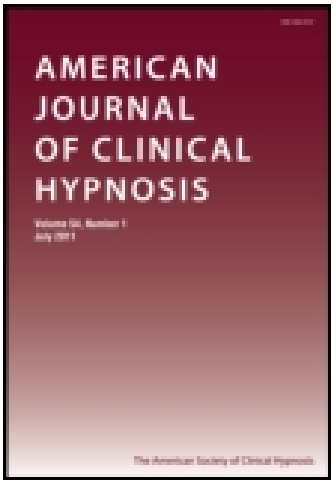

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Virtual Reality Hypnosis Pain Control in the Treatment of Multiple Fractures: A Case Series[1]

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This case series evaluated the use of virtual reality hypnosis (VRH) for the treatment of pain associated with multiple fractures from traumatic injuries. VRH treatment was administered on 2 consecutive days, and pain and anxiety were assessed each day before and after VRH treatment as well as on Day 3, which was 24 hours after the second treatment session. Pain reduction from baseline to Day 3 was from 70% to 30%, despite opioid analgesic use remaining stable. The subjective pain reduction reported by patients was encouraging, and the results of this case series suggest the importance of further study of VRH with larger samples using randomized controlled trials.

Keywords: virtual reality hypnosis, trauma, pain

The pain that results from severe orthopedic trauma can be substantial but has received little attention in the literature. Most of what has been published on the treatment of pain with trauma has focused on pharmacologic analgesic approaches. Opioid analgesics are used in a variety of trauma pain settings and should usually be the foundation of treatment (Brown, Albrecht, Pettit, McFadden, & Schermer, 2000). However, pharmacologic approaches do not control all pain in all patients. Moreover, analgesics can have undesirable side effects such as nausea, constipation, sedation, itchiness, urinary retention, cognitive impairment, hallucinations, and respiratory depression (Cherny et al., 2001). Opioid analgesics also have the potential downside of increasing length of hospitalization (secondary to weaning patients after high doses) and also may fail to fully address some types of pain after trauma (Perry & Heidrich, 1982). As a result, clinicians should consider nonpharmacological pain control techniques to supplement the traditional pharmacological options.

Hypnosis has received increased attention as an effective means of treating acute pain. Patterson and Jensen reviewed 17 randomized controlled trials of hypnosis for

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treating pain from etiologies such as burn pain procedures, labor and delivery, bone marrow aspirations, and other painful medical procedures (Patterson, 2010). Hypnosis universally fared well relative to standard or comparative treatments in this series of studies.

However, although promising, there are a number of logistical drawbacks to the use of hypnosis in some settings. First, it can be difficult to find clinicians well trained in this modality. Further, the effects of hypnotic analgesia may be less effective in patients with low levels of hypnotizability (Hilgard & Hilgard, 1975).

To expand the application of hypnosis for pain control, it is desirable to develop methods for delivering this treatment in a way that is not dependent on the availability of highly trained clinicians and that can create a therapeutic response among patients who show low levels of hypnotic susceptibility. There is a certain degree of cognitive effort required of hypnosis, and virtual reality hypnosis (VRH) might be useful for those whose hypnotizability is diminished by opioid medications, or have challenges with using their imagination (Patterson, 2010). Because VRH does not involve the use of a clinician or technician trained in hypnosis, it has the potential to offer this approach on a more widespread basis (Patterson, Jensen, Wiechman, & Sharar, 2010).

VRH relies on immersive virtual reality technology as a means to provide hypnosis treatment. Immersive virtual reality, a technology designed to capture attention, may serve to facilitate a subject's response to hypnosis (Patterson, Tininenko, Schmidt, & Sharar, 2004; Patterson, Wiechman, Jensen, & Sharar, 2006). We originally designed software for virtual reality distraction, and this has provided the foundation for our virtual reality hypnosis software. The original purpose of our virtual reality distraction (VRD) software was to capture patients' attention and distract them from painful medical procedures. The participant "looked" around the virtual environment and aimed via the head-tracked virtual reality (VR) helmet (a Rockwell Collins SR80 model VR helmet obtained through www.imprintit.com with Intersense IC3 head tracker), and pushed a mouse trigger button to shoot virtual snowballs at virtual snowmen, igloos, and penguins (Hoffman, 2004). This helmet has an approximately 80-degree diagonal field of view for each of the rectangular eyepieces with 100% overlap between the right and left eye images. The VR system consisted of a Voodoo Envy laptop with NVIDIA GForce Go 7900 GTX (512 MB) video card; Intel Core 2 Duo (T7400) CPU @ 2.16 GHz, 2 GB RAM @ 994 MHz. A Torroid Isolation Transformer was used. SnowWorld software (www.vrpain.com) was run on a Windows XP operating system. The hardware for VRH is largely the same; however, using the VRH software, patients are on a fixed path as they descend into the canyon, cannot determine their point of view by moving their head, and do not engage with the environment (i.e., shooting at objects). In other words, they did not actually interact with the illusory environment; they acted as passive recipients, which is often the case with standard hypnosis. Also, in VRH as opposed to VRD, patients are encouraged to rest comfortably and not move their head (in VRD, the patients are typically actively moving their head to engage with the virtual world). A

black felt cloth placed over the head eliminated any visual stimuli from the outside environment. In addition, patients wore headphones designed to eliminate all noises from the external environment so they can only hear the auditory instructions that constituted part of the VRH induction.

Once in the immersive virtual reality environment, patients had the illusion of floating at the top of the canyon while they heard initial hypnotic instructions. They then "floated" downward, with instructions for deeper relaxation as they saw numbers from one to 10. The 10 numbers appeared visually; at the same time, a recorded voice paired relaxation and hypnotic suggestions with each number. After reaching number 10 and descending to the bottom of the canyon, patients went through a tunnel and emerged over a lake surrounded by rolling green hills and a blue sky. Patients floated over this lake and received a number of auditory suggestions for increased comfort and pain control (Patterson, 2010). After approximately five minutes of posthypnotic suggestions for comfort and well-being, patients were given the suggestion that they were going to ascend up the canyon, see the numbers 10 through one and become more awake and alert with each passing number.

There have been a number of studies showing the efficacy of VRH on acute pain. Our first study on VRH was with a 37-year-old man with severe burns who was given VRH before his burn wound care. With VRH, pain ratings dropped 40% and anxiety scores dropped 50% while opioid requirements for wound care dropped from 37 opioid equivalents to 23 opioid equivalents. In a subsequent clinical case series of 13 patients, we used hypnotic analgesia delivered through virtual reality technology for patients with burn injuries. Pre- and postprocedure pain ratings were collected on patients undergoing painful wound care procedures over a 3-day period. With VRH, there was a significant and substantial decrease in pain and anxiety, the need for opioid medication was cut in half, and there were no reports of undesirable side effects (Patterson et al., 2006).

There has only been one study done on VRH for pain associated with orthopedic trauma (Patterson et al., 2010). This study was a randomized, controlled trial of 21 hospitalized trauma patients examining the effects of VRH on background pain, anxiety, and sleep. Pain ratings were obtained immediately and 8 hours after VRH. The ratings were compared with patients who received virtual reality without hypnosis and patients who received standard care. VRH patients reported less pain compared with the two control groups. However, this study did not address the effect of treatment on opioid analgesic use.

Given that there has been only one study on the use of VRH with a trauma pain population, as well as a limited number of studies of VRH in general, we wanted to add to the literature by examining the use of this modality more in depth with a series of case studies. Further, we wished to explore whether this intervention would have an effect on opioid analgesic use—a variable that was not investigated in the previous study on trauma pain.

Method

Participants

Participants included 3 patients admitted to and treated at a major regional trauma center for orthopedic injuries. The patients were selected based on high levels of reported pain and having no brain injuries that would prevent them from wearing a virtual reality helmet.

Patient 1 was a 29-year-old Caucasian man who was an unrestrained driver in a high-speed motor vehicle collision involving a fatality. The patient sustained significant face, head, and bilateral lower extremity trauma. He also sustained multiple left mid-foot fracture-dislocations with open fourth and fifth metatarsal tarsal dislocation, as well as dislocated talonavicular, subtalar, and tibiotalar joints, a right navicular fracture, and right third, fourth, and fifth metatarsal fractures. He went to the operating room on the day following admission for management of complex foot fractures. This was the first of a series of operations to his left foot. Analgesic medications included morphine, oxycodone, and acetaminophen.

At admission, he had decreased functional mental status from which he slowly recovered. To be eligible to participate in the hypnosis studies conducted at our institution, the patient must be alert and oriented to person, place, and date. This patient also displayed symptoms of alcohol withdrawal early during his hospital stay. Because of these issues, he was not enrolled in the present study until the 30th day of his hospitalization. His total length of hospitalization was 46 days.

Patient 2 was a 23-year-old Caucasian man who was admitted with an isolated, comminuted left Schatzker IV tibial plateau fracture from skateboarding. He reportedly fell down 8–10 stairs and was hospitalized for 24 days. After admission, the patient went to surgery for a closed manipulation of the tibial plateau fracture and the application of a uniplanar external fixator in the left lower extremity. After surgery, he went to the acute in-patient floor. He returned to the operating room for the open reduction and internal fixation of his tibial plateau fracture on the 12th day at the hospital. He was also followed by a rehabilitation psychologist to help him to address issues related to his hospitalization and recovery. The patient used a continuous passive motion machine and worked with a physical therapist to mobilize safely while maintaining non–weight-bearing status through his left lower extremity. His pain medications included morphine, oxycodone, and acetaminophen. The patient was distressed about his level of pain and expressed interest in the study. He consented to participate in the current study three days after admission.

Patient 3 was a 59-year-old Caucasian man who was involved in a motorcycle versus car collision, which was T-boned at 40–50 miles per hour. He did not lose consciousness or sustain a head injury. Upon admission to the trauma center, he was found to have multiple fractures, including a left perilunate dislocation, open left distal femur

fracture, a right partial sacroiliac joint disruption and pubis symphisis disruption, and a T3 compression fracture with paraplegia. The patient was in the hospital for 54 days. During his hospital course, his analgesic medications included oxycodone, aspirin, and acetaminophen. He consented to the VRH study 1 month after admission. He only completed 2 (of 3) days of the study and elected to not complete the questionnaire on the final study day.

Measures

The outcome measures used for this study assessed pain and anxiety using a graphic rating scale ranging from 0 to 100. This scale has wide support for its validity as a measure of pain intensity, as evidenced by a strong association with other measures of pain intensity as well as a responsiveness to treatments that are known to influence pain (Jensen & Karoly, 2011).

The outcome measures were administered just before and then again 60 minutes after each VRH session. The patients were asked to rate "time spent thinking about pain," "unpleasantness of pain," "worst pain," and anxiety/nervousness during the past 24 hours (for the ratings administered just before the VRH session) or 60 minutes (for the ratings administered 60 minutes after the VRH session). For each outcome domain, patients were asked to provide a number between 0 and 100, with 0 being "no pain/none of the time" and 100 being "excruciatingly painful," or "I thought about my pain all of the time." For the anxiety scale, 0 was "no anxiety at all" and 100 was "excruciating anxiety."

Medications were not manipulated in the study because they were at the discretion of the patients' care team, but they were recorded. We assessed medications given for pain, anxiolytics, antiemetics, and sleep inducers. Opioid equivalencies, which are opioid doses that were converted into an equivalent unit of measurement for comparison, were calculated for all *pro re nata* (PRN) and background pain medications.

Procedures

Patients hospitalized at our regional Level I trauma center were approached by an attending psychologist and asked if they were willing to participate in a trial of a novel approach to pain control. Patients were made aware that they would undergo a nonpharmacologic but largely untested form of pain control. When each of the three patients indicated an interest in the study they were referred to a research assistant. The research assistant had the patient sign a written, informed consent form that was approved by the Institutional Review Board.

After consenting to the study, on Day 1 each patient completed a graphic rating scale (GRS) with the four items assessing current pain and anxiety. Patients then participated in a VRH treatment session, which occurred in the patients' rooms at the hospital. This

VRH approach has been described in detail in a number of publications (Patterson, 2010; Patterson et al., 2004; Patterson et al., 2006) as well as the introduction. The VRH program began by giving the participant the sense that he was hovering at the top of a snowy canyon while a recording of the hypnotist's voice prepared the patient for what he would experience during the virtual hypnosis. Then the patient began a descent into the canyon and experienced the feeling of floating past numbers 1 through 10. At number 10, he was told that he was in his most relaxed state and had descended deep into the canyon. Next he experienced himself hovering above a lake in a valley and was given posthypnotic suggestions. He was instructed to use his mind as a resource to help him feel comfortable and to heal faster. He was asked to go to a pleasant time and place from the past before imagining himself moving forward to a happy time in the future. He would become more relaxed, sleep well, exercise and participate in physical therapy without difficulty, transform the pain to a more positive sensation, and simply enjoy life.

After the valley portion was complete, he ascended back up through the canyon and floated by numbers 10 through one in reverse order, gradually becoming more and more alert until the conclusion of the treatment when he would be fully awake. The postsession GRSs were repeated 1 hour after treatment.

On Day 2, the GRS was administered again and patients were asked to assess their pain over the past 24 hours since the previous treatment session. Patients then experienced the VRH treatment a second time and the posttreatment GRS was administered one hour afterward. On Day 3, patients completed the scale for the previous 24 hours. There was no VRH treatment on Day 3.

Results

Patient 1

For Patient 1, time spent thinking about pain decreased 50%, from 60 to 30 on the 0–100 GRS, from baseline (pretreatment) to posttreatment (see Table 1). On Day 2, this pain report decreased from 100 to 40 (60%) from pre- to posttreatment. It remained at 40 on Day 3, which was 24 hours after treatment on Day 2 (33% lower than the baseline rating).

For the unpleasantness of background pain rating, the GRS score dropped from 70 to 10 (86%) from baseline to Day 1 posttreatment. There was a smaller drop from 60 to 50 from pre- to posttreatment on Day 2. On Day 3, it rose slightly, back to 60. However, on Day 3 this GRS score was still 14% less than the Day 1 baseline rating.

The patient rated his worst pain at baseline at 100, which dropped to 40 (60%) after the VRH on Day 1. On Day 2, his worst pain decreased from 90 to 50, from 24 hours post-VRH to one hour post-VRH. From the Day 1 baseline to Day 3, there was a 20% reduction in worst pain.

TABLE 1
Results for Patient 1, 0–100 Scale

	Day 1 Before VRH	*Day 1 1 Hr After VRH*	*Day 2 Before VRH*	*Day 2 1 Hr After VRH*	*Day 3 24 Hr After VRH*
Time spent thinking about pain	60	30	100	40	40
Unpleasantness of background pain	70	10	60	50	60
Worst pain	100	40	90	50	80
Nervousness	40	0	20	20	30

Note. VRH = virtual reality hypnosis.

Nervousness was rated 100 at baseline and 0 at posttreatment on Day 1. On Day 2, it stayed constant at 20 both before and after VRH, and on Day 3 it increased to 30. However, this final score was still 70% less than the Day 1 baseline rating. Total opioid equivalent use was 6.2 on Day 1, 7.7 on Day 2, and back down to 6.2 on Day 3.

Patient 2

Patient 2 showed a decrease from 90 to 20 on time spent thinking about pain between baseline and post-VRH treatment on Day 1 (see Table 2). On Day 2, 24-hours after treatment, it increased to 80 but was still less than the baseline rating. After treatment on the second day the time spent thinking about pain decreased by 50% to 40. On Day 3, it rose to 50, which was 44% lower than baseline.

There was a large improvement in Patient 2's nervousness ratings. Nervousness dropped from 50 to 0 after VRH on Day 1. There was an increase to 40 on Day 2, but a return to 0 after the treatment, and it remained at 0 on Day 3. Overall, nervousness dropped 100% from baseline to Day 3. Total opioid equivalent analgesic use was 10.15 on Day 1, 10.65 on Day 2, and 8.81 on Day 3.

TABLE 2
Results for Patient 2, 0–100 Scale

	Day 1 Before VRH	*Day 1 1 Hr After VRH*	*Day 2 Before VRH*	*Day 2 1 Hr After VRH*	*Day 3 24 Hr After VRH*
Time spent thinking about pain	90	20	80	40	50
Unpleasantness of background pain	50	50	80	100	80
Worst pain	100	100	100	100	100
Nervousness	50	0	40	0	0

Note. VRH = virtual reality hypnosis.

TABLE 3
Results for Patient 3, 0–100 Scale

	Day 1 Before VRH	*Day 1 1 Hr After VRH*	*Day 2 Before VRH*	*Day 2 1 Hr After VRH*	*Day 3 24 Hr After VRH*
Time spent thinking about pain	25	15	0	5	NA
Unpleasantness of background pain	55	30	30	30	NA
Worst pain	100	15	30	30	NA
Nervousness	100	0	5	0	NA

Note. VRH = virtual reality hypnosis.

Patient 3

Patient 3 rated his time spent thinking about pain at 25 at baseline on Day 1, which decreased to 15 after treatment (see Table 3). On Day 2, time spent thinking about pain was reduced to 0, and then went up slightly to 5 after VRH. The patient's rating of unpleasantness of background pain dropped from 55 to 30 from baseline to posttreatment on Day 1, and remained there for the remainder of the study period. The patient's worst pain in the past 24 hours on Day 1 was rated at 100 at baseline. After treatment, there was a large decrease of 85% to 15. On Day 2, he reported that it had risen to 30 at 24-hours posttreatment, and it remained there 1 hour after VRH treatment. Nervousness started at 100 on Day 1 at baseline and was completely eliminated after treatment, but increased slightly to 5 on Day 2, 24-hours posttreatment. At 1 hour posttreatment on Day 2, it was back down to 0. Total opioid equivalent use was .33 on Day 1 and .75 for Day 2.

The patient opted not to participate in filling out the measures on Day 3. He did not give a specific reason for discontinuing participation, but it is common for patients in a trauma center to refuse to continue participating in research because they are overwhelmed and fatigued because of their health conditions.

Figure 1 provides a representation of one selected outcome variable, that of patient reports of worst pain. As can be seen, all three patients gave baseline ratings of 100. Patients 1 and 3 showed substantial drops with varying levels on this variable, but Patient 2 reported that worst pain remained at 100.

Discussion

This study evaluated the effect of immersive VRH on a series of three patients with traumatic bone fractures severe enough to result in hospitalization at a major regional trauma center, and the necessity of surgical interventions to correct the fractures. Like the pain after many types of trauma (Choiniere, Grenier, & Paquette, 1992; Ptacek, Patterson,

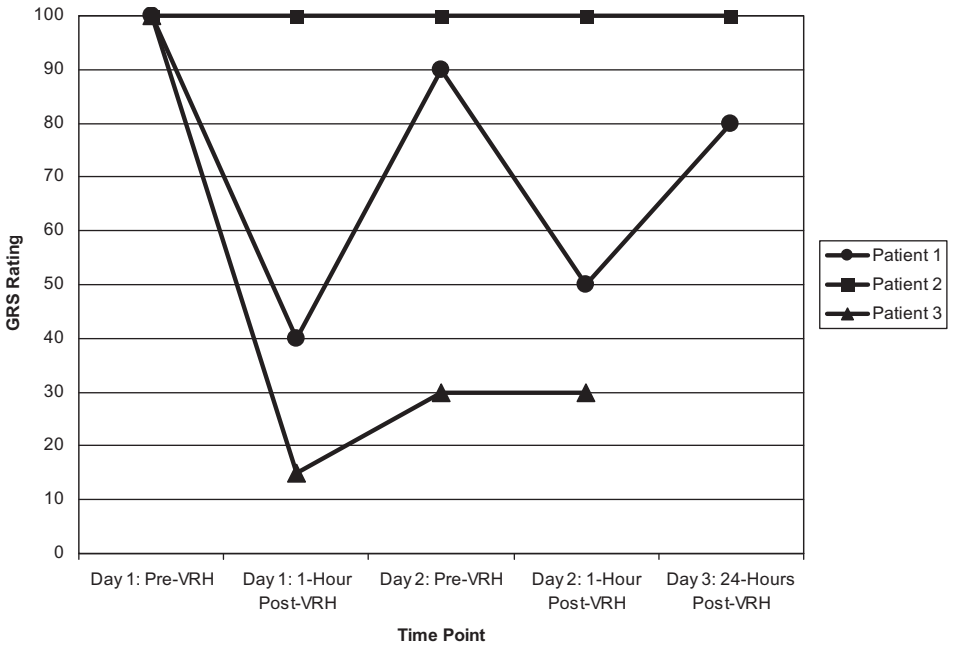

FIGURE 1 Worst pain for Patients 1–3.

Montgomery, Ordonez, & Heimbach, 1995), the reported pain levels and the amount of pain reduction varied in our subjects. The pain reduction was substantial overall, with rates of reduction (relative to the baseline) varying from 30% to 70% for the outcome variables studied. However, it should be noted that there was not a consistent effect for all patients on all days, and for some patients, there was no effect on a given variable for a given day.

Although VRH generally showed a substantial effect on subjective pain and anxiety reports on most days, opioid analgesic use was generally stable on all study days. Because opioid analgesic dosing was determined by the patients' care team independent of the study protocol, this finding suggests that the improvement in subjective pain scores was not related to changes in pharmacologic analgesia, but rather that VRH exhibited an adjunctive analgesic effect.

There are a number of limitations of this study. Most notably, this was a case series with no control group or control treatment condition. It is therefore not possible to determine whether reductions of pain were the result of historical or other factors, such as expectations associated with the use of a new treatment modality. In addition, we only collected data for two days of VRH. Future researchers should seek to assess outcomes for longer when possible, to help determine the extent to which

the beneficial effects of VRH maintain over time. Last, hypnotizability, an important variable to be considered in any study of the clinical use of hypnosis, was not measured because of the time constraints and other logistical issues associated with trauma hospitalization.

These limitations not withstanding, the case series showed some encouraging results for clinical pain in a population that has received little attention in the research literature. The magnitude of pain reduction reported by patients over a several day period was encouraging. These findings indicate that controlled trials studying the efficacy of VRH with larger samples and a longer duration of treatment is justified. Clinically, the use of VRH provides an exciting potential adjunct to opioid analgesic medications. Hypnosis delivered through this therapist-independent technique can potentially reach far more people than traditional hypnosis. Although the initial startup costs of a sophisticated immersive virtual reality system are substantial, these costs will likely decrease a great deal as the technology becomes more common. Costs aside, VRH has the potential to eliminate the burden upon treatment facilities to have clinicians trained in hypnosis. Furthermore, multiple VRH versions can be created in various languages to accommodate non-English speakers or patients that are hearing impaired (i.e., instructions can be visually displayed). VRH for acute pain warrants further trials.

Note

1. The software expertise necessary to design the immersive virtual reality delivery system was provided by Hunter Hoffman, Ph.D. at the University of Washington, Human Interface Technology Lab.

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