Music before Dental Surgery Suppresses Sympathetic Activity Derived from Preoperative Anxiety: A Randomized Controlled Trial

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Abstract: The aim of this study was to estimate the relieving effect of music intervention on preoperative anxiety by using heart rate variability (HRV) analysis. In this randomized controlled trial, 86 adult patients were scheduled to undergo impacted tooth extraction under intravenous sedation and local anesthesia and were classified as either fearful or nonfearful based on a questionnaire. Thereafter, the patients were subdivided into 2 groups: those who listened to music from the time that they arrived at the outpatient clinic until immediately before entering the operating room and those who did not listen to music. The effect of music intervention was evaluated by assessing 1) the low-frequency/high-frequency ratio of HRV, in which positive changes indicate increased sympathetic nervous activity, and 2) the coefficient of component variance for high frequency, in which positive changes indicate increased parasympathetic nervous activity, assessed by means of HRV analysis. Subjective preoperative anxiety was evaluated on a visual analog scale. For fearful patients, the mean magnitude of low-frequency/high frequency changes from baseline among those who listened to music was significantly lower as compared with those who did not listen to music (in the private room: −1.45 ± 1.88 vs. 1.05 ± 1.88, P = 0.0096, 95% confidence interval of effect size = −4.52 to −0.48, Cohen’s d = −0.75; in the operating waiting room: −2.18 ± 2.39 vs. −0.10 ± 3.37, P = 0.011, 95% confidence interval of effect size = −3.94 to −0.22, Cohen’s d = −0.71, respectively). Visual analog scale scores were also significantly different. Coefficient of component variance for high frequency and heart rate did not differ significantly between the 2 groups. From the perspective of autonomic nervous activity, music intervention is useful for relieving anxiety in patients with dental fear before they enter a dental outpatient operating room. Music intervention may relieve anxiety by reducing sympathetic nervous activity, while parasympathetic nervous activity is not involved (UMIN000016882).

Knowledge Transfer Statement: The results of this study revealed that music intervention is useful for clinicians when planning preoperative anxiety management of patients with dental fear who undergo impacted tooth extraction under intravenous sedation and local anesthesia. As a bridging intervention, music intervention enables stress management to continue uninterrupted from the patient’s...
arrival at the dental outpatient clinic to intravenous sedation until completion of the dental surgery. With consideration of cost-effectiveness, absence of adverse physical effects, immediate effect, safety in terms of not using drugs, and lack of concerns about recovery, this information could lead to more appropriate decisions regarding anxiety management in dentistry.

Keywords: sound, preoperative care, dental anxiety, dental anesthesia, conscious sedation, autonomic nervous system

Introduction

In the Dental Fear Survey, the proportion of respondents indicating that they felt some sort of anxiety about dental treatment was 76.6% in Japan, 75% in the United States, 65.5% in Indonesia, and 65.7% in Brazil, showing that dental anxiety affects between two-thirds and three-quarters of individuals (Kleinknecht et al. 1973; Tsubouchi et al. 1990).

Intravenous sedation reliably reduces mental stress, which may cause vasovagal reflex stimulation or other intraoperative complications via autonomic nervous activity (Shepherd et al. 1988; Becker 2014). In particular, its use seems to be essential when removing impacted teeth from dental-phobic patients under local anesthesia. Intravenous sedation, however, does not relieve the anxiety felt by patients between their arrival at the outpatient clinic and the start of drug administration. Therefore, we focused on anxiety relief prior to dental surgery.

Candidate methods of anxiety relief during this period include anxiolytic drugs, cognitive behavioral therapy, autogenic training, and music intervention. Music intervention is psychological therapy that has many advantages when used in outpatient treatment, including its cost-effectiveness, absence of adverse physical effects, immediate effect, safety in terms of not using drugs, and lack of concerns about recovery (Bradt et al. 2013; Thoma et al. 2015). As a bridging intervention, music intervention enables stress management to continue uninterrupted from arrival at the outpatient clinic to intravenous sedation until completion of the dental surgery.

However, it is difficult to blind subjects in studies on music intervention, and many investigations utilize subjective evaluation parameters, which might compromise the quality of evidence (Cooke et al. 2005; Bradt 2012; Bradt et al. 2013). A study design that minimizes the risk of bias is therefore required (Bradt et al. 2013). However, there have been few comparative trials on the efficacy of music intervention before or during dental treatment and surgery (Lahmann et al. 2008; Eitner et al. 2011; Kim et al. 2011; Thoma et al. 2015). All 4 previous studies found that music intervention was effective in reducing anxiety. There is only 1 randomized controlled trial (RCT) on the effect of music intervention before entrance to an outpatient dental treatment room: that of Thoma et al. (2015), which used 3 subjective evaluation parameters.

We therefore performed an RCT to objectively investigate the effect of music intervention—applied from arrival at the dental outpatient clinic to immediately before entrance to the operating room—in patients with dental fear, by using heart rate variability (HRV) analysis for evaluation of autonomic nervous activity. We hypothesized that listening to music would alleviate the fear induced by anticipation of the dental operation and that this effect would probably be more obvious in patients with dental fear. Nonfearful patients were also included in the study, to take into account the possibility that the indications for music intervention might expand if it were also found to be effective in these patients.

Materials and Methods

Subjects

The study subjects were 86 patients aged 18 to 60 y who underwent impacted teeth extraction under intravenous sedation and local anesthesia administered by the Department of Dental Anesthesiology as an outpatient procedure between April 2013 and August 2014. Patients with ear disorders (i.e., unsuitable for music intervention), arrhythmia, and physical status III or above (American Society of Anesthesiologists classification) were excluded. Patients with psychiatric disorders—such as schizophrenia and depression, which affect parasympathetic nervous activity (Rechlin et al. 1994; Boettger et al. 2006)—were also excluded.

Written informed consent was obtained from all subjects. The experimental protocol of this study was approved by the local ethics committee (Institutional Review Board of Hokkaido University Hospital, clinical study code 012-0208) and conducted in accordance with the guidelines of the Helsinki Declaration.

Study Design

The present study is an open-label, parallel-group randomized trial. First, the subjects were divided into 2 groups according to whether they were assessed as being fearful or not, based on a questionnaire devised in-house; then, these 2 groups were randomly allocated (per centralized allocation) to listen to music or not, thereby making a total of 4 groups: fearful nonmusic, fearful music, nonfearful nonmusic, and nonfearful music.

Figure 1 shows the study protocol. All measurements were performed before intravenous sedation and surgery by a single investigator. First, the subjects sat in a comfortable chair in a quiet private room separated from a operating waiting room, and 5 min after rest, baseline measurements of HRV and visual analog scale (VAS) scores were obtained. Thereafter, subjects in the music group (fearful and nonfearful) chose a favorite piece from 4 prepared music pieces (described below). Five minutes after the end of the baseline period, they started receiving music intervention of the chosen piece, after which the HRV and VAS measurements were
repeated (‘private room’ period). Music intervention lasted until immediately before entrance to the operating room, other than time to change into the operating room gown. Subjects in the nonmusic group (fearful and nonfearful) did not listen to music but were seated in a comfortable chair in the private room and underwent the same HRV and VAS score measurements as members of the music groups. Finally, all subjects transferred to the locker room, changed into the operating room gown, and moved into the operating waiting room, where the final HRV and VAS recordings were repeated (‘operating waiting room’ period). Duration for transfer and changing the clothes was about 5 min. In nonmusic groups, the use of mobile phones and reading material was prohibited, but no restrictions were placed on talking with other patients who were sitting in the operating waiting room. The duration of HRV analysis in the 3 measurement periods was 10 min at baseline, 20 min in the ‘private room’ period, and the entire time spent in the operating waiting room as the ‘operating waiting room’ period, respectively.

**Subject Allocation**

Prior to the experimental day, the subjects were asked to answer the questionnaire described below in detail.

**Question 1:** How frightened are you of tooth extraction? Please choose the option that best describes your feelings from among the 5 options mentioned here: very afraid, afraid, slightly afraid, neutral, and not afraid.

**Question 2:** If you selected “slightly afraid” in question 1, please circle all the choice numbers mentioned here that accurately apply to you: 1) afraid of pain; 2) no fear of anything in particular but generally feel afraid; 3) afraid of tooth extraction; 4) afraid of drilling sounds during dental treatment; 5) afraid of local anesthesia; 6) afraid of all dental treatment procedure; 7) if others, please write a concrete fear.

Subjects who responded “very afraid” or “afraid” in response to question 1 were enrolled in the fearful group, and those who answered “neutral” or “not afraid” were enrolled in the nonfearful group. Those who answered “slightly afraid” were enrolled in 1) the nonfearful group if they chose response 1 or 2 in question 2 and 2) the fearful group if they had a concrete fear of something other than pain, as revealed by choosing one or several of the responses among responses 3 to 7 to question 2.

Concealment of music or nonmusic group allocation was ensured by using centralized allocation of the randomization sequence. Random allocation was done by a researcher not involved in measurement and analysis of variables or management of intravenous sedation. The researcher used the envelope method. Patients and an investigator who was responsible for measurement of variables were informed of the allocation only on the day when the operation was performed.

**Music Intervention**

We conducted a preliminary study in which we played 17 prepared healing pieces for 15 volunteers, scored pieces that they described as “calming” as 1 and “not calming” as 0, and identified the 4 top-scoring pieces. Of them, 2 pieces were instrumental music, including piano and string instrument, and the other 2 were sounds of nature, such as birds singing or the murmur of a stream. The length of the 4 pieces ranged from 5 min 1 s to 7 min 20 s. The subjects allocated to the music group were played the first 20 s of each piece immediately before commencing the study and were asked to choose a piece that they found most calming. During the music intervention period, the subjects commenced repeated listening to their chosen music piece via earphones.

**HRV Analysis**

Electrocardiography electrodes were attached to both wrists, and heart rate and HRV measurements were performed. A Relax Meijin HRV monitor (Crosswell Co.) was used for HRV analysis. In this technique, autonomic nervous activity is evaluated by measuring R-R intervals on electrocardiography and analyzing their frequency domains (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology 1996). These frequency domains are divided into 2 components: low frequency (LF; 0.05 to 0.15 Hz) and high frequency (HF; >0.15 Hz). The HF component is regarded as an indicator of parasympathetic nervous activity (Pomeranz et al. 1985). The LF component is believed to reflect sympathetic and parasympathetic nervous activity. The ratio of these 2 components (LF/HF) indicates the
balance of autonomic nervous activity (Pomeranz et al. 1985) and is regarded as an index of relative sympathetic nervous activity (Pagani et al. 1986; Malliani et al. 1991; Pagani et al. 1991). The coefficient of variation of R-R intervals is considered to represent the overall activity of the autonomic nervous system (Akselrod et al. 1981). The coefficient of component variance for high frequency (CCVHF; Hayano et al. 1991), which can be used for intragroup and intergroup comparisons, was used as an index for HF evaluation. HRV analysis enables the intensity of sympathetic and parasympathetic nervous activity to be analyzed separately (Akselrod et al. 1981), providing a more detailed picture of autonomic nervous activity.

Visual Analog Scale

Although the VAS is used as an index of subjective pain, it may also be used as an indicator of anxiety (Facco et al. 2011). In this study, we asked subjects to indicate their anxiety levels at each time point, on a horizontal 100-mm straight line, with 100 being the highest subjective level of anxiety ever experienced in one’s life. The subjects used a ballpoint pen to mark the appropriate point along a 100-mm straight line. The investigator later measured the distance of this mark from the zero point for use as data.

Statistics

In a similar previous study (Huikuri et al. 1992), the resting LF/HF value for healthy adults was found to be 0.9 ± 0.3 (mean ± SD). In this study, we therefore regarded an increase ≥30% over the mean value of 0.9 as a significant change. A calculation of the required sample size (α = 0.05, β = 0.2) by 2-sample t test with equal variance showed that 21 members were needed in each group. The number of subjects in the present study was therefore set as 86, divided into 4 groups.

The primary evaluation parameters of this study were LF/HF and CCVHF in HRV analysis, and the secondary evaluation parameters were coefficient of variation of R-R intervals in HRV analysis, heart rate, and VAS score. The measured parameters were compared for members of the music and nonmusic groups in the fearful and nonfearful groups. The mean value of HRV analysis for each period was regarded as the representative value for that period. The difference between the representative value for each analysis period and the representative value at baseline was used to make intergroup comparisons. Specifically, the difference between “private room” values and baseline values was compared as Δ(private room – baseline) and the difference between “operating waiting room” values and baseline values as Δ(operating waiting room – baseline).

JMP software (SAS Institute Inc.) was used for statistical analysis. An unpaired Student’s t test was used to test for differences in patients’ age, height, weight, and body mass index; the χ² test was used to test for sex differences; and the Wilcoxon signed-rank test with Bonferroni correction (intragroup comparison) and the Mann-Whitney U test (intragroup comparison) were used for the comparison, with the level of significance set at ≤5% in all cases. Cohen’s d was used to provide a measure of standardized effect size (difference in mean between groups divided by the pooled standard deviation of change).

Results

Of those subjects who were enrolled in the fearful group, 26.2% responded “very afraid”; 45.2%, “afraid”; and 28.6%, “slightly afraid.” Of the subjects in the nonfearful group, 52.3% responded “slightly afraid”; 35.7%, “neutral”; and 12%, “not afraid.”

Figure 2 shows a flowchart of subject enrollment, allocation, and data analysis in this study.

Table 1 shows basic patient data of each parameter evaluated. For the fearful patients, there was no significant difference in any parameter between the music and nonmusic groups. Height was the only parameter that was significantly different between the music and nonmusic groups in nonfearful patients. There was no significant difference between the 2 groups in the time at which HRV measurements in the operating waiting room were carried out: for fearful patients, 11.9 ± 4.83 min for the music group and 14.65 ± 8.44 min for the nonmusic group; for nonfearful patients, 10.65 ± 6.13 min for the music group and 11.9 ± 5.03 min for the nonmusic group. Mean time at which the subjects listened to music at the “operating waiting room” period was 11.3 min in the music group (fearful and nonfearful).

Table 2 shows the post–music intervention changes in primary and secondary outcomes. For the fearful patients, both Δ(private room – baseline) and Δ(operating waiting room – baseline) for LF/HF—the high values of which indicate an increase in sympathetic nervous activity—were significantly lower in the music group as compared with the nonmusic group (P = 0.0096 and P = 0.0111, respectively).
respectively, with all 95% confidence intervals of mean difference between groups [effect size] within the negative range), and the values of Cohen’s $d$ were $-0.75$ and $-0.71$, respectively. The same was true for VAS scores, for which both $\Delta$ (private room – baseline) and $\Delta$ (operating waiting room – baseline) were significantly lower in the music group versus the nonmusic group ($P = 0.0046$ and $P = 0.0032$, respectively, with all 95% confidence intervals of effect size within the negative range). The LF/HF values for the “private room” period and “operating waiting room” period decreased significantly by 27% and 40% when compared with the baseline value in the fearful music group ($3.84 \pm 2.32$ vs $5.29 \pm 3.05$ and $3.11 \pm 2.19$ vs $5.29 \pm 3.05$, respectively). The VAS values for the “private room” period and “operating waiting room” period also decreased significantly by 32% and 29% when compared with the baseline value in the fearful music group ($28.0 \pm 16.2$ vs $41.0 \pm 18.3$ and $29.3 \pm 19.0$ vs $41.0 \pm 18.3$, respectively). However, for the “operating waiting room” period, the values of CCVHF—the high values of which indicate an increase in parasympathetic nervous activity—increased significantly as compared with the baseline and “private room” periods in all 4 groups. There were no significant differences in intra- and intercomparisons for any of the other evaluation parameters.

There were no adverse physical effects derived from the music intervention for all subjects.

Discussion

The results of this study revealed that LF/HF and VAS scores in fearful patients declined by listening to music, demonstrating that music intervention from their arrival at the outpatient clinic until immediately before entrance to the operating room effectively relieves anxiety in patients with dental fear, as seen by HRV analysis, an objective index of autonomic nervous activity, and the subjective anxiety scale. Our results also showed that this effect involves the suppression of sympathetic nervous activity without the involvement of parasympathetic nervous activity.

The LF/HF value while waiting in the operating waiting room decreased significantly by 40% when compared with the baseline value in the fearful music group ($3.11 \pm 2.19$ vs $5.29 \pm 3.05$; upper part of Table 2). The value of 3.11 did not fall within the standard normal range of 1.5 to 2.0 (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology 1996), suggesting lack of a significant anxiolytic effect with

Table 1.
Basic Patient Data of Each Parameter Evaluated.

<table>
<thead>
<tr>
<th>Basic Data</th>
<th>Music Group ($n = 21$)</th>
<th>Nonmusic Group ($n = 21$)</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fearful</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex, $n$</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Men</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>17</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>$28.2 \pm 8.59$</td>
<td>$31.4 \pm 8.12$</td>
<td>0.24</td>
</tr>
<tr>
<td>Height, m</td>
<td>$1.62 \pm 0.09$</td>
<td>$1.61 \pm 0.09$</td>
<td>0.65</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>$53.8 \pm 10.9$</td>
<td>$55.1 \pm 8.8$</td>
<td>0.7</td>
</tr>
<tr>
<td>Body mass index</td>
<td>$20.4 \pm 3.1$</td>
<td>$21.1 \pm 2.6$</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Nonfearful</strong></td>
<td></td>
<td></td>
<td>0.35</td>
</tr>
<tr>
<td>Sex, $n$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>9</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>$29.4 \pm 8.01$</td>
<td>$32.9 \pm 9.73$</td>
<td>0.22</td>
</tr>
<tr>
<td>Height, m</td>
<td>$1.62 \pm 0.08$</td>
<td>$1.67 \pm 0.08$</td>
<td>0.022</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>$58.5 \pm 17.3$</td>
<td>$61.7 \pm 8.4$</td>
<td>0.46</td>
</tr>
<tr>
<td>Body mass index</td>
<td>$22.0 \pm 5.0$</td>
<td>$21.9 \pm 2.8$</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Values presented in mean ± SD unless noted otherwise.
Table 2.
Postmusic Interaction Changes in Primary and Secondary Outcomes.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Music Group</th>
<th>Nonmusic Group</th>
<th>Effect Size (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Private Room</td>
<td>Operating Waiting Room</td>
</tr>
<tr>
<td></td>
<td>Operating Waiting Room</td>
<td>Baseline</td>
<td>Private Room</td>
</tr>
<tr>
<td>LF/HF</td>
<td>5.29 ± 3.05</td>
<td>3.84 ± 2.32 (^a)</td>
<td>3.11 ± 2.19 (^a)</td>
</tr>
<tr>
<td>CCVHF</td>
<td>0.79 ± 0.65</td>
<td>0.73 ± 0.28</td>
<td>2.23 ± 0.86 (^ab)</td>
</tr>
<tr>
<td>CVRR</td>
<td>6.00 ± 1.68</td>
<td>5.80 ± 1.61</td>
<td>9.60 ± 5.23</td>
</tr>
<tr>
<td>HR</td>
<td>77.9 ± 13.2</td>
<td>76.4 ± 10.4</td>
<td>77.0 ± 14.5</td>
</tr>
<tr>
<td>VAS, mm</td>
<td>41.0 ± 18.3</td>
<td>28.0 ± 16.2 (^a)</td>
<td>29.3 ± 19.0 (^a)</td>
</tr>
</tbody>
</table>

Δ(Private Room – Baseline) Δ(Operating Waiting Room – Baseline)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Music Group</th>
<th>Nonmusic Group</th>
<th>Effect Size (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Private Room</td>
<td>Operating Waiting Room</td>
</tr>
<tr>
<td></td>
<td>Operating Waiting Room</td>
<td>Baseline</td>
<td>Private Room</td>
</tr>
<tr>
<td>LF/HF</td>
<td>−1.45 ± 1.88 (^c)</td>
<td>1.05 ± 4.08</td>
<td>−2.5 (−4.52, −0.48)</td>
</tr>
<tr>
<td>CCVHF</td>
<td>−0.07 ± 0.67</td>
<td>0.04 ± 0.42</td>
<td>−0.11 (−0.47, 0.25)</td>
</tr>
<tr>
<td>CVRR</td>
<td>−0.20 ± 1.02</td>
<td>−0.18 ± 1.48</td>
<td>−0.02 (−1.01, 0.61)</td>
</tr>
<tr>
<td>HR</td>
<td>−1.55 ± 3.53</td>
<td>−0.21 ± 2.37</td>
<td>−1.3 (−3.26, 0.58)</td>
</tr>
<tr>
<td>VAS, mm</td>
<td>−13.0 ± 10.9 (^c)</td>
<td>−3.38 ± 8.14</td>
<td>−10 (−15.8, −3.52)</td>
</tr>
</tbody>
</table>

Values presented in mean ± SD unless noted otherwise. Effect size denotes the difference in mean value (music group minus nonmusic group). Cohen's $d$ is the effect size divided by the pooled standard deviation of change. $n = 21$ per group.

95% CI, 95% confidence intervals (for effect size); CCVHF, coefficient of component variance for high frequency; CVRR, coefficient of variation of R-R intervals; HR, heart rate (beats per minute); LF/HF, low-frequency component/high-frequency component; VAS, visual analog scale.

\(^a\)P < 0.01 (vs. baseline).
\(^b\)P < 0.01 (vs. private room).
\(^c\)P < 0.01 (vs. nonmusic group).
\(^d\)P < 0.05 (vs. nonmusic group).
music intervention. However, the music intervention seemed to have clinical significance as a bridge to intravenous sedation because of the many advantages of its use in dental offices, as described above (Bradt et al. 2013; Thoma et al. 2015), and little demerit.

Although the stress-relieving effect of music before general anesthesia for surgical procedures has been well reported (Cooke et al. 2005; Bradt et al. 2013), to our knowledge, the only study of its pretreatment use in outpatient dental treatment is that of Thoma et al. (2015). The differences between our own study and that of Thoma et al., on one hand, and those involving other surgeries, on the other, include the gap between local and general anesthesia and the difference between outpatient dental offices and hospital operating rooms, which render direct comparison difficult. We therefore selected 4 studies from an exhaustive list of previous similar RCTs (including semi-RCTs) dealing with the use of music before treatment, tests, or procedures while patients were conscious (Chiu et al. 2003; Hayes et al. 2003; Buffum et al. 2006; Thoma et al. 2015; Table 3), and we compared them with our study.

All 4 previous studies as shown in Table 3 found that music intervention is effective in reducing anxiety. The only study that confirmed the effect of music intervention by using subjective and objective evaluation parameters in the same way as our study was that of Buffum et al. (2006). The subjects of the study by Thoma et al. (2015) were patients who underwent regular dental hygiene treatment as outpatients, which was obviously less invasive than the procedure in our study, but it did identify an effect of music intervention on the State-Trait Anxiety Inventory (STAI) scores. This did thus suggest that listening to music before treatment is effective in the dental outpatient context, irrespective of differences in the level of invasiveness. In our study, however, we did not observe any effect of music intervention on nonfearful subjects. The precise reason for this difference is unknown, but in the study by Thoma et al., subjects were not blinded to their group allocation and received the subjective test (STAI). Therefore, intended or unintended assumption may have induced overevaluating the outcome.

With respect to the time spent listening to music, the “private room” period lasted 20 min in this study, and the mean length of the “operating waiting room” period was approximately an additional 10 min, which is similar to the duration of intervention (20 to 30 min) described in a systematic review of preoperative music intervention (Bradt et al. 2013). The 4 reviewed medical studies, however, used shorter intervention periods of 5 to 15 min (Table 3). Further studies will be required to reach a broad consensus that listening to music for periods of only 5 to 15 min can be effective. There is also no unified consensus on the type of music to be used, with one study finding that it should have a beat of 60 to 80 times per minute, similar to the resting heart rate (Bonny 1986) and with another reporting that “quiet” and “relaxing” music should preferably be used (Bringman et al. 2009). With respect to who is responsible for the choice of music, in 2 of the 4 studies that we reviewed, the investigators chose the pieces, whereas the other 2 studies followed the same method used in our study of asking subjects to choose from among pieces prepared by the investigators in advance (Table 3).

A previous study (Ledowski et al. 2005) on preoperative anxiety based on HRV analysis found the HF component to be significantly smaller and the LF/HF to trend be higher in the patient group versus the control (volunteer) group. Previous studies (Chiu et al. 2003; Lee et al. 2012) on the effect of preoperative music intervention based on HRV analysis found that the HF component increased significantly and the LF/HF decreased significantly with music. In contrast, for the fearful subjects in this study, music intervention reduced LF/HF but did not change the HF (Bradt et al. 2013). However, only 3 of the other 4 studies (Chiu et al. 2003; Lee et al. 2011; Lee et al. 2012) have been reported; hence, it will be necessary to conduct a much greater number of studies in this area. A previous report stated that the LF/HF ratio does not accurately measure cardiac sympathovagal balance (Billman 2013). Although no consensus currently exists regarding the accuracy of the LF/HF ratio in assessing sympathovagal balance, physiologic (LF/HF) and emotional/subjective (VAS) types of tests indicated similar results in this study.

The difference in baseline LF/HF values between fearful and nonfearful patients is small in this study. The reason for this result may be as follows. First, patients
Table 3.
Comparison with Similar Studies.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Dental Outpatient Clinic</th>
<th>Medical Testing/Operating Room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>University department of dental anesthesiology outpatient clinic (Japan)</td>
<td>University dental outpatient clinic (Switzerland)</td>
</tr>
<tr>
<td>Treatment, test, or procedure</td>
<td>impacted tooth extraction</td>
<td>Dental hygiene treatment</td>
</tr>
<tr>
<td>Subjects and study design</td>
<td>n = 86, RCT</td>
<td>n = 92, RCT</td>
</tr>
<tr>
<td>Music and person responsible for choice</td>
<td>Subjects chose from 4 pieces from 17 selected by the investigators</td>
<td>Latin choral (“soothing and calm” tracks) chosen by the investigators</td>
</tr>
<tr>
<td>Listening time and device</td>
<td>20 to 30 min, earphones worn by the music group only</td>
<td>10 min, closed headphones worn by both groups</td>
</tr>
<tr>
<td>Location</td>
<td>Private room and operating room anteroom</td>
<td>Separate area of the outpatient waiting room</td>
</tr>
<tr>
<td>Evaluation parameters and results\textsuperscript{a}</td>
<td>Decrease in LF/HF; no change in HF, CVRR, or HR</td>
<td>None</td>
</tr>
<tr>
<td>Evaluation parameters and results\textsuperscript{b}</td>
<td>Decrease in VAS score</td>
<td>Decrease in STAI-S; no change in STAI-T, VAS, or mood assessment</td>
</tr>
</tbody>
</table>

Reports of RCTs of music intervention before treatment, tests, or procedures in which patients were conscious.

BP, blood pressure; CVRR, coefficient of variation for R-R intervals; DBP, diastolic blood pressure; HF, high-frequency component; HFnu, HF normalized unit; HR, heart rate; LF, low-frequency component; PR, pulse rate; RCT, randomized controlled trial; RR, respiratory rate; SBP, systolic blood pressure; STAI, State-Trait Anxiety Inventory; STAI-S, STAI state scale; STAI-T, STAI trait scale; VAS, visual analog scale.

\textsuperscript{a}Objective indicators.

\textsuperscript{b}Subjective indicators.

who had answered that they had no fear for dental treatment, including tooth extraction, in the questionnaire might still feel fear on the operative day from just entering the dental office for the extraction of an impacted wisdom tooth. Second, a comparatively large proportion of subjects in the nonfearful group (52.3%) chose the response “slightly afraid,” which was regarded as the demarcation of whether they were actually frightened, meaning that this group may have included some hidden subjects with dental fear. One way of enabling clearer stratification on the basis of fear might have been to exclude subjects who chose the “slightly afraid” response.

We did not compare the effect of music intervention before and after the establishment of a venous route, because delaying the start of intravenous sedation would have entailed severe stress for subjects in the fearful nonmusic group. If music intervention is continued after entrance to the operating room, it is highly likely that this will alleviate
stress before the establishment of a venous route. However, investigation of the effect of music intervention and intravenous sedation was not performed in this study, because we believed that the effect of music intervention would be overwhelmed by the strong sedative effect of intravenous sedation.

The limitations of this study include 1) whether the identification of dental fear based on the questionnaire was appropriately performed, 2) the impact on fearful nonmusic subjects of prolonging their waiting time, and 3) the fact that it was methodologically impossible to blind subjects with respect to listening to music. The fearful subjects included 71.4% with a clearly expressed fear of dental treatment, and their selection was therefore regarded as generally valid. However, it may be necessary to consider using other methods of classifying dental fear that combine techniques, such as the STAI (Hayes et al. 2003) and Dental Anxiety Scale (Corah et al. 1978). In this study, we set the duration of listening to music as at least 20 min on the basis of a systematic review of preoperative music intervention (Bradt et al. 2013), and we took measurements at 3 points (baseline, private room, and operating waiting room) with the aim of identifying spatiotemporal effects before entrance to the operating room. However, it is possible that the protracted total preoperative waiting time may have been a major cause of stress. In future similar studies, it may be better to shorten the time spent waiting without listening to music as well as the HRV measurement times. With respect to the binding of subjects, single blinding should have been carried out to improve the evidence level further. However, only 3 of the 26 RCTs and semi-RCTs addressed in a systematic review (Bradt et al. 2013) of preoperative music intervention clearly described the binding of subjects, and this is the most important issue yet to be resolved in this area.

Music intervention seems to be useful for preoperative stress management in dentistry in addition to its other advantages, such as high applicability and no adverse side effects, and is likely to benefit a large percentage of the population.

Conclusions

We used HRV analysis, an objective indicator of autonomic nervous activity, to demonstrate that music intervention from arrival at the dental outpatient clinic to immediately before entrance to the operating room is effective in relieving anxiety in patients with dental fear. Our results also suggested that music intervention may relieve anxiety by reducing sympathetic nervous activity and that parasympathetic nervous activity is not involved in the effect.

Author Contributions

K. Miyata, contributed to conception, design, data acquisition, analysis, and interpretation, drafted the manuscript; H. Odnaka, Y. Nitta, S. Shimoji, contributed to conception, design, data acquisition, and analysis, drafted the manuscript; T. Kamehira, T. Fujisawa, contributed to conception, design, and data interpretation, critically revised the manuscript; M. Kawanami, contributed to conception and design, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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