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Virtual Reality

Virtual reality hand therapy: A new tool for nonopioid analgesia for acute procedural pain, hand rehabilitation, and VR embodiment therapy for phantom limb pain

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ABSTRACT

Introduction: Affordable virtual reality (VR) technology is now widely available. Billions of dollars are currently being invested into improving and mass producing VR and augmented reality products.
Purpose of the Study: The purpose of the present study is to explore the potential of immersive VR to make physical therapy/occupational therapy less painful, more fun, and to help motivate patients to cooperate with their hand therapist.
Discussion: The following topics are covered: a) psychological influences on pain perception, b) the logic of how VR analgesia works, c) evidence for reduction of acute procedural pain during hand therapy, d) recent major advances in VR technology, and e) future directions—immersive VR embodiment therapy for phantom limb (chronic) pain.
Conclusion: VR hand therapy has potential for a wide range of patient populations needing hand therapy, including acute pain and potentially chronic pain patients. Being in VR helps reduce the patients' pain, making it less painful for patients to move their hand/fingers during hand therapy, and gamified VR can help motivate the patient to perform therapeutic hand exercises, and make hand therapy more fun. In addition, VR camera–based hand tracking technology may be used to help therapists monitor how well patients are doing their hand therapy exercises, and to quantify whether adherence to treatment increases long-term functionality. Additional research and development into using VR as a tool for hand therapist is recommended for both acute pain and persistent pain patient populations.

Introduction

Excessive pain during medical procedures is a worldwide medical problem.[1-3] For example, preventing infection via frequent wound cleaning is crucial for surviving a severe burn injury. Unfortunately, most children with large severe burn injuries report severe to excruciating pain during these crucial burn wound debridement/scrubbing sessions in the ICU tankroom, despite treatment with powerful analgesics shortly before the wound care.[4] Excessive pain during medical procedures increases patients' risk of developing expensive long-term medical issues such as persistent/

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chronic pain and/or post-traumatic stress disorder.[5,6] In addition to traumatic memories for the original burn injury accident/event (eg, a fire), memories for traumatic wound cleaning sessions can form pathological memory "hot spots" needing future psychotherapy for post-traumatic stress disorder. There is a growing urgency to develop effective nonpharmacologic analgesics.[7,8]

The current brief review explores the potential of immersive virtual reality to enhance analgesia for hand therapy, to make physical therapy (PT)/occupational therapy (OT) more fun, and to help motivate patients to cooperate with their hand therapist. As discussed in the following, VR hand therapy has potential for a wide range of patient populations needing hand therapy, including acute pain and potentially chronic pain patients.

Psychological influences on pain perception

Pain is a subjective experience of the patient, and pain has a strong psychological component. Unhelpful psychological influences work against the pain medications. Fear, anxiety, depression,[9] and expectations of pain,[10] memories for previous painful experiences,[11-13] the direction patients look/focus their attention,[14] and other psychological factors can unhelpfully increase how much pain patients experience during painful medical procedures.[15] Fortunately, the opposite is also true. Psychological treatments such as attention distraction can help reduce how much acute procedural pain patients experience during medical procedures such as wound cleaning, physical therapy, or occupational therapy for a wide range of medical problems. Therefore, psychological and pharmacologic approaches are often combined. Psychological treatments (and medications) that reduce depression, fear, anxiety, patients' expectations of pain, and/or catastrophizing can help reduce the patient's pain and may increase the effectiveness of the pharmacologic analgesics. For example, reducing patients' expectations of how much pain they are about to experience has been shown to helpfully reduce the intensity of nociceptive pain signals entering the brain.[10]

Attention distraction

Attention distraction is one of the simplest psychological treatments for acute pain. However, the most widely used conventional distraction, listening to music during wound care, is a step in the right direction but has limited analgesic effectiveness.[16-19] Adjunctive immersive virtual reality is emerging as an unusually effective high-tech distraction that takes distraction to a whole new level and can result in large, clinically meaningful reductions in acute pain. During virtual reality, patients look into a pair of VR goggles, and interact with virtual objects in a computer-generated virtual reality world during painful medical procedures. The essence of immersive virtual reality is the user's illusion of "being there" in the 3D computer-generated world, as if the virtual world is a place they are visiting, an illusion known as "presence" or "feeling present" in virtual reality.[20]

The logic of how virtual reality analgesia works

Although more research is needed to investigate the mechanism of how VR works to reduce acute pain, researchers propose that VR reduces pain via an attentional mechanism.[21-29] The logic is as follows. Pain requires attention.[30,31] During medical procedures with no VR, burn patients typically watch the nurse clean their burn wound during their wound care sessions, and much of the patient's attention is directed toward the painful procedure and pain-related stimuli in the hospital room. The patient sees objects, nurses, and their own unbandaged burn wounds in the wound care room that patients have learned to associate with pain, via aversive conditioning from previous painful experiences in the same wound care room. During no VR, patients are both physically and mentally in the hospital wound care room. By contrast, virtual reality takes the patient's mind to a different place. Virtual reality puts the brain into "divided attention" mode. Instead of all of their attention being directed toward pain, now a considerable portion of the patients' limited attentional resources are diverted into the VR goggles and focused on the computer-generated virtual world, flooding the brain with pleasant sensory input. Researchers propose that VR uses up so much attention and that the patient's brain has fewer attentional resources available to process incoming nociceptive signals.[21-23] fMRI brain scan studies show significant reductions in subjective pain ratings and significant reductions in pain-related brain activity during virtual reality vs during no VR[32,33] (see Fig. 1). In one fMRI study, the reduction of pain-related brain activity during VR was comparable to a moderate dose of hydromorphone.[33]

Clinical studies show growing clinical evidence that virtual reality reduces acute procedural pain during hand therapy.

A number of studies have explored the use of VR to distract burn patients from their acute pain during PT/OT skin stretching exercises[23] (see Figs. 2 and 3). Burned skin has a natural inclination to contract and harden (hyperossification) during the healing process. Skin contraction has the consequence of reducing skin elasticity, and reducing limb range of motion, which can lead to weakening muscles, and reduced ability to use the injured limb, and can eventually lead to permanent disability. Passive range of motion during the rehabilitation process can be painful, especially for children with large severe burn injuries who are already receiving several painful medical procedures on a daily basis. Virtual reality helps reduce the amount of pain experienced by the burn patients during therapy sessions.[23]

In a study by Carrougher et al,[34] burn patients rated their pain during physical therapy range of motion exercises on two different days. Patients received their usual pain medications on both days. On one day, they performed range of motion exercises while "in" virtual reality, and on the other day, they performed their range of motion exercises during no virtual reality (treatment order randomized). Patients reported large and significant reductions in pain when they received VR during physical therapy while achieving equal range of motion angle in VR vs no VR (ie, patients stretched as far during VR as during no VR).[34] See also Schmitt et al, 2001 and Soltani et al, 2018.[35,36]

The improvements in range of motion achieved during hospitalization can be quickly lost after discharge if the patient does not continue to perform their PT/OT exercises at home. Although home exercise programs are an important predictor of treatment outcomes,[37] noncompliance rates can be high,[38,39] thus impacting

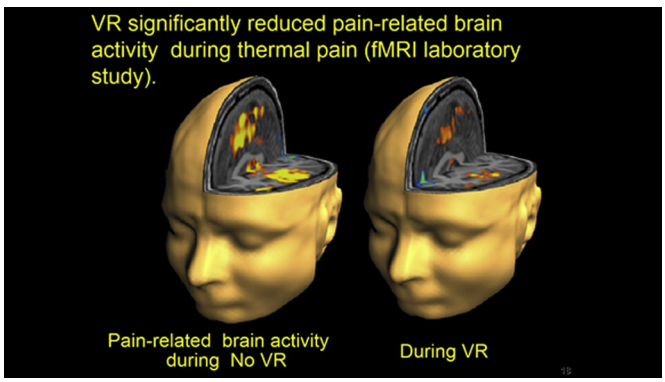

Fig. 1. fMRI brain scans showed large reductions in pain-related brain activity during virtual reality. Image copyrighted, used with permission.

Fig. 2. A pediatric burn patient using virtual reality during occupational therapy range of motion exercises. Photo copyrighted, used with permission.

results. In the future, patients may be more willing to perform their hand therapy homework exercises using gamified virtual reality systems customized by the hand therapist to encourage and motivate patients to make repetitious prescribed therapeutic motions (to score points in a custom virtual reality game, and gradually work their way up to more difficult levels of game play, etc.).

VR analgesia during burn wound cleaning procedures

In the first study to test whether immersive VR can act as an adjunctive nonpharmacologic analgesic,[22] two male adolescent patients rated how much pain they felt during burn wound care. Each patient received their usual pain medications before wound care. Each patient had several staples removed from a healing skin grafted burn wound by the wound care nurse while the patient (1) played a conventional PlayStation Nintendo video game (the "no VR" plausible control condition). The patients then had an equal number of staples removed while (2) wearing a VR helmet and "going into" an immersive computer-generated virtual reality (within subjects, within-wound care design, treatment order randomized). Each of the two patients reported large reductions in pain during wound care during staple removal while in virtual reality, compared to their pain during staple removal during the nonimmersive Nintendo video game (a plausible no VR control condition) during the same wound care procedure.[22] In other words, VR reduced how much pain the adolescents experienced during burn wound care, and in a subsequent study, patients even reported having more fun during burn wound care during VR.[4]

Fig. 3. A pediatric burn patient using virtual reality pain distraction during physical/occupational therapy. Photo copyrighted, used with permission.

SnowWorld (www.vrpain.com; see Fig. 4) is the first immersive VR world specifically designed for pain reduction.[23,40] In SnowWorld, patients float slowly through a 3D computer-generated snowy canyon, where they interact with virtual snowmen, penguins, and igloos. Virtual objects freeze and shatter when hit by snowballs, with sound effects, and music (eg, by Paul Simon) playing in the background.

In a military study conducted at Brooke Army Medical Center Institutes of Surgical Research in San Antonio Texas, soldiers with combat-related burn injuries reported large reductions in pain during wound care using VR (SnowWorld) vs standard of care (usual pain medications with no VR)[41–43] (see Figs. 5 and 6).

In a clinical pediatric VR analgesia study by Hoffman et al, 2019,[4] using SnowWorld, 48 children with very large severe burn injuries (burns on 40% of their bodies, on average) received standard of care pain medications with no VR for some portions of their burn wound debridement (burn wound scrubbing) session and the children "went into" VR for other portions of the same burn wound care session (treatment order randomized). During VR, these pediatric burn patients reported significant reductions in worst pain intensity, and significant reductions in pain unpleasantness, patients spent significantly less time thinking about their pain during wound care, and wound care was significantly more fun.[4] Encouragingly, VR continued to be effective at reducing patients' pain and increasing how much fun patients experienced during wound care, even when used during several different wound care sessions per patient on different days.[4]

Many patients have burns on their heads or face that make it difficult for them to wear conventional VR helmets on their heads. To address this problem, studies by Hoffman et al, 2019, Maani et al, 2011a, Maani et al, 2011b, and Hoffman et al, 2014[4,40-44] used a custom-made robot-like goggle holder to hold the VR goggles near the patient's eyes, with little or no contact between the patient and the VR system, so patients did not have to wear a VR helmet.

Fig. 4. SnowWorld: A screenshot. Patients float slowly through a 3D computer-generated virtual world, during painful medical procedures. Image copyrighted, used with permission.

VR analgesia has now been shown to reduce pain for a wide range of patient populations.[45-51] A VR analgesia study at the University of Montreal found significant reductions in pain during burn wound care in young children (average age 2 years old).[45]

Hoxhallari et al[51] explored using VR during hand surgery during wide awake local anesthesia. VR significantly reduced patients' anxiety and increased fun during the injection and during the hand surgery.

Recent major advances in VR technology, and future directions for using VR and other emerging technologies to help patients needing hand therapy

The early VR systems were very heavy (8 lb VR helmets in the early 1990s, 50 lbs for the VR computer), and very expensive (eg, $90,000 for the VR system researchers used in the first VR analgesia studies in the 1990s).[21,22] Most VR analgesia studies conducted before 2016 have been conducted in hospital and University settings, using expensive pre-Oculus VR technology.

The cost of a highly immersive VR system dropped very dramatically in 2016 (Oculus and HTC VIVE, SONY and other new high-quality, low-cost, mass-produced VR helmets became available to mainstream consumers). Historically, high-tech computer companies make conventional video game hardware (eg, Xbox) very inexpensive, often selling the video game station hardware at a loss. But they later make huge profits on the software (eg, video games). Following this same pattern as conventional video game marketing, major tech companies have begun mass marketing millions of VR helmets per year. VR hardware is inexpensive and is continuing to get less expensive each year, while the quality of VR technology (eg, VR goggles) is rapidly improving.

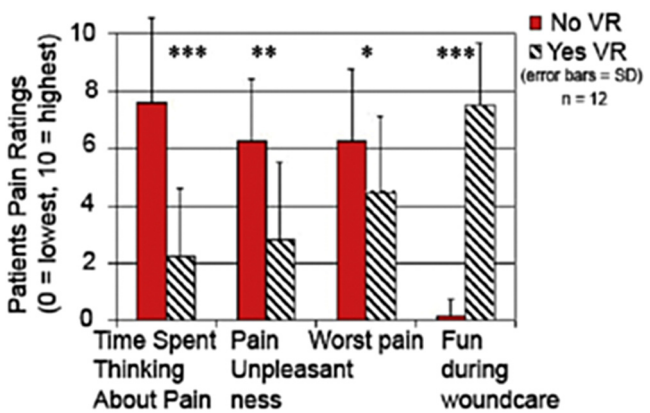

Fig. 5. Soldiers with combat-related burn injuries reported significant reductions in worst pain intensity during VR, and significantly more fun during VR. Image copyrighted, used with permission.

Virtual reality goggles

With the naked eye, the human visual field is approximately 220° horizontal. VR goggles do a reasonably good job of presenting visual stimuli to the fovea of the human eye, but VR helmets partially limit peripheral vision (limited field of view). Because of the small size of the VR eyepieces/optics, patients essentially see the virtual world while wearing blinders that partially block peripheral vision. Early laboratory studies have shown that 60° field-of-view VR goggles were significantly more effective at reducing pain compared to 35° field-of-view VR goggles.[52] In 2013, the price of a 90° field-of-view VR helmet was $35,600. Only three years later, in 2016, the price of a 90° FOV helmet dropped from $35,600 to $600. Thus, in other words, in 2016, a 90° field-of-view VR helmet became $35,000 less expensive, per helmet. (The 2019 luxury high-resolution VR custom helmet named "XTAL" with 180° field of view www.VRgineers.com is also a fraction of the price of a 2013 90° FOV helmet.) Affordable VR hand therapy technology is now possible.

Eye tracking

Burn patients with large severe burn injuries often have burned hands, making it challenging for the patients to use their hands to control a computer mouse during burn wound cleaning sessions. One new option recently became commercially available: immersive virtual reality goggles with eye tracking technology. Miniature video cameras mounted inside the VR goggles track the patients' eye movements and can tell the VR system which virtual objects the patient is looking at in VR. Thus, patients can use their eye movements to interact with the virtual world. For example, in SnowCanyon (www.bigenvironments.com, www.vrpain.com), burn patients can aim snowballs at virtual snowmen, by simply looking at the snowman they want to hit with a Snowball.[53] Hands-free interactivity with VR via eye tracking could be especially valuable for patients with limited hand mobility, for example, double amputees, stroke patients, and paralyzed or partially paralyzed patients.

Optical hand tracking

Thanks to recent improvements in very low-cost optical tracking (eg, LEAP motion, https://www.leapmotion.com/) and related tracking technologies, camera-based hand tracking can be used as input to the VR computer. In the future, patients will be able to perform therapeutic hand movements, wrist movements, and/or movement gestures to interact with virtual reality as part of their rehabilitation. While in virtual reality, hand movements in the real world (eg, patients clinching and unclinching a fist) can be captured by video cameras attached to the VR helmet and communicated to the virtual reality software.[54] The patient does not have to hold any controllers in their hands, and does not have to wear gloves. The patient wearing virtual reality goggles sees his/her cyberhand clinching and unclinching, and the patient can use these movements of their virtual hand to interact with virtual objects in the computer-generated world (see Figs. 7 and 8). Being in VR helps reduce the patients' pain, making it less painful for patients to move their hand/fingers during hand therapy, and gamified virtual reality

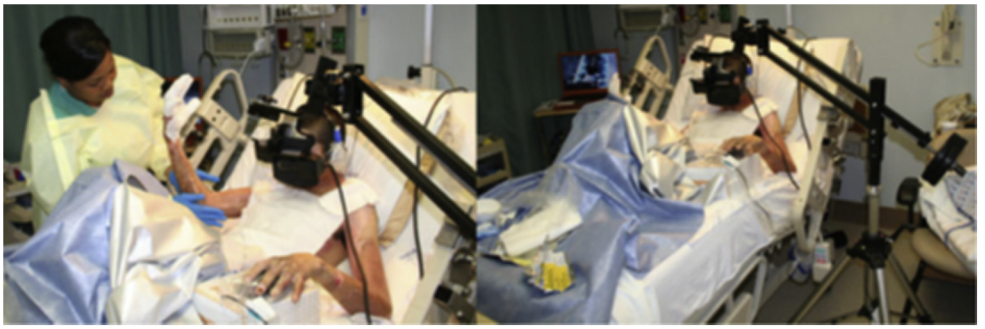

Fig. 6. A soldier with combat-related burn injuries at Brooke Army Medical Center Institutes of Surgical Research in San Antonio Texas. The custom robot-like arm goggle holder holds the VR goggles near the patient with little or no contact with the patient, so the patient does not have to wear a VR helmet. Image copyrighted, used with permission.

can be programmed to help motivate the patient to perform therapeutic hand exercises and to make hand therapy more fun. According to one study,[55] PT/OT involving VR with a LEAP Motion control optical hand tracking system (40 min OT = 20 min VR on four treatments) increased finger ROM, reduced scar thickening, and improved hand functioning compared to patients who received 60 min of OT + no VR, on multiple treatments.

Using VR to measure dynamic range of motion during performance of daily tasks

As described by Shefer-Eini et al,[54] clinicians have traditionally used a goniometer to measure range of motion during extension and flexion motions of the wrist, fingers, and other joints as the "gold standard" measurement of joint range of motion. However, the goniometer only gives "snapshots," whereas VR optical tracking technology can measure wrist and hand movements in real time, as the patient performs various real-world tasks. VR camera tracking allows measurement of more complex and ecologically valid movements of the wrist and fingers during performance of daily tasks. The first few generations of camera-based tracking were initially too expensive and required a technician, and even today, the measurements still need further validation.[54] However, due in part to recent multi-billion dollar investments in VR and related technologies, camera tracking is undergoing rapid improvements for immersive virtual reality applications, at a fraction of the previous cost, and these technologies have a number of potential near future medical applications for hand and wrist therapy and beyond that may quickly disseminate to hand therapy applications during the next few years. In the near future, camera-based hand, finger, and wrist "motion capture" will also become commercially available with untethered (no wires) VR helmets for VR, and for some helmet models, no laptop will be required. VR technology is quickly becoming easier for novice VR users to set up and use, and less expensive (eg, allowing home use).

Tech experts predict that medical applications of virtual reality will emerge as the second largest application of virtual reality (second only to using virtual reality for entertainment).

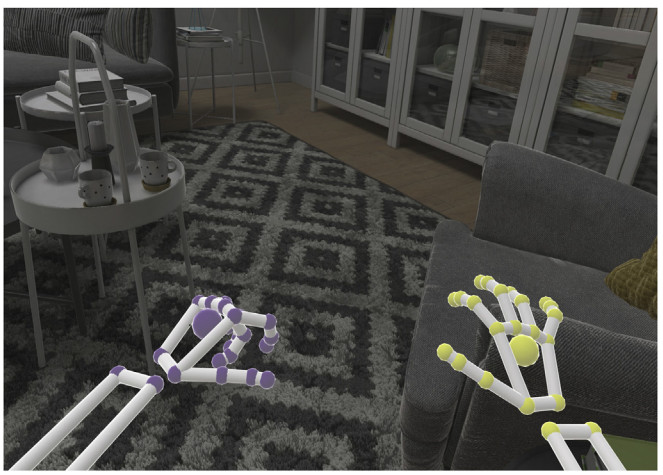

Fig. 7. Using optical camera hand-tracking technology mounted on their virtual reality helmet (eg, VRgineering.com XTAL as shown above) allows hand therapy patients to use their real hand gestures to control their cyberhand gestures allowing patients to interact with virtual objects in the virtual world. (copyrighted image, used with permission). Haptic feedback using sound waves can further enhance the illusion, www.ultraleap.com/haptics/.

Virtual reality works for acute pain, what about for chronic pain?

As described previously, there is growing evidence that immersive virtual reality distraction can help reduce acute pain, for example, during painful medical procedures.[4,44,50] Immersive virtual reality distraction is a perfect match for reducing acute pain for 20 min or less, while the person is wearing the VR goggles and/or looking into the VR goggles, and interacting with the virtual world (although longer VR sessions with occasional breaks are becoming more feasible, thanks to less nauseogenic VR technology and calm VR worlds).

There is much less research (but growing interest) on whether immersive virtual reality can reduce chronic persistent pain.

Fig. 8. At the higher end of the new VR market, a new highly immersive VR helmet named XTAL is available at VRgineering.com, allowing high realism in VR. This helmet has 180° field of view and comes with magic leap optical hand tracking/cyberhand technology already integrated. (copyrighted image, used with permission).

Encouragingly, preliminary unpublished evidence suggests that virtual reality distraction can temporarily reduce some types of chronic pain, at least during the time that the patient is in virtual reality (while they are wearing the VR helmet and interacting with the virtual world. For example, PBS reporter Miles O'Brien, an amputee with phantom limb pain, reported reductions in his own phantom limb pain during virtual reality; see the third story at https://www.pbs.org/newshour/show/understanding-science-pain-help-virtual-reality. Presumably, when used simply for pain distraction, when the patient takes off the VR helmet, their chronic pain may return. However, beyond distraction, as discussed next, new VR worlds specifically designed to help reduce persistent pain could in theory permanently change/improve the way patients perceive pain, even after the patient takes off their VR helmet.[7,8,50,56]

Virtual reality has previously been used to enhance the effectiveness of conventional cognitive behavioral clinical therapy (eg, virtual reality exposure therapy to treat phobias,[57-59] post-traumatic stress disorder,[60-62] for training VR mindfulness skills,[63-66] and patient education).[67] Educating patients about the neuroscience of pain (eg, presurgically) can help change how patients interpret their pain,[68] can improve patients satisfaction, reduce health care costs, and communicate to patients that it is important for them to stay as active as possible.[69] Chronic pain health care professionals can also benefit from pain neuroscience education.[67] Researchers have begun to explore pain neuroscience education delivered via virtual reality.[70] Similarly, mindfulness skills training can teach patients new pain coping skills (eg, mindfulness skills) that they can use later when they are no longer in VR. This could help reduce anxiety[64] and could potentially help reduce chronic pain and/or improve patients attitudes and behavior toward persistent pain (eg, to become less fearful and more acceptant of pain). As discussed in the following, VR may help permanently reduce pathological phantom limb pain in amputees (an early example of VR therapy for chronic pain).

Traditional low-tech mirror therapy for phantom limb pain

After amputation, amputees often report pain sensations in the missing limb, a phenomenon known as “phantom limb pain.” For example, one patient had a severe injury to their hand, which included severe cramps and pain in their hand. The doctors amputated the patient's hand, and yet the amputee continued to experience sensations of cramping and pain in their “phantom limb,” although they no longer had a hand. Although the phantom limb pain—related disease mechanism is not well understood,[71-73] it may be the result of maladaptive brain plasticity …. “mainly caused by reorganization in the primary somatosensory cortex, presumably characterized by functional degradation of the missing hand representation and remapping of other body part representations.”,[73] p. 174 In the 1990s, Ramachandran and Rogers-Ramachandran[74] experimented with an unusual technique of treating phantom limb patients using “mirror therapy,” using a simple low-tech store-bought mirror (not immersive virtual reality). Ramachandran describes the mirror therapy setup as follows: “A mirror is placed vertically on the table, so that the mirror reflection of the patient's intact hand is ‘superimposed’ on the felt position of the phantom.”,[74] p. 377 The idea of mirror therapy was to give patients the illusion of moving their phantom limb. Instead of seeing a stump with the hand missing, during mirror therapy, patients have the illusion that their hand has not been amputated, and they have the illusion of control over their missing (phantom) hand and fingers again. In other words, Ramachandran[74] used an illusion (mirror therapy) to treat an illusion (phantom limb pain). Ramachandran[74] speculated that the brain was still sending signals down to the amputated limb, but the missing limb was no longer sending signals to the brain, and somehow the patient's mental representation of their body had not adjusted to the new reality that the patient no longer had a (eg, right) hand.

In a case series of ten patients, after a number of mirror therapy sessions, Ramachandran's patients' phantom limb disappeared for several of the ten patients studied.[74] When the phantom limb disappeared, in many cases, the phantom limb pain also disappeared.

Although Ramachandran's[74] results are intriguing as a case series, subsequent small studies exploring whether mirror therapy works have reported encouraging but somewhat mixed results.[75-79] Some patients appear to benefit from mirror therapy,[80] but many patients with phantom limb pain show little or no long-term improvement after low-tech “simple mirror” therapy. Plasticity-based approaches such as traditional mirror therapy suffer from technological limitations that hinder their effectiveness.[75] Low-tech mirror-based limb visualization is simple and widely available, but it can be difficult for patients to self-administer correctly, and compliance is poor because it is difficult, repetitive, and not engaging.[75] Researchers are currently developing/exploring the use of high-tech immersive virtual reality to create a more compelling illusion and to help treat phantom limb pain more effectively.

Immersive virtual reality embodiment therapy for phantom limb (chronic) pain

Using head-mounted VR goggles, what people see in virtual reality changes as the user moves their head to view the environment and their avatar body. This results in a first-person visual experience of the virtual limb attached to the virtual body. This is key to providing potent illusions of ownership/embodiment of the virtual depiction of the body[81] (ie, being the avatar, “the avatar body I control in virtual reality is my body.”

As reviewed by Matamala-Gomez et al, 2019,[82] researchers are exploring whether embodiment can be used to help relieve pain (eg, phantom limb pain or even other types of persistent chronic pain).

Patients wearing a VR helmet look down and see two virtual arms and two virtual hands. They are able to use their virtual body/hand to interact with objects in the virtual world. This can be used for amputees, or even for nonamputees.[82]

A study of home therapy using traditional low-tech mirror therapy (not VR) for people with upper limb hemiparesis suggests that compliance is a major factor for improvement.[83] Gamification of embodiment therapy (using immersive VR) has the potential to capture the patient's attention and encourage active engagement with the task, increasing compliance. In the future, augmented reality may allow patients to see mixtures of virtual images while still in the real world (www.magicleap.com).

Conclusion

Immersive virtual reality technology is proving to be effective as an adjunctive nonpharmacologic analgesic for reducing acute procedural pain during wound care and physical and occupational therapy, including hand therapy. Billions of dollars[84] are currently being invested into mass-producing virtual reality and augmented reality products to sell to the general public (eg, primarily for entertainment). Consumer-ready immersive virtual reality and augmented reality technologies can likely be harnessed by physical and occupational therapists to help improve the medical and psychological outcome of patients undergoing hand therapy, improve patient satisfaction, and thus reduce health care costs. In the future, VR may increase patients' compliance with hand therapy homework exercises, by making the hand therapy exercises less painful and more fun, during home use. In addition, VR can be used to help monitor whether, when, and how well patients are doing their hand therapy exercises, and to quantify whether adherence to

treatment increases long-term functionality. Additional research and development into using virtual reality as a tool for hand therapist is recommended.

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1. The focus of the article is VR
   a. as a substitute for therapists' treatment plans
   b. as a method to reduce the cost of hand therapy
   c. for its analgesic effect
   d. for its appeal to today's tech savvy younger generations
2. Many VR devices are
   a. inexpensive
   b. too complex for neurological patients
   c. fragile and hence unreliable
   d. inaccessible for many patients
3. The authors postulate that integrating VR into a HEP has the potential to
   a. make therapy fun
   b. increase the total dosage of performed exercise
   c. make exercise less painful
   d. all of the above
4. A significant factor in the success of VR is the concept of
   a. trading reality in favor of fantasy
   b. eliminating the stress of dealing face-to-face with the therapist
   c. attention distraction
   d. trickery
5. SnowWorld is the first immersive VR world specifically designed for pain reduction
   a. not true
   b. true

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