Virtual Reality Videos and Their Effect on Adolescent Anxiety during Orthodontic Treatments: A Parallel Randomized Controlled Trial

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ABSTRACT

Background: Fear of dental procedures is one of the main reasons why patients tend to avoid dental clinics. The present study aimed to investigate the effect of using Virtual Reality (VR) videos during dental treatments on anxiety levels of the adolescents receiving treatment in dental clinics.

Methods: A total of 66 patients aged 12-15 years were referred to the dental clinic at the Orthodontic Department of Birjand University of Medical Sciences. The participants were randomly assigned to two groups (n=33). The patients in the experimental group were engaged in watching a VR clip using a headset, while the control group directly observed the treatment procedure. Beck Anxiety Inventory (BAI) was administered to measure the participants' anxiety levels before and after the treatment. SPSS (Version 18) was used to analyze the data.

Results: The results of Mann-Whitney U test revealed a statistically significant difference between the anxiety levels of the participants in experimental and control groups (P=0.014). However, the results of Spearman Correlation test did not suggest any significant direct correlation between the participants' age and anxiety scores after the intervention in control (r=0.002, P=0.992) and experimental (r=0.2755, P=0.122) groups. Additionally, the results of the Mann-Whitney U test indicated that there was no statistically significant difference between gender and anxiety scores after the intervention in the control (P=0.203) and experimental (P=0.207) groups.

Conclusion: The results of the present study showed that the patients receiving VR distraction experienced lower anxiety caused by orthodontic procedures. This finding implies the effectiveness of the VR-based techniques to reduce anxiety during dental treatments.

Keywords: Virtual Reality, Multimedia, Dental Anxiety, Orthodontics, Children

Introduction

Dental Anxiety (DA), first introduced in 1992 as "an abnormal fear or dread of visiting the dentist for preventive care or therapy and unwarranted anxiety over dental procedures" (1, 2), is considered a serious oral-healthcare challenge in many countries. The literature reveals that 33.3% of people suffer from anxiety disorders during their lifetime, and the risk of developing anxiety disorders is estimated as 14% (3). Dentists should be able to recognize dental anxiety and its possible effects on dental care, and identify the behaviors reflecting anxiety. In fact, they should use complementary strategies to minimize the stress and anxiety in dental patients (4).

Given the fact that dental practice is one of the most anxiety-inducing procedures, especially among children and adolescents, it is absolutely essential to use distraction methods to control and manage dental fear and anxiety, thereby ensuring a successful treatment (5). Providing effective dental services can significantly contribute to the improvement of health indicators in society. Accordingly, dental fear, which can prevent patients from receiving treatment in clinics, may negatively impact community health indicators (6). Pain is considered as a commonly reported complaint in medical interventions. A wide range of psychological methods, including cognitive-behavioral and hypnotic methods, are usually applied to reduce pain (7-9). Distraction is a psychological approach proposed to control pain and anxiety caused by medical interventions. A growing body of research has verified the effectiveness of this technique. Common distraction methods include deep breathing, listening to soothing music, and watching a favorite movie (5).

The term Virtual Reality (VR) was coined about two decades ago. In recent years, VR has been extensively used in different sectors and it is destined to become a part of people's everyday lives (10, 11). There are four essential elements in a VR setting: the virtual world, immersion, sensory feedback, and interaction. VR displays a set of objects in a 360-degree virtual space, and defines rules and relationships governing these objects. The virtual world in VR is generated by a computer (12). This technology has found its way to healthcare industry as well. It is used as a simulation and interaction tool in education and treatment, respectively. In the field of healthcare, VR technology has a wide range of applications in the areas of diagnosis, counseling and rehabilitation of patients, as well as hospital design (13).

Several studies have confirmed the effectiveness of VR in the treatment of a variety of phobias, including acrophobia, agoraphobia, flying phobia, spider phobia, as well as other disorders such as eating and body dysmorphic disorders (14-17). The rationale for this form of treatment is that the patient is exposed to the source of the anxiety while learning some adaptation skills such as relaxation by training (18). Engaging children and adolescents in fun activities like watching amusing videos based on VR technology has been suggested as an effective means of alleviating their anxiety in dental clinics. This technique aims to immerse the clients in the VR space and temporarily distract them from the real environment of the clinic and dental practices (8).

The present study aimed to investigate the effect of using VR-based videos during orthodontic treatment on adolescent anxiety levels in dental clinics.

Methods

Study Design

This parallel Randomized Controlled Trial (RCT) was conducted in accordance with the 2010 Consolidated Standards of Reporting Trials (CONSORT) criteria. This study was approved by the ethical committee of the Research Committee of Birjand University of Medical Sciences (Iran) (IR.BUMS.REC.1397.307) and the Iranian Registry of Clinical Trials (IRCT20140611018063N8).

Participants

The participants included 66 patients aged 12-15 years, and were referred to the dental

clinic at the Orthodontic Department of Birjand University of Medical Sciences. They were randomly assigned to control (n=33) and intervention (n=33) groups.

Eligibility Criteria

The inclusion criteria consisted of being 12-15 years old, not having any visual and auditory impairment, and ability to complete the questionnaire. Additionally, the patients who suffered from visual and auditory impairments or had problems in completing the questionnaire were excluded. The exclusion criteria were hypersensitivity reaction to the materials and any phobia of using the VR device.

Setting

The statistical population included all adolescents referred to the orthodontics section at the dentistry clinic of Birjand University of Medical Sciences (Birjand, Iran) in 2019-2020.

Intervention

The intervention group used a VR headset and watched exciting videos during the orthodontics treatments while the patients in the control group received usual treatments. In the intervention group, the VR headset was placed on the patients' eyes when the dental procedure started (Figure 1). The patients in this group were not able to see the clinic environment during the dental procedure, which made them deeply involved in video-audio communication with the VR entertainment space by watching a 360-degree video. In the control group, the participants' eyes were completely open and the patients could see the clinic and the dental procedures around them.

Outcomes

The main outcome was the assessment of the participants' anxiety levels before and after the orthodontic procedures as well as the comparison of the two groups' anxiety levels. BAI Beck Anxiety Inventory was used to measure the patients' anxiety.

Sample Size

The participants were 66 adolescents in the age range of 12-15 who referred to the orthodontic department, were examined by an orthodontist, and received fixed orthodontic treatment. The sample size was calculated based on Elmali *et al.*'s study (19) (group 1: 32.93±20.28, group 2: 48.96±24.11). Accordingly, the sample size was estimated as 33 participants in each group (95% confidence level and 80% strength). Convenient sampling was used to select the participants. The patients were randomly assigned to the control and intervention groups.

Randomization

All individuals were initially listed from 1 to 66 in order of numbers. Then, 33 random numbers using software from 1 to 66. These 33 patients were assigned to the intervention group. The two groups (i.e., intervention and control groups) were matched according to age and sex.

Statistical Methods

The SPSS software (Version 22) was used to analyze the data. A range of statistical

Figure 1. A patient in the intervention group during the orthodontic treatment

tests including Mann-Whitney, Wilcoxon, and Spearman correlation coefficients were used at 0.05 significance level (α=0.05). The normality of the data was used by Kolmogorov-Smirnov statistical test. Mean descriptive indicators (standard deviation) and frequency (percentage) were used to describe the data. In addition, the internal consistency coefficient (alpha coefficient) was 0.92. Its validity varies by 0.75 with a one-week retest method and the correlation of its materials varies from 0.30 to 0.76. Five types of content validity, simultaneous, structural, and diagnostic and factor have been measured for this test, all of which show the high efficiency of this tool in measuring the severity of anxiety.

Ethical Considerations

The research protocol was explained to all participants as well as one or both of their parents. The patients' informed consent was obtained and they were ensured that their participation was completely voluntary. The participants in the intervention group were allowed to remove the headset whenever they wished all through the treatment. However, these participants were subsequently excluded from the study (Figure 2).

Exergaming and Executive Functions

All patients received fixed orthodontic treatments and had two or three appointments for clinical examination and evaluation of their diagnostic records before the orthodontic treatment sessions (i.e., the bonding orthodontic appliances session). The course of orthodontic treatment usually lasts 18-24 months during which patients are asked to refer to the clinic on a monthly basis. Therefore, the first session of the active treatment in which the orthodontic appliances are bonded can be considered as the most anxiety triggering one for most of the patients since they are faced with new and strange procedures. Following monthly visits, it usually cause patients to feel less anxiety because of presenting a familiar place and experiencing and to some extent known procedures. Thus, it was decided to evaluate the patients' anxiety at the session of the orthodontic appliances initial bonding. To this end, the patients' anxiety was evaluated right after they entered the operating room while waiting to receive the treatment. The procedure was completely explained to the participants and measures were taken to make them feel relaxed. The patients in the intervention group wore VR headset
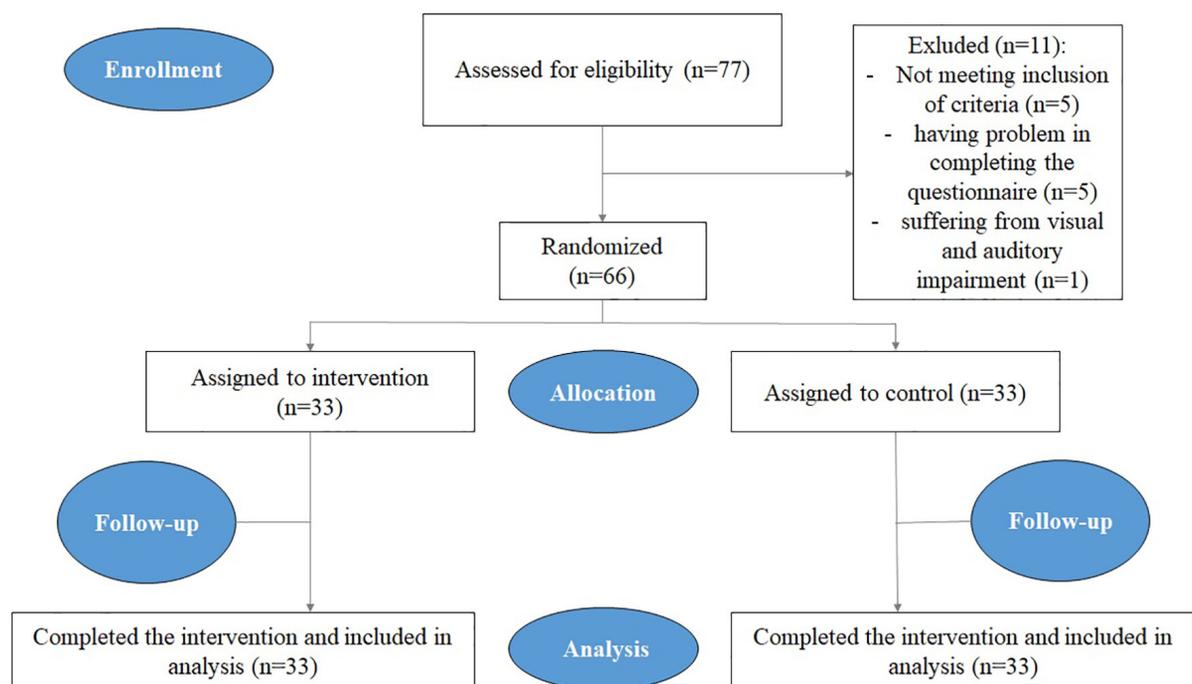

Figure 2. Flow diagram of the participant recruitment (CONSORT Flow Diagram).

(Samsung Gear Oculus VR Headset) (Figure 1) while those in the control group received the usual treatment.

An amusing VR based video clip was played through the headset when the patients lay on the orthodontics treatment unit. The video was an exciting 15-minute imaginary animation, and there was no option in the video for user interaction. The same VR video was played for all participants in the intervention group while those in the control group were free to see the dentist and clinic room during the orthodontic treatment. The BAI - Beck Anxiety Inventory was used to measure the participants' anxiety before and after the dental procedures. In this questionnaire, four options for each question were scored from zero to 3 on a four-Likert scale. The total score range was 0-60.

Results

The results of the descriptive statistics showed that the mean ages of the patients in the control and intervention groups were 12.85±1.40 and 12.15±1.37. There were 19.0 (61.3%) in the intervention group and 17.0 (51.5%) women in the control group. The results demonstrated that there was no statistically significant difference between the two groups in terms of age and gender (P>0.05). The mean anxiety scores before the orthodontics treatment in the control and intervention groups were 9.06±6.51 and 9.45±4.88, respectively. The mean anxiety scores after orthodontics in the control and intervention groups were 12.21±8.74 and 7.24±4.67, respectively.

There was a statistically significant difference in the anxiety scores before and after orthodontics in both the control (P=0.036) and the intervention (P=0.003) groups (Table 1). The results of Mann Whitney U test showed a statistically significant difference between anxiety scores after using VR videos during dental treatments between the control and intervention groups (P=0.014) (Table 2).

The results of Spearman correlation test indicated that there was no significant, direct correlation between age and stress scores after the intervention in control (r=0.002, P=0.992) and intervention (r=0.2755, P=0.122) groups. Additionally, the results of Mann-Whitney U test showed that there was no statistically significant difference between gender and anxiety scores after intervention in the control (0.203) and intervention (P=0.207) groups (Table 3).

Discussion

The present study aimed to investigate the effect of entertaining VR video clips during dental treatments on the anxiety levels of the patients referring to the Birjand Orthodontic Clinic. Based on the results,

Table 1. The comparison of the patients' anxiety scores in intervention and control groups before and after orthodontics

Anxiety score/ Group		Median (IQR)	Average rank	
Control	Before	8 (4-11)	13.1	P=0.036
	After	8 (5-17.5)	16.7	Z=-2.09
Intervention	Before	9 (6-12.5)	15.3	P=0.003
	After	6 (4-9)	13.83	Z=-2.92

Table 2. Statistical analysis of pre- and post-questionnaires

	Mean	Standard deviation	n	Mann-whitney U	Z Value	P value
Pre questionnaire	9.25	5.71	66	474	-0.908	0.364
Post questionnaire	9.72	7.39	66	353.5	-2.46	0.014
post - pre score=changes	0.46	8.07	66	269	-3.54	0.001

Mann-whitney U test was used to evaluate the differences between pre/post anxiety scores (post - pre score=changes).

Table 3. The comparison of the patients' anxiety scores in intervention and control groups before and after orthodontics based on their age and sex.

Variable	Group		Z-value	P value
Age	Control	12.15±1.37		0.22
	Intervention	12.58±1.40		
Sex	Control	Male	16.0 (48.5%)	0.43
		Female	17.0 (51.5%)	
	Intervention	Male	12.0 (38.7%)	
		Female	19.0 (61.3%)	

there was a statistically significant difference between the anxiety scores before and after orthodontic treatment in the intervention and control groups. After the intervention, the anxiety levels in the intervention and control groups decreased and increased, respectively, which indicates the effectiveness of virtual reality technology (i.e., the application of VR entertaining videos) in controlling the patients' anxiety during the orthodontic procedures.

The results of the present study are in line with those obtained in previous studies. Ahmadpour *et al.* conducted a scoping review by analyzing the results of 1386 articles published between 2013 and 2019 and found that VR can be a viable choice for managing pain and anxiety in a range of medical treatments (20). Additionally, Hua *et al.* showed that the use of VR for patients with burn pain could reduce pain and anxiety as well as the time required for treatment (21). They maintained that using a VR system could reduce children's pain and make them more relaxed and cooperative. In another study, Garrett *et al.* found that the use of VR space in patients with feelings of discomfort and pain due to chronic illnesses can relieve and treat their pain (22). Furthermore, Aliakbari *et al.* assessed the impact of VR on improving psychological symptoms such as anxiety and depression among patients suffering from cancer. Their results demonstrated a significant difference between the experimental and control groups in terms of anxiety and depression. More specifically, anxiety and these components were significantly lower in the experimental group (23). Previous research has showed

that the type of equipment or VR devices, patients' age, anxiety and depression levels, and the type of medical care affect the control of pain, anxiety, and depression caused by medical care (21, 24).

Mitrakul *et al.* showed that audio-visual and the congruence of bimodal stimuli can affect the subjective perception of emotions (25). Al-Khotani *et al.* conducted a clinical trial to assess the effect of visual distraction on children's behavior during medical treatment and reported a statistically significant difference in the mean scores of anxiety and behavior in the intervention group (receiving VR clips) compared to the control group. Thus, the mean scores of the intervention group were lower than the control group (26). Furthermore, the results of a study by Prabhakar *et al.* indicated that the use of visual distraction during dental treatment was more effective than auditory distraction (27).

The findings of the present study are in line with Ram *et al.* indicating the effectiveness of virtual reality-based glasses to create visual distraction in children during dental procedures (28).

Jimeno *et al.* evaluated the effects of mental distraction from the treatment environment and found that children's anxiety levels significantly improved by watching cartoons (29). In another study, Wiederhold *et al.* assessed the effects of VR systems on reducing anxiety and pain during dental procedures. The results showed that patients were less anxious and had less pain after receiving VR intervention (30). Regarding the anxiety factor, the findings of the present study were in line with Wiederhold *et al.* However, the

advantage of our study was the fact that this study only evaluated the role of engaging VR-based videos in reducing anxiety among adolescents who are more prone to anxiety during dentistry treatments. Further, BAI - Beck Anxiety Inventory (standard professional questionnaires), rather than self-evaluation questionnaires, was used to assess anxiety.

Virtual reality is a new form of non-pharmacological pain therapy and distraction. The effectiveness of virtual reality techniques on reducing pain and anxiety caused by treatment could be attributed to a variety of reasons (21, 31). It is suggested that the use of a distraction VR system may be a good option for patients with mild to moderate anxiety levels associated with dental treatment. This system may have a useful application in dental offices to help reduce anxiety, discomfort, boredom, and the time required to perform routine dental procedures.

The results of the present study indicated decreased anxiety levels among patients receiving VR-based entertaining video clips. This finding implies the effectiveness of VR-based techniques to overcome anxiety and distress caused by dental services in children and adolescents. Hence, the application of VR technology may facilitate dental treatments in this age group.

Limitations

Considering the fact that dental anxiety is a multidimensional issue with behavioral, cognitive, and psychological components, pain experience after treatment can affect the incidence of this complication. Therefore, in analyzing it, all aspects should be considered.

The use of this technology during treatment makes the patients' positive self-perceptions appear more strongly, which causes them to become more resilient to discomfort and pain. Psychologically, it helps the patients have appropriate physiological reactions to deal with their stress, depression, and anxiety. It can be concluded that increasing the patients' involvement with VR technology does not allow them to think more about their disease, problems, and pain, which could be considered

as an important reason for reducing anxiety in patients.

Suggestions for Future Studies

Based on previous research on VR technology, brain reactions are similar to those caused by taking strong painkillers. Therefore, the brain can prevent pain transmission by activating some of its parts, which can prevent a person from thinking about pain. More extensive studies are required to shed light on how these mechanisms work.

Ethical Considerations

The study was approved by the Deputy of Research and Technology and Ethics Committee of Birjand University of Medical Sciences (Ethics code: IR.BUMS. REC.1397.307) and Iranian Registry of Clinical Trials (IRCT20140611018063N8).

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Authors' Contributions

M.G.M. developed the theory and helped conduct the project in the field.
S.H.S. wrote the manuscript with support from M.Z.B.
S.B.M. developed the theory, verified the analytical methods, and contributed to the writing of the manuscript.
S.M. and S.B.M. planned the anxiety test and analyzed the results.
R.A. S.B.M. developed the theory and contributed to the writing of the manuscript.
A. E. provided virtual reality and ICT supports for running the project.
H.A. collected and analyzed the data..
M.Z.B. conceived of the presented idea and finding of this work.

Conflict of Interests

The authors declare that they have no conflict of interests.

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