Virtual Reality Distraction on Dental Anxiety and Behavior in Children with Autism Spectrum Disorder

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Abstract

A large population of children with Autism Spectrum Disorders (ASD) fail to receive adequate dental care. The dental care of these patients poses great difficulties to dental practitioners. Although many of basic behavior management techniques can be employed to enable dental treatment in these patients, their success in reducing the children's dental anxiety and improving behavior has been limited.

Since the thought patterns of children with ASD favor the application of auditory and visual stimuli, we aimed to assess the effectiveness of Virtual Reality (VR) distraction in managing the anxiety and behavior of children with ASD in the dental environment. 68 children aged 8 – 15 years with a known diagnosis of ASD, requiring routine, non-invasive dental treatments were included in the study. These children were scheduled to undergo routine, non-invasive dental treatment procedures, in two dental visits, spaced 3 months apart. In both visits, the dental anxiety and behavior of all the children were measured using Venham's Picture Test and Frankel's Behavior Rating scales, respectively at the end of their dental treatment.

Completion of dental treatment and data collection was carried out in 40 children whose results were analyzed. There was a significant reduction in patient reported anxiety scores and a significant improvement in their dental behavior was noted when VR distraction was used (p=0.042 and p=0.0001, respectively). Virtual Reality distraction can be used as a successful behavior management method in autistic children during routine dental treatment.

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Introduction

As dental patients, children with Autism Spectrum Disorders (ASD) are often considered to pose great challenges to dental practitioners as their varied symptoms and complex set of clinical manifestations often interferes with the delivery of routine dental care.[1] It is commonly observed that patients with ASD are unable to cooperate in the dental setting as their developmental impairments lead to many difficulties that hamper their ability to interact with other people. Their altered cognitive abilities also lead to these individuals having difficulties in understanding and following instructions. Changes in the environment, daily schedule or other routines often elicit behavioral resistance and tantrums.[2] Many children with ASD do not receive dental care because of fear associated with dental procedures.[3] The dental care of these patients poses great difficulties,[4] and oftentimes they require general anesthesia for regular dental procedures,[5] placing them at high risk of associated complications.[3]

Behavioral methods for dealing with patient stress and anxiety have become increasingly popular in dentistry. Behavioral management and prevention of dental diseases form the foundation of good pediatric dental practice.[6] A variety of basic behavior guidance techniques can be utilized to enable dental treatment in patients with ASD, including the presence of parents or aides, the use of Tell-Show-Do technique, short, clear commands, and positive and negative verbal

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reinforcements.[7,8] A combination of desensitization, symbolic remodeling and reinforcement can also enable autistic patients to undergo dental examination.[9] Thus, management is of a multidisciplinary nature, the most effective strategies being those based on educational programs.[10]

In general, distraction is perhaps the simplest and most common of all behavior management procedures used during dental procedures in children. Conventional distraction techniques used in dental practice include, for example, watching movies, listening to music, counting objects in the room, and even casual conversations with the dental team.[11] In recent years, however, distraction as a behavior management technique has seen a sudden increase in popularity, using digital technology as a medium for its enhanced and enriched application in the form of Virtual Reality (VR) and the Virtual Environment (VE).

Virtual Reality is essentially a reference to any human-computer interface that enables the human participant to interact dynamically with the virtual, computer-generated environment. The application of VR technology, as a medium for distraction, may be superior to traditional distraction because it offers more immersive images delivered through the occlusive headsets that in addition to projecting images right in front of the eyes of the user also have the capacity to block out real-world (visual, auditory, or both) stimuli.[12] The present state of VR technology, as can be successfully applied to dentistry, focuses on visual and auditory stimuli. This method is, in principle, like its earlier counterpart otherwise known as Audio-Visual (A/V) distraction systems.

The thought patterns of children with ASD have been shown to rely mainly on visual stimuli. As such, the use of visual teaching materials has been a fundamental principle in designing educational programs for children with ASD.[3] Utilizing the immersive nature of VR in the dental setting, the dentist can isolate autistic individuals from their surroundings and help them focus on a specific situation, thereby distracting them from the dental environment. Thus, a virtual environment can build on the child's specific visual skill,[13] and VR distraction could prove a particularly beneficial tool in managing children with ASD in the dental environment.

To the best of our knowledge, till date, no study has explored the effect of VR distraction technique on the anxiety and behavior in children with ASD during routine, non-invasive dental treatments.

Hence, this study evaluates the impact of Virtual Reality distraction technique on dental anxiety and behavior in 8 – 15-year-old children with ASD during routine, non-invasive dental treatment. The aim of the study was (1) to assess the impact of VR distraction on anxiety in 8 – 15-year-old children with ASD during routine, non-invasive dental treatment procedures using Venham's Picture Test (VPT); (2) to assess the impact of VR distraction on the behavior in 8 – 15-year-old children with ASD during routine, non-invasive dental treatment procedures using Frankel's Behavior Rating Scale.

Materials and methods

Source of Data

68 children aged 8 – 15 years with a known diagnosis of autism spectrum disorders (ASD), requiring routine, non-invasive dental treatments were included in the study. Informed consent was obtained from the parents and caregivers of the participants.

The inclusion criteria were: 1) children with a known diagnosis of ASD, showing an understanding of, and ability to comply with, short, clear and simple instructions; 2) children with fair to poor oral hygiene, requiring routine, non-invasive dental treatment procedures. While, the exclusion criteria were: 1) children with a previous history of very violent and highly uncooperative dental behavior; 2) children with severe debilitating conditions, sensory deprivation, exhibiting very low IQ (unable to follow clear and simple instructions), and a history of epilepsy; 3) children refusing to undergo dental treatment wearing the VR eyeglasses and those unwilling to use the VR device for the duration of the dental treatment.

Study Protocol

68 children fulfilling the inclusion criteria were identified from three vocational schools catering to the needs of children with special health care needs. Following a routine dental examination, these children and their parents and caregivers were introduced to the VR eyeglass system, allowing the children and parents to participate in a live demonstration session at the primary healthcare facility. Informed consent was then collected from those parents and caregivers,

who were willing to let their children participate in the study.

These children were scheduled to undergo routine, non-invasive dental treatment procedures (hand scaling, restoration using atraumatic restoration technique, topical fluoride application and pit and fissure sealant placements), in two dental visits, spaced 3 months apart (washout period). At the first treatment visit, these children received dental care using conventional behavior management techniques. At the end of this visit, the children were allowed to sit and view a cartoon video for 5 minutes using the VR eyeglasses device as a form of reward system to aid in the acceptance of the device for the next visit.

In their second treatment visit, the same children received the VR device (Merlin i-theatre cordless, Merlin digitals, Sharjah, UAE) during dental treatment, which blocked out the visual field of the child completely and had inbuilt headphones to deliver the sound.

The study was conducted after obtaining the necessary clearance from the institutional review board and all treatments were carried out in a primary care setting within surroundings familiar to the children. Careful consideration was given to perform the treatment procedures in the mornings (between 10.00 a.m. to 11.30 a.m.), in the presence of their primary caregivers, without overt disruption of the daily schedule of these children.

The anxiety and behavior of all the children during treatment were measured using Venham's Picture Test and Frankel's Behavior Rating scales, respectively. Venham's Picture Test is a tool used in routine dental practice to rate a patient's dental anxiety. It consists of a series of eight picture sets, showing a diagrammatic representation of two children, where one child is highly anxious or upset and the other child is not. The image of the child that most closely resembles the feeling and behavior of the patient is marked on each one of the eight picture sets, and the scores are tallied. Thus, the anxiety score for any child can range from a minimum score of zero, which means that the child was not anxious at all, to a maximum score of eight, which means that the child was extremely anxious. Frankel's Behavior Rating scale is a simple four-point scale used by general dental practitioners to rate a patient's level of cooperation or behavior in the dental setting. The behavior and relative cooperation of the child enables the dentist to grade the child's behavior as either definitely positive (happy to comply and looks forward to the treatment – rating score of 4), positive (can be made to sit for treatment – rating score of 3), negative (reluctant and uncooperative – rating score of 2), or definitely negative (hysterical and disrupts treatment procedure – rating score of 1).

Venham's Picture Test was performed on the children with the help of their parents and care-providers, at the end of treatment, at both the first and second dental visits. Behavior rating was also scored at the end of the dental treatment, by the dental care provider. A single operator carried out the dental treatment at all three centres, in both dental visits.

Statistical Analysis

The data collected from the children participating in the study, at both dental visits, were tabulated and subjected to statistical analysis using the EZR software (version 1.37). The level of significance was fixed at 5% ($\alpha \leq 0.05$).

Wilcoxon's Rank Sum test was used to compare the median dental anxiety scores obtained by the children. Cochran Armitage test for trend was used to compare the difference in distributional trends between the participants' anxiety levels and behavior rating scores at the first and second dental visits. Finally, Spearman's correlation test was used to measure the correlation between behavior rating and dental anxiety scores in both the visits.

Results

Of the total 68 children who were examined, at the time of recruitment into the study, 16 children were excluded according to the exclusion criteria stated. Permission and consent were gathered from the remaining 52 children and were scheduled to undergo dental treatment (first visit). However, at their scheduled first dental treatment visit, only 48 children and their caregivers were in attendance. Their dental treatments, limited to a time of 20 – 25 minutes, were carried out and a second visit was scheduled, after a washout period of three months. At the second dental visit, 3 out of the 48 children who were treated at the previous visit were absent and another 5 could not be treated

using the VR distraction device for the entire duration of dental treatment (20 – 25 minutes). Thus, the data obtained from the remaining 40 children who were successfully treated at both the dental visits were considered and further analyzed.

Anxiety rating

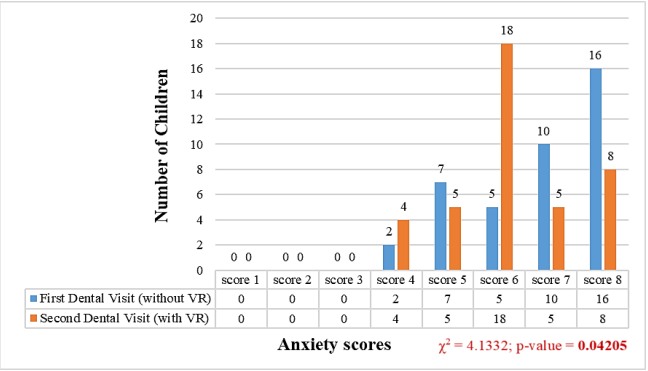
The mean and median dental anxiety scores at the first (without VR) dental treatment visit were 6.77 (±1.29) and 7; whereas the mean and median dental anxiety scores at the second dental treatment visit were 6.2 (±1.2) and 6, respectively (Table 1). Since the data did not follow normal distribution, comparisons were carried out using the median anxiety scores, which revealed a statistically significant difference (W = 4.1332; p=0.037).

Anxiety Scores	n	Mean (SD)	Minimum	**Median** (Q1 – Q3)	Maximum	W statistic	p-value
First Visit (without VR)	40	6.775 (1.291)	4	**7** (6 – 8)	8	1010.5	**0.037***
Second Visit (with VR)	40	6.200 (1.203)	4	**6** (6 – 7)	8		

*) p-value ≤ 0.05 is significant; p-value > 0.05 is not significant

Table 1. Comparison of The Median Dental Anxiety Scores Between The Two Dental Visits, without and with VR Distraction.

While the differences were statistically significant, the magnitude of the difference does not indicate clinical relevance. Therefore, distribution of children according to their anxiety scores was tabulated (Graph 1). Maximum number of children obtained an anxiety score of 8, followed by score 7 (16 and 10 children, respectively) in the first dental treatment visit. These numbers had reduced to 8 and 5 in the second dental visit. Also, it was observed that the number of children obtaining a lower score of 6 in the first dental visit had increased to the maximum in the second dental visit (from 5 to 18 children). Comparison of the differences in trend was carried out using Cochran Armitage test for trend, assuming independence between the visits because of the wash-out period. A statistically significant difference in trend was observed (χ^2 = 4.1332; p=0.042) (Figure 1).



*) p-value ≤ 0.05 is significant; p-value > 0.05 is not significant

Figure 1. Comparison of The Distribution of Children According to Their Anxiety Scores at the 2 Dental Visits, without and with VR Distraction.

Behavior rating

The number of autistic children exhibiting a behavioral score of 1 (definitely negative behavior) during the dental treatment had reduced from 19 (47.5%) without VR distraction to 7 (17.5%) when VR distraction was used (Table 2). Similarly, the number of autistic children exhibiting a behavioral score of 2 (negative behavior) had also reduced from 15 (37.5%) to 11 (27.5%) when VR was used. However, the percentage of children obtaining a behavioral score of 3 (positive behavior) had increased from 6 (15%) to 22 (55%) when VR distraction was used. Comparison between the behavior rating scores in the first and second dental visits revealed a statistically significant difference (χ^2 = 14.532; p = 0.0001378) (Table 2).

Behavior Rating Score	Frankel's behavior rating (1st visit – without VR)	Frankel's behavior rating (2nd visit – with VR)	Cochran-Armitage test for trend
1	19	7	χ^2 = 14.532
2	15	11	
3	6	22	
4	0	0	
Total	40	40	**p = 0.0001***

*) p-value ≤ 0.05 is significant; p-value > 0.05 is not significant

Table 2. Frankl's Behavior Rating Scores of Autistic Children without and with VR Distraction.

Correlating Dental Behavior and Anxiety

There was very good negative correlation between the behavior rating and anxiety scores in the first and second dental treatment visits, respectively, with high statistical significance ($p<0.001$) (Table 3).

		Anxiety Score (1st visit)	Anxiety Score (2nd visit)
Frankel's Behavior Rating (1st visit)	Correlation Coefficient	-0.780**	-
	Sig. (2-Tailed)	<0.001*	-
	N	40	-
Frankel's Behavior Rating (2nd visit)	Correlation Coefficient	-	-0.660**
	Sig. (2-Tailed)	-	<0.001*
	N	-	40

*) p-value ≤ 0.05 is significant; p-value > 0.05 is not significant
**) Correlation coefficient value inference: 0 to 0.2 – poor; 0.2 to 0.4 – fair; 0.4 to 0.6 – good; 0.6 to 0.8 – very good; 0.8 to 1.0 – excellent

Table 3. Correlation Between Frankel's Behavior Rating Scores and Anxiety Scores in The 1st and 2nd Dental Visits, without and with VR Distraction, Respectively.

Discussion

Virtual reality (VR) distraction is an emerging technology that has shown much promise as a behavior management tool during dental and medical treatments.[11,12] There has been some evidence to support its use in the special needs population, like children with Autism Spectrum Disorders (ASD).[3,13] It is estimated that VR technology may have particular application in these children, though substantiating evidence in this regard is lacking.

The methodology followed in this study was carefully constructed with the counsel of an experienced clinical psychologist, pediatric dentists and a few well-educated parents of children with ASD (not part of this study). Thus, the decision to perform routine, non-invasive dental treatment within the confines of the special child care centres, transformed into a primary dental healthcare facility. This attempt is different from a similar study conducted by Isong et al, where dental treatments were carried out in an established dental clinic.[3] This decision was made to facilitate a reduction in anxiety levels and elicit greater cooperation from the children at the dental visits, since many of the children recruited in the study had had limited exposure to dental teams prior to conducting the study.

A washout period of three months was included in the methodology of this study to account for bias that may result from any increasing familiarity with the dental team and the dental procedures. A similar approach has been undertaken in a previous study by Isong et al, where the washout period ranged from 4 to 6 months.[3] A standard single episode of Chhota Bheem, a popular cartoon series in India, was used for viewing through the VR device.

In the present study, a high dropout rate (58.8%, from participant inclusion till final data collection at the second dental treatment visit) was present. It is interesting to note that majority of these dropouts (10 out of the 16 initial dropouts) were because of additional health concerns (children with a history of violent behavior at previous dental visits, epilepsy etc.), and not due to lack of willingness to participate. In any case, the chief attraction for most caregivers was the provision of dental care within the confines of their children's familiar surroundings. Further, dropouts were seen due to non-attendance of children at the scheduled dental treatment visits (4 and 3 at the first and second treatment visits, respectively).

Another interesting occurrence was that many of the participants who had initially withdrawn from the study and who had expressed unwillingness to participate, had returned with requests to follow through with the dental treatments at the second dental treatment visits. However, these participants, as well as those unable to comply with the VR distraction protocol for the entire duration of the dental treatment, could not be included and any data therein was not considered.

Within the limits of the present study, it was observed that using VR headsets during treatment in autistic children had resulted in a significant reduction in the children's reported anxiety scores (Table 1, Figure 1). This reduction is similar to the findings from various studies

conducted in normal children, where the use of VR distraction during dental and medical treatments had led to a reduction in the subjects' reported pain, anxiety and discomfort.[13,14,15]

The difficult management of children with ASD has been noted in this study, as the behavior rating for most children fell in the negative and definitely negative categories in the first dental visit, where conventional behavior modification techniques (without VR distraction) were used (Table 2). Corresponding observations were also seen in the anxiety ratings over the first visit, since there was an increase in the number of autistic children obtaining dental anxiety scores over the higher end of the spectrum (Figure 1). This was despite having the routine dental treatments carried out in surroundings familiar to these children. Similar findings were noted by Murshid EZ in his study, as well.[16] However, during the subsequent dental visit, when VR distraction was employed, a general trend towards positive behavior was noted in the children and similar observations can also be noted from the children's anxiety rating scores (Table 2, Figure 1). These findings are in accordance with our study hypothesis, stated earlier.

We can also note that the number of children obtaining scores over the higher end of the spectrum (scores 6, 7 and 8) remained high between the first and second dental visits, despite the shift in trend at the second visit (Figure 1). This observation suggests that, while the dental anxiety in children with ASD did reduce with the application of VR distraction, it remained high. Corresponding observations can also be made over the behavior scores, as the number of children rated with negative dental behavior (rating score 2) did not show any drastic reduction, i.e. the number of children had only reduced from 15 in the first visit to 11 in the second visit, when VR was used (Table 2). Such observations are to be expected in children with ASD, since any deviation from the routine has been known to cause anxiety and behavioral disruptions in these children.[2,3,4,5,7] In the present study, dental treatments were performed in environmental settings familiar to the children; however, the introduction of the dental team could have inadvertently caused a rise in their anxiety levels and lead to negative behavioral changes.

We also observed a significant negative correlation between the behavior rating and anxiety scores, indicating that a reduction in the children's anxiety levels elicited a corresponding improvement in their behavior (Table 3). This correlation adds to the significance of our present study as an improvement in the behavior of the children would enable them to undergo routine dental treatments in dental settings without overtly exhausting the parents and caregivers and the dental team owing to constant disruption and violent outbursts in their behavior. Thus, a careful application of this technique could, in turn, increase the willingness of general dental practitioners to treat children with ASD.[17]

While our study supports the use of virtual reality distraction during routine, noninvasive dental treatments of short duration in children with ASD, these results should be confirmed with a larger sample size. Furthermore, as the treatment procedures in this study were limited to routine, non-invasive dental procedures, at a primary care setting, the further scope of applying VR distraction to invasive and other treatment procedures in autistic children should be explored. It must also be kept in mind that like any other neuro-developmental disorder, autism is also multifactorial in nature. Thus, the efficient dental management in this group of differently abled individuals requires the application of multiple behavior management modalities, including VR distraction.

Conclusions

In our study, there was a significant reduction of anxiety and improvement of behavior seen in children with Autism Spectrum Disorders during routine, non-invasive dental treatment procedures using Virtual Reality distraction. Virtual Reality distraction can be used as a successful behavior management method in autistic children during routine dental treatment. Further research is needed to explore the effectiveness and applicability of virtual reality distraction in this population of children with a larger sample size, and in various other dental treatment procedures.

Declaration of Interest

The authors declare that they have no conflict of interest. The present study was self-financed by principal investigator and guide (Dr.

LR Suresh) and was carried out after obtaining institutional ethical clearance for the same.

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