



# Influences of 432 Hz Music on the Perception of Anxiety during Endodontic Treatment: A Randomized Controlled Clinical Trial

Luca Di Nasso, PhDc,\* Andrea Nizzardo, MBIostat,<sup>†</sup> Riccardo Pace, DMD,\* Felicità Pierleoni, DMD,<sup>‡</sup> Gabriella Pagavino,\* and Valentina Giuliani, PhDc\*

## Abstract

**Introduction:** Patients undergoing endodontic therapy often have severe perioperative and intraoperative anxiety, which may lead to increased perceptions of pain and vital sign instability throughout treatment. The purpose of this study was to test the influences of music, as a nonpharmacologic adjuvant, in terms of significant changes for systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) before, during, and after endodontic treatment in a population with different levels of anxiety assessed with the Corah Dental Anxiety Scale. **Methods:** A total of 100 patients were recruited in the present study; before starting the endodontic treatment, the interviewer administered the Corah Dental Anxiety Scale to the participants to assess the baseline level of anxiety. Patients were randomly divided into 2 groups: the first one listened to the music and the second one did not. Before, during, and after the endodontic procedures, the vital signs (diastolic and systolic blood pressure and heart rate) were recorded. Results were collected and statistically analyzed. **Results:** Direct contrasts between patients listening or not listening to music showed that all the measured vital signs decreased considering the overall period (during and after the canal therapy) in the group of patients listening to music ( $P < .05$ ). **Conclusions:** This study shows the effects of music therapy on vital values and on subjective perception of anxiety during endodontic therapy. Music and medicine always work together; the soothing effects of sounds and musical frequencies make this union an extraordinary tool of synergistic care. Music therapy is a valid nonpharmacologic adjuvant to anxiety perception in endodontic therapies. (*J Endod* 2016;42:1338–1343)

## Key Words

Anxiety, endodontic therapy, sedation

Patients in general perceive dental care as invasive. Although the term “dental anxiety” does not have an exact definition in the literature, it covers a wide range of emotions, from mild apprehension to extreme anxiety or dental phobia.

Studies have documented a high demand of dental sedation, even in cases of endodontic treatment; during these procedures, anxiety and stress produce fear in patients (1, 2). The presence of dental anxiety and the lack of patient compliance could complicate the treatment (1, 3, 4).

During endodontic treatments, patients are continuously exposed to auditory stimuli, such as the metallic sounds of instruments and drill noises as well as disturbing sharp instruments and annoying rubber dams. Fear of suffocation because of the altered management of salivation and swallowing and the professional conversations of staff members are all perceptions that are further emphasized, especially if the patient(s) had previous negative experiences at the dentist’s office. Sedation is used to control anxiety and pain (4, 5).

One study has shown that 51% of patients who underwent endodontic treatment showed a positive interest in sedation if that option was available (6). There are different ways of administering sedation, and each method has its own benefit and risks. The level of sedation can be inconsistent because of the variability in absorption that affects the amount of active drug reaching the target organ, namely the central nervous system (7).

The current trend supporting narrative-based medicine that calls for the rehumanization of medicine also draws from nonpharmacologic sources (8–11). The relationship between music and medicine has been studied extensively, especially regarding the use of music in clinical practice. It is a very old tradition, which goes back to the classical world and the Middle Ages through various Western and Eastern cultural traditions (12, 13).

Steelman (14) reported that musical intervention was associated with decreased blood pressure (BP) in patients undergoing local anesthesia. Marwick (15) also reported that music therapy could induce relaxation, decrease BP, and normalize arrhythmias during an operation with local anesthesia.

Musical interventions have the additional benefit of decreasing exposure to fear-some noises during treatments (16). Musical interventions affect not only physiological domains of patient functions, such as BP and heart rate (HR), but also emotional

## Significance

432 Hz music administered to subjects during root canal treatment significantly decreased SBP, DBP, and HR during the endodontic procedures.

From the Departments of \*Endodontics and <sup>†</sup>Cranio-Mandibular Disorder, University of Florence, Florence, Italy; and <sup>‡</sup>Department of Biostatistics, University of Milan, Milan, Italy.

Address requests for reprints to Dr Valentina Giuliani, University of Florence, Via del Ponte di Mezzo 46/48, Florence 50127, Italy. E-mail address: [dr.v.giuliani@gmail.com](mailto:dr.v.giuliani@gmail.com)

0099-2399/\$ - see front matter

Copyright © 2016 American Association of Endodontists.

<http://dx.doi.org/10.1016/j.joen.2016.05.015>

domains, such as perioperative anxiety levels and pain thresholds (17). Many studies on the effects of music therapy have been performed on children (18, 19). Our research concerned adolescents and adults.

The purpose of this study was to test the influences of music as a nonpharmacologic adjuvant in terms of significant changes for systolic blood pressure (SBP), diastolic blood pressure (DBP), and HR at 3 different time points (before, during, and after endodontic treatment) in a population with different levels of anxiety assessed with the Corah Dental Anxiety Scale (DAS).

## Materials and Methods

### Sample Size Determination

A total of 100 patients (50 patients per arm) were evaluated to reject the null hypothesis of equality between patients listening to and not listening to music in terms of SBP, DBP, and HR on the basis of the following assumptions:

1. A power of approximately 90% in rejecting the null hypothesis of equality
2. Expected means at baseline of 139 for SBP, 89 for DBP, and 85 for HR
3. Expected means gain after music therapy of 120 for SBP, 80 for DBP, and 75 for HR
4. Standard deviation of 15% from the mean at baseline
5. Overall significance level = 5% 2 sided

For the expected means at baseline, the high/normal values of each parameter were considered adequate for the type of population and procedure. The normal values of each parameter were used for the expected means gain after music therapy.

### Study Procedure

This single-center, parallel-group, blinded participant-physician study was conducted at the University Hospital of Florence, Florence, Italy. The study protocol was submitted and approved by the Ethics Committee of the University Hospital of Florence (SPE14.138 University Hospital of Florence).

One hundred participants were recruited from among all patients scheduled for endodontic treatment at the Department of Endodontics at the University of Florence from October 2014 to February 2015. During the first visit, ethical approval was requested and granted, and informed consent was obtained from each patient. In cases of patients under the age of 18, their parents gave their informed consent. Each patient recruited was examined, and routine preoperative information with respect to the number of appointments, duration of the procedure, and possible intraoperative and postoperative complications was given to all enrolled patients. All participants were informed of the aim of the present study.

All root canal therapy procedures were performed in a standardized manner and limited to 3 (R.P., L.N., and V.G.) experienced endodontists; they operated with the assistance of an undergraduate university student. All treatments were performed under local anesthesia using 1.8 mL mepivacaine hydrochloride in a standardized manner (Optocaine; Molteni Dental SRL, Scandicci, Italy); the teeth were isolated with rubber dams, and the duration of the treatment did not exceed 1 hour.

The patients were randomly divided into 2 groups: patients who received root canal therapy listening to music (group 1) and patients who received root canal therapy without listening to music (group 2).

### Selection of Music

The music selected for this study consisted of 5 tracks (1: lotus, 2: summer, 3: signs, 4: white flower, and 5: melody) composed by Stefano Crespan Shantam. The music was played on instruments such as pianos, guitars, and synthesizers and Eastern instruments such as lake bansuri and tanpura flute, and it had been used for a previous study (20). The music was composed by referring raga, scales based on pentatonic intervals. The compositions are tuned to 432 Hz instead of 440 Hz, the standard general tuning for musical pitch.

### Preoperative, Intraoperative, and Postoperative Questionnaire and Measurement

An interviewer (N.P.) was instructed about the purpose of each question in order to help the participants if needed. She read the questions in a plain fashion so as not to convey any of her own personal biases. The questionnaire was anonymous and did not contain any information that might disclose the participants' identities. Cognitive/decisional impairments were the criteria for exclusion.

In the waiting room, before starting the endodontic treatment, the interviewer administered the Corah DAS to the participants; the investigator supervised the process of completing the questionnaire (21).

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 0–20. Based on the results of the Corah DAS, the patients were classified into 4 anxiety levels (22): no anxiety (score <4), mild (4–8), moderate (9–12), and severe (>12).

The participants were offered assistance if they encountered any problems when responding to the questionnaire. Objective measurements in variations of vital signs were also recorded before local anesthetic injection, at the treatment midpoint, and after the removal of the rubber dam.

### Statistical Analysis

Data were analyzed using SAS Version 9.3 software (SAS Institute Inc, Cary, NC). As a preliminary analysis, DBP, SBP, and HR were analyzed descriptively in order to numerically determine whether differences in terms of mean were present between the different anxiety groups at baseline and among patients listening or not listening to music during the root canal therapy.

A mixed linear model for repeated measures was used to measure percentage changes in DBP, SBP, and HR one at a time between baseline and therapy in groups 1 and 2.

Percentage changes were calculated as follows:  $([(v_t - v_0)/v_0] * 100)$  with  $t = (1, 2)$ , where  $v_t$  and  $v_2$  are values collected, respectively, during and after the root canal therapy, and  $v_0$  is the value observed at baseline before the canal therapy. The mixed model includes as covariates terms of music (listening/not listening) the anxiety level before the therapy assessed with the Corah DAS and the time point.

The minimum variance quadratic unbiased estimation method was used to estimate the model parameters because it does not require any particular assumptions on the data. The Akaike information criterion was used to select the most appropriate variance/covariance matrix to be used in the model. The most commonly used matrices (ie, diagonal, compound symmetry, autoregressive (1), Toeplitz, and unstructured) were tested, and the one with the lowest Akaike information criterion was selected.

Adjustment for multiplicity is not required according to European guideline CPMP/EWP/908/99 "Points to consider on multiplicity issues in clinical trials" in which §2.1.1 clearly states that when 2 or more primary variables are needed to describe relevant treatment benefits,

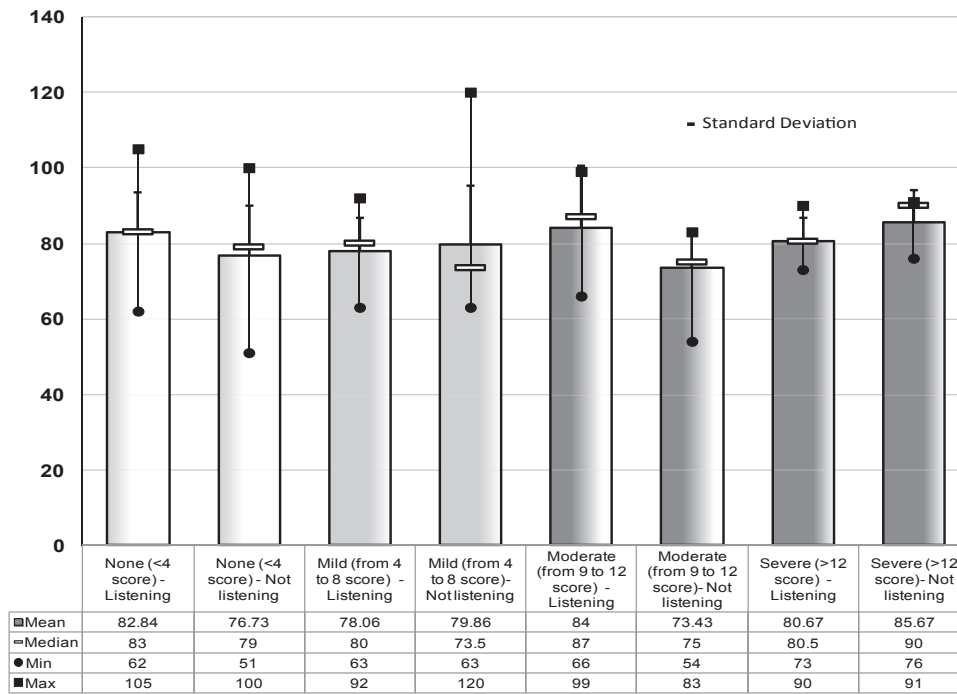


Figure 1. DBP at baseline by anxiety level and grouped by patients listening and not listening to music.

statistical significance is needed for all the primary variables, and, therefore, no formal adjustment is necessary.

Results

A total of 100 patients, from 13–83 years of age, 46 men and 54 women, were included in the present study. Descriptive statistical

analysis of DBP, SBP, and HR measured at baseline is shown in Figures 1–3, respectively.

No relevant differences in terms of vital parameters at the baseline were detected between group 1 and group 2, so we can consider them homogeneous. The percentage change of DBP, SBP, and HR between baseline and other time points is shown descriptively by different anxiety level in Table 1.

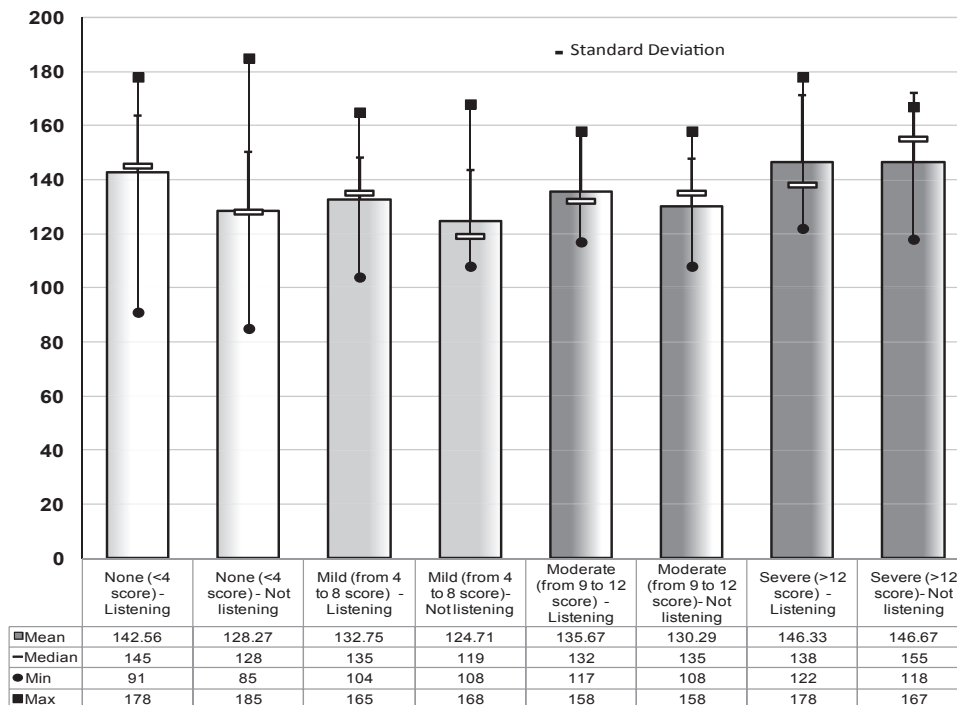


Figure 2. SBP at baseline by anxiety level and grouped by patients listening and not listening to music.

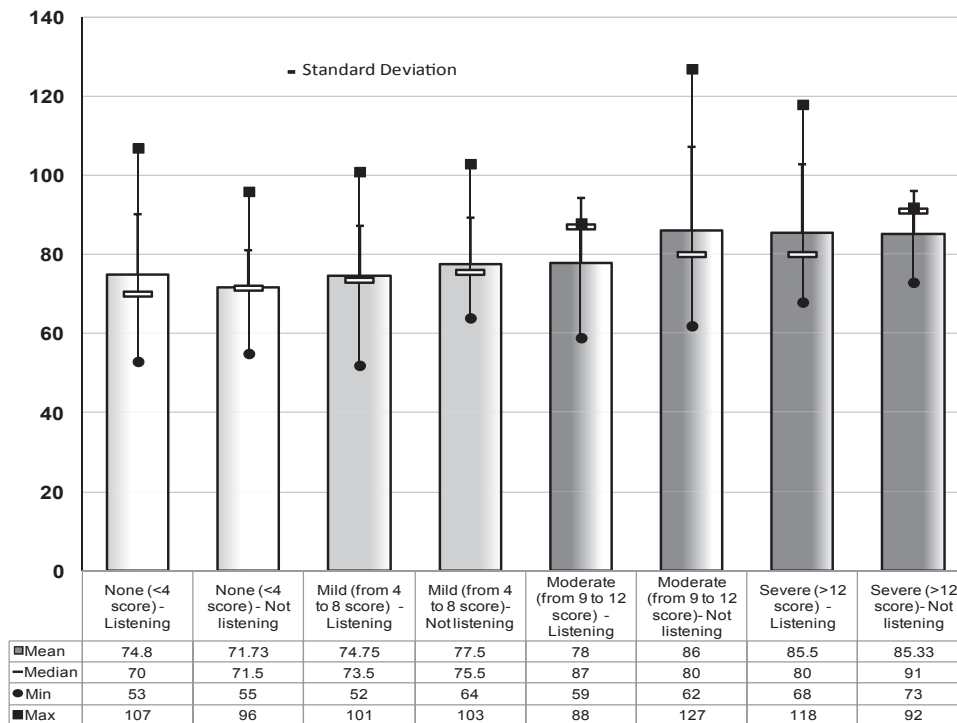


Figure 3. HR at baseline by anxiety level and grouped by patients listening and not listening to music.

Analysis of variance (Table 2) obtained by the mixed linear model for repeated measurement, selecting the unstructured variance/covariance matrix as the most appropriate, showed that the anxiety level at baseline did not statistically influence the cardiovascular percentage changes ( $P > .05$ ), whereas the effect of music was statistically significant ( $P < .001$ ). The time of reading the parameters

(during or after the canal therapy) did not have an effect on the percentage changes, with the exception of DBP as confirmed also by descriptive statistics in Table 1.

Direct contrasts between patients listening or not listening to music are also given in Table 3 and clearly show that all the measured cardiovascular parameters decreased during and after the canal therapy

TABLE 1. Descriptive Statistics (Mean [±standard deviation]) for Diastolic Blood Pressure, Systolic Blood Pressure, and Heart Rate during and after Canal Therapy by Level of Anxiety

Variable	Time point	Level of anxiety at baseline measured with the Cohen test	Mean (± standard deviation)	
			Music: yes	Music: no
Diastolic blood pressure	During canal therapy	None (<4 score)	-8.8 (±8.086)	0.1 (±10.26)
		Mild (from 4-8 score)	-8.72 (±11.546)	-1.47 (±9.164)
		Moderate (from 9-12 score)	-3.61 (±13.353)	-0.8 (±12.583)
		Severe (>12 score)	-10.4 (±8.514)	1.03 (±2.036)
	After canal therapy	None (<4 score)	0.52 (±9.206)	9.2 (±25.91)
		Mild (from 4-8 score)	3.12 (±10.93)	2.17 (±12.06)
		Moderate (from 9-12 score)	5.54 (±8.908)	4.39 (±16.672)
		Severe (>12 score)	0.57 (±9.128)	0.16 (±3.555)
Systolic blood pressure	During canal therapy	None (<4 score)	-9.11 (±9.188)	0.36 (±8.525)
		Mild (from 4-8 score)	-8.73 (±7.481)	1.21 (±7.487)
		Moderate (from 9-12 score)	-10.77 (±10.61)	0.07 (±12.992)
		Severe (>12 score)	-15.57 (±7.338)	-1.87 (±5.598)
	After canal therapy	None (<4 score)	-5.01 (±9.599)	-1.29 (±21.056)
		Mild (from 4-8 score)	-4.08 (±10.076)	0.58 (±7.688)
		Moderate (from 9-12 score)	-5.99 (±11.225)	2.81 (±13.918)
		Severe (>12 score)	-8.27 (±9.186)	-2.67 (±6.23)
Heart rate	During canal therapy	None (<4 score)	-10.55 (±8.006)	0.42 (±7.385)
		Mild (from 4-8 score)	-7.54 (±6.393)	0.64 (±7.425)
		Moderate (from 9-12 score)	-10.28 (±8.919)	-4.38 (±8.555)
		Severe (>12 score)	-11.88 (±10.118)	-4.85 (±6.841)
	After canal therapy	None (<4 score)	-9.11 (±9.599)	2.1 (±15.894)
		Mild (from 4-8 score)	-3.2 (±8.662)	-0.48 (±10.893)
		Moderate (from 9-12 score)	-7.04 (±8.28)	-9 (±15.771)
		Severe (>12 score)	-10.11 (±11.822)	-1.1 (±3.795)

**TABLE 2.** Analysis of Variance Model: Fixed Effects Analysis for Diastolic Blood Pressure, Systolic Blood Pressure, and Heart Rate

Dependent variable	Selected variance/covariance Matrix	Covariates	Num DF	F value	Pr > F	Significant
Diastolic blood pressure	Unstructured	Music (yes/no)	1	15.37	0.0002	Yes
		Level of Anxiety at baseline	3	0.14	0.9377	No
		Time point: during/after	1	28.98	<0.0001	Yes
Systolic blood pressure	Unstructured	Music (yes/no)	1	29.58	<0.0001	Yes
		Level of anxiety at baseline	3	0.94	0.4249	No
		Time point: during/after	1	2.64	0.1076	No
Heart rate	Unstructured	Music (yes/no)	1	36.34	<0.0001	Yes
		Level of anxiety at baseline	3	1.46	0.2307	No
		Time point: during/after	1	1.81	0.1819	No

Num DF, degrees of freedom of the numerator.

in group 1 ( $P < .05$  and confidence calculated on the estimated means differences not containing 0 as a possible result).

**Discussion**

Dental care is considered an invasive treatment and a source of anxiety for patients. The present study aimed to evaluate if the presence of music could help improve patient cooperation during endodontic treatment by reducing anxiety levels. In the present study, music was the only significant variable for cardiovascular changes. The anxiety level and time of recording did not significantly influence the cardiovascular percentage changes.

According to many musicians and musicologists, 432 Hz is the frequency closest to natural human frequencies (23). The music used was characterized by slow rhythms and melodies that can produce physical and emotional relaxation in listeners. These characteristics make the music “neutral,” free from any emotion that other choices could have triggered physiological responses in patients. In the past, Lai et al (24) postulated that the choice of music could be an important factor on the variables of cardiovascular values. They observed a decreased level of anxiety in patients who had been listening to music during endodontic treatment but no decrease in blood pressure that could be attributed to the musical selection. The different results of the present study could be caused by the effect of music preference on the autonomic nervous system; listening to music that one generally likes could have a positive effect as opposed to music that is disliked or unfamiliar (25). In addition, Lai et al (24) measured cardiovascular values at different time points (6 times at 10-minute intervals until the end of root canal treatment); in the present study, only 3 time points for measurement of cardiovascular change were recorded.

In this study, the anxiety level of the subjects before treatment was measured by the Corah DAS. This scale has been used in several studies (16, 22, 26); it is considered reliable for its simplicity of application and the ease of translation into the patients’ native languages. In the present study, 61% of the patients claimed not to be anxious, and only 4% said

they were extremely anxious. Measurements of vital signs indicate a strong influence of music on BP and HR.

No vasoconstrictor agents were used in anesthesia procedures in order to not influence the change of cardiovascular parameters. SBP decreased at the treatment midpoint and then rose slightly at the end in patients who listened to music during endodontic treatments. DBP decreased at the treatment midpoint and then increased, stabilizing at the end, in patients who listened to music during endodontic therapy. HR decreased at the treatment midpoint and then rose slightly at the end in patients who listened to music during endodontic treatment. In addition to the tests, the patients who used music said that they felt relaxed and that the music distracted them from the instrument noises and the voices of the medical staff.

The literature reports dental anxiety and dental phobia in surgical extractions and implant procedures and in young patient populations. Only a few studies have evaluated the level of anxiety and the different approaches available for the treatment of dental anxiety in adults although the demand for sedation in endodontics is high (6). The use of sedation has been shown to be useful in managing an inferior alveolar block in patients with irreversible pulpitis (27). As reported in a previous study (24), listening to music during endodontic treatment could significantly reduce the level of anxiety at the end of the treatment but not necessarily because of cardiovascular parameters, as also was borne out in this study.

The present study is one of the first articles investigating the effects of music therapy on dental anxiety during endodontic procedures (6, 24); the literature primarily reports on the use of music therapy in cases of dental surgery (16, 22). Therefore, this could be very interesting because endodontic procedures are among the most common dental therapies.

In the present study, 2 possible limitations can be identified: the first one is that all the patients enrolled came to an endodontics university department and could not reflect the demographic characteristics of a private endodontic practice. The second is that the endodontic treatment was performed by 3 different operators with 3 different emotional approaches with the patients.

**TABLE 3.** Analysis of Variance Model: Contrasts (listening to music vs not listening to music) for Diastolic Blood Pressure, Systolic Blood Pressure, and Heart Rate

Dependent variable	Music	Estimated mean (confidence interval)	Estimated difference (confidence interval)	T value	Pr >  t	Significant
Diastolic blood pressure	No	3.3561 (0.1128–6.5994)	–7.5006 (–11.298 to –3.7031)	–3.92	0.0002	Yes
	Yes	–4.1445 (–7.3986 to –0.8903)				
Systolic blood pressure	No	0.1197 (–2.7632 to 3.0025)	–9.3374 (–12.7461 to –5.9287)	–5.44	<0.0001	Yes
	Yes	–9.2177 (–12.1104 to –6.325)				
Heart rate	No	–0.8305 (–3.4484 to 1.7874)	–9.2755 (–12.3296 to –6.2213)	–6.03	<0.0001	Yes
	Yes	–10.106 (–12.7326 to –7.4794)				

## Conclusion

Within the limits of the present study, 432 Hz music administered to subjects during root canal treatment significantly decreased SBP, DBP, and HR during the endodontic procedures.

## Acknowledgments

*The authors deny any conflicts of interest related to this study.*

## References

1. Chanpong B, Haas DA, Locker D. Need and demand for sedation or general anaesthesia in dentistry: a national survey of the Canadian population. *Anesth Prog* 2005; 52:3–11.
2. LeClaire AJ, Skidmore AE, Griffin JA, Balaban FS. Endodontic fear survey. *J Endod* 1988;14:560–4.
3. Cooper CL, Watts J, Kelly M. Job satisfaction, mental health, and job stressors among general dental practitioners in the UK. *Br Dent J* 1987;162:77–81.
4. Dionne RA, Gordon SM, McCullagh LM, Phero JC. Assessing the need for anesthesia and sedation in general population. *J Am Dent Assoc* 1998;129:167–73.
5. Zanette G, Manani G, Favero L. Conscious sedation with diazepam and midazolam for dental patient: priority to diazepam. *Minerva Stomatol* 2013;62:355–74.
6. Hub YK, Montagnese TA, Harding J, et al. Assessment of patients' awareness and factors influencing patient demands for sedation in endodontics. *J Endod* 2015; 41:182–9.
7. Malamed SF. *Sedation: A Guide to Patient Management*, 5th ed. St Louis: Mosby Elsevier; 2010.
8. Atterbury RA. The use of verbal relaxation therapy for sedation during dental therapy. *Anesth Prog* 1984;31:27–30.
9. Morse DR, Cohen BB. Desensitization using meditation hypnosis to control "needle" phobia in two dental patients. *Anesth Prog* 1983;30:83–5.
10. Jafarzadeh M, Arman S, Pour FF. Effect of aromatherapy with orange essential oil on salivary cortisol and pulse rate in children during dental treatment: a randomized controlled clinical trial. *Adv Biomed Res* 2013;2:10.
11. Tanja-Dijkstra K, Pahl S, White MP, et al. Improving dental experiences by using virtual reality distraction: a simulation study. *PLoS One* 2014;3:e91276.
12. Lippi D, Roberti di Sarsina P, D'Elios JP. Music and medicine. *J Multidiscip Healthc* 2010;3:137–41.
13. Marwah N, Prabhakar AR, Raju OS. Music distraction: its efficacy in management of anxious pediatric dental patients. *J Indian Soc Pedod Prev Dent* 2005; 23:168–70.
14. Steelman VM. Intraoperative music therapy. Effect on anxiety, blood pressure. *AORN J* 1990;52:1026–34.
15. Marwick C. Leaving concert hall for clinic, therapists now test music's charm. *JAMA* 1996;275:267–8.
16. Kim YK, Kim SM, Myoung H. Musical intervention reduces patients' anxiety in surgical extraction of an impacted mandibular third molar. *J Oral Maxillofac Surg* 2010;69:1036–45.
17. Winter MJ, Paskin S, Baker T. Music reduces stress and anxiety of patient in the surgical holding area. *J Post Anesth Nurs* 1994;9:340–3.
18. Hartling L, Newton AS, Liang Y, et al. Music to reduce pain and distress in the pediatric emergency department: a randomized clinical trial. *JAMA Pediatr* 2013; 167:826–35.
19. Bekhuis T. Music therapy may reduce pain and anxiety in children undergoing medical and dental procedures. *J Evid Based Dent Pract* 2009;9:213–4.
20. Modesti PA, Ferrari A, Bazzini C, et al. Psychological predictors of the antihypertensive effects of music-guided slow breathing. *J Hypertens* 2010;28:1097–103.
21. Corah NL. Development of dental anxiety scale. *J Dent Res* 1969;48:596.
22. Liau FL, Kok SH, Lee JJ, et al. Cardiovascular influence of dental anxiety during anesthesia for tooth extraction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; 105:16–26.
23. Tuis RT. *432 Hertz: la Rivoluzione Musicale—L'Accordatura Aurea per Intonare la Musica Alla Biologia*. Padova: Nexus Edizioni; 2014.
24. Lai HL, Hwang MJ, Chen CJ, et al. Randomised controlled trial of music on state anxiety and physiological indices in patients undergoing root canal treatment. *J Clin Nurs* 2008;17:2654–60.
25. Lai HL. Music preference and relaxation in Taiwanese elderly people. *Geriatr Nurs* 2004;25:286–91.
26. Bodner E, Iancu I. Recalling the threat: dental anxiety in patients waiting for dental surgery. *Isr J Psychiatry Relat Sci* 2013;50:61–6.
27. Stanley W, Drum M, Nusstein J, et al. Effect of nitrous oxide on efficacy of the inferior alveolar block in patients with symptomatic irreversible pulpitis. *J Endod* 2012;38: 565–9.