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Title:

Reducing pain during wound dressing in burn care using VR: A study of perceived impact and usability with patients and nurses.

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Title

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Abstract

Burns patients often suffer severe pain during interventions such as dressing changes, even with analgesia. Virtual Reality (VR) can be used to distract patients and reduce pain.

However, more evidence is needed from the patients and staff using the technology about its use in clinical practice and the impact of different VR strategies. This small-scale qualitative study explored patient and staff perceptions of the impact and usability of active and passive VR during painful dressing changes. Five patients took part in three observed dressing changes - one with an active VR scenario developed for the study, one with passive VR and one with no VR - following which they were interviewed about their experiences. Three nurses who performed the dressing changes participated in a focus group. Thematic analysis of the resulting data generated four themes: 'Caution replaced by contentment', 'Distraction and implications for pain and wound care', 'Anxiety, control and enjoyment' and 'Preparation and communication concerns'. Results suggested that user-informed active VR was acceptable to burn patients, helped manage their perceived pain, and was both usable and desirable within the clinical environment. Further testing with larger samples is now required.

Key words: Burn Pain, Wound Care, Virtual Reality, Distraction, Usability, Acceptability, Patient Perspectives, Staff Perspectives, Qualitative Methods.

Introduction

Burns patients often experience severe pain during interventions, such as when wound dressings are changed, combining the pain of treatment with the background pain of tissue damage[1,2]. Opiates are routinely administered for burn pain[3]. However, opiates come with side effects[4] and their effectiveness in managing the pain of procedures, such as dressing changes, has been questioned[5,6]. Inadequate pain control has detrimental effects on psychological and physical wellbeing[7,8,9], patient confidence[5] and compliance[10]. Therefore, evidence suggests other forms of analgesia should be considered. Pain theories, such as Gate Control Theory and neuromatrix theory[11,12], highlight the importance of psychological determinants of the pain experience, including perception, attention and anxiety. Interventions, such as hypnosis, which address these determinants, have proved effective in distracting patients[6].

Virtual Reality (VR) as a clinical intervention can also act upon pain perception[13]. VR's 'artificial three-dimensional environment'[14] works to increase demands upon attention[15] and reduce cues to pain and anxiety before and during procedures[16]. When compared with analgesia alone, VR plus analgesia has been shown to achieve a significant reduction in procedural pain scores [17,18], and qualitative reports identify increased relaxation and cooperation, reduced pain and anxiety, and effective communication despite immersion in the VR technology[18]. Costs of VR technology are falling, and recent developments have both addressed shortcomings of earlier technology (such as nausea) and improved VR's applicability to the clinical area[5, 19, 20].

Based on dissatisfaction with current methods of pain control and a growing evidence base for the effectiveness of VR, reviewers have recommended its introduction to burn care and rehabilitation[21]. However, further detailed work is required to explore specific influential variables by considering the impact on different patient groups of different VR environments[22]. VR environments may need tailoring to specific groups for maximum effect[23], for example, using ‘cold’ scenarios for burn patients, and developing different VR scenarios to suit children of different ages[18]. One variable of interest is the degree of immersion offered by the intervention.[1,22, 19, 24]. VR can offer active involvement for the user, or a passive experience of simply watching and listening. Tashjian et al. reported significantly greater reductions in pain when patients were involved in an active VR scenario via headset, compared with the passive experience of watching a video by the bed[25]. However, given the differences between the two interventions, it was unclear to what extent whether the result was achieved through the active vs. passive element alone[26]

A recent study conducted by the Authors (2018) developed user-informed scenarios based on active and passive VR and compared their effects on the experimental pain of a cold pressor test. Experimental pain studies offer greater variable control: participants can be administered the same pain stimulus and intervention, which makes it easier to distinguish the effects of the target variables on outcomes. Previous results have shown that experimental pain is lower with VR[24,27,-28]. Our study supported these findings, demonstrating significant differences between VR conditions overall and the no-VR baseline in both pain threshold (the point at which pain was first experienced) and pain tolerance (the point at which the cold pressor pain became intolerable and participants removed their hand). In addition, findings showed that pain threshold was significantly higher in active, immersive VR conditions than passive ones. When results for active and passive scenarios were considered separately, significant differences from baseline were only demonstrated for the active condition. The small sample size is acknowledged; however these results indicated that the most effective form of VR in managing pain for this sample was an active, immersive experience (Authors, 2018).

Findings regarding VR - and especially immersive VR - in experimental pain relief are encouraging; however, experimental pain is relatively mild, of limited duration, escapable, and implies no health threat. It is not clear whether the effects on pain can be said to transfer easily into the clinical environment[22]. Patients' types and levels of clinical pain are likely to differ, and their medical needs often influence how an intervention can be delivered[22]. It is therefore important that VR be trialled in the clinical arena to confirm its real world usability and effectiveness. The current study applied the VR interventions developed and trialled in our experimental pain trial to a small sample of burn inpatients undergoing regular dressing changes at a single UK Burns Unit. Approaching people who will actually use the intervention - patients and staff - has been described as a 'person-centred' approach which enhances the evidence base for intervention development and feasibility[29]. The work was supported by a Medical Research Council Confidence in Concept grant [number will be supplied after blind review].

Aims

This study aimed to explore:

- patient and staff perceptions of the effect of active and passive VR on perceived pain and anxiety during painful dressings changes;

- patient perceptions of the usability, acceptability, engagement with active and passive VR scenarios;

- staff perceptions about the usability and implications of the VR technology within a Burns Unit inpatient setting.

Methods

Design

This was a small-scale qualitative usability study, employing qualitative methods in keeping with the person-centred approach to intervention development and feasibility work[29].

Review and Approval

The original study protocol was reviewed by the Patient and Public Involvement (PPI) Panel for the Directorate of Therapeutics and Palliative Care, [City] Teaching Hospitals NHS Foundation Trust, and their suggestions were followed. Ethical approvals for the trial as described were granted by The University Research Ethics Committee and NHS Research Ethics Committee (IRAS 221071).

Participants

Patients: Participants were adult inpatients at the local Burns Unit who were undergoing regular dressing changes during the study period. Exclusion criteria included head and neck burns, wound infection, current diagnosis of PTSD, active psychotic symptoms or high levels of distress. Suitable patients were briefly introduced to the study and supplied with a full information sheet, with details about aims, procedures and rights. Before taking written consent, participants were encouraged to try out a short VR experience. We aimed to recruit up to 10 participants, in keeping with similar intervention development and usability studies[30] Five patient participants were recruited during the time available. Hospital stays which were too brief for the trial, mental health problems, injury location and infection control problems were key factors in those who were not eligible or declined participation. Participant details are provided in Table 1.

TABLE 1 HERE

Staff: Three qualified (female) nurses who had been directly involved in the care of participating patients were invited to and participated in a short post-study focus group, to share their impressions of the VR technology, its impact, usability and acceptability.

Materials

Equipment: An Oculus Rift CV1 headset, PC and digital recorder.

VR Scenarios: From the four tested under experimental conditions (Authors, 2018), we offered participants a choice two active VR scenarios, both of which had proved effective. These were named 'Basket' and 'Flocker'. In Flocker the user-controlled character was engaged in herding sheep through various obstacles. Basket was an energetic scenario based on in which the user was involved making basketball shots and building up their score. As described in Authors (2018) these scenarios were developed by a games designer, following a consultative workshop which included burn survivors, games designers, clinical and academic psychologists. As described above, they were trialled under experimental conditions and proved acceptable and enjoyable to users, and effective in reducing perceived pain. As a passive VR experience, participants were offered a choice of videos from the Oculus video application, which included scenes such as seeing the world from the viewpoint of an eagle, swimming with dolphins, or exploring a space station.

Procedure

Patients took part in three observed dressing changes during the study - one without VR, one with an active VR scenario and one with the passive VR scenario. The order of dressing changes was altered between participants, as shown in Table 1. Decisions about the suitable timing of each were made between the patient, the clinical team and the researcher, and the order was varied between the five participants. IP spent time with the participant before, during and after the dressing. He prepared the equipment, provided instruction and facilitated short familiarisation sessions for the patients before they used each scenario. Dressings ranged from 12 minutes (P5, active VR) to 70 minutes (P3, active VR) in length, with most lasting between 25 and 40 minutes.

Data Collection

Patient Interviews: IP conducted interviews at the bedside following completion of the two observed VR dressing changes once participants were comfortable. Questions included such as 'How was your pain during the dressing change while you were in the VR environment?' 'How did you feel generally during the experience?' and 'How helpful did you find the VR during the dressing change?' IP conducted a second interview with each participant at the end of the study, to gather overview data, with questions such as, 'Which VR experience did you prefer and why?' and 'From your experience how does a dressing change under VR compare with one with no VR experience?'

Staff Focus group: PF conducted the staff focus group. It took place in a private room near the ward and was audio-recorded. Questions focused on staff members' experience, their sense of the patient experience, and their general impressions of the VR technology. Items included: 'How did the VR dressing changes differ, if at all, from the dressing change without VR?'; 'What do you think the patients' experience was of the VR dressing change?'; 'What have the difficulties or complications been when using this technology?' and 'On balance, do you feel this sort of intervention is beneficial; if so / if not, why?'

Analysis

Data from staff and patients were transcribed and anonymised. For example, nurses were identified by ns1, ns3, etc., and patient participants by pt2, pt4, etc.

Transcripts were analysed for themes using an in-depth inductive coding, thematic mapping and theme development process [31]. This was a semantic analysis, in which the focus was data content (rather than underlying assumptions) and interpretation involved identifying the significance and implications of themes and constituent data in the context of existing knowledge[31]. Themes were refined through constant comparative analysis within and between transcripts and then across the whole dataset. Key themes reflected what seemed to be important aspects of the experience of VR among participants. PF acted as primary analyst, and themes were shared, discussed and refined through discussion with all authors.

Results

Four themes were generated from the combined dataset from patients and nurses: Caution replaced by contentment, Distraction and implications for pain and wound care':, Anxiety, control and enjoyment' and Preparation and communication concerns'.

Caution replaced by contentment

This theme reflected how participants' initial reluctance regarding VR had given way to positive perceptions. Two of the five participating patients initially decided against participating, but later changed their minds, based on the pain they had experienced without VR: 'I didn't want to, but it did good, and I'm glad I did' (pt2). The novelty of and her unfamiliarity with VR technology initially caused pt5 anxiety and uncertainty; however, in retrospect, she commented, 'I don't think people should be afraid of doing it.' It is not surprising that people experiencing the combined trauma of burn-injury, hospitalisation and severe pain were anxious and reluctant to take on something new. Nonetheless, these five participants had been willing to try VR and were unanimous that this had been a good idea. After the first VR trial, any initial anxiety had disappeared: as they approached the next VR trial, they were 'excited to try it' a second time (pt4).

Nurses were similarly impressed with how well VR had worked: 'Generally my experience has been that the VR's very helpful, very good at distracting' (ns2). Both groups felt that nurses could 'sell it more' to patients, and one person suggested that hearing others' positive experiences would help. Comments about VR and their experience of it from staff included 'it was all positive' (ns2), and from patients, 'great' (pt5), 'brilliant' (pt3, pt4), 'it's worth its weight in gold' (pt1) 'now I know what I want for Christmas' (pt4), and 'If I get any money, I'll get one of these' (pt5). Based on their experience, patients wanted to use VR again for dressing changes, even if this meant paying:

> 'I will have it, and I would even say, as an option, you know. If people said, this is early days, and you had to pay for it, I'd say, right then, I'd pay for it, I'd pay extra for that. I would pay, rather than not have it. (pt3).

Staff expressed their wish to be involved with any future funded research, were positive about its future potential and impatient for it to be routinely available in the clinical arena.

Both groups suggested additional applications for VR in physiotherapy, rehabilitation, childbirth, chronic pain and disabling conditions.

'Distraction and its implications for pain and wound care

This theme reflected the positive distracting effects of VR, and especially active scenarios, which impacted on pain tolerance and gave nurses scope to do more and spend longer on dressing changes.Additional nuanced data reflected the fluctuations in, and, sometimes, increased pain resulting from more intensive wound care.

A key factor in reducing pain and increasing tolerance of wound care seemed to be the degree of distraction created by VR:

> 'It drags you off. It drags you off, definitely. They are picking off stuff where, say they *pick one or two off ... you'd be on it, wouldn't you, you're concentrating on the pain* all the time, where that does help me, it's distracting, the whole thing' (pt3).

Active scenarios were more effective in distracting patients: '[it was] better with VR; [but] scenarios [were] better for taking mind off' (pt1). In contrast, the relative slowness and passivity of passive version facilitated only a limited degree of distraction for most participants. Four spoke of feeling frustrated by the slowness and passivity of the experience and needing better distraction from the pain. Immersion was further compromised during the passive VR by swooping movements in videos, which induced dizziness and motion sickness in some.

Patients were unanimous that they had achieved good levels of distraction (and no nausea) in the active VR. Some spoke of awareness of pain and of what the nurses were doing - 'felt it but not concentrating on it' (pt2) - but their focus remained on the engaging scenario. Nurses spoke of patients being 'amazed' (ns2) by what they had done afterwards, and several patients reported losing track of time, so immersed had they been in the virtual world: 'It seemed to go much quicker than I thought' (pt5).

In addition, wearing the headset and watching the scenario meant patients could not see the wound and nursing activities: *'I didn't see what they were doing … if I could see what they* were doing, I wouldn't let them' (pt1). Without this distraction, normal behaviour involved being drawn to and focusing on the wound and wound care, which increased pain. Not watching meant reduced pain: 'Before you were thinking, it hurts, because watching them do it makes it worse' (pt2).

However, data suggested that the distraction of VR actually contributed towards pain in unexpected ways. Participants' greater distraction from and tolerance of pain compared with normal circumstances meant that nurses could spend longer on dressings and carry out more intensive wound care, such as removal of numerous surgical staples and more extensive debridement:

> 'he was a lot better with the VR on and I d*id pick quite a lot … he'd not allowed staff* to do what we would normally want to do because of the pain, whereas with the VR he allowed me to do that' (ns1).

This nurse commented that this patient's pain tolerance allowed her to remove more dead tissue from the wound bed, with a potentially positive impact on healing and infection. Without VR, the dressing change would therefore far more painful, yet with VR he had been able to tolerate it and both he and the nurses were positive about the impact of VR on both pain and wound care. However, pain relief and distraction for all patients came to an abrupt end when the VR was removed after the dressing. A few patients - particularly where wound care was more intensive - complained of lasting pain afterwards in both VR and non-VR trials, as painkillers wore off. Participants suggested offering VR after a dressing, to extend the positive distracting and analgesic effects.

Although there were reports of pain after dressings, perceived pain was clearly reduced during the procedure with active VR. Nurses also believed patients had required less analgesia with VR, but acknowledged the considerable variations brought about by differences in the dressing change intervention and stage of healing, making it hard to attribute this solely to VR:

> Ns3: 'My patient didn't need any extra analgesia during, before or after the dressing change. I think she probably would've liked some otherwise. I think she felt she needed some, pre-dressing, and then she didn't.'

> Ns1: '*I get the feeling, on the whole, it did reduce it a little bit but then again …* different dressing changes are different on the same person as things get better.'

This theme reflected the overall positive effects on pain and distraction of VR, and in particular the active scenarios. That it might facilitate intensive wound care and potentially affect post-procedural pain was not fully anticipated. These aspects are worthy of consideration and will be discussed below.

Anxiety, control and enjoyment

This theme included data suggesting that VR had not only reduced negative psychological effects of burns procedures, and had also created positive experiences, which were unexpected. Participants believed that VR had reduced their pre-dressing anxiety before and during their second trial of VR, because of their experience of distraction and its impact on pain, especially in the active condition. Nurses' data were in agreement: their perception had been 'lessened anxiety' (ns1) and distress from patients during VR dressings. Some suggested offering VR before (as well as during) a dressing change, to reduce anxiety, and on days between dressings to reduce stress.

Most spoke of positive emotions in response to the VR. The active VR in particular was 'fun', 'challenging', and 'enjoyable' (various pts). Ns1 expressed surprise at participants' apparently pleasurable engagement with the technology. She spoke about the 'laughter', an outcome rarely associated with painful dressing changes. Ns2 commented on occasional 'hilarity' and 'comical' moments, noting that VR had 'lightened' the experience for everyone.

One concern among eligible patients when deciding to take part was a fear of losing the ability to talk easily with staff, for example, to ask them to stop, when engaged with the VR scenarios. However, among those who actually participated, the technology had the opposite effect: two described feeling they could control part of the otherwise passive and traumatic dressing change experience when using VR. Having control meant retaining one's 'humanity.' The sense of having some control over the situation, along with the distraction and reduced pain, helped some patients control their own emotional responses to the experience. For example, pt5 spoke of 'trying to be a grown up' despite the dreadful pain of her burns. The VR, described as a ' crutch,' meant that, rather than 'howling' in response to dressing pain, she had found 'something as trivial as a video was actually quite empowering for me because I could take myself away' (pt5). There was a sense of pride in her achievement of self-control in circumstances which could otherwise be experienced as shameful, humiliating and disempowering.

Preparation and communication concerns

Preparation and communication emerged as potentially problematic issues which impacted primarily upon the nurses involved, but also by consequence upon the patients themselves. In order to avoid burdening clinical staff, research team members took on the roles of preparing participants for VR, managing the technology during dressing changes, and collecting data. Therefore, although nurses were fully aware of the study, they did not receive training and preparation in the technology. This limited their ability to discuss VR with patients before, during and after its use between researcher visits. Both patients and staff commented that greater staff knowledge would have helped: 'I thought the VR was really good but I didn't know a lot about it before the dressing change. I hadn't got a clue how it worked' (ns2). Both patients and nurses suggested more preparation time (perhaps assisted by trained nurses) would help, for example with 'the physicality of wearing it' (pt5), or 'a practice with the VR pre-*dressing, so that …. they'd know what they'd like to do, what activity, and how to do it*' (ns1). Greater direct involvement in the study could have allowed nurses to play a more active role in preparing, supporting and informing VR users. Learning about the technology together might also contribute towards development of closer staff-patient relationships. Experienced burns staff may lose touch with the novelty of the experience of dressing changes for patients. Shared unfamiliarity with and co-learning about VR in this context may foster a greater empathy and understanding between staff and patients. Staff hopes in future research for greater involvement with and 'training' in VR use were mentioned in discussion, and will be considered below.

Practitioner-patient communication during procedures also emerged as a concern for the nursing staff. For optimal distraction, pain and anxiety relief effects, the user ideally requires deep immersion and minimal interruption from the outside world. Good nursing practice involves keeping the patient informed and involved:

'Normally when I'm doing a dressing, I'd explain what I'm doing, you know, explain things on their legs or whatever, how their wound is, what it looks like' (ns2).

Conflicting requirements placed nurses in a difficult position, caught between communication as interruption and communication as involvement: '*I couldn't kind of work out what my role was and what I should be doing… do you interrupt them when they're in t*hat zone?' (Ns2). Despite a sense of 'inadequacy' in uncertain circumstances, these experienced practitioners navigated the situation well, opting to minimise their verbal interruptions to the most vital information, such as imminent body position changes etc. Nurses discussed how they might in future negotiate short breaks in the VR, when activities would temporarily cease to facilitate communication.

Discussion

This study explored the acceptability, perceived effectiveness and usability of active and passive VR scenarios in the clinical setting during inpatient dressing changes. Previous evidence has demonstrated reduced pain in burn patients when using VR, but detailed patient and staff perspectives have rarely been gathered. A recent mixed methods study set in a US burns outpatient clinic collected quantitative data from staff and quantitative and qualitative data from patients, which demonstrated satisfaction with and feasibility of the technology[33]. Our findings add to what is already known, by providing in-depth qualitative evidence from both staff and patients which demonstrated that VR was acceptable, feasible and welcomed by all participants when used during in-patient dressing changes. VR promoted distraction, reduced perceived pain during dressings, enhanced wound care, and improved wellbeing. Findings further suggested that immersive, active VR might be more useful in supporting pain and anxiety relief than more passive versions of the technology. O

Previous authors have recommended research focusing on the extent to which fun and presence contribute to effectiveness in VR interventions[22]. Our findings provide some insight into these aspects, indicating that user-informed immersive scenarios (e.g. those with increased presence and engagement) were particularly effective in distracting patients. They also suggest that, as well as reducing the negative impacts of dressing change on pain, anxiety and distress, immersive VR can create positive experiences of fun, challenge, hilarity and laughter, 'lightening' the experience for all parties. This study compared VR to normal care, which is minimal distraction, at best using a TV / video, but most often no pain relief beyond pharmacological methods. It has been noted that, while other distraction techniques, such as hypnosis, are effective, non-pharmacological interventions are rarely used in practice[34]. A majority of European Burn Centres have expressed dissatisfaction with their current pain-management strategies for burns patients[35]. This study contributes to a body of evidence demonstrating the potential for VR in addressing procedural pain.

Several unanticipated effects of the VR are worthy of discussion.

First, increased patient tolerance offered the nurses greater scope to provide intensive wound care, as reported elsewhere[32], with positive potential for wound healing and recovery. This was tolerated well during the procedure but may have contributed to some reports of lasting pain afterwards. In addition, no matter how intensive the wound care, removing the VR also removes the distraction and analgesic effects. There will probably never be a way of eradicating pain completely; however these unanticipated (negative) effects on the pain experience should be considered. It may mean the patient should be offered continued access to the VR afterwards, with the immersive experience gradually reduced rather than suddenly removed. It also suggests that VR and other forms of pain relief (such as analgesic medication) may be used in a complementary way, with one introduced before the other is withdrawn.

Second, communication during dressing changes is part of normal care, as a nurse informs the patient about what he/she is doing, answers questions, including about wound progress, and provides instruction to the patient, for example, about movements they need to assist with. Nurses were unsure how to manage this part of their role and activities in the present study, an issue which could be addressed more explicitly in future work. However, we noticed that, despite their uncertainty, nurses navigated this challenge very successfully. As a small team, the staff came to know their patients well and quickly developed an understanding of how to tailor communication to meet patient need. Individual preferences about communication could also be discussed with the patient, giving them an active role in decisions about their wound care, which should also support effective pain management[36].

Third, outcomes suggested that the decision to avoid burdening staff inadvertently limited their ability to support patients with its use. A recent mixed-methods study reported similar findings from its qualitative interviews[33]. Short-term research projects led by funded research teams, in which researchers deliver the intervention, help demonstrate efficacy of an intervention[33,37], and indeed, our work suggested benefits to both staff and patients. However, more research needs to be done in which staff members are involved and empowered to engage, understand, and independently operate the equipment and explain the technology to patients. This helps ensure new treatments are properly costed and effectively integrated into the clinical setting after the research is finished. Markus et al.[38] trialled VR as an adjunct to physiotherapy and found that the costs to staff in terms of time, setting up, managing and cleaning the equipment were so great, that they arguably outweighed the benefits to patients. Morris et al. [37] explored VR for burns physiotherapy in South Africa, and found, in contrast, that time spent managing the technology was not seen as problematic. Instead physiotherapists felt freed to focus more on movement than pain using VR, potentially benefitting patient recovery. This has resonance with our finding that nurses believed VR allowed them to focus more intensively on wound care (rather than pain management). The back-up systems, such as staff training, technical support, maintenance and cleaning of equipment, which would allow an intervention such as VR to support existing care without unduly burdening busy staff, simply aren't there[38]. However, although systems are rarely in place yet, once set up and established, VR systems could be applied without great time and effort in routine clinical care of burn patients and others requiring dressing changes, such as those undergoing reconstructive surgery[22]. Indeed, if hospitals make the investment in the systems, there seems no reason why broader patient groups should not benefit, as suggested by the patients and staff in the current study.

Our study had methodological strengths and limitations. Strengths included user involvement in the development of the trialled active VR scenarios (for more detail, see Authors, 2018), which proved very acceptable and apparently effective in reducing perceived pain and anxiety. User involvement was recently recommended as a priority for burn rehabilitation research[21]. The qualitative approach was a strength: interview data from both staff and patients were very valuable in revealing unanticipated outcomes of this still relatively novel intervention, including unexpected experiential aspects, and detailed insights into implications of the technology for various stakeholders. This approach has been recommended in intervention feasibility and development work[29]; however it is relatively unique in the field of VR research, which is dominated by quantitative approaches. Ford et al.[33] gained some useful qualitative insights from patients but collected only quantitative data from staff, which limited its depth.

Limitations include the very small sample, which was constrained by the single-centre design, time limitations on funding use and clinical exclusion criteria. Future work should adopt multi-centre designs, allow longer for recruitment, and consider ways to reduce exclusions. For example, infection control concerns could be addressed by utilising replaceable foam inserts for use with the VR kit. Patients with head or neck burns were also excluded; however, one previous study found a way around this issue using arm-mounted VR equipment. While less immersive than a headset, authors found that those using the VR reported significantly lower pain than both passive distraction (watching a movie) and standard care[39]. This was similar to our findings indicating the superiority of active VR. Having both head- and arm-mounted versions available would prevent excluding large sections of the burn population from accessing effective VR-based pain relief.

Finally, previous authors[39] have recommended physiological measures of pain, and, in keeping with its 'person-centred' approach[29], our study collected subjective perceptual data. Our sense is that, if patients themselves believe their pain is reduced and more tolerable, this should be sufficient recommendation. Indeed, pulse and BP ratings can increase under conditions of excitement (such as when playing an immersive scenario) as well as pain, so are open to misinterpretation. The patients' subjective experience and interpretation of their pain may be the most useful measure in improving their experience and reducing short and long-term impacts. Alternatively, if a more objective mode of pain assessment were required, one promising approach could be treating pharmacological analgesia use as a proxy for pain. A recent study found a 39% reduction in opioid requests under their immersive VR condition, despite no significant differences in pain and anxiety ratings[40]. Like ours, their intervention was very positively evaluated, and 75% were willing to use it again. The finding of reduced opiate analgesia during (and before and after) dressings due to lower pain perception[40] has some support in our qualitative results. Reducing analgesia also reduces costs of care and unwanted side effects. Side effects of opiates include respiratory depression, constipation, sedation, nausea[41-43], and possibly even immunosuppression and infection[42]. Decreased use of sedating, nauseating opiates may promote earlier mobilisation in recovery from burns[21]. VR could have a role to play here, as suggested in physiotherapy studies[37,38], since it could enable patients to focus on recovering movement, rather than on their pain.

This small study demonstrated the usability and acceptability of VR technology in a single clinical setting, and the perceived effectiveness of active VR scenarios in managing the pain and anxiety associated with dressing changes for five inpatients. Next steps would be to trial on a multi-centre basis, using controlled approaches, as recommended by reviewers in the area[34]. Measures should also be taken to reduce exclusions, extend application of the technology and recruit larger samples. Our experience suggests that future trials should consider mixed methods because qualitative data help capture nuanced and unanticipated outcomes. Staff preparation and involvement are important concerns, and teams should consider the broader impact and analgesic potential of VR to address pain relief before, during and after the procedure.

References

1. Hoffman HG, Patterson DR, Magula J, et al. Water-friendly virtual reality pain control during wound care. Int J Clin Psychol 2004;60(2):189-95.

2. Pardesi O, Fuzaylov G. Pain Management in Pediatric Burn Patients: Review of Recent Literature and Future Directions. J Burn Care Res 2017;38:335-47.

3. Patterson DR, Sharar SR. Burn Pain. In JD Loeser, SH Butler, CR Chapman et al. (eds.) Bonica's management of pain. Philadelphia: Lippincott Williams and Wilkins; 2001, pp. 780-787.

4. Cherny N, Ripamonti C, Pereira J. et al. Strategies to manage the adverse effects of oral morphine: an evidence-based report. J Clin Oncol, 2001;19:2542-54.

5. Edwards J. Managing wound pain in patients with burns using soft silicone dressings. Wounds 2011;7(4):1-4

6. Hoffman HG, Patterson DR, Carougher GJ et al. Effectiveness of Virtual Reality-Based Pain Control With Multiple Treatments. Clin J Pain 2001;17:229-235.

7. Stoddard FJ, Saxe G, Ronfeldt H et al. Acute stress symptoms in young children with burns. J Am Acad Child Adolesc Psychiatry 206;45:87-93.

8. Macleod R, Shepherd L, Thompson AR. Posttraumatic Stress Symptomatology and Appearance Distress Following Burn Injury: An Interpretative Phenomenological Analysis. Health Psychol 2016;35(11):1197-1204.

9. Berger MM, Davadent M, Marin C, et al. Impact of a pain protocol including hypnosis in major burns. Burns 2010;36:639-46.

10. Richardson P, Mustard L. The management of pain in the burns unit. Burns 2009; 35:921-36.

11. Melzack R. Pain and the neuromatrix in the brain. J Dent Educ 2001;65:1378-1382.

12. Melzack R. Evolution of the neuromatrix of pain. The Prithvi Raj Lecture: presented at the third World Congress of World Institute of Pain, Barcelona 2004. Pain Pract 2005;5:85-94.

13. Gold JI, Belmont KA, Thomas DA. The neurobiology of virtual reality pain attenuation. Cyberpsychol Behav 2007;10:536-544.

14. Garrett B, Taverner T, Masinde W et al. Rapid Evidence Assessment of immersive Virtual Reality as an Adjunct Therapy in Acute Pain Management in Clinical Practice. Clin J Pain 2014;30(12):1089-1098.

15. Hoffman HG, Prothero J, Wells M et al. Virtual chess: the role of meaning in the sensation of presence. J Hum-Comput Interaction 1998;10:251-263.

16. Hoffman HG, Patterson DR, Carougher GJ. Use of virtual reality for adjunctive treatment of adult burn pain during physical therapy: a controlled study. Clin J Pain 2000;16(3):244-250.

17. Farrar JT, Portenoy RK, Berlin JA et al. Defining the clinically important difference in pain outcome measures. Pain 2000;88:287-294.

18. Das DA, Grimmer KA, Sparnon AL et al. (2005) The efficacy of playing a virtual reality game in modulating pain for children with acute burn injuries: A randomised controlled trial. BMC Pediatrics 2005;5:1.

19. Hoffman HG, Patterson DR, Seibel E et al. Virtual Reality Pain Control During Burn Wound Debridement in the Hydrotank. Clin J Pain 2008;24(4):299-304.

20. Jones, T., Moore, T., Choo, J. The impact of virtual reality on chronic pain. PLoS ONE 2016;11(12):e0167523.

21. Schneider JC. Rehabilitation Research Priorities: The Next 10 Years. J Burn Care Res 2017;38:e635-e637.

22. Malloy KM, Milling LS. The effectiveness of virtual reality distraction for pain reduction: A systematic review. Clin Psychol Rev 2010;30:1011-1018.

23. Hua Y, Qiu R, Yao W et al.. The Effect of Virtual Reality Distraction on Pain Relief During Dressing Changes in Children with Chronic Wounds on Lower Limbs. Pain Manage Nurs 2015;16(5):685-691.

24. Dahlquist LM, McKenna KD, Jones KK et al. Active and passive distraction using a head-mounted display helmet on cold pressor pain in children. Health Psychol 2007;26:794-801.

25. Tashjian VC, Mosadeghi S, Howard AR et al. Virtual Reality of Management of Pain in Hospitalized Patients: Results of a Controlled Trial. JIMR Health 2017;4(1):e9

26. Taylor TF. The influence of shame on posttrauma disorders: have we failed to see the obvious? Eur J Psychotraumatol. 2015; 6: 10.3402/ejpt.v6.28847.

27. Hoffman HG, Seibel EJ, Richards TL et al. Virtual reality helmet display influences the magnitude of virtual reality analgesia. J Pain 2006;7:843-850.

28. Patterson DR, Hoffman HG, Palacious AG et al. Analgesic effects of posthypnotic suggestions and virtual reality distraction on thermal pain. J Abnorm Psychol 2006;115:834-841.

29. Yardley L1, Morrison L, Bradbury K et al. The person-based approach to intervention development: application to digital health-related behavior change interventions. J Med Internet Res. 2015; 30;17(1):e30. doi: 10.2196/jmir.4055.

30. Riiser, K., Løndal, K., Ommundsen, Yet al. - Development and Usability Testing of an Internet Intervention to Increase Physical Activity in Overweight Adolescents. JMIR Res Protoc. 2013; 2(1): e7, doi: 10.2196/resprot.2410

31. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol 2009; 3(2):77-101.

32. Faber AW, Patterson DR, Bremer M. Repeated Use of Immersive Virtual Reality therapy to Control Pain During Wound Dressing Changes in Pediatric and Adult Burn Patients. J Burn Care Res 2013;34:563-568.

33. Ford CG, Manegold EM, Randall CL et al. Assessing the feasibility of implementing low-cost virtual reality therapy during routine burn care. Burns 2018; https://doi.org/10.1016/j.burns.2017.11.020.

34. Sheffler M, Koranyi S, Meissner W et al. Efficacy of non-pharmacological interventions for procedural pain relief in adults undergoing burn wound care: A systematic review and meta-analysis of randomized controlled trials. Burns 2017. https://doi.org/10.1016/j.burns.2017.11.019.

35. Retrouvey H, Shahrokhi S. Pain and the Thermally Injured patient - A Review of Current Therapies. J Burn Care Res 2015;36:315-323.

36. Solowiej K, Mason V, Upton D. Psychological stress and pain in wound care, part 3: management. Journal of Wound Care, 2010; 19(4); 153-155.

37. Morris LD, Louw QA, Crous LC. Feasibility and potential effect of a low-cost virtual reality system on reducing pain and anxiety in adult burn injury patients during physiotherapy in a developing country. Burns 2010;36:859-64.

38. Markus LA, Willems KE, Maruna CC et al. Virtual reality: Feasibility of implementation in a regional burn center. Burns 2009;35:967-69.

39. Jeffs D, Dorman D, Brown S, et al. Effect of Virtual Reality of Adolescent Pain During Burn Wound Care. J Burn Care Res 2014;35:395-408.

40. McSherry T, Atterbury M, Gartner S et al. Randomized, Crossover Study of Immersive Virtual Reality to Decrease Opioid Use During Painful Wound Care Procedures in Adults. J Burn Care Res 2017; doi:10.1097/BCR.0000000000000589.

41. Christie MJ, Connor M, Vaughan CW et al. Cellular actions of opioids and other analgesics: implications for synergism in pain relief. Clin Exp Pharmacol Physiol 2000;27:520-3.

42. Rittner HL, Roewer N, Brack A. The clinical (ir)relevance of opioid-induced immune suppression. Curr Opin Anaesthesiol 2010;23:588-92.

43. Maani CV, Hoffman HG, Fowler M et al. Combining ketamine and virtual reality pain control during severe burn wound care: one military and one civilian patient. Pain Med 2011;12:673-8.

Table 1: Patient Participant Details

Participant code	Gender	Age	Burn Type, location, TBSA*	Admission / grafting details	Order of VR conditions
P1	M	68	Flash burn Hands, arms, face, 18%	Admitted 2.5 weeks before first trial Grafted between trials 1 and 2	1. Active 2. Control 3. Passive
P2	F	38	Flash burn Lower legs, 19%	Admitted 1.5 weeks before first trial Grafted after third VR trial	1. Active 2. Passive 3. Control
P3	M	56	Flame burn Legs, arms, 20%	Admitted 1.5 weeks before first trial Grafting before all VR trials	1. Control 2. Active 3. Passive
P4	F	19	Scald Leg, abdomen, 4%	Admitted 0.5 weeks before first trial No grafting	1. Passive 2. Active 3. Control
P5	F	60	Scald Thigh, 3%	Admitted 0.5 weeks before first trial Grafted between trials 2 and 3.	1. Active 2. Passive 3. Control

* Total Body Surface Area