



C2- Virtual and Augmented Reality In Interventional Radiography Procedures

The majority of catheter-based skills are learned **on real patients** — while using **real radiation**.

VR changes that — offering **zero-radiation, high-precision,** and **repeatable** training.

Objectives

Differentiate between Virtual and Augmented Reality

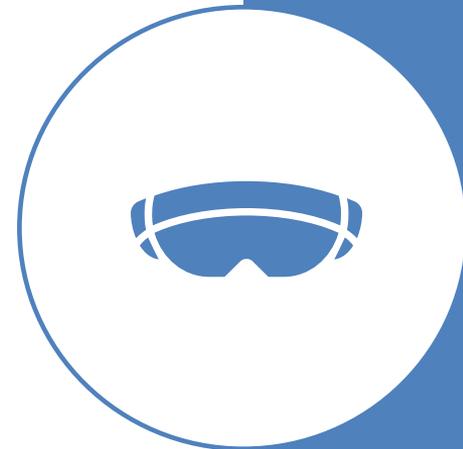
Identify types of VR

State the benefits in utilizing VR and AR

Examine patient safety effects

Discuss professional training needs

Explore current trends





Citation: (Elsakka et al., 2023)

Interventional Radiology

- Minimally invasive image-guided procedures
 - Requires precision & spatial reasoning
 - Relies on fluoroscopy, CT, Ultrasound



What is Virtual Reality?

- Immersive 3D computer-generated environments
 - User interacts with headsets/controllers
 - Simulates real-world procedures



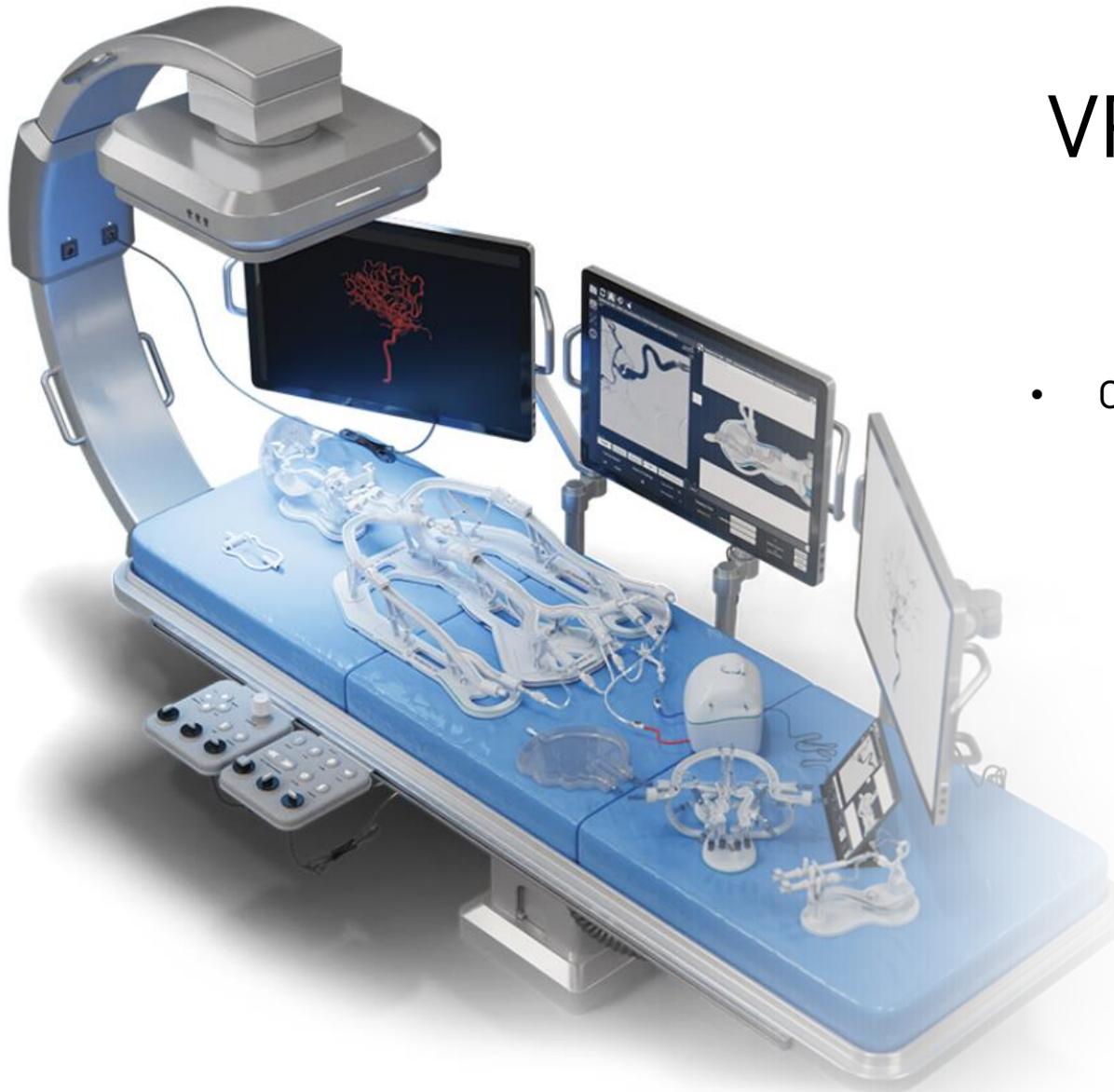
What is Augmented Reality?

- Digital overlay on real-world patients
 - Enhances perception and precision
 - Can show underlying anatomy based on previous scans, reducing dose to patients

Types of VR Used in Healthcare

- Full-immersion headsets
 - Desktop VR simulators for pre-operative planning
 - Movement-enabled systems that use the operator's movements to guide virtual needles and catheters





VR Simulators in IR

- Catheterization simulators
 - Endovascular navigation modules
 - Can use pre-operative imaging to create a individual anatomical model to plan the operation
 - Fluoroscopy simulation
 - Can simulate the patient procedure without radiation

The image shows two surgeons in a dimly lit operating room. They are wearing blue scrubs, surgical masks, and caps. One surgeon on the left is wearing a VR headset. In the center, a glowing 3D anatomical model of a vascular system, possibly a spine or a complex organ, is displayed in a reddish-pink color. The surgeons appear to be examining this model. The background is dark with some medical equipment visible.

Why VR in Interventional Radiology?

- Safe procedural practice
 - Reduces patient risk
 - Improves spatial anatomy understanding

VR for Drainage & Biopsy



Needle trajectory practice

Better spatial accuracy



Improved catheter metrics

AR tracking accuracy reported to be within 5mm in live patients and 0.75 mm in phantom models

CT-guided Lesion Targeting Study



Mean Needle Passes

Without AR: 7.4 passes

AR-overlay: 3.4 passes



Placement Times

Without AR: 8.93 minutes

AR-overlay: 4.42 minutes



Intraoperative Dose

Without AR: 28.7 mGy

AR-overlay: 16.9 mGy

AR-overlay was used to target lesions on an abdominal phantom. The total number of needle passes to reach targeted lesions decreased along with procedure time and dose when using AR guidance compared to traditional procedure without AR



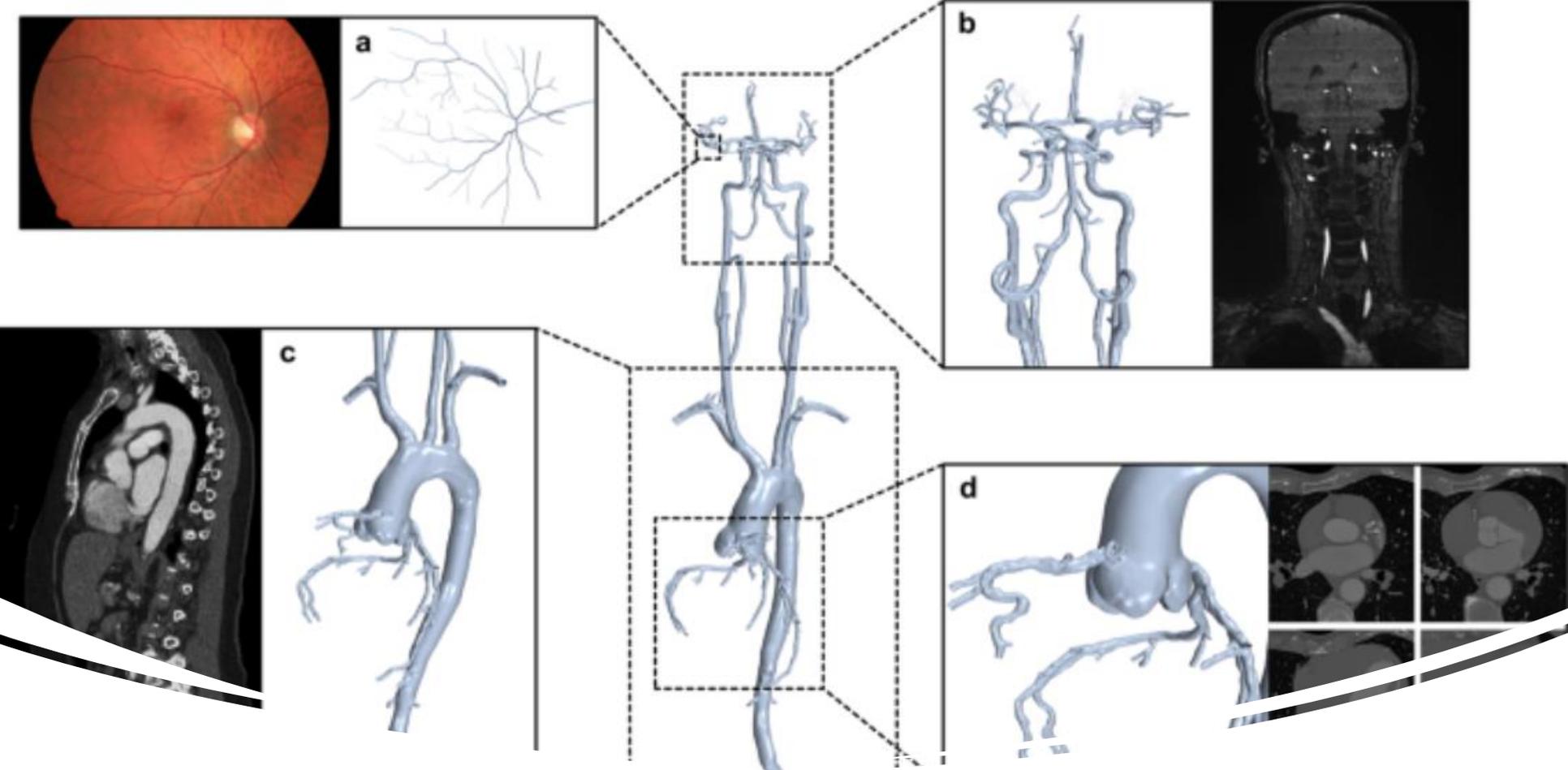
VR for Anatomical Visualization

- 3D anatomy comprehension
 - Enhanced procedural planning
 - Can be personalized to each patient's anatomy



Multimodal VR and AR Integration

- VR + AR hybrid systems
 - Holographic anatomy overlays can be created using imaging from CT and MRI
 - Shows patient anatomy intraoperatively



VR in Endovascular Training

- Catheter navigation practice
 - Simulated arterial trees allows for more accuracy during practice

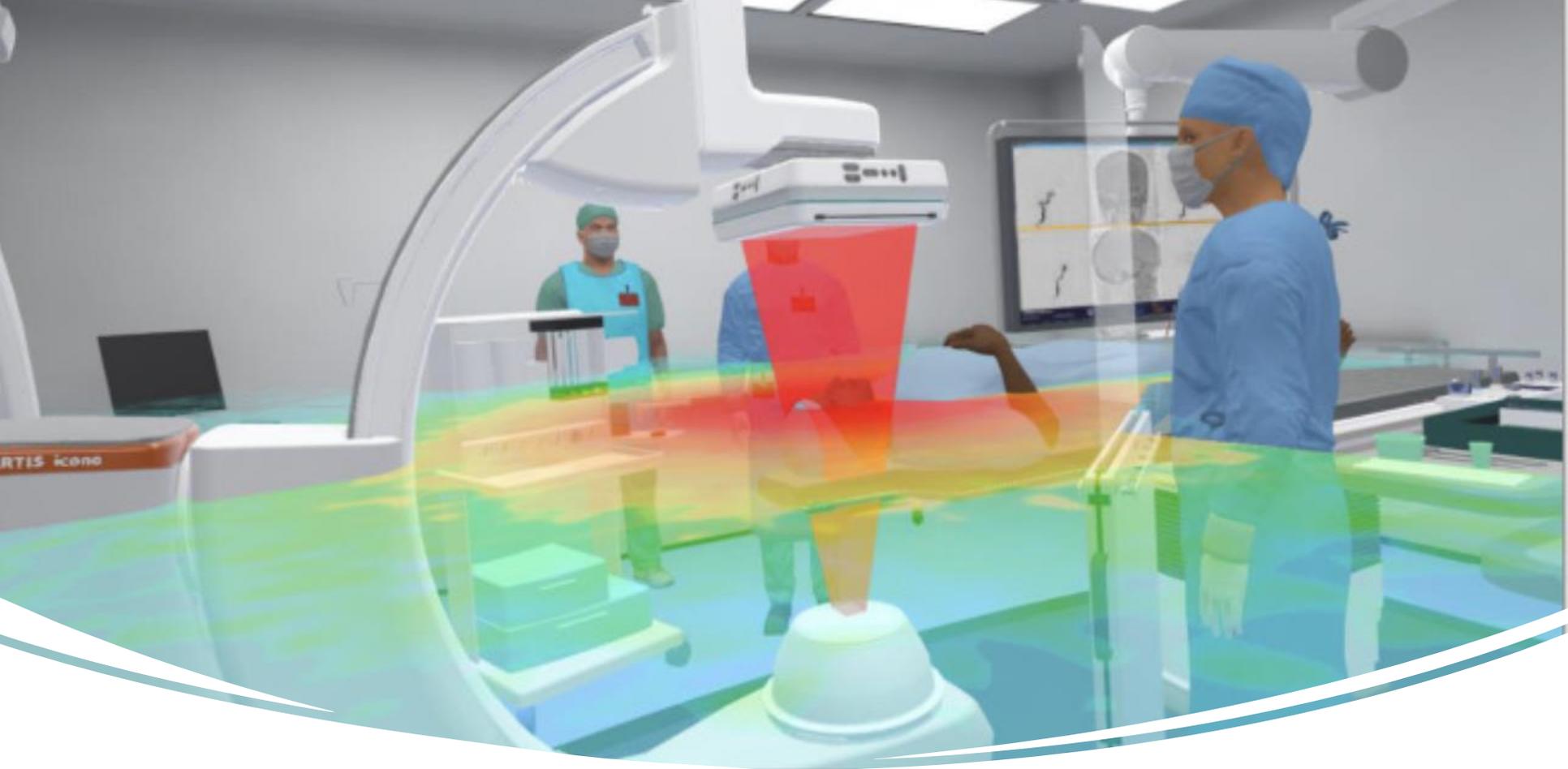
Patient Safety Advantages





VR for Patient Anxiety & Pain

- VR reduces anxiety
 - Lower reported pain scores when patients wear VR during procedures
 - During PICC line insertion there was a lower increase in blood pressure in patients that had VR headset on
 - Already being used in other fields such as dentistry
- Explains procedures visually
 - Improves patient understanding

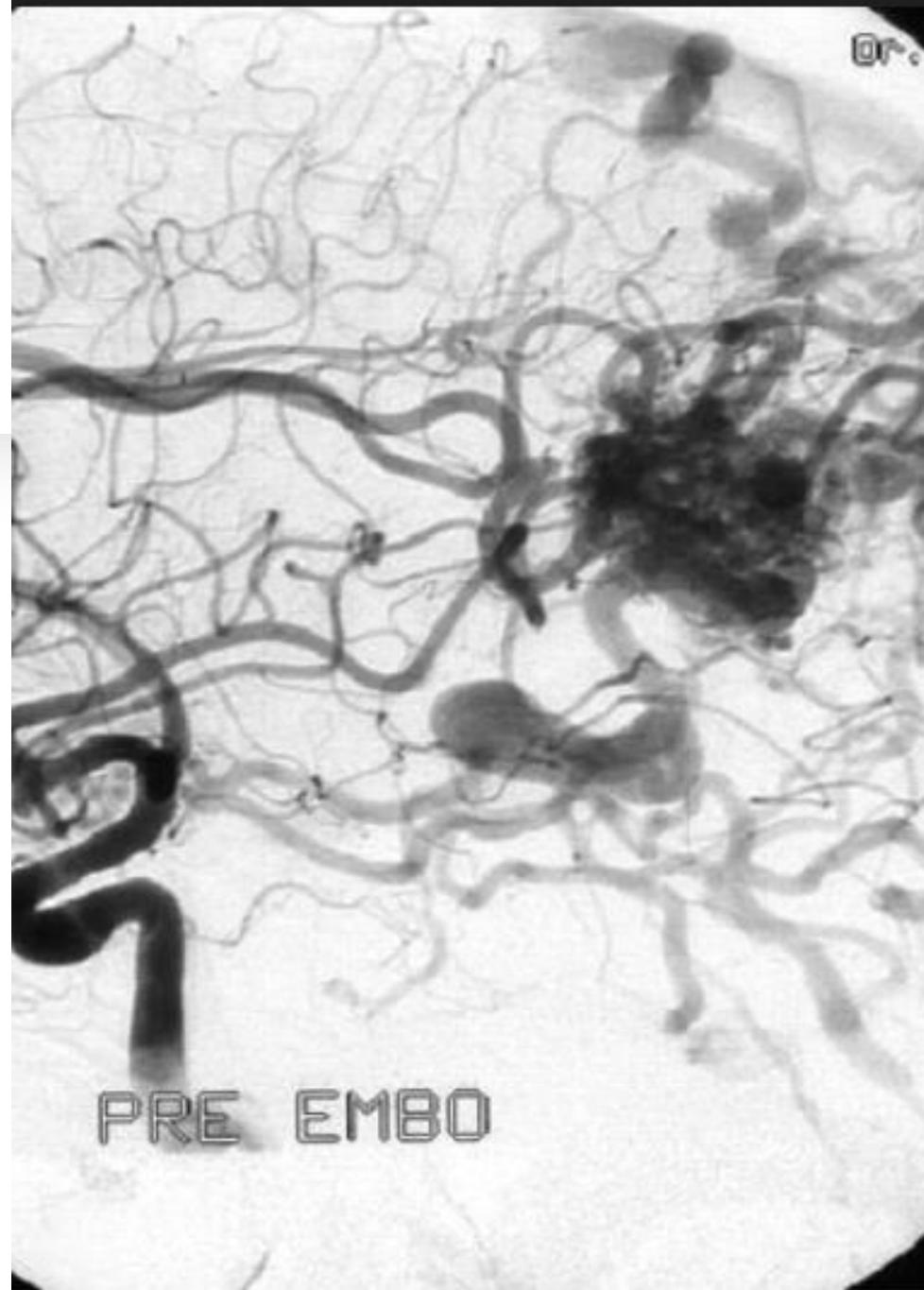


Reducing Radiation Exposure

- Virtual Zero Radiation Fluoroscopy Use
 - More efficient navigation
 - Supports ALARA Principle
- 3D AR Preclinical Model
 - In a rat model for trans-arterial embolization there was a 37% reduction in Fluoroscopy time

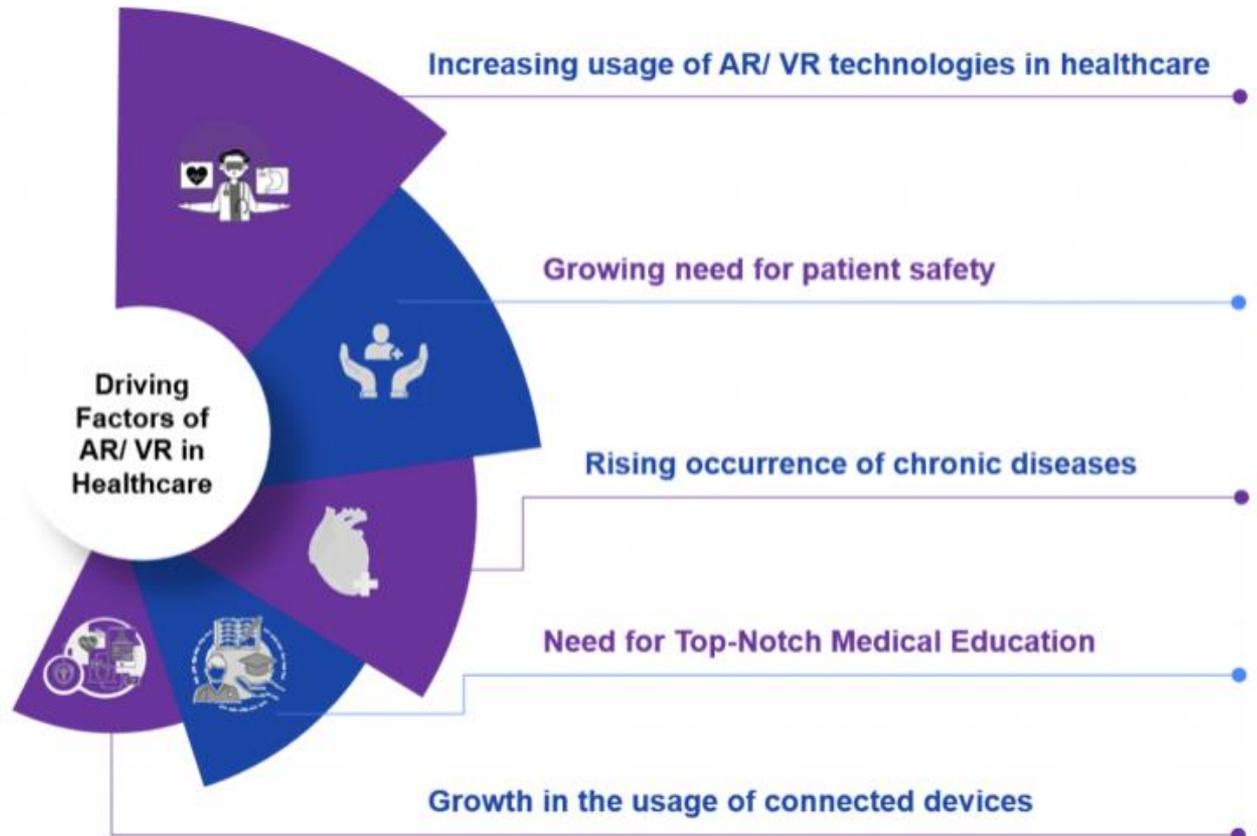
Safer Contrast Usage

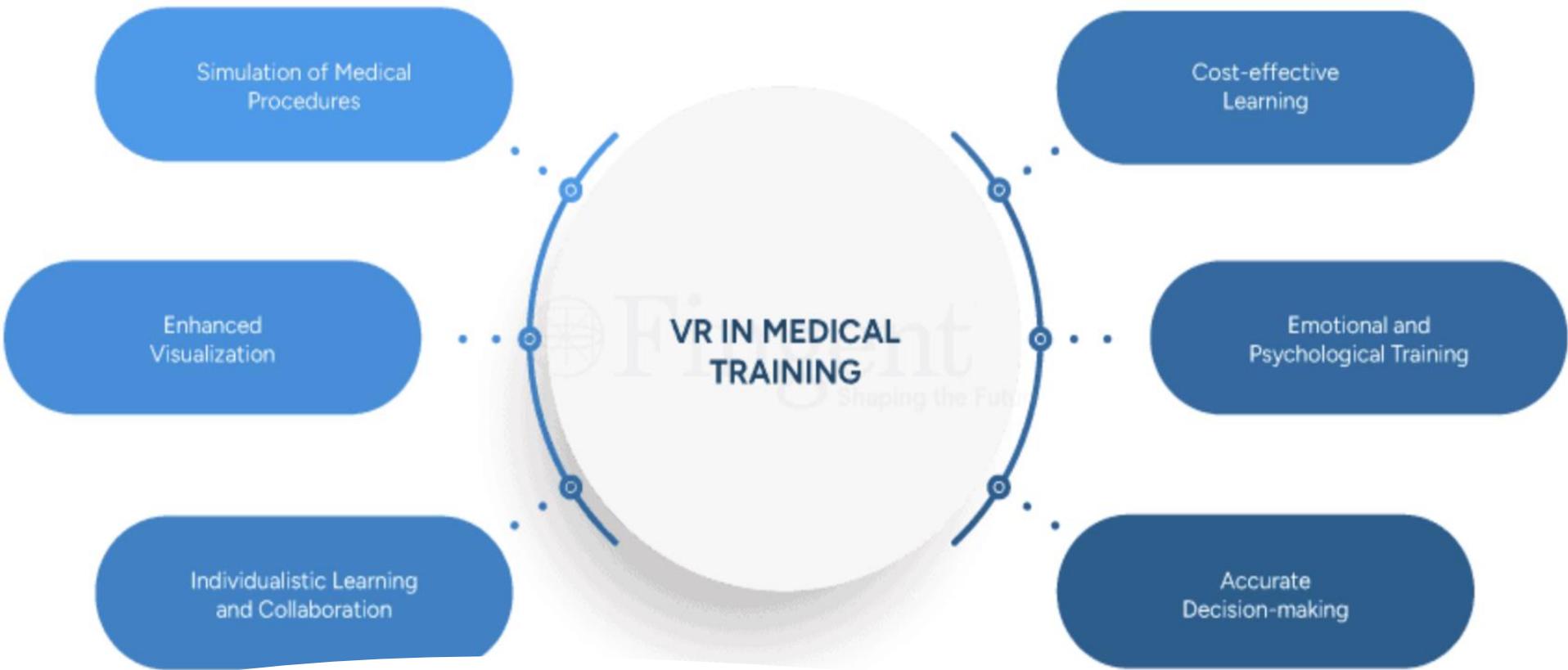
- VR-trained users use less contrast
 - 28ml of contrast in the VR trained group vs 40ml of contrast in the traditionally trained group
 - More efficient wire/catheter control
 - Less kidney damage
 - Gives patients with preexisting kidney conditions more options for procedures



Educational Advantages of VR

- Improves hand-eye coordination
 - Strengthens muscle memory
 - Zero-radiation practice
- Fluoroscopy time decreased from 19.3 minutes to 9.3 minutes after repeated simulator sessions by medical students





VR vs Traditional Training

- Traditional: limited repetitions
- VR: unlimited practice
 - Objective metrics available
 - Less radiation dose received during training

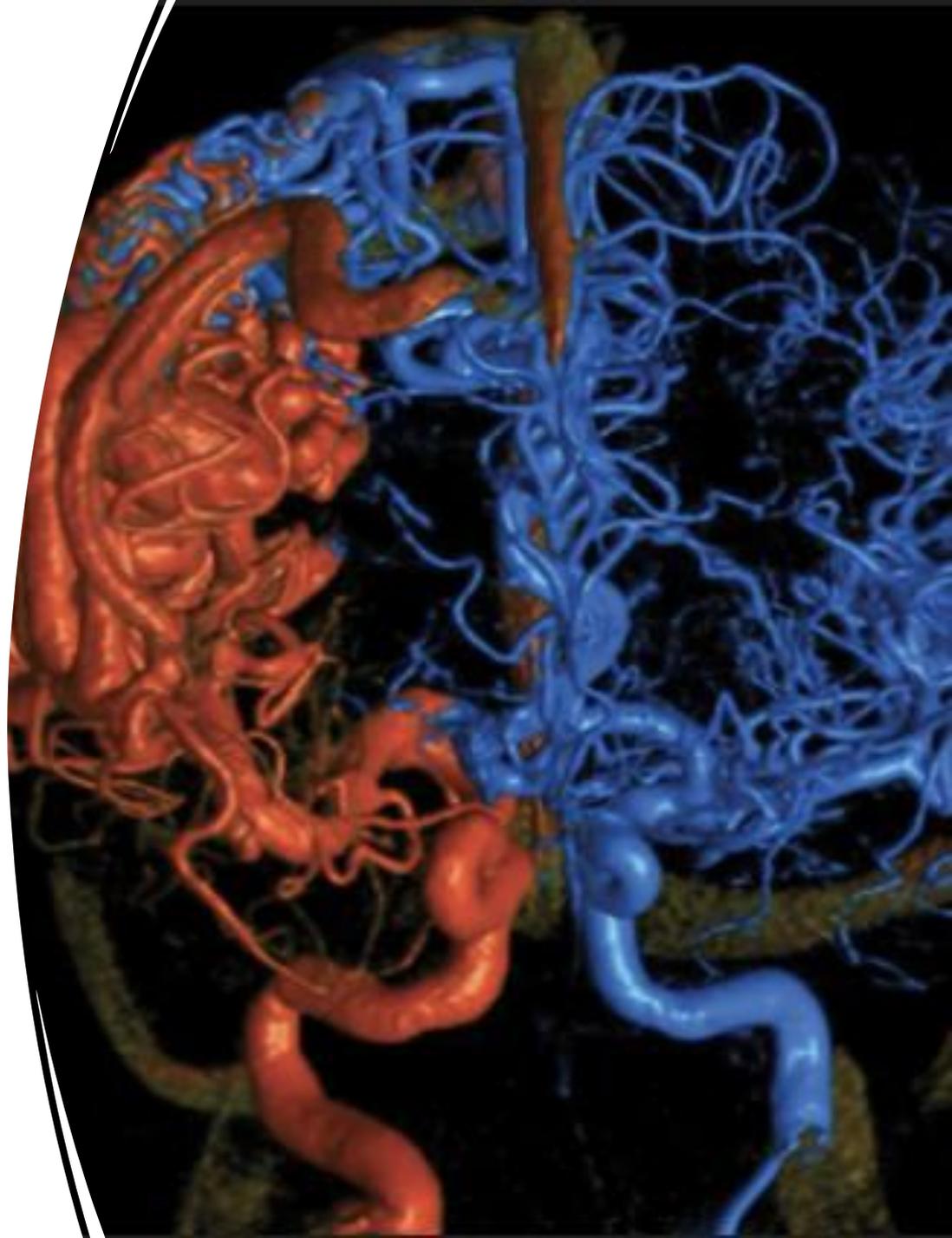
Assessment & Competency Tracking

- Built-in scoring
 - Real-time feedback on accuracy and efficiency
 - Benchmark comparisons on overall ability



VR for Embolization Training

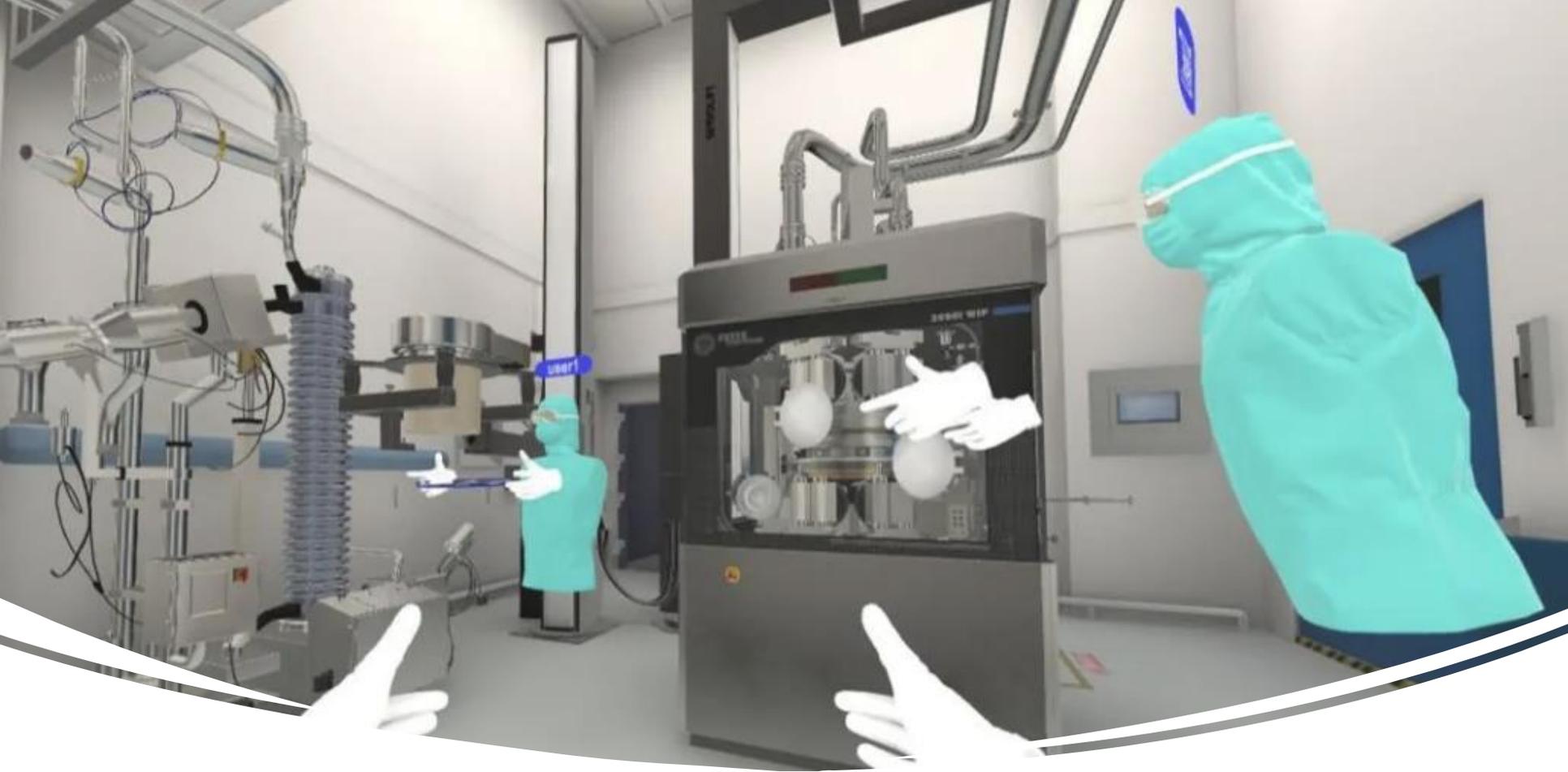
- Microcatheter practice
 - Target vessel selection
 - Assists with neuro-vasculature visualization
 - Can be used to train pre-operatively for challenging cases



Institutional Implementation

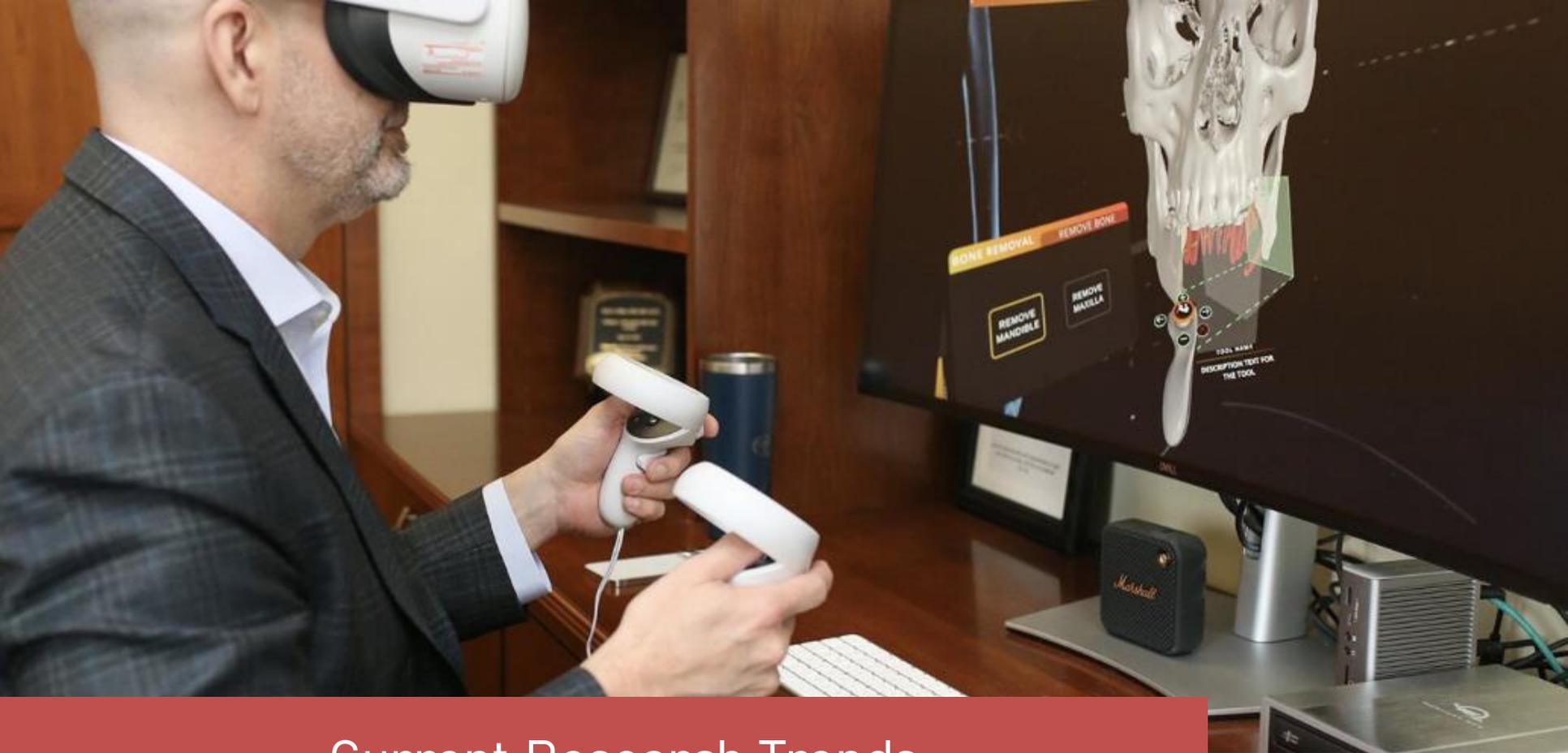
- Hardware & software needs
 - Cost barriers
- Faculty Training
 - Curriculum gaps





Workflow Integration

- Scheduled VR time
 - Progress monitoring
 - Can be a challenge to get already training time when schedules are already full



Current Research Trends

- Improved haptics
 - Improved sensors to increase accuracy of movements virtually compared to real life
- Tactile feedback of tissue densities and resistance during training
- Improved patient modeling of anatomy



AI-Enhanced VR

- AI-driven simulation feedback
 - Adaptive difficulty for training
 - Can increase the difficulty of patient anatomy or simulate different patient factors such as unexpected bleeding or vital signs
 - Improve decision making skills



Future Directions

- Mixed reality in live IR suites
 - Using virtual and augmented reality intra-operatively to reduce radiation dose, procedure time, and complications
- VR-based credentialing may be required

Conclusion

Interventional Radiology is image guided minimally invasive procedures

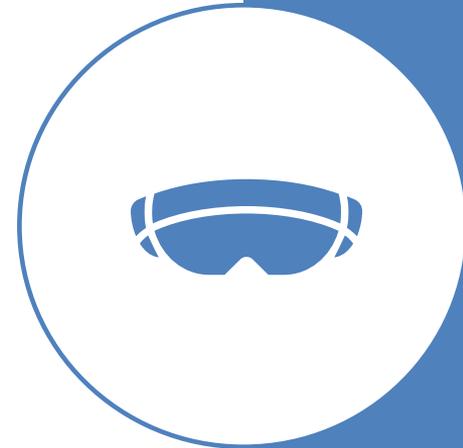
Virtual reality is an immersive 3D computer-generated environments

Augmented reality is a digital overlay on real-world patients

Adding VR and AR to Interventional Radiology can reduce radiation dose, increase patient safety, increase patient satisfaction, and create more training opportunities

VR and AR can also be linked with AI to simulate real-world patient conditions to aide in training

VR and AR is coming soon to be used in live IR suites



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