Comparative Evaluation of the Efficacy of Virtual Reality Distraction, Audio Distraction and Tell-show-do Techniques in Reducing the Anxiety Level of Pediatric Dental Patients: An *In Vivo* Study

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ABSTRACT

Objectives and methods: Children, in the age-group of 6 to 8 years, with moderate level of anxiety, (measured with M-DAS), requiring inferior alveolar nerve block (IANB) for mandibular tooth extraction were selected. Informed consent was obtained from parents. Selected children were allocated randomly into 3 groups virtual reality (VR) distraction group, audio distraction group and Tell-show-do (TSD) group. Pre- and post-distraction anxiety level of children was measured subjectively with facial image scale and objectively with pulse rate and oxygen saturation (measured with pulse oxymeter).

Results: There was a statistically significant decrease in pulse rate after distraction (with a $p < 0.01$) in all the three groups. Postdistraction pulse rate was lowest in the VR distraction group when compared to other groups .While comparing postdistraction pulse rate values in the three groups, the difference in pulse rate between TSD and VR distraction group was significant. But while comparing the pulse rate between audio distraction and TSD group ($p = 0.06$), and audio distraction and VR distraction group ($p = 0.24$) was not statistically significant. Oxygen saturation increased in all the three groups which was statistically significant ($p < 0.01$). There was a statistically significant difference in the postdistraction oxygen (O_2) saturation levels between TSD and audio distraction groups ($p < 0.05$) with more O_2 saturation in audio distraction group. But while comparing the audio distraction with VR group and TSD with VR group, the difference was not significant. Facial image scale (FIS) scores decreased in all the three groups ($p < 0.01$).

Conclusion: The overall results revealed by all the parameters indicate that children were most relaxed in VR group, followed by audio group and were least relaxed in TSD group during dental visits. Hence VR distraction can be considered as a useful technique for behavior management of pediatric patients during a conventional dental treatment.

Keywords: Pediatric dental care, Pain, Pain perception, Parental acceptance, Patient accept, Pharmacological management, Nonpharmacological, Tell-show-do (TSD).

International Journal of Clinical Pediatric Dentistry (2021): 10.5005/jp-journals-10005-2106

INTRODUCTION

Pediatric dentistry is a unique field of dental practice, which covers a high level of expertise and technical skills customized to the needs of young patients. A successful pediatric dental practice requires a positive psychological environment for each child. The dental visit will be fearful as well as disturbing for the child. Previous poor medical or dental events can also trigger dental anxiety in children. This may influence the cooperation of children with the required frequency of dental appointments in future.

Several advanced intervention methods have been developed to manage children's uncooperative behaviors in dental settings. Although traditional behavior management methods are effective; the attitudes of parents toward these techniques are changing. Recent studies have indicated that distraction can be used to reduce the pain and anxiety during dental procedures. Distraction is defined as a state of mind that draws the attention away from unpleasant stimuli.[1] The process of distraction involves an optimal amount of attention and active emotional participation of the patient.

Virtual reality distraction is a novel technique of behavior management in children. Virtual reality was solely recognized for

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its entertainment value in past. Recently, it was introduced into medical and dental practices for effective management of patient during painful procedures. In the present research, an effort has been made to study the anxiety management of pediatric dental patients, using methods like VR distraction, audio distraction and TSD techniques.

MATERIALS AND METHODS

The present short-term clinical study was commenced following clearance from the institutional ethical and research committee. The study subjects were healthy children coming to the Department of Pediatric and Preventive Dentistry, in the age-group 6–8 years, requiring inferior alveolar nerve block (IANB) for mandibular tooth extraction. The minimum sample size was statistically calculated as 30 in each group. Healthy children with moderate level of anxiety requiring inferior alveolar nerve block for mandibular tooth extraction were included in the study. Children with special health care needs were not included in the study.

90 children of 6 to 8 years old with moderate level of anxiety (measured with M-DAS), requiring inferior alveolar nerve block (IANB) for mandibular tooth extraction were selected. Informed consent was obtained from parents. Selected children were allocated randomly into 3 groups

- Virtual reality distraction (VR) group
- Audio distraction group
- TSD group

In VR group, the distraction was done using, VR box and an android phone playing a 3D video with audio (VR roller coaster). Audio distraction was done using an android phone playing white noise (relaxing white noise by meditation relax club). In TSD group, behavior management was done with conventional TSD technique. Predistraction anxiety level of children was measured subjectively with facial image scale[2] and objectively with pulse rate and oxygen saturation (measured with pulse oximeter), before giving the inferior alveolar nerve block. After giving IANB, postdistraction anxiety level was also measured subjectively with facial image scale and objectively with

pulse rate and oxygen saturation levels (measured with pulse oximeter) (Fig. 1).

RESULTS

The results were statistically analyzed. One way ANOVA test was used to compare pulse rate and oxygen saturation among the three groups. Post-hoc test by Turkey's method (Scheffe multiple comparisons) was used for pair wise comparison. Krusskal Wallis test was used to compare the values of facial image scale and Mann-Whitney U test was used for pair wise comparison. P value was kept significant at 0.01 level. SPSS17.0 version was used to analyse the data.

Comparison of Postdistraction Pulse Rate

There was a statistically significant decrease in pulse rate after distraction (with a $p < 0.01$) in all the three groups. Pulse rate was lowest in the VR distraction group when compared to other groups. Inter group comparison of postdistraction pulse rate shows a statistically significant difference between TSD and VR distraction groups ($p < 0.01$). But the difference between audio distraction and TSD, and audio distraction and VR distraction were not significant (Table 1 and Fig. 2).

Comparison of Postdistraction O_2 Saturation Levels in Three Groups

Oxygen saturation increased in all the three groups which was statistically significant ($p < 0.01$). There was a statistically significant difference in the postdistraction oxygen saturation levels between TSD and audio distraction groups, ($p < 0.05$) with more O_2 saturation in audio distraction group. But while comparing the audio distraction with VR group ($p = 0.555$) and

Fig. 1: Virtual reality distraction using VR box and Android phone

Table 1: Comparison of postdistraction values of pulse rate based on group

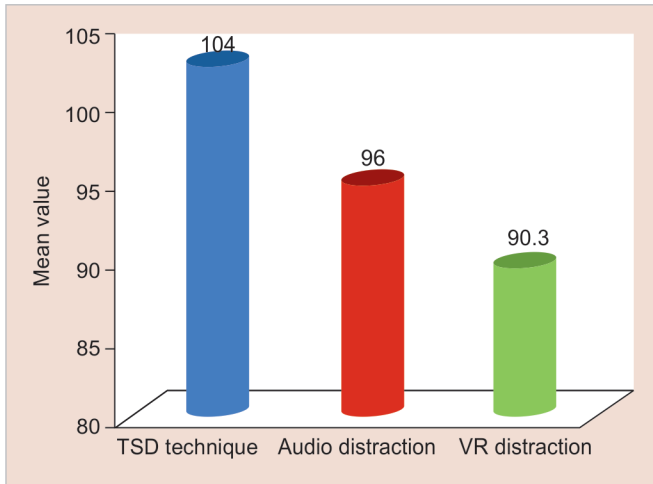| Group	Mean	SD	N	F	Sig.	Pair	F`	p
						Scheffe multiple comparisons		
TSD technique (A)	104.0	13.9	28			A & B	2.9	0.060
Audio distraction (B)	96.0	12.7	28	8.56**	0.000	A & C	8.5**	0.000
VR distraction (C)	90.3	10.5	28			B & C	1.5	0.240

**p < 0.05

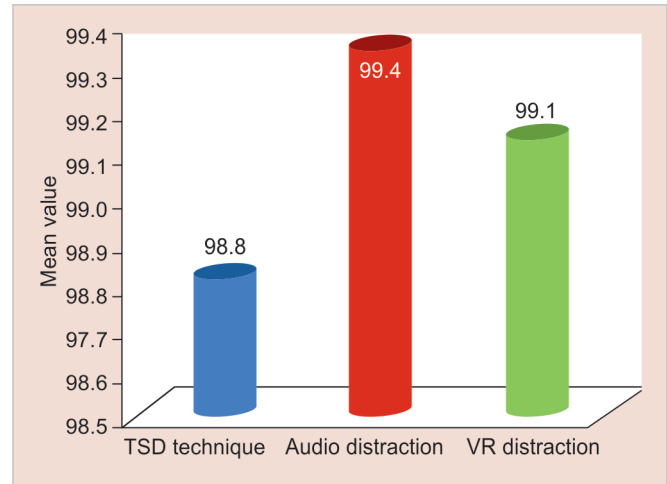Fig. 2: Comparison of postdistraction values of pulse rate based on group

Fig. 3: Comparison of postdistraction values of O$_2$ aturation based on group

Table 2: Comparison of postdistraction values of O$_2$ saturation based on group

| Group | Mean | SD | N | F | Sig. | Scheffe multiple comparisons | | |
						Pair	F`	p
TSD technique (A)	98.8	0.9	28			A & B	3.7*	0.029
Audio distraction (B)	99.4	0.6	28	3.75*	0.028	A & C	1.3	0.270
VR distraction (C)	99.1	0.7	28			B & C	0.6	0.555

Table 3: Comparison of postdistraction values of FIS scores based on group

| Group | Mean ± SD | Median | Z$ | Sig. | Mann-Whitney U Test | | |
					Pair	Z#	p
TSD technique (A)	3 ± 1	3			A & B	4.6	p < 0.01
Audio distraction (B)	1.8 ± 0.5	2	34.1	p < 0.01	A & C	5.06	p < 0.01
VR distraction (C)	1.5 ± 0.5	1			B & C	1.98*	0.047

TSD with VR group, the difference was not significant (p = 0.270) (Table 2 and Fig. 3).

Comparison of Postdistraction Facial Image Scale

Facial image scale (FIS) scores decreased in all the three groups (p < 0.01). While comparing the postdistraction facial image scale score among the three groups, the lowest score was in the VR distraction group followed by audio distraction group. There was a statistically significant difference in the score between TSD group and VR distraction group, TSD and audio distraction group and audio and VR distraction group (Table 3 and Fig. 4).

DISCUSSION

In this research, we compared the effectiveness of audio distraction, VR distraction and TSD techniques. The procedures used in this study were carefully developed to reduce bias and erroneous results. Randomization and inclusion-exclusion criteria were established for appropriate sampling. 90 children, between 6 and 8 years of age with moderate level of anxiety were selected for the study. Modified dental anxiety rating scale (MDAS) questionnaire was used to select children with moderate level of anxiety. Tunc et al[3] and Ilgüy et al.[4] have proved that MDAS is
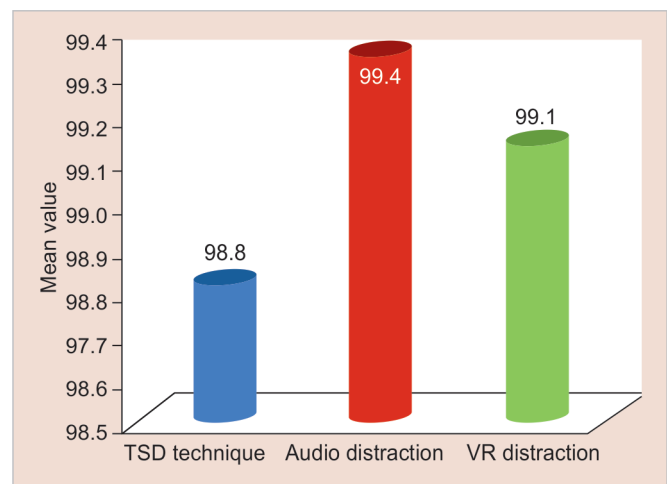

Fig. 4: Comparison of postdistraction values of facial image scale scores based on group

one of the most reliable scale for measuring dental anxiety[5,6] in children. Determination of the dental anxiety among children will be helpful to plan the treatment and also to equip with preventive measures.

Anxiety measurement was done by both objective and subjective measures in this study. Anxiety level before and after the treatment procedure was assessed subjectively with FIS and objectively with pulse rate and oxygen saturation (measured with pulse oximeter). Studies by Messer et al.,[7] confirmed that the physiological changes occur in the body as a result of dental anxiety. The physiological changes like variation in pulse rate or oxygen saturation are very useful for measuring anxiety level in a patient.

In the present study, pulse oximeter was used to measure pulse rate and oxygen saturation as it requires no calibration or tissue preparation. Pulse oximeter, which measures the pulse rate and oxygen saturation, is one of the most acceptable method for measuring the physiological changes as it gives continuous measurements of the patient's arterial haemoglobin oxygenation as well as heart rate.

Pulse rate and oxygen saturation has been used as an outcome measure in numerous studies of fear and anxiety in dental patients.[8,9] The pulse rate is regulated by the autonomic nervous system (ANS) which reflects negative emotions in terms of physiological parameters such as heart rate, respiratory rate and body temperature.[10] Therefore, physiological responses of the ANS are used as indicators to notify if a person is under stress or anxiety. Anticipation of injection act as a stress stimulus and provide sympathetic stimulation and can increase the pulse rate.[11]

In VR distraction group, there was a significant reduction in pulse rate and an increase in oxygen saturation after distraction. The mean predistraction pulse rate in VR group was 100.3 and the mean postdistraction pulse rate score was 90.3. The mean predistraction oxygen saturation level in VR group was 98.0 and the mean postdistraction oxygen saturation was 99.1. The results of the present study confirm that use of VR distraction is an effective technique in decreasing anxiety level of children. Similar results were concluded in studies done by Weiderhold et al.[12] and Sullivan et al.[13]

In audio distraction group, there was a significant reduction in pulse rate and increase in oxygen saturation after distraction. The mean predistraction pulse rate score in audio distraction group was 106.4 and the postdistraction pulse rate score was 96 ($p < 0.01$). The mean predistraction oxygen scores in audio distraction group were 97.9 and the postdistraction oxygen score was increased to 99.4 ($p < 0.01$). This was in accordance with the study conducted by Marwah et al.,[11] in which the choice of music was left to the child dental patient. Parkin,[14] also found significant reduction in the rating of clinical anxiety during dental treatment when child patients were exposed to ambient music for 5 minutes beforehand. In a study by Yamini et al.[15] in 2010, anxiety during dental treatment was assessed by psychological means and it was concluded that audio distraction reduced the anxiety level in music group significantly in procedures under local anesthesia. The results of the present report are also consistent with studies carried out by Sivakumar et al.[16] and Lahmann et al.[17]

In the present study there was a significant difference in anxiety levels between audio distraction group and TSD group (without distraction). Audio distraction is effective due to relaxation effects of music and distraction effect of the soothing sound over the sound of dental instruments. In TSD group, there was a significant decrease in pulse rate and increase in oxygen saturation after distraction. TSD is a universally accepted non aversive behavior management technique, practiced by dentists without any level of expertise. TSD technique remains the most commonly used technique in pediatric dentistry, according to various researchers.[18-22] The technique incorporates verbal explanations of procedures, appropriate to the developmental level of child (Tell); demonstrations of the procedure (Show); and then, reproducing the procedure in real time (Do).[23] Following TSD technique, the treatment must be performed immediately according to Kreinces et al.,[24] which is also followed in the current study.

Facial image scale, is among one of the consistent measures of self-reported anxiety in children. Facial image scale scores were decreased in all the three groups ($p < 0.01$). The FIS is a state measure of children's dental anxiety and comprises a row of five faces ranging from very happy to very unhappy. Facial image scale scores range from 1 to 5; 5 indicating the highest anxiety. Various studies have shown that FIS is a suitable scale to assess the state dental anxiety even in very young children.[2,25-27]

Postdistraction pulse rates were reduced in all the three groups, and was least in TSD group (90.3) when compared to audio distraction group (96.0) or TSD group (104.0). While comparing postdistraction pulse rate values in all the three groups, the difference in pulse rate between TSD and VR distraction was significant. To the best of our knowledge, there is no published data with comparison between VR distraction and TSD technique till date. But according to a study by Bansal et al.[28] there was a statistically significant difference in pulse rate between a virtual reality headset (VRH) group and a control group without VRH. Intergroup comparison between audio distraction and VR distraction group was not statistically significant. But according to studies by Prabhakar et al.[29] and Khandelwal et al.[30] audio distraction was less effective when compared to audio video (AV) distraction.

Intergroup comparison between TSD and audio distraction showed that the reduction in pulse rate was not statistically significant. The result was in accordance with a study conducted by Khandelwal et al.,[31] where the postdistraction pulse rate scores was reduced to a minimum in audio-visual distraction group when compared to TSD group.

Postdistraction oxygen (O_2) saturation increased in all the three groups which was statistically significant ($p < 0.01$). Postdistraction oxygen saturation was highest in audio distraction group (99.4 %), when compared to VR group (99.1 %) or TSD group (98.8%). Anxiety due to pain releases corticosteroids, glucagon and catecholamines. This increases the heart rate, constricts the blood vessels and affects the tissue perfusion and oxygenation. So, if anxiety reduces, these processes are reversed and there will be increase in oxygen saturation. There was a statistically significant difference in the postdistraction oxygen saturation levels between TSD and audio distraction groups, ($p < 0.05$) with more O_2 saturation in audio distraction group. The results of the current study were similar to a study by Arpana et al.,[28] where the oxygen saturation levels where more in a distraction group, when compared to a non-distraction group. While comparing the postdistraction oxygen saturation levels in audio distraction group with VR group and TSD group with VR group, the difference was not significant. The results were similar to a study conducted by Khandelwal et al.,[31] where postdistraction oxygen saturation was highest in audio video distraction (AVD) group than TSD group. They concluded that the AVD was found to be more capable in reducing anxiety than TSD.

While comparing the postdistraction facial image scale scores among the three groups, the lowest score was in the VR distraction group followed by audio distraction group. There was a statistically significant difference in the score between TSD group and VR distraction group, TSD and audio distraction group, and Audio and VR distraction group. To the best of our knowledge, similar studies, assessing facial image scale scores, in the above three groups was not available in literature till date. But the results were similar to a study conducted by Khandelwal et al.,[31] where the postdistraction FIS score was least in an audio-visual distraction (AVD) group when compared to TSD group.

The overall results revealed by all the parameters indicated that children were most relaxed in VR group, followed by audio group and were least relaxed in TSD group during dental visits. The benefits in VR group may be related to more immersive images in VR system. Also, the VR headset will block out real world sensory inputs from dental settings. The child's attention will be focused on the virtual world rather than the treatment settings.[32]

Within the confines of this experimental design, absolute conclusions cannot be drawn. These findings should be supported by conducting extensive clinical trials using larger sample size to validate the observations. A further research is needed to identify the underlying mechanisms that account for the effects of VR distraction in dental settings. Research is also required to determine whether virtual reality continues to reduce anxiety when used repeatedly on subsequent dental visits.

Conclusion

The principal findings of this in vivo study are as follows:

- The postdistraction pulse rates were lowest in VR distraction group when compared to audio distraction or TSD group.
- The postdistraction oxygen saturation levels were highest in audio distraction group, when compared to VR distraction or TSD group.
- The postdistraction FIS scores were better in VR distraction group when compared to audio distraction or TSD group.

The overall results revealed by all the parameters confirm that children were most relaxed in VR group compared to audio distraction group or TSD group. However, within the limitations of this experimental design, we cannot draw definitive conclusions. It would be necessary to aid these findings by conducting comprehensive clinical trials using these techniques and parameters with a substantial sample size to validate the observations.

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