MENTORS IN ORTHOPEDICS

# IMMERSIVE VIRTUAL REALITY TO POTENTIATE HYPNOSIS: AN INNOVATIVE AND POWERFUL APPROACH TO SUPPORT SURGERY

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## SUMMARY

**Background:** Surgical patients frequently experience significant perioperative distress, with over 50% of hospitalized individuals reporting acute pain. Preoperative anxiety and intense postoperative pain are established risk factors for the development of chronic postsurgical pain, a phenomenon observed in orthopedic models such as total knee arthroplasty. While pharmacological analgesia remains the standard of care, its efficacy is often limited by adverse effects, financial costs, and the risk of dependency. Non-pharmacological interventions, specifically hypnosis, have demonstrated efficacy in modulating nociceptive processing but face implementation barriers, including the requirement for specialized clinician training and significant time investment.

**Objective:** This review evaluates the integration of immersive virtual reality (VR) with hypnotic techniques to manage perioperative anxiety and pain in surgical populations.

**Key Points:** VR facilitates high-level immersion through multisensory integration and sensorimotor correspondence, inducing a sense of presence that modulates cognitive perception. When combined with hypnosis, VR technology standardizes the delivery of therapeutic suggestions, reducing the cognitive load required for patients to achieve a dissociated state. Clinical applications include acute pain reduction during wound care, intravenous access, and orthopedic rehabilitation. The technology acts as an active distractor, potentially attenuating nociceptive stimuli via gate control mechanisms. However, limitations persist regarding technical complexity, equipment costs, and potential sensory dissonance in specific demographics, such as geriatric patients.

**Conclusion:** Virtual reality-assisted hypnosis represents a viable adjunctive strategy for mitigating perioperative distress. By automating hypnotic induction and enhancing patient immersion, this modality addresses traditional barriers to non-pharmacological pain management and may improve surgical outcomes through reduced stress-related complications.

## KEYWORDS

Virtual Reality; Hypnosis; Pain, Postoperative; Anxiety, Preoperative; Perioperative Care

## INTRODUCTION

Since it was first developed, virtual reality (VR) has been ceaselessly improving, advancing at an exponential rate over the past few years [1].

The earliest VR systems were based on concepts developed in cybernetics: an artificial system that is capable of intensifying sensory stimuli, removing the user from their real environment and placing them in an artificial one [2]. This perspective led to the quest for totally immersive systems that would be able to entirely encapsulate the human body and senses. Immersion is the point of entry into VR, providing the conditions to set the cognitive processes in motion. It is defined as the capacity of a VR system to create the perception in the user that they have been relocated into what is known as an immersive virtual environment [3]. This high-level immersion of the individual in the VR is made possible by multisensory integration [4], and the neurocognitive mechanisms underlying this are still being examined in cross-disciplinary studies in engineering and the cognitive sciences [5].

The surgical applications of VR are expanding rapidly. Some examples of these are dexterity training (technical skills), anatomy training and planning surgical procedures. Education and training currently appear to be the main fields of application for VR in surgery [6].

VR could also be used to offer more direct benefits to patients in surgery. In our current way of thinking, the success of surgery is too often focused on the surgeons and their ability to perform an intervention. However, beyond the intervention itself, the way in which patients respond to the intervention also has an impact on post-operative outcomes. The perception of the patient is an integral factor in the success of their care. When a patient becomes an active and involved partner their own care, they develop a sense of autonomy and self-determination, which plays a role in the patient becoming or remaining invested in self-management [7].

There are a growing number of studies that support the efficacy of hypnosis and hypnotic therapies in acute pain [8], chronic pain [9] and anxiety [10]. Unlike pharmacological management using analgesic medications for pain, which can incur significant financial costs (due to the need for continued usage), have unpleasant side effects and involve social costs (associated with issues of misappropriation), hypnosis interventions are relatively simple and low-cost to provide. There are numerous benefits, such as an improved sense of being able to control the pain and its impact, and feelings of well-being. The negative side effects are minor [11].

The purpose of this work, then, is to carry out a literature review to demonstrate the potential offered by the combination of virtual reality and hypnosis in the population of “surgical” patients, who are particularly vulnerable to stress and anxiety.

## STRESS AND ANXIETY IN SURGICAL PATIENTS

Patients admitted to hospital often feel physical, emotional and social distress, and this is exacerbated by a radical change to their lifestyle, the loss of their usual rights and privileges and a high prevalence of pain [12]. More than half of all patients admitted to hospital experience pain [13]. In order to take a rounded view of patient management, hospital clinicians need to consider not only the physical impact of the disease on their patient, but

also the psychological and social impact. However, the dynamic pace of hospital medicine, with the small amount of time available to dedicate to each patient, is an obstacle to offering holistic care to hospitalised patients.

Over 230 million people globally undergo an operation every year, and this figure is continually on the rise [14].

Pre-operative anxiety is a common phenomenon in patients waiting to have surgery [15]. This anxiety can be a contributing factor to a sense of discomfort throughout the whole peri operative process [16]. Individuals who are preparing for an operation often feel less sure of themselves, as well as being tense and stressed, because they believe that they are in an unpredictable situation [17]. The operation itself and being under general anaesthesia represent two of the most anxiogenic events in the patient's life [18], and are characterised by three separate negative components: fear of the unknown, the idea of being ill and the possibility of the end of life [19].

However, the clinical management of pain after an operation is far from being a success, in spite of a dramatic expansion in scientific studies in this field. Many patients suffer from intense pain after a surgical intervention [20]. A state of anxiety before the operation, a tendency to amplify pain and the acute pain experienced in the days after the operation are all factors that increase the risk of suffering from chronic pain three months after the operation, irrespective of the type of surgical intervention [21]. Post-operative pain is a complex and specific issue that requires an effective treatment to reduce suffering, prevent complications and encourage recovery and rehabilitation [22]. Adequate pain relief offers access to quicker rehabilitation, earlier mobilisation, greater patient satisfaction and a faster discharge from hospital [23].

The patient's pain is usually managed by analgesic mediations. However, there are currently strong arguments for and a growing interest in developing complementary non-pharmacological strategies for pain management. One such approach is hypnosis in virtual reality, an innovative technique that involves delivering hypnotherapy to patients, inducing "a state of consciousness that implies focalised attention and reduced peripheral consciousness" [24] and combining this with VR, which is a computer-generated environment that immerses the user in an artificial world.

## HYPNOSYS

Hypnosis has existed in western societies for at least 200 years. It is a psychotherapy technique that places major significance on the notion of presence [25].

In hospital, hypnosis is used to achieve a specific therapeutic objective. It involves inducing, through spoken prompts, a state of consciousness that is modified or "dissociated". In this state, attention is focused and the patient becomes more receptive to suggestions (Figure 1 A, b). Hypnotherapy makes use of this unique state of consciousness to guide and assist the patient in changing their perceptions of pain or negative states, such as anxiety.

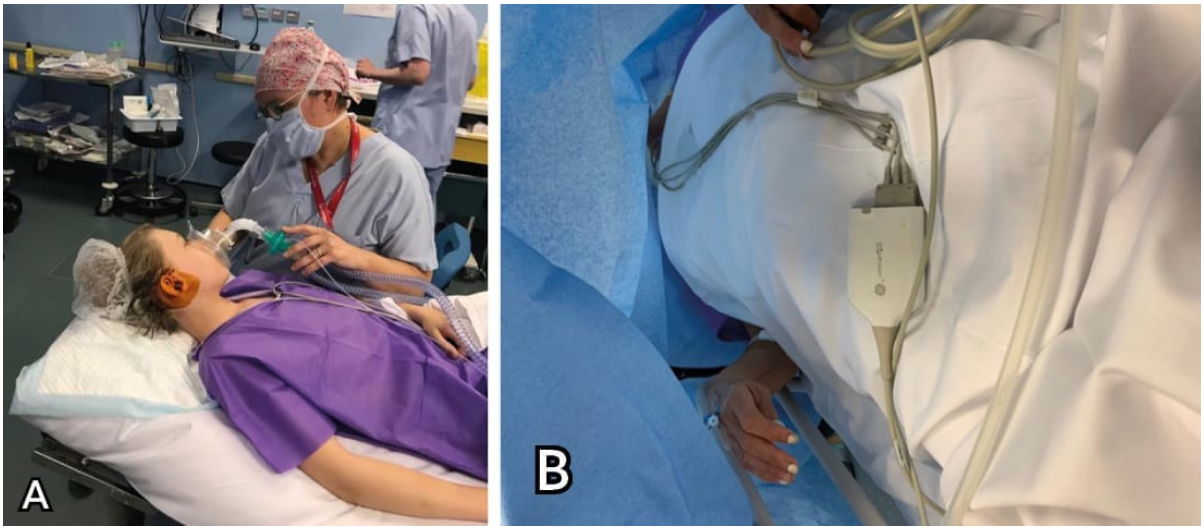


Figure 1: A. Hypnosis session in the operating theatre for an otoplasty patient. B. Patient in the operating theatre in a dissociated state lifting her hands in response to a prompt during surgery to her head.

A hypnotic state, sometimes called a trance, is often defined as a spontaneous or induced state of consciousness, with the attention focused on something important, combined with reduced peripheral consciousness [26]. An individual in a trance also has an increased capacity to respond to suggestions [26]. These suggestions may lead to changes in the sensations, perceptions, emotions, thoughts and behaviours of the patient [27]. An individual who responds to suggestions under hypnosis is often referred to as hypnotisable. To make the patient more receptive to suggestions, the therapist can help them to enter into a trance state by using specific techniques (prompts), such as fixing the eyes on a point, gradually relaxing the muscles or guided imagery [27] and, more recently, through VR.

## VIRTUAL REALITY

The idea of immersing a human being in a virtual environment is difficult to date, but the American film director Morton Heilig was one of the first to attempt to put it into practice. In 1955, he designed a multisensory system intended to give the experience of being “in the movie”. Seven years later, he presented a working prototype, the Sensorama. The Sensorama experience simulated a motorcycle ride through an urban environment. This electromechanical system looked like an arcade game. It consisted of a chair that vibrated to simulate movements, a stereoscopic screen with a wide-angle view and stereo speakers. It included a fan to recreate the effect of the wind and scents were released to replicate the smell of motorbike exhaust. However, investors were not convinced by the Sensorama and it never made it on to the market (Figure 2).

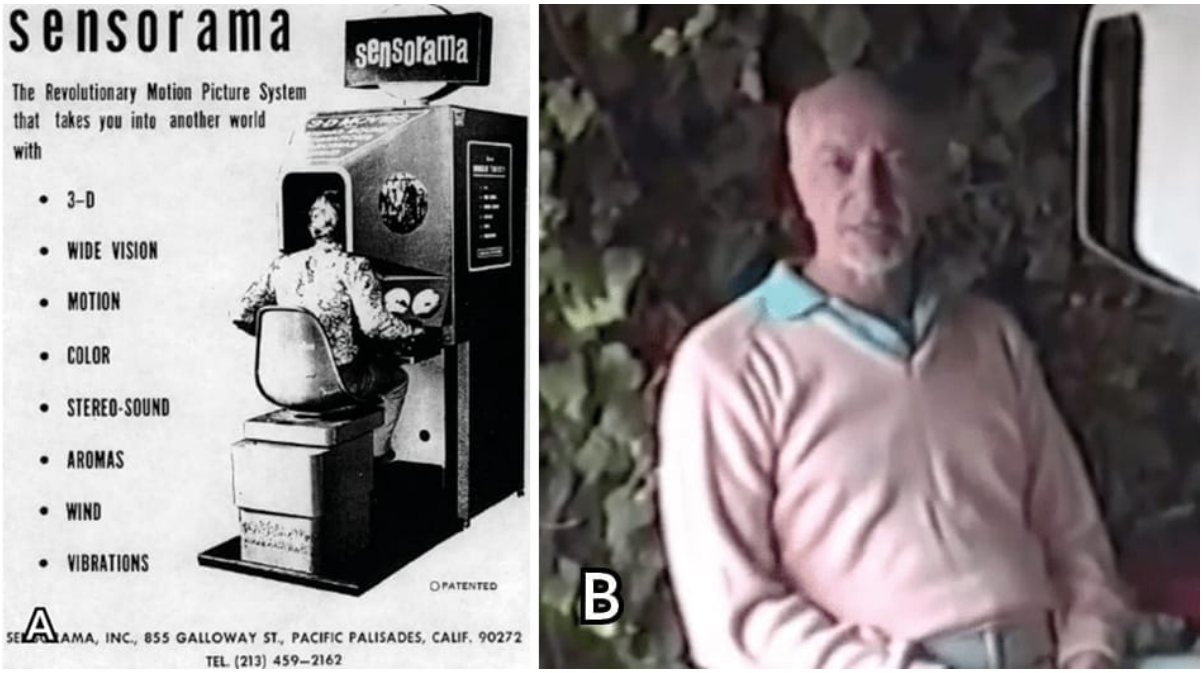


Figure 2: A. A poster for Sensorama B. Photo of its inventor Morton Heilig (1955).

The term “Virtual Reality” was coined in the mid-1980s by Jaron Lanier, the founder of VPL Research, a computer hardware company that had started to develop equipment specifically for virtual reality, such as glasses and gloves.

The years 1980 and 1989 marked a golden age in this field. Advances in optic devices went hand in hand with projects for haptic systems and other instruments that allowed the user to experience the virtual space. At NASA’s Ames research centre, one example developed in the mid-1980s was the Virtual Interface Environment Workstation (VIEW) (Figure 3), combining a head-mounted device and gloves to enable haptic interaction.


Figure 3: Workstation with a virtual interface

Today's virtual reality equipment owes a great deal to the pioneering inventors of the past six decades, who paved the way for the high quality and low-cost devices that are easy to find in the current market. Since it was first developed over 50 years ago, virtual reality has been continually improving, advancing at an exponential rate over the past few years (Figure 4).

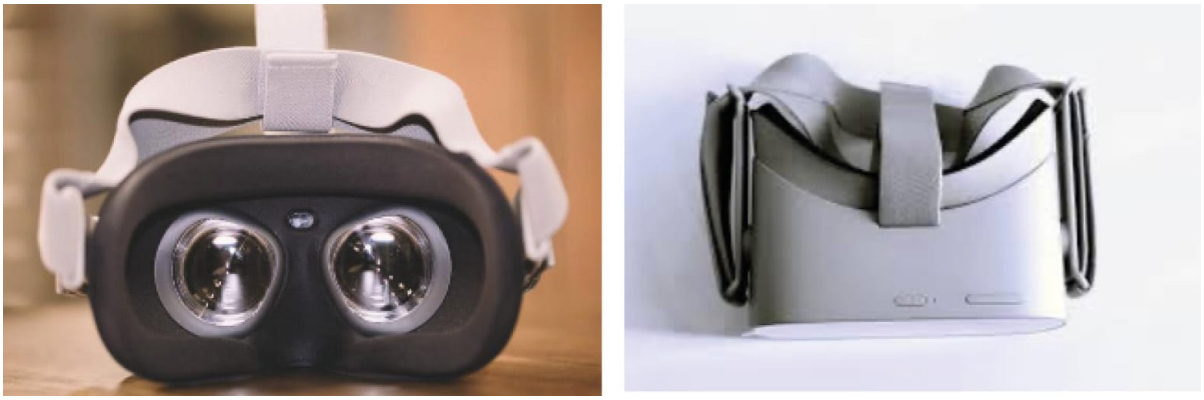

Figure 4: Virtual reality headset 2020

## Immersion, a sense of presence and embodiment: the process of Virtual Reality

Virtual reality (VR) is generating a growing interest because of its outstanding ability to immerse its users in artificial environments. The work of Riva et al. (2019) [5] has shown that immersion in VR is closely linked to the activation of the brain's perceptual mechanisms such as vision, hearing, and in some cases, touch. This synchronised sensory stimulation creates a coherent multisensory experience, inducing a state of immersion in

which the user finds themselves psychologically absorbed in the virtual environment (Figures 5 and 6). Elsewhere, Slater and Sanchez-Vives's research (2016) [28] has highlighted the crucial role of sensorimotor correspondence in the immersion process, emphasising the idea that when the user perceives their behaviour to cause an immediate action in response this reinforces the illusion of reality. These psychological phenomena, the willing suspension of disbelief and the effect of presence, contribute to the extent of the immersive experience in virtual reality [29]. In this way, the combination of sensory synchronisation, sensorimotor correspondence and perceptual illusions go a long way to explaining the unique ability that virtual reality has to fully immerse individuals in artificial environments.

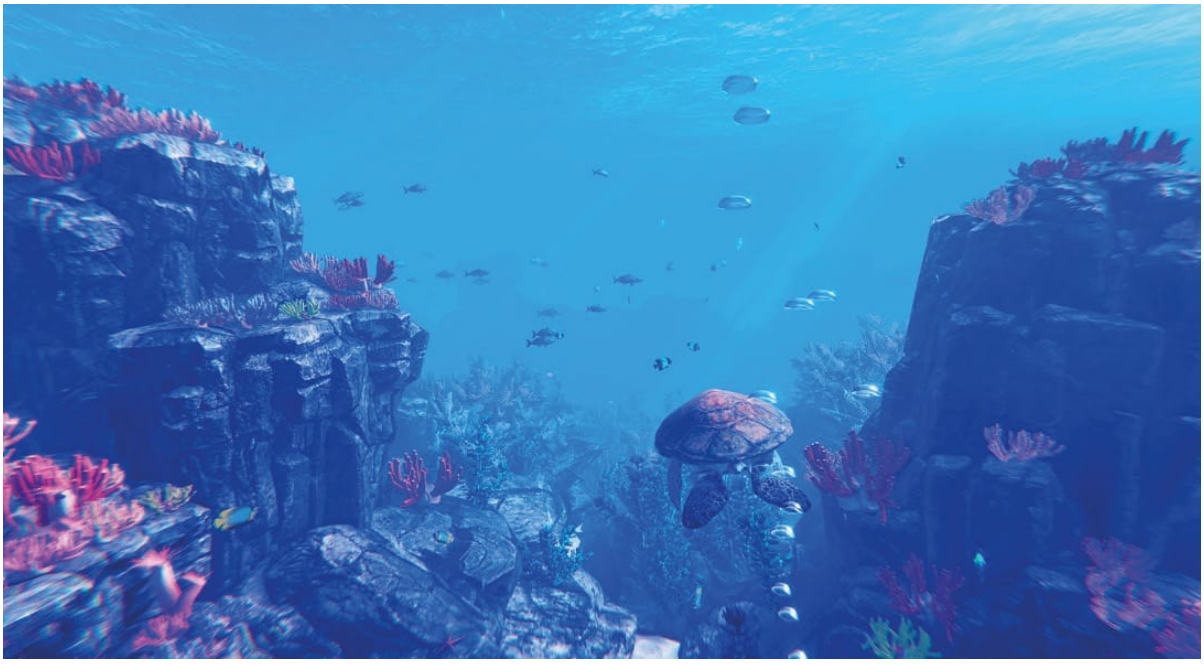

Figure 5: Underwater world in HypnoVR software

Figure 6: Winter forest world in HypnoVR software

The sense of presence and immersion in virtual reality (VR) form a key field of study in cognitive psychology, bringing to light the complex mechanisms that underlie the user's experience. The work of Witmer and Singer (1998) [30] laid the conceptual foundations by defining presence as the subjective perception of being physically present in a virtual environment, while being aware that this space is artificial. This illusion of presence is closely linked to factors of perception and cognition, as explained by Sanchez-Vives and Slater (2005) [31], who emphasised the importance of sensorimotor correspondence between the user's actions and the responses generated by the virtual reality system. The work of Biocca and Delaney (1995)[29] also foregrounds the impact of sensory synchronisation on the sense of presence, emphasising that concordance between visual, auditory and, in some cases, haptic sensory stimuli plays a key role in creating an immersive experience. Furthermore, the theory of embodied cognition (Varela et al., 1991) [32] suggests that when the user interacts directly with the virtual environment this reinforces the sense of being fully immersed, which underscores the importance of motor engagement in building a sense of presence in VR. If we integrate these concepts from cognitive psychology, an understanding of the sense of presence and immersion in virtual reality takes shape as a delicate balance between sensory perception, motor interaction and the awareness that the environment is artificial. It is worth noting that these studies have generally looked at virtual reality environments displayed on 2D screens, and not usually at headsets. As visualisation devices have improved, this naturally reinforces the process of immersion. Today we can much more readily refer to immersive VR.

## HYPNOSIS IN VIRTUAL REALITY

Scientific evidence to support hypnosis as a viable pain management strategy has mounted up over the past two decades [33]. However, widespread application has been held back by factors such as the advanced expertise, time and effort required by clinicians to provide hypnosis, and the cognitive effort required of patients to commit to it.

Practically speaking, significant in-depth training of care providers would be needed for hypnosis to become an effective pain management modality. Hypnotherapy training is not currently offered in medical schools or even in higher education psychology programmes. Another reason is that administering hypnosis takes more time and effort than giving a pain-relieving pill or injection. The fact that training, skills and patience are required to administer hypnosis makes it difficult to implement in medical centres where the pace is often fast and the clinician's time is in great demand.

Finally, in an acute care context, the attention and cognitive effort that is required to undergo hypnosis may exceed what is possible for these patients, who are often under the influence of opiate drugs and benzodiazepines. Making hypnosis a standard care offering in these kinds of environments is a challenge.

Over the past 25 years, researchers have been studying the ways in which hypnosis could be made more standardised and more accessible. A handful of studies have looked at whether using audio cassettes is an effective method of providing a hypnotherapy intervention [34]. The results of these studies have proven to be mixed, leaving us to conclude that hypnosis delivered by audio cassette is more effective than an absence of treatment, but less effective than when delivered by a hypnotherapist. Grant and Nash (1995) [35] were the first to use computer-assisted hypnosis as a behavioural measure to assess hypnotic ability. This involved a digital voice guiding subjects through a procedure that the software adapted in response to their unique reactions. However, this technique used a conventional 2D screen, so patients were required to focus their attention on a computer screen meaning they were susceptible to distractions that would likely appear in their environment.

Our goal, in developing hypnosis in virtual reality, is to use three-dimensional and immersive VR technology to guide the patient through the steps used when hypnosis is induced through an interpersonal process. The virtual reality system replaces most of the stimuli that the patient would otherwise endeavour to imagine in response to the therapist's verbal prompts.

Using VR to trigger the hypnotic trance state means that the effects of each one potentiate the other. Used while the patient is under sedation induced by the anaesthesia team in the pre-operative phase, the beneficial effect on the stress component and related peri-operative and post-operative parameters can be measured. The value lies in improving the patient's environment when they are sedated to reduce the impact of stress and pain on them and on their surgical outcome (Figure 7).

Figure 7: Patient in the anaesthesia room a few minutes before being intubated for the operation

## USE OF VIRTUAL REALITY FOR PATIENTS

VR has been used in many different clinical contexts to help to treat anxiety disorders, control pain, support physiotherapy and to distract patients during wound care [36] (Figure 8). For example, VR in conjunction with medications is an effective strategy for pain reduction when changing bandages in severe burns [37]. It also reduces pain and provides a positive distraction during routine procedures like fitting IV lines [38] and dental procedures [39]. Other studies have found that VR can help to manage chronic pain, such as in complex regional pain syndrome and [40] chronic neck pain [41]. By stimulating the visual and auditory senses [42], VR acts as an active distraction that can lessen the user's processing of nociceptive stimuli [43]. The effective "distraction" strategy involves a phenomenon of disembodiment, inducing a sense of being distanced from the painful body.


Figure 8: Using virtual reality to distract the patient in the operating theatre

The introduction of VR has led to numerous disorders being treated with immersive therapeutic applications. Exposure therapy used in psychiatry is one example. This treatment strategy involves a patient being gradually confronted with the source of their trauma to help them little by little to adopt a new and more constructive behaviour [44]. In this area, VR has shown results in the treatment of phobias (flying, driving, heights, spiders, etc.)[45]. Another promising potential use is as support for physical rehabilitation in patients who have lost motor control. VR could hypothetically open up an enhanced level of reintegration in neurodegenerative or acute pathologies, such as stroke and traumatic injuries [46],[47]. The virtual scenario improves sensory return in the central nervous system, involving changes in synaptic plasticity and as a result reinforcing the acquiring of motor skills and rehabilitation. In fact, platforms for rehabilitation in altered cognitive function or recovery after traumatic brain injury have recently been set up [48]. Another successful medical application for VR has been the demonstration by Dunn et al of its ability to reduce phantom limb pain in people living with amputation or paraplegia [49].

## DISCUSSION CONCLUSION

The key feature of VR is that it is capable of producing a sense of immersion. The ability to concentrate and heighten attention is a useful tool in medicine, especially when addressing anxiety and pain. It offers highly effective “gate control”. There is already evidence to support a number of therapies like hypnosis that use distraction of attention. We can now consider the possibility of potentiating the effect of these therapies by using them in conjunction with VR.

However, as with any new system, VR technology has its limitations. These limitations are broadly technical, with software still in development and sometimes too complex to be easily used and financially accessible. There is also

a dissonance felt between actual and “false” reality, which could lead to poor adherence in some populations, such as older people. Ultimately, VR is still delivered through a screen, with all the constraints that this implies and the associated emerging pathologies caused by overexposure and proximity to artificial light.

In a hospital environment, pain and anxiety predominate but there is only so much human care can offer in terms of available staff and their time to dedicate to each patient. In situations when human suffering makes care difficult, VR can be a powerful solution and an important tool in the treatment arsenal for managing patients’ pain and anxiety.

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