be constant.

Some factors that may have had an impact on the results of the current study, but were not standardised due to limitations in sample size, include educational qualification, frequency of dental visits, and past experiences with dental care. Future studies should take these factors into consideration for improved accuracy. Another intriguing aspect to consider is the examination of objective variables, such as blood pressure, pulse rate, pulse oximetry, finger temperature, and galvanic skin response and their correlation with subjective factors (similar to the focus of this particular investigation). Owing to the constraints of the circumstances, we were unable to incorporate objective variables; however, it is recommended that they be explored in forthcoming research endeavors.

Conclusion

Binaural music can be used as a nonpharmacologic approach to reduce anxiety during dental procedures. It significantly reduced the patients' overt ($P = .001$) and covert ($P = .000$) anxiety.

Conflict of interest

None disclosed.

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Author contributions

Substantial contributions to conception and design or analysis and interpretation of data: NS, RR, SJM, MES, and AP. Substantial contributions to drafting the article or revising it critically for important intellectual content: NS, MES, MPA, and AP. Final approval of the version to be published: NS, AP, MES, MPA, and SJM.

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