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Is Virtual Reality Exposure Therapy the Future Treatment for Anxious Dental Patients?

Kumar Raghav Gujjar, BDS, MDS, and Ad de Jongh, PhD

ABSTRACT Virtual reality exposure therapy (VRET) is a promising modality for the treatment of anxiety disorders. The aim of this paper is to acquaint the reader with the application of VRET within the general dental practice. We present two case reports of successful use of VRET in the treatment of dental phobia of an adult and a pediatric patient. The essential setup, advantages and limitations for using VRET in a general dental practice are described and discussed.

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Conflict of Interest
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Conflict of Interest
Disclosure: None reported.

Fear of dental treatment is very common.¹⁻⁴ It is estimated that as many as 75% of U.S. adults experience dental fear ranging from mild to severe.^{5,6} In the U.K., 15% of adults suffer from extreme dental fear.⁷ Dental phobia, the severe form of dental fear that entails a set of diagnostic criteria as defined by DSM-5, has been found to be the most common type of phobia (about 4%) in the general population, followed by height phobia and spider phobia.¹

Research has consistently demonstrated that dental fears and phobias result in reduced dental visits,⁸ poor oral health⁹ and reduced quality of life.¹⁰ People who display apprehension to undergoing dental treatment often find themselves caught in a vicious cycle of avoidance. Dental fear makes people avoid dental care until they are confronted with a dental emergency requiring invasive treatment that further reinforces their fear of dental objects and situations.^{11,12}

Dental phobia and related avoidance of dental care are significant problems for both patients and the dental professional. Treatment of patients with this condition may be more time consuming as they are difficult to manage during treatment session and are likely to be dissatisfied with the treatment they receive.¹³ Adequate management of distress and fear associated with dentistry is important as it can enhance the overall treatment experience of both patient and dentist by reducing patients' perceived pain and unpleasantness¹⁴ and by enabling the dentist to work effectively and efficiently.¹⁵

Treatment of Dental Phobia

There is broad consensus that those experiencing dental fear and phobia benefit from cognitive behavioral therapy- (CBT)¹⁶⁻¹⁸ based interventions. The standard procedure advocated for management of dental phobia is in vivo exposure therapy that involves systematic

and repeated encounters of patients with situations that cause anxiety (e.g., an injection needle or the sound of the drill).^{18,19} However, in vivo exposure therapy is often difficult to administer as phobic patients are reluctant to face the threat. It has been widely reported that when patients realize that the exposure therapy entails facing the threat (in this case dental treatment), about 25% of them either refuse the therapy or terminate it.²⁰ Consequently, a significant number of individuals fail to achieve clinically significant symptom relief or experience a return of fear following exposure therapy.²¹ Even delivery of appropriate therapy for dental phobia may not be feasible or affordable as psychological services for dentally anxious patients are scarce²² and treatment costs are high.²³ Also, not all general dentists have time or the training to provide CBT. Pharmacological interventions such as intravenous sedation and general anesthesia frequently advised in cases of dental phobia do not extinguish the fear response in the long term, resulting in maintenance of avoidance of dental situations.²⁴

During the last decade, several technology-based interventions such as Computer-Assisted Relaxation and Learning (CARL),²⁵ computerized-CBT (C-CBT)²⁶ and virtual reality exposure therapy (VRET)^{27,28} have been developed to help alleviate patients' dental anxiety. CARL is a computer-based exposure therapy that trains the patient in relaxation, distraction and enhancement of their self-efficacy. This program is designed to first run in an in vitro mode followed by an in vivo mode. The in vitro mode involves computer-controlled, hierarchical exposure to videotaped scenes of the injection procedure, while the in vivo mode involves exposing patients to a hierarchy of a real-life injection procedure. C-CBT involves computerized psychoeducation,



FIGURE 1. Showing the VRET device.

motivational interviewing and fear reduction via exposure to videos of patients' fear-eliciting stimuli. However, both CARL and C-CBT have drawbacks, such as not being engaging enough due to their video-based formats and possible reluctance of phobic patients to face needles in real life in the case of CARL's in vivo mode.²⁰ VRET does not involve making the patient face real-life threats or view videos passively and could address the limitations of CARL and C-CBT. Further, VRET allows exposure to be carried out in multiple dental contexts (e.g., diagnostic instruments, syringe and dental drills) while being both less invasive and more immersive for the patients.

VRET

According to the dictionary, virtual reality (VR) is an "artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer."²⁹ Using VR for treatment of phobias involves controlled exposure of phobic patients to the virtual sights and sounds of their fear-provoking stimuli. VRET integrates real-time computer graphics and body-tracking devices to systematically expose patients to an immersive, interactive and highly controllable computer-generated virtual environment with rich sensory visual, olfactory and auditory cues³⁰ within a

contextually relevant setting.³¹ From a theoretical perspective, the suggested VRET mechanism embodies the mechanism of traditional exposure therapy wherein emotional processing is facilitated by activation of the underlying fear structure through controlled confrontations with individuals' feared (i.e., conditioned) stimuli in absence of an aversive event in a therapeutic setting until extinction occurs.³⁰ For VRET to be effective, patients should feel engaged and perceive themselves to be physically present and interacting in the virtual world. Thus, presence is assumed to be an important mediating variable between the VR media and the level of the anxiety induced.³²

The rich, multisensory VRET is effective in the treatment of several specific phobia subtypes, including flying phobia, arachnophobia, height phobia, driving phobia and dental phobia.^{27,30,33,34} In fact, results of five independent meta-analyses show that VRET is effective in reducing symptoms of anxiety-related disorders.^{31,35-38} Furthermore, there is evidence suggesting that VRET is slightly, but significantly, more effective than in vivo exposure therapy in the treatment of specific phobias.³⁷

The purpose of this paper is to present two unique cases and discuss the use, the potential advantages and limitations of

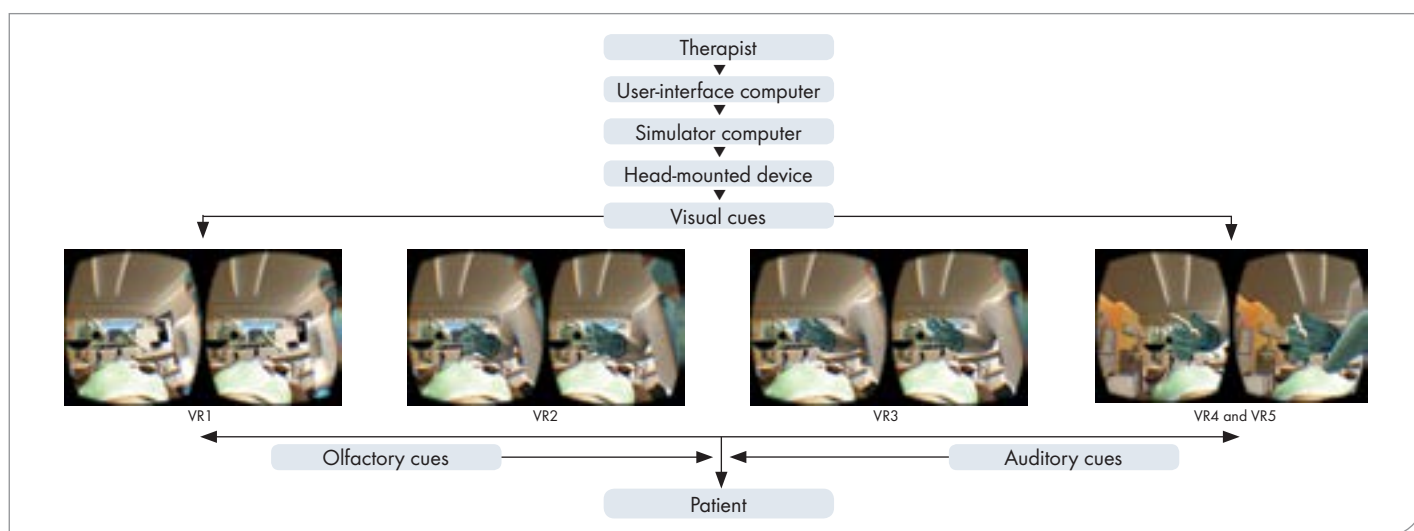


FIGURE 2. Showing the pictorial representation of the VRET setup.

VRET within the context of general dental practice. We have conducted pioneering research examining the potential of VRET in the treatment of dental phobia. Results of our studies (a multiple baseline feasibility study²⁷ and RCT³⁴) show that VRET is associated with a significant reduction in both state and dental trait anxiety scores and an improvement in dental treatment acceptance compared to the study control condition. Although VRET has shown promising results in the treatment of dental phobia in our earlier studies,^{27,28,34} it should be noted that we only tested VRET among adults in a single session. Because multiple VRET sessions generally yield larger effect sizes,³⁷ we present the first findings about the applicability of VRET in an adult patient with severe dental phobia. Furthermore, we present the results of our first case in a pediatric patient with dental phobia who underwent a single VRET session. However, as VRET is a novel technique, we first describe the VRET setup.

VRET Setup

The VRET device consists of a user-interface computer, a simulator computer and a head-mounted device (HMD) as shown in **FIGURE 1**. A simulator computer systematically exposes the patient to a virtual dental environment by displaying a 3D stereoscopic scene

through the HMD worn by the patient. The virtual dental environment is comprised of a simulated dental operator with a dental chair, overhead light, dental instruments and a virtual dentist. Patients see their virtual counterpart (torso and legs as seen by ourselves when sitting in a dental chair) in first person and the entire dental operator through the HMD when they turn their heads around to look. The VRET operator (e.g., general dentist/therapist) watches and controls what the patients observe in the virtual dental environment with a user-interface computer. Patients undergoing VRET with our current VRET device receive standardized step-wise exposure to the following hierarchy of virtual dental scenarios:

- VR1 — Sitting in the dental chair and looking around the dental operator surrounded with instruments and a virtual dentist on the right-hand side.
- VR2 — Virtual dentist moves with a dental mirror toward the patient seemingly to do an oral examination.
- VR3 — Virtual dentist carries a dental syringe toward the patient.
- VR4 — Virtual dentist carries a dental drill (with no sound) toward the patient.

- VR5 — Virtual dentist carries a dental drill (with sound) toward the patient.

Patients are encouraged to keep their mouths open during scenarios VR2 through VR5. During the session, patients are requested to focus on their fear-eliciting stimuli and to describe any strange sensations or feelings. They are asked to rate their level of distress on the Subjective Unit of Distress Score (SUDS) ranging from 0 to 10 where 0 is “no discomfort” and 10 is “the worst distress experienced.”³⁹ Each scenario is repeatedly presented to the patient until an SUDS of ≤ 2 is achieved, after which the next scenario is presented. Patients undergo exposure at their own pace and the duration of VRET is flexible based on the ability of patients to confront all the VR scenarios in a single visit. For instance, if they feel overwhelmed due to fear during the first session, they are scheduled another appointment for an additional VRET session and the exposure starts again with the first scenario (VR1). Additional VRET sessions are conducted until the patient confronts all VR scenarios (VR1–VR5) in a single session. **FIGURE 2** shows the pictorial representation of the VRET setup.

TABLE 1

Description of Outcome Measures

Measure	Description
Visual analogue scale for anxiety ⁴⁰	VAS-A is a simple, fast and valid tool used for assessing state dental anxiety. It is recorded by asking the patients to draw an X on a 0–100 mm scale from totally calm and relaxed (0) to worst fear imaginable (100).
Modified Dental Anxiety Scale ⁴¹	MDAS is a five-item scale assessing anticipatory dental anxiety, fear of dental cleanings, drilling and injections on a 5-point Likert scale. The possible scores range from 5 to 25, with greater scores indicating higher levels of dental anxiety.
Dental Fear Survey ⁴²	DFS is a 20-item measure to identify the patient's emotional and physiological reactions associated with dentistry as well as avoidance of dental care. Possible scores range from 20 to 100, with greater scores indicating higher levels of dental anxiety.
Behavioral Avoidance Test ⁴³	In this test, the patient is evaluated by observing the behavior of and interviewing the patient before and after intervention. The test includes five situational steps that occur during a routine dental visit (e.g., sitting in the dental chair, inspection of the oral cavity using two dental mirrors, approaching dental syringe, approaching dental drill without sound and approaching dental drill with sound). The approaching steps of the patient toward their fearful stimuli (similar to VRET stimuli) are evaluated and compared before and after intervention. Also, the anxiety state of the patient is measured on a scale of 0–10 in each situation and compared before and after intervention. To measure whether the patient is able to tolerate the situations, the number of steps completed and the state anxiety scores are noted.
VR experience ⁴⁴	*Presence, realism and cybersickness (severity of nausea) were measured with an 11-point verbal rating scale.

*0 = No presence, realism and cybersickness

1–3 = Mild presence, realism and cybersickness

4–6 = Moderate presence, realism and cybersickness

7–9 = Strong presence, realism and cybersickness

10 = Profound presence, realism and cybersickness

Case Studies

The two case studies that we describe here were conducted at SEGi Oral Health Centre in Kota Damansara, Malaysia. To examine the effectiveness of the treatment, patients first received a detailed explanation about VRET and signed an informed consent form. Their baseline state anxiety was measured using the visual analogue scale (VAS-A)⁴⁰ while their dental trait anxiety scores were indexed using both the Modified Dental Anxiety Scale (MDAS)⁴¹ and the Dental Fear Survey (DFS).⁴² Both patients were assessed for the presence of dental phobia using the phobia checklist criteria¹ created by the author KRG. The phobia checklist is made up of four questions based on the DSM-IV-TR with a sensitivity of 0.95, specificity of 0.99 and an overall hit rate of 97%. During the phobia checklist interview, patients are asked to respond yes or no to the following questions related to their dental anxiety:

- Does the sight of the feared object or experiencing the situation evoke an excessive fear response?
- Is the fear greater than justified?
- Is there avoidance or giving up things because of the fear?

- Does avoidance of the situation or object cause daily impairment?

An individual is diagnosed as dental phobic only upon answering yes to all four questions of the phobia checklist.

A behavioral avoidance test (BAT)⁴³ was performed before and after the final VRET session. This involved standardized observation of behavior and an interview to determine avoidance toward five different commonly encountered dental situations (i.e., sitting in the dental chair, inspection of the oral cavity using two dental mirrors, approaching dental syringe, approaching dental drill without sound and approaching dental drill with sound). After the BAT, patients' self-reported state anxiety (VAS-A) and dental trait anxiety (MDAS and DFS) were recorded. The VRET session was planned to be conducted in a single session; however, if it was deemed that a patient required additional VRET sessions, the postintervention state and dental trait anxiety questionnaires (VAS-A, MDAS and DFS) and BAT were administered at the end of the last VRET session. The VR experience (presence, realism

and cybersickness) of the patients was evaluated with an 11-point Verbal Rating Scale (VRS)⁴⁴ after the final VRET session. See **TABLE 1** for a detailed description of outcome measures that could be used for VRET.

Alia

Alia (pseudonym), a 40-year-old Pakistani female patient, reported to SEGi Oral Health Centre with a history of repeated dental avoidance and self-reported dental fear. She reported that her first negative dental event occurred approximately 13 years prior when she had to undergo root canal treatment on one of her molars. She recollected being terrified of the syringe, the dental drill and the endodontic files that were used during her appointment. She recalled that when she cried out in pain, the dentist admonished her, dismissed her fear and told her to be brave. Alia reported that after this traumatic appointment she often visualized the distressing events, resulting in her avoiding visiting the dentist for prolonged periods of time. The second negative dental experience occurred four years prior

TABLE 2

Pre-VRET and Post-VRET Scores of Behavioral Avoidance Test

Behavior test	Alia		Claire	
	Pre-VRET	Post-VRET	Pre-VRET	Post-VRET
Sitting in the chair	3	0	6	1
Mouth mirror	4	0	6	2
Syringe	10	2	10	2
Drill with no sound	8	1	9	2
Drill with sound	10	1	10	2

when she visited another dentist for a dental extraction. This time she tried deep-breathing techniques to distract herself but to no avail. She repeatedly asked the dentist to be gentle and told them that she was afraid of injections. However, the dentist did not consider her plea and she continued to feel helpless throughout the extraction procedure. When Alia reported for treatment at SEGi Oral Health Centre, she complained about a painful lower right molar. Her baseline state and dental trait anxiety scores were high (VAS-A = 75, MDAS = 25 and DFS = 92). A number of her teeth required extractions. Upon evaluation of the phobia checklist criteria,¹ a diagnosis of dental phobia was confirmed. After receiving a detailed explanation about VRET, Alia signed the consent form after which she underwent three VRET sessions. The total duration of the VRET over three sessions was 47 minutes. During the first VRET session, Alia only tolerated VR1 to VR3 scenarios, during which she constantly gripped the arms of the dental chair and reported experiencing intrusive images from previous traumatic dental experiences, muscle stiffness and numbness in the lower jaw upon watching the syringe scenario (VR3). In the second session, Alia was able to tolerate VR1 to VR3 scenarios and felt less muscle stiffness and numbness in the lower jaw with the syringe scenario (VR3) compared to the first VRET

session. In the third VRET session, she successfully completed all VR (VR1–VR5) scenarios without signs of fear (e.g., gripping the arms of the dental chair) and reported no intrusive memories about her past traumatic dental experience and no muscle stiffness and numbness in the lower jaw with the syringe scenario (VR3). She experienced strong presence and realism and no cybersickness (nausea) after completion of the VRET sessions. After the last VRET session, Alia expressed that she felt confident that in the future she would be able to face all injections and dental instruments. Her VAS-A, MDAS and DFS scores decreased to 10, 8 and 25 respectively. Further, there was reduction in behavioral avoidance as seen in **TABLE 2**. Within six months, Alia scheduled her dental appointment and underwent dental treatment including scaling, extractions and multiple restorations. At the six-month follow-up, the VAS-A (20), MDAS (12) and DFS (41) scores were found to be reduced relative to the baseline and Alia had no dental phobia, according to the phobia checklist.

Claire

Claire (pseudonym), a 10-year-old female child, reported with dental fear that had begun three years prior when she underwent dental extraction of one of her lower back deciduous teeth. She reported that the procedure was very painful and that she had continuously

cried throughout the procedure. The dentist, who was rude to her, did not acknowledge her pain and consequently did not take measures to manage her pain. Claire indicated that she was scared of dentists and hid at home when her parents wanted to take her to the dentist. When Claire first visited our dental practice, her baseline state and dental trait anxiety scores were VAS-A = 50, MDAS = 20 and DFS = 65, respectively. She required scaling and restorations on a few of her teeth. A diagnosis of dental phobia was confirmed after evaluation with phobia checklist criteria.¹ Claire underwent a single VRET session for a duration of 23 minutes. She fidgeted, shivered and was constantly rubbing her closed hands as the exposure unfolded to higher levels of anxiety-provoking stimuli. A reduction in SUDS scores (≤ 2) was noted with all VR scenarios in a single session. Post-VRET her VAS-A, MDAS and DFS scores reduced to 40, 14 and 45. Also, there was improvement in her behavioral avoidance, as shown in **TABLE 2**. Further, Claire experienced strong presence and realism and no cybersickness after VRET. Within six months, she underwent scaling and restorations of her teeth. At the six-month follow-up, lowered VAS-A (25), MDAS (11) and DFS (35) scores were maintained and Claire no longer fulfilled the diagnostic criteria of dental phobia.

Discussion

The cases described in this paper are the first in dental literature that have explored the applicability of VRET in an adult patient with severe dental phobia using multiple VRET sessions and the usability of VRET in a pediatric dental

TABLE 3

Clinical Tips for General Dental Practitioners That Could Be Helpful While Carrying Out VRET

- VR setup requires a spacious area to work freely.
- The dentist needs to pay attention to establishing rapport and a good working alliance with the patient.
- To enhance immersion, a characteristic odor (drops of clove oil on cotton wool) of the dental operatory could be used.
- The head-mounted device (HMD) could be bulky for the patient. It would be good to use a neck pillow (with a disposable cover) so that the neck is supported, adding to the comfort when the patient is seated in the dental chair with HMD.
- The surface of HMD could be cleaned with antiseptic wipes and covered with disposable plastic covers or cling wraps between patients.
- To familiarize the patient prior to VRET, allow the patient to watch the VR environment for two minutes.
- Provide 10-minute breaks to prevent cybersickness.
- Be cautious that the introduction of the stimuli is gradual and that the patient does not feel overwhelmed.
- After the VRET session, allow the patient to remain seated for at least 15 minutes so that they can adapt to the real world.

phobic patient. Our earlier case study²⁸ and feasibility study²⁷ tested the effects of a single VRET session on adult patients with dental phobia. In the present report, VRET resulted in noteworthy reductions in state anxiety, dental trait anxiety and behavioral avoidance. The self-reported measures were validated by patients' behavioral changes when they scheduled their dental appointments and underwent dental treatment.³⁶ In addition, both patients had no dental phobia at the six-month follow-up.

VRET's Relevance for General Dental Practice

There are several advantages that might make VRET an enticing alternative treatment modality for dental phobia. It can be specifically tailored to apply exposure treatment more ecologically and effectively.³³ In individuals who are reluctant to confront the real threat as in in vivo exposure therapy, VRET could be used as a first step in the exposure hierarchy.⁴⁵ It is flexible as the exposure can be easily controlled by the therapist.^{30,46,47} The sense of security and lack of embarrassment that VRET offers to

the patients can enable them to freely express their thoughts and feelings, which otherwise could be difficult to express explicitly upon confronting the real-life situations.^{48,49} To this end, VRET may improve the relationship between the general dentist and patient. Furthermore, the safe, protected, realistic and controlled exposure may make this therapy invaluable for use in children and in individuals with special health care needs who cannot undergo exposure in real life situations due to mental and physical disabilities. Moreover, VRET could be cost effective as the exposure can be repeated as many times as needed.⁴⁸ **TABLE 3** has clinical tips for the use of VRET by the general dental practitioner.

Limitations of VRET

Some limitations of VRET are worth noting. Firstly, the initial cost involved for the VRET setup and the development of software may be relatively high (around \$10,000). However, in recent years, there appears to be a dramatic reduction in the cost of VR technology. For instance, today a wide variety of smartphones support

VR, and the therapy could easily be administered using inexpensive Google cardboard glasses (costing \$15 or less). Also, there have been unprecedented improvements in computer technology, such as inexpensive memory, low-cost, faster graphic accelerators as well as better quality of VR in terms of better graphics and more realistic VR environments. Rapid development in VR has led to speculations that the number of VR users was going to increase by 400% by the end of 2018.⁵⁰ Secondly, treatment providers would need additional training to run the VRET software. However, due to technological advancements, current VRET software and devices are user-friendly and easy to master. Thirdly, some patients may experience cybersickness during and post-VRET.^{27,28} Cybersickness could be limited to some extent by increasing the frequency of breaks during VRET²⁷ or by using medication.²⁷

It should be noted that there is more to being successful with behavioral-based applications such as VRET than simply confronting the patient with fearful scenes. In general practice, psychologists and dentists with a cognitive behavioral background should be involved to carefully screen patients for their appropriateness to undergo therapy, assess the patient to select the appropriate fear-eliciting stimuli for the treatment, titrate the exposure to the feared stimulus and monitor and provide support to the patient undergoing the procedure, among other interventions. In addition, there are nonspecific factors (i.e., those associated with the relationship with the dentist or therapist) that may contribute to what is needed for a successful outcome. Therefore, it is conceivable that not all dental patients (and probably not all dentists) are

appropriate candidates for the use of this type of intervention. In line with this, it could be argued that without paying attention to these issues, for instance, if the VR experience is too overwhelming, the treatment may be ineffective or even potentially harmful. However, despite these seemingly important factors, it is interesting to note that there is mounting evidence showing that the standard VRET applications have become an effective alternative and, with regard to efficacy, comparable to the results of traditional treatments for phobias.³³ Yet, in certain more severe cases, dental professionals need to work collaboratively with mental health professionals in using these technologies or to assess whether individuals with, for instance, a psychiatric background and/or a history of childhood trauma may be too vulnerable to undergo VRET and need expert help. In other words, in such instances specialized forms of psychotherapy (e.g., EMDR⁴³) might be a more appropriate option to reduce patients' burdens of phobic fear and comorbid mental health problems.

Conclusion

Multiple VRET sessions in an adult patient and a single VRET session in a pediatric patient successfully treated their dental phobia. This is in line with our previous clinical experiences with the use of VRET and results of our research that support the safety and efficacy of VRET in the treatment of dental phobia.^{27,28,34} The use of VRET in children and other populations, including individuals with intellectual disabilities, needs to be explored further using controlled studies, however, sufficient preliminary evidence exists for general dentists to explore VRET in their dental practice. ■

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