

# Use of Augmented Reality in Alleviating Dental Anxiety among Paediatric Patients: A Randomised Control Study

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## ABSTRACT

**Introduction:** The management of anxiety and fears in patients receiving medical treatment has always been a significant issue. Patients with dental anxiety are challenging to manage in dental offices, as they may require more time for treatment and are often dissatisfied with their dental care, especially among paediatric dental patients. Although Augmented Reality (AR) has not been widely used in dentistry, it is theoretically believed to have a role in alleviating dental anxiety among paediatric patients.

**Aim:** The aim of this study is to explore the level of dental anxiety among children aged 6-14 years, based on age, gender, and treatment status. Additionally, the study aims to investigate whether the preoperative use of AR can alleviate anxiety. The effect of AR on anxiety was evaluated using Corah's Dental Anxiety Scale (DAS).

**Materials and Methods:** This randomised controlled study was conducted at a private clinic in Bahcesehir, Istanbul, Turkey. The study duration was two months, from March 2021 to May 2021. The study design aimed to compare the level of anxiety among paediatric patients in an AR exposure condition with those in a control condition. A total of 511 paediatric

patients were randomly assigned to either the control group or the intervention condition (i.e., preoperative AR experience versus no preoperative AR experience). A questionnaire survey, including demographic questions and the DAS, was conducted to compare the DAS scores between patients who engaged in the AR experience and those who did not. The data were analysed using the Chi-square test, the Kruskal-Wallis test, and the Mann-Whitney U test.

**Results:** The control group consisted of 134 females and 118 males, while the experimental group consisted of 139 females and 120 males. The mean DAS scores differed based on age ( $p < 0.001$ ). The median DAS score of the 10-14 years age group was lower than that of the 6-8 years age group. The mean DAS score was significantly lower in the group that received AR intervention compared to the control group ( $p < 0.001$ ). The median DAS score was 6 for those with AR experience, while it was 10 for those without it.

**Conclusion:** The preoperative use of AR applications was found to be effective in reducing dental anxiety among children in this study. AR shows promise as a tool that has not been sufficiently utilised among anxiety-relieving techniques for paediatric patients.

**Keywords:** Anxiety-reducing techniques, Dental anxiety scale, Distraction

## INTRODUCTION

Dental anxiety is defined as a cognitive-emotional response to a stimulus or an experience associated with dental treatment [1]. It not only leads to the rejection and avoidance of dental procedures but can also impact an individual's overall growth and development [2, 3]. Although it can be managed through pharmacological interventions as general anaesthesia [4,5], non-pharmacological interventions such as musical distraction are gaining more acceptance from parents, patients, and practitioners due to the disadvantages associated with pharmacological approaches, such as nausea and vomiting [6]. Distracting a patient's attention away from noxious or unpleasant stimuli is a non-pharmacological intervention commonly used in clinical practice to reduce pain, anxiety, and fear during the medical procedures [7, 8].

Augmented Reality (AR) may be an effective and relevant tool for diverting patients' attention away from clinical procedures, particularly among younger populations who have grown up with such technologies [9]. AR is a rapidly emerging technology that overlays digital objects onto real-world environments, viewed in real-time through a smartphone, tablet, or headset [10]. While the preoperative use of Virtual Reality (VR) and other technologies has been well-documented in dental literature regarding pain and anxiety reduction [11], there is currently no documented study on the potential uses of AR in managing dental anxiety. However, AR likely offers more advantages compared to other technologies, as it enhances the existing environment by adding virtual elements

rather than creating complete immersion in a virtual world, as seen in VR. Additionally, AR requires active involvement from the users rather than simply being exposed to soothing music or watching movies/cartoons [12-14].

To date, AR remains largely untapped as a method for managing dental anxiety, particularly for paediatric patients. The present study aims to examine the efficacy of using AR to alleviate dental anxiety through patient-reported surveys. Dental anxiety will be measured using the Turkish version of Corah's Dental Anxiety Scale (DAS), the most widely used psychometric instrument for measuring dental anxiety. The DAS was originally developed by Corah NL et al. [15].

The study aims to explore the level of dental anxiety among children aged 6-14 years, considering factors such as age, gender, and treatment status. Additionally, it investigates whether the preoperative use of AR can alleviate dental anxiety in this age group.

## MATERIALS AND METHODS

The present randomised controlled study was conducted at a private dental clinic in Bahcesehir, Istanbul, Turkey. The study duration was two months, from March 2021 to May 2021. The study included 511 paediatric dentistry patients (53.4% girls and 46.6% boys) aged between 6-14 years. Participants were selected using simple randomisation. The study protocol and all procedures were approved by the Ethics Committee of Bahcesehir University, Istanbul, Turkey before the start of the study (letter no. E-20021704-604.02.02-50236).

**Inclusion criteria:** Children between 6-14 years old, patients and parents who accepted and signed the informed consent, and those whose first language was Turkish.

**Exclusion criteria:** Participants who were already familiar with the application used in the study, participants with mental disorders, and those unable to comprehend the questionnaire.

### Study Procedure

A convenient sample of 525 patients was included in the study. One participant was excluded based on the exclusion criteria. All participants and their parents were informed about the objectives of the study, and an information sheet and consent form were provided before administering the questionnaires. Each participant approved the non-interventional consent form. A total of 13 participants who marked more than one option in the questionnaire or submitted incomplete answers were excluded from the study. Finally, data from the remaining 511 participants were analysed in the next phase. The questionnaire was divided into two sections: demographic questions and the DAS, both of which consisted of four questions [16].

The demographic details collected in this study included items such as gender, age, experience with AR, and frequency of dental visits. The Dental Anxiety Scale (DAS) primarily focused on the patient's subjective reactions to going to the dentist, waiting in the dentist's office, and anticipating procedures such as drilling and scaling. Participants were asked to rate their level of dental anxiety for each item on a scale ranging from 1 (not anxious) to 5 (extremely anxious), resulting in a possible score range of 4-20 for the DAS. Corah NL et al. reported that a DAS score of 13 or 14 indicates dental anxiety, while a score of 15 or higher represents a high level of anxiety [15]. In this study, dental anxiety levels were categorised as suggested by Corah NL et al. [15]. The DAS has a Cronbach's alpha value of 0.8, indicating high reliability [16].

The AR application used in this study was a mobile application created by Vivarra Dental, which offers customised AR solutions for public spaces such as museums, hospitals, and dental offices. The application can be downloaded from application stores and Google Play Store to mobile devices. It brings virtual characters to life using existing wall murals in dental offices, providing an interactive experience that includes jokes, games, and information on healthy habits and good hygiene practices, such as how to floss. The researchers purchased the application and downloaded it onto the dental clinic's tablet before the participant recruitment process. Sample collection took place during working hours over a period of three months.

Participants were randomly assigned to different groups based on their preoperative AR experience. The preoperative AR group was introduced to the AR application using the dental office's tablet. They were provided with instructions on how to use the application and given time to explore its features, including entertaining content such as AR adventures and educational information on topics like how to floss. After spending 20 to 30 minutes with the application, they were given the questionnaire to reassess their level of dental anxiety. On the other hand, the no preoperative AR group had no AR experience. Instead, they spent time with their families, played games with existing toys in the waiting room, or simply waited. They were also given the questionnaire again right before their treatment. The data was collected by a paedodontist, two orthodontists, two dental technicians, and a dental hygienist under the supervision of a pedagogue.

### STATISTICAL ANALYSIS

The data was analysed using the International Business Machines (IBM) Statistical Package for Social Sciences (SPSS) version 23.0.

The normal distribution of the data was evaluated using the Kolmogorov-Smirnov test. The Chi-square test was used to compare categorical variables between the groups. The Kruskal-Wallis test and Mann-Whitney U test were used to compare the non-normally distributed DAS scores between the groups.

### RESULTS

The control group included 134 females and 118 males, while the experimental group included 139 females and 120 males. The most frequent age category in the control group was 10-14 years (61.9%), followed by 8-10 years (19.04%) and 6-8 years (19.04%). Similarly, the most frequent age category in the experimental group was 10-14 years (42.9%), followed by 8-10 years (30.9%) and 6-8 years (26.3%) [Table/Fig-1]. There was no statistically significant difference in the distribution of AR experience by gender ( $p > 0.050$ ).

Variables	AR intervention		Test statistics	p-value
	Experimental group	Control group		
<b>Age (years)</b>				
6-8	68 (26.3) <sup>a</sup>	48 (19) <sup>a</sup>	$\chi^2 \chi^2 = 18.940$	<0.001
8-10	80 (30.9) <sup>a</sup>	48 (19) <sup>p</sup>		
10-14	111 (42.9) <sup>a</sup>	156 (61.9) <sup>b</sup>		
<b>Gender</b>				
Female	139 (53.7)	134 (53.2)	$\chi^2 \chi^2 = 0.012$	0.911
Male	120 (46.3)	118 (46.8)		
<b>Frequency of dental visits</b>				
First time	114 (44) <sup>a</sup>	94 (37.3) <sup>b</sup>	$\chi^2 \chi^2 = 9.978$	0.007
Sometimes	33 (12.7) <sup>a</sup>	59 (23.4) <sup>a</sup>		
Always	112 (43.2) <sup>a</sup>	99 (39.3) <sup>a</sup>		

**[Table/Fig-1]:** Distribution of samples according to demographic characteristics.  $\chi^2$ : Chi-square test. <sup>a</sup><sup>b</sup>: no significant difference between variables with the same letters

To further ensure randomisation, all participants were given the questionnaire prior to any intervention. There was no significant difference in DAS scores between the control group (M=10.5, SD=4.9) and the experimental group (M=10.7, SD=4.2);  $t(51) = -683$ ,  $p$ -value=0.49, as shown in [Table/Fig-2]. The magnitude of the t-value, which is large in this case, suggests a substantial difference between the groups. However, it is important to note the p-value of 0.49 indicates that, this observed difference is not statistically significant at the conventional alpha level of 0.05.

Variables	DAS score Mean±SD		p-value
	Experimental group	Control group	
Baseline	10.7±4.2	10.5±4.9	0.49
Postintervention	7.3±3.2	10.5±4.9	<0.001

**[Table/Fig-2]:** Comparison of DAS scores before and after intervention between experimental and control group.

The results regarding the post-intervention DAS scores in relation to age, frequency of dental visits, and AR experience are presented in [Table/Fig-3]. The median values of the DAS scores differed based on age ( $p < 0.001$ ). The mean score was least in the children of age group 10-14 years and highest among 6-8 years of age. The mean value of the DAS score also differed based on the presence of preoperative AR experience ( $p < 0.001$ ). The score was significantly lower in children who were exposed to AR. Additionally, the score was lowest in those who made frequent visits to dental offices. The median value of the DAS score did not differ based on gender ( $p = 0.111$ ). As the age of the patient increased, the level of anxiety decreased. Similarly, as the frequency of treatment increased, the level of dental anxiety decreased. However, gender did not have any effect on the level of dental anxiety.

Variables	DAS score		Test statistics	p-value
	Mean±SD	Median (minimum-maximum)		
<b>Age (years)</b>				
6-8	10.2±4.4	10 (4-20) <sup>a</sup>	$\chi^2=\chi^2=19.317$	<0.001
8-10	8.9±4.4	7 (4-20) <sup>ab</sup>		
10-14	8.2±4.3	6 (4-20) <sup>b</sup>		
<b>Gender</b>				
Female	8.5±4.3	7 (4-20)	U=29846	0.111
Male	9.2±4.6	8 (4-20)		
<b>AR intervention</b>				
Yes	7.3±3.2	6 (4-18)	U=44525	<0.001
No	10.5±4.9	10 (4-20)		
<b>Frequency of dental visits</b>				
First time	10.5±4.6	10 (4-20) <sup>b</sup>	$\chi^2=\chi^2=35.687$	<0.001
Sometimes	9.2±4.2	8 (4-20) <sup>b</sup>		
Always	7.8±4.4	6 (4-20) <sup>a</sup>		

**[Table/Fig-3]:** Comparison of DAS scores after intervention in terms of age, gender, AR experience and frequency of dental visits.  $\chi^2$ : Kruskal-Wallis test; U: Mann-Whitney test U; <sup>a,b</sup>: no significant differences between the variables with same letters

## DISCUSSION

The aim of the study was to explore the level of dental anxiety among children aged 6-14 based on age, gender, and treatment status, and to investigate whether preoperative use of AR can alleviate dental anxiety in this age group. The post-survey results showed that paediatric patients who received AR intervention had significantly lower levels of dental anxiety compared to those who did not receive AR intervention ( $p<0.001$ ).

Regarding the age factor, there is an ongoing debate on its association with the development of dental fear. Some authors argue that fear scores decrease with age, while others have found a significant increase in dental fear with age. However, there are also studies indicating no association between dental fear and age. In the present study, it was observed that the level of dental anxiety decreases with increasing age among children aged 6-14 years.

Although many studies suggest that girls report higher dental anxiety scores compared to boys, some studies have found no association between gender and dental anxiety. Similarly, no significant difference in dental anxiety levels related to gender was found in the present study. This trend is consistent with the findings of other studies investigating the relationship between gender and dental fear in children aged 6-12 years.

It appears from the literature that there has not yet been a study investigating the use and efficacy of AR as a factor in relieving children's dental anxiety. However, studies on the use of VR in reducing dental anxiety in children have shown that VR distraction can effectively decrease pain perception, anxiety, and stress levels during routine dental treatment. Nevertheless, some contradictory results have also emerged, with a study finding that VR distraction was ineffective in decreasing anxiety levels in children undergoing invasive dental procedures.

The results of the present study demonstrated that AR applications offer enhanced opportunities to manage dental anxiety among children aged 6-14 years. The study highlighted the significant effect of AR on preoperative control of dental anxiety. The authors suggested that AR applications are of increasing importance in reducing dental anxiety and should be incorporated into dental clinics as a distraction technique. These distraction techniques are based on the gate control theory of pain, where the interpretation and intensity of pain signals can be altered through sensory and emotional components, which AR technology can provide. Thus, AR can be a promising tool for complex procedures and can

help deliver safe and entertaining therapeutic experiences while controlling dental anxiety in paediatric patients.

One limitation of the current study is the recruitment of participants with similar socioeconomic backgrounds and similar reasons for visiting the dental office. This may have influenced the results by potentially affecting the variables studied. Another limitation is the paucity of available literature on the use of AR in healthcare settings, which prevents the study from making definitive conclusions about the common knowledge and effectiveness of AR applications in relieving dental anxiety in paediatric patients.

## CONCLUSION(S)

The present study provides initial encouraging support for the use of AR as a technique to control fear and anxiety during dental procedures. The study concluded that paediatric patients who received preoperative AR intervention had significantly lower levels of dental anxiety compared to those without intervention. AR is a promising tool that has been underutilised in anxiety-relieving techniques for paediatric patients. The use of AR applications in dentistry, even with just a tablet, has shown effectiveness in distraction. Further empirical research is needed to determine whether AR can become a viable method for fear and anxiety control during dental treatments. Techniques that are effective in treating dental pain are likely to be effective for other painful procedures as well. Future research should continue to focus on the use and role of various AR procedures in managing dental anxiety in routine clinical practice.

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