

3-D Virtual Reality Takes Patient Education to the Next Level





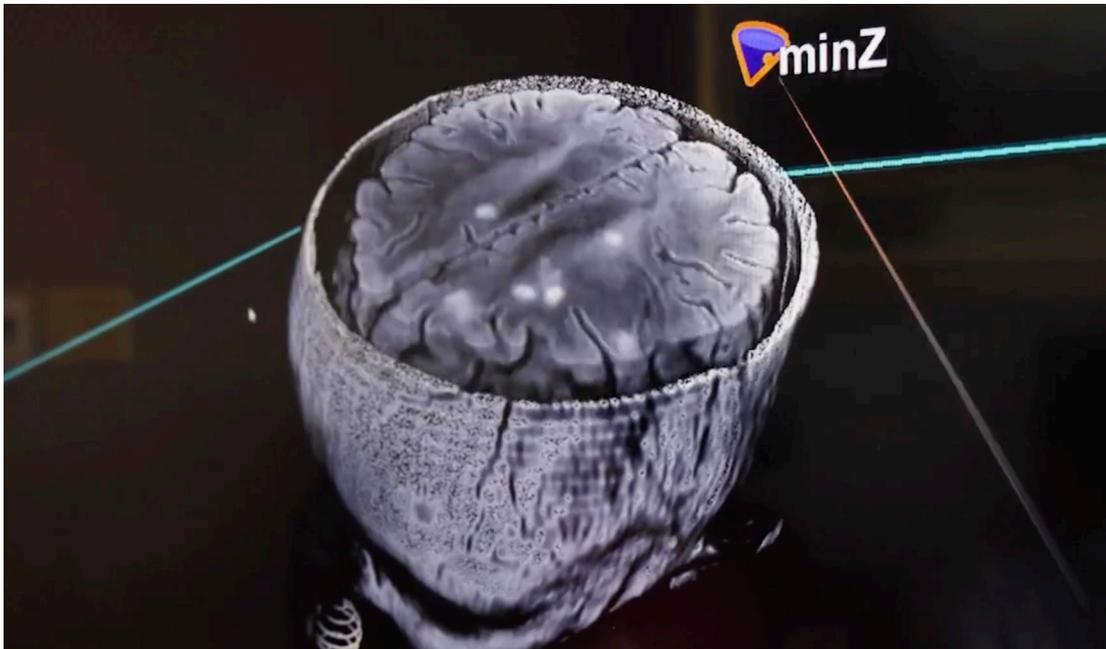
After a cancer diagnosis, patients and their caregivers often struggle to understand what is happening within patients' bodies. These challenges can be around comprehension of their disease, the treatment regimen, and/or specific symptoms or side effects. Studies have demonstrated that patients forget up to 80 percent of the information presented to them almost immediately after their medical consultation.¹⁻³ Additionally, up to 50 percent of the information patients do retain can be inaccurate.^{3,4} These issues are further compounded by highly complex or a large volume of information,¹ poor health literacy,² language barriers,⁵ and high anxiety or stress.⁶ These data should concern healthcare providers because patients are making important and life-altering decisions based on their own limited comprehension of their disease.

Poor Understanding Negatively Impacts Patients

Though patient understanding may not directly impact how well a physician performs a surgery, delivers radiation therapy, or prescribes a systemic regimen, it can have negative consequences for patients and their families. Patients can experience increased anxiety if they do not fully understand their disease and/or recommended treatments.^{1,7} Compliance concerns and avoiding recommended treatments can occur with poor patient understanding. Non-compliance can result from patients not knowing what to do or not possessing the rationale of why a certain treatment is important or necessary.⁸ Misconceptions or fear of their treatments can also cause patients to avoid recommended therapies.⁹

Some providers simply overestimate how effectively they teach and incorrectly think that patients understand more than they do.²³⁻²⁵ This cognitive bias is known as the "curse of knowledge," where persons with more knowledge than those around them are communicating with others, assuming others have the background knowledge to understand.²⁶

A lack of or poor understanding can lead to reduced patient satisfaction and lower engagement in their own care.¹⁰ The patient-physician relationship and patients' trust in their providers can also be harmed when patients do not feel that they have good insight into their disease,¹⁰ sometimes resulting in patients seeking medical care elsewhere.^{11,12} An important medical concept is shared decision-making. Patients who do not possess a reasonable understanding of their disease, treatment, and related side effects are simply unable to participate in shared medical decision-making.^{13,14} Most important, all of these factors are associated with poorer clinical outcomes.¹⁵⁻¹⁸



A 3-D volumetric rendering of a MRI brain depicting multiple intraparenchymal lesions.

Provider Challenges

Providers can make incorrect assumptions that patients and caregivers simply do not wish to be informed about their disease and suggested treatments. A sentinel 1961 study performed in Chicago, Ill., asked physicians whether they would inform their patients of a new cancer diagnosis. Surprisingly, 90 percent of physicians indicated that they would *not* inform their patients about the new diagnosis.¹⁹ Fortunately, much has changed since then with the movement toward patient education and patient-centered care. For many decades, it has been well understood that the vast majority of patients with cancer wish to be thoroughly informed about their disease and treatment.¹⁹⁻²²

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Providers may also struggle to understand what it is like to have cancer. Even though providers treat hundreds to thousands of patients, they may not be able to fully comprehend the experience of being diagnosed and living with cancer and undergoing treatment. Numerous reports of providers who have developed cancer or a significant illness have found that providers simply did not understand the patient experience until they lived it themselves.^{27,28} This means that providers may not be able to relate to what patients with cancer want or need, which may negatively affect the patient experience.

One of the largest hurdles in teaching patients with little to no background in medicine is the subject matter itself. Anatomy, cancer, and cancer treatment are difficult, abstract, and complex. For example, understanding the three-dimensional (3-D) and spatial interface of a tumor and its anatomy is vital for oncologists when staging and making treatment recommendations. But conveying this information to patients is challenging. However, if patients could be given the tools to better grasp this information, it could help them contextualize their disease and treatment, better understand the cause of their symptoms and treatment-related toxicities, and improve shared medical decision-making.

Evolution of Patient Education

Providers are always looking at ways to improve patient education. Below is a synopsis of how teaching has evolved:

- **Verbal discussion or description alone**, which has shown to be the least effective method²⁹⁻³¹ and, unfortunately, the most used strategy.



Provider with patient and caregiver donning virtual reality headsets during a virtual reality 3-D session.

- **Handouts, diagrams, videos, and medical imaging.** These additional methods are helpful²⁹⁻³¹ but likely still inadequate.
- **Two dimensional (2-D) medical imaging to show patients their disease in their body.** Though better, this information is difficult for the lay person to interpret. For example, without training, interpreting 2-D slices from magnetic resonance imaging (MRI) or computed tomography (CT) scan has been equated to reading a Rorschach inkblot. Due to the complexity and abstract nature of anatomy, cancer, and its treatments, these tools are likely insufficient to intuitively convey information in a format that patients and caregivers can understand.
- **3-D printed models show promising results in being able to display the 3-D spatial relationships of a tumor and local anatomy.**³²⁻³⁴ However, this approach may be limited due to the lack of context of the model within the body, along with logistical issues, such as scaling, cost, and time delay for 3-D printing.
- **Virtual reality.** This next-generation teaching tool displays individual 2-D planar slices of a CT, MRI, or positron emission tomography/CT as a complete 3-D volume. This approach is ideal because it is personalized to patients, enabling them to explore and interact with their own anatomy. This technology also allows patients to see the problem and tumor within their own body, while providing a 3-D framework for added learning and discussion.³⁵ Finally, presenting information in 3-D versus 2-D can reduce cognitive load, which is important for improved learning.³⁶

Several learning theories support the use of virtual reality, including constructivist,³⁷ embodiment,³⁸ and situational,³⁹ for not just hearing or seeing information but experiencing a new realism while interacting with a 3-D object in a new environment. Virtual reality has shown to be very effective in patient education. Though limited, recent studies have noted that the use of virtual reality has led to increased patient satisfaction, higher engagement, and a strong preference for this technology.⁴⁰⁻⁴² Momentum is building for the use of virtual reality in medicine, with the U.S. Food and Drug Administration now recognizing mixed extended reality.

The University of Colorado Cancer Center Experience

In 2019, at the University of Colorado, Douglas Holt, MD, led the effort to implement and study the use of virtual reality within the clinic for patient education in oncology. The University of Colorado Cancer Center received a 2021 ACCC Innovator Award for this work.

Implementing this technology took time and buy-in. Funded by a grant from the Colorado Cancer Coalition and one from the University of Colorado Cancer Center's radiation oncology department, the virtual reality solution transposed patients' medical images into a 3-D environment. To deploy this tool, the cancer program used state-of-the-art computers and virtual reality headsets that could be moved from room to room via a portable cart. By August 2020, the virtual reality cart was ready to use.

To better engage patients in their cancer treatment, providers used virtual reality to give patients a concrete visualization of what was happening in their bodies by taking the individual 2-D

Patients and caregivers noted virtual reality was a much easier format to learn from, while also providing improved understanding and engagement with their own treatment and providers.⁴³ Additionally, virtual reality was able to positively change patients' attitudes towards improved compliance.⁴³

planar image slices of their medical imaging scans and stacking them on top of one another to form a 3-D image of their bodies and tumors. With virtual reality technology, patients gained a better understanding through a clear visualization of their tumor: where it is located in their body, what organs it is near, and its size.

Patients step into the virtual reality space with their caregiver(s), and the provider visually demonstrates how their radiation treatment plan will work, showing them the size of the radiation beam and where it will be targeted. Going beyond 2-D images and verbal explanations, virtual reality technology gives patients the much-needed intuitive context regarding their disease and treatment.

Measuring the Impact of Virtual Reality on Patients with Cancer

Objectively measuring subjective patient experiences is quite challenging, unlike typical studies of medicine and cancer with hard endpoints of overall survival, disease-free survival, and toxicity. In 2020, working with clinical psychology and a psychometrician, the cancer program used both quantitative and qualitative methods to prospectively evaluate the impact of virtual reality on its patients with cancer and their families. Study abstract results were presented at the 2021 American Society for Radiation Oncology (ASTRO) Annual Meeting.⁴³ The published ASTRO abstract findings are shared below. Limited findings are shared here. (Manuscript currently in preparation for full results.)

The study included 25 virtual reality sessions with patients and their caregivers in which patients reviewed their 3-D medical imaging scans in consultation with their providers. Patients' ages ranged from 11 years to 95 years old. Patients were asked to rate their understanding of their disease and tumor—once before and then again after their virtual reality patient education consultation—using a 10-point scale (0 = no understanding to 10 = full understanding).⁴³ Patient understanding of their disease and tumor improved from a mean of 5.6 pre-virtual reality consultation to 9.2 post-virtual reality consultation.⁴³ When patients were asked about their preferred method for medical imaging review (3-D virtual reality versus a 2-D image on a computer), 97 percent

preferred 3-D virtual reality.⁴³ Virtual reality was the top-ranked educational tool (83 percent over all other current teaching methods, including verbal discussion, self-research, 2-D computer screen imaging review, illustrations, and handouts).⁴³ Additionally, the vast majority of patients and caregivers (97 percent) agreed that virtual reality should be a standard-of-care teaching tool for patients with cancer.⁴³

Qualitatively, patients shared how challenging it had been to learn upfront about their disease and treatment with standard consultation methods.⁴³ Patients and caregivers noted virtual reality was a much easier format to learn from, while also providing improved understanding and engagement with their own treatment and providers.⁴³ Additionally, virtual reality was able to positively change patients' attitudes toward improved compliance.⁴³

As shared by one patient in testimonial shared outside of study data and included as part of the 2021 ACCC Innovator Award Video (youtube.com/watch?v=NQDfeYMuK9M):

I was diagnosed with a squamous cell carcinoma at the base of the tongue. It's [so] difficult to understand where [the tumor's] at, because it's my body right, and I don't know where [or] what's going on inside of it. It is hard to look at a simple picture [of 2-D medical imaging]. When I came here, I got to see my body in front of me and in 3-D, I didn't have to look at some [2-D] images that are sliced through my body. [In virtual reality] you could go in there and zoom in, cut through it and be clear where in the body the tumor is at, and where the problem regions [are that] they have to attack. I could actually see where the [radiation] would be going and that was just really remarkable. It was like comparing a child's drawing to the Mona Lisa. [Virtual reality] did make it more real for me. Because I was able to look at myself in a third person perspective. Everyone should have the opportunity to do this. [Virtual reality] was really helpful.

Future Directions

With data from this study, Dr. Holt is working to expand use of this technology. He is currently in the process of pursuing additional prospective clinical trials to further investigate and validate its findings. Dr. Holt also will be working with additional institutions to implement and evaluate the use of virtual reality in patient education within the radiation oncology clinic along with other disciplines in oncology and medicine.

Another issue Dr. Holt will address is implementation of virtual reality within the clinical workflow to enable widespread, mainstream use. The ultimate goal is for virtual reality to become the standard-of-care in patient education to help improve the patient-physician relationship and communication by enhancing patient engagement and shared medical decision-making. 

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The author reports that there are no competing interests to declare.

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Presentations

This project was awarded the 2021 ACCC Innovator Award and was presented on at the 38th ACCC [Virtual] National Oncology Conference. Additionally, the results of this study were presented at the 2021 ASTRO Annual Meeting in Chicago, Ill. The abstract received the abstract travel award, and the results were also presented at the ASTRO News Briefing.

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