ePoster #3
A Comparison of Immersive versus Non-Immersive Virtual Reality Technology in Hip Arthroscopy Training

Omar Rahman MD MBA, Kyle Kunze MD, Kaisen Yao MD, Susan Kwiecien PhD, Anil Ranawat MD, Michael Banffy MD, Bryan Kelly MD MBA, Greg Galano MD

Cedars Sinai Kerlan-Jobe Institute
Lenox Hill Hospital Northwell Health®
HSS HOSPITAL FOR SPECIAL SURGERY

Disclosures of Interest

Item 1. Board member/owner/officer/committee appointments: MB (American Orthopaedic Society for Sports Medicine; Arthroscopy Association of North America; Hip Society; ICJR), AR (AAOS; American Orthopaedic Society for Sports Medicine; EOA)

Item 2. Royalties: AR (DePuy, A Johnson & Johnson Company)

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Item 4. Paid consultant or employee: OR (Arthrex, Inc), MB (Arthrex, Inc; Smith & Nephew; Vericel), AR (Anika; Bodycad; Cervos; Moximed; NewClip; Ranfac; Smith & Nephew), GG (Stryker)

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Item 7. Stock or stock options: AR (Enhatch), BK (HS2)

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Overview

- Introduction
- Objective of the Study
- Materials and Methods
- Results
- Conclusions

Hip Arthroscopy Training

- Most rapidly growing sub-specialty within arthroscopy
  - 495% increase between 2004 to 2016
- Technically challenging with steep learning curve
  - Increased complication rates, OR Time, Reoperation rates
- Patient safety is paramount
  - 388 HA for < 10% chance of revision within 5 years
  - Plateau in learning curve after 30 HA cases
- Not all residencies/fellowships with adequate exposure to hip
- HA cadaver courses: ~ $4000
- Need for realistic arthroscopic simulators with haptic feedback

Mehta et al. AJSM, 2018. Hoppe et al., Arthroscopy 2014.

Arthroscopic Simulators

- Skill refinement w/o compromising patient safety and OR time
- Increased resident work hour restrictions
- Virtual Reality (VR) simulators
  - Cognitive Task Simulation and Rehearsal
  - Deliberate Practice
  - Non-immersive and Immersive VR
- Multiple simulators on the market, vary in:
  - Haptic & Tactile Feedback
  - Realism / Fidelity
  - Cost

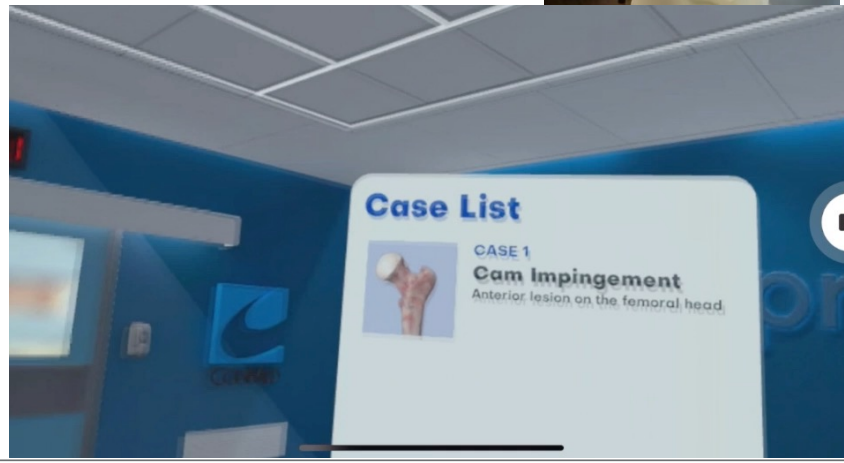
Non-Immersive VR: VirtaMed ArthroS

- Bench-top VR Simulator with high fidelity
- Hip Manikin with Arthroscopic Equipment
- Magnetized for Tactile Feedback
- Multiple Hip Arthroscopy Modules
  - Performance Metrics Recorded
- Drawbacks
  - Physical footprint (Bioskills Lab needed)
  - Cost
    - **~ $383,400.00 for machine and 2-year subscription**

Bishop et al., Arthroscopy, 2021., Gallagher et al., Surgical Technology International, 2019

Immersive VR: Precision OS

- Portable wireless device using Oculus Quest 2 headset/controllers
- Interactive features in an immersive environment
  - Vibration for haptic feedback; Realistic auditory stimuli
- 570% reduction in learning time with iVR compared to traditional learning
- Hip Arthroscopy Module
  - Diagnostic Scope and CAM decompression
  - Performance Metrics
- Cost
  - **~ $2,900 headset/controllers**
  - **2 year VR subscription**



Lohre et al., JAMA, 2020., Lohre et al., JBJS, 2020., Feely et al., Arthroscopy 2021.

Objective of the Study

- Compare efficacy of immersive VR to non-immersive VR training in hip arthroscopy on procedural and knowledge-based skills acquisition
- Evaluate the relative cost-effectiveness of each training platform

- Hypotheses:
  - iVR would be as effective as non-iVR training in hip arthroscopy
  - iVR training would be more cost-effective than non-iVR training

Materials & Methods: Training

- 14 orthopaedic junior residents randomized to two training methods
  - Non-iVR (Virtamed) vs iVR (Precision)
  - Training metrics recorded **(average simulation time)**

Key Virtamed Metrics
Total Simulation Time
Overall Safety Score
% Scratching of Acetabulum
% Scratching of Femoral Head
Total Simulation Score “VR score”

Key Precision Metrics
Total Simulation Time
# of Fluoro Images Taken
Bony Contacts with Scope in Error
Accuracy of CAM Decompression
Precision Score “VR Score”

Materials & Methods: Performance

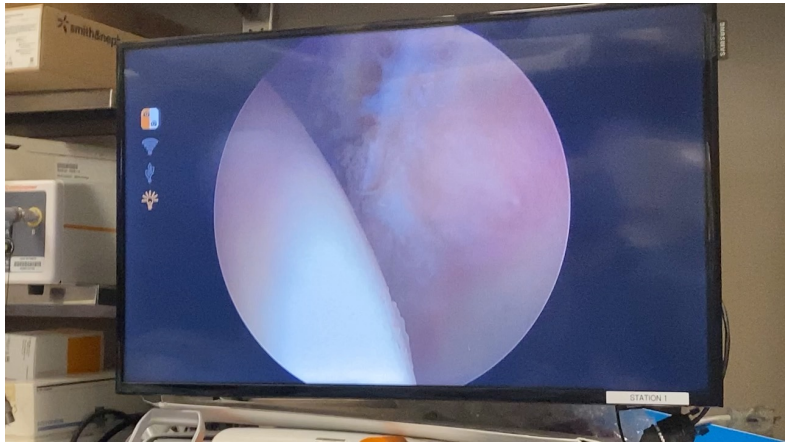
- Diagnostic Hip Arthroscopy on Cadaver
  - Pre-established AL and MA portals
  - Arthroscopic video recorded
  - Metrics: **Time to Task Completion**

Diagnostic Hip Arthroscopy of Central Compartment
Anterior acetabular wall and labrum
Posterior acetabular wall and labrum
Acetabular Fossa
Ligamentum Teres
Anterior-superior chondrolabral junction

Stone et al., Arthroscopy Techniques, 2017

Materials & Methods: Assessment

- Arthroscopic video review by 4 expert hip arthroscopists
  - Scoring based on OSATS & ASSET



Objective Structured Assessment of Technical Skills (OSATS)
Respect for Tissue
Time and Motion
Instrument Handling
Flow of Operation and Forward Planning

Arthroscopic Surgery Skill Evaluation Tool (ASSET)
Safety
Field of View
Camera Dexterity
Instrument Dexterity
Bimanual Dexterity

Lohre et al., JBJS, 2020., Bishop et al., Arthroscopy, 2021.

Materials & Methods: Cost Analysis

- **Transfer Effectiveness Ratio (TER)**
  - Skill comparison relative to control for improvements in task completion time
- **Cost-Effectiveness Ratio (CER)**
  - Comparison of cost-related training and task completion times
- **Direct Cost Comparison (DCC)**

$$TER = \frac{(T_{non\text{-}iVR\ (cadaver)} - T_{iVR\ (cadaver)})}{T_{iVR\ (simulated)}}$$

$$CER = \frac{TER}{Cost_{(iVR)} / Cost_{(non\text{-}iVR)}}$$

$$Cost_{(iVR)} / Cost_{(non\text{-}iVR)}$$

Gallagher et al., Ann Surg, 2013., Lohre et al., JAMA, 2020.

Results: Performance Metrics

Group	Simulation Time (sec)	Cadaver Time (sec)	OSATS Score %	ASSET Score %
non-iVR (Virtamed)	310	52	70%	67%
iVR (Precision)	280	69	66%	62%
Total	295	61	68%	65%

- OSATS: iVR 13.1/20 (3.0) vs non-iVR 14.0/20 (2.7) **p=0.55**
- ASSET: iVR 23.7/38 (4.5) vs non-iVR 25.8/38 (4.8) **p=0.43**
- **No difference in OSATS or ASSET performance with iVR & non-iVR**

Results: Performance Metrics

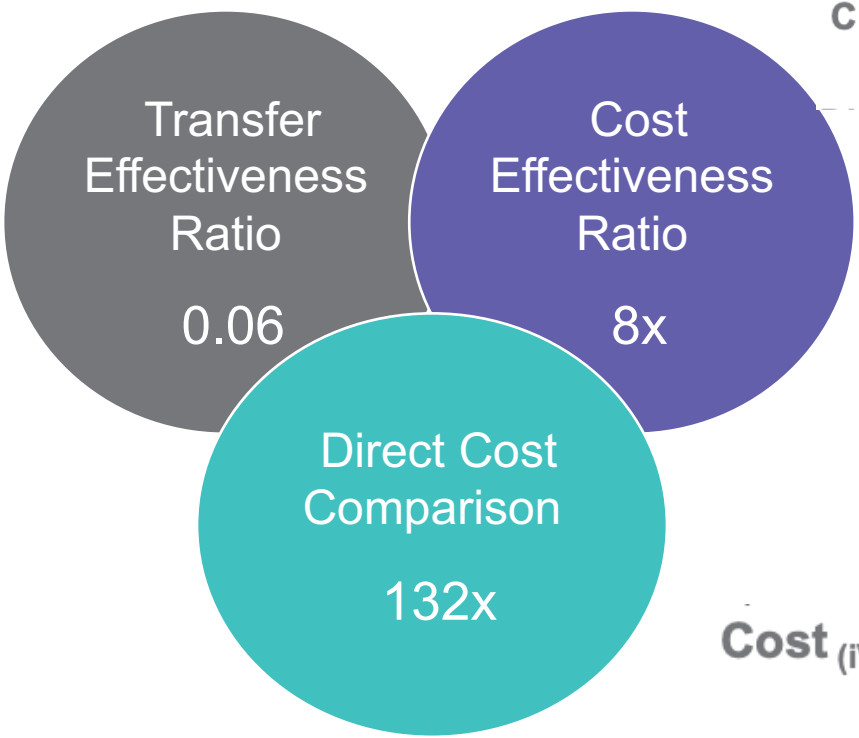
- No difference in “overall VR score” between Precision and Virtamed
  - Precision 77.1 % (13.7) vs Virtamed 72.7 % (14.5) (p=0.569)
- VR Score not correlated to OSATS (p=0.67) or ASSET (p=0.90)
- No correlations found between individual Virtamed & Precision metrics to OSATS or ASSET

Virtamed Metrics	OSATS (p-value)	ASSET (p-value)
% Scratching of Acetabulum	0.15	0.35
% Scratching of Femoral Head	0.25	0.13
Overall Safety Score	0.09	0.14

Results: Cost Analysis

$$TER = \frac{(T_{non\text{-}iVR\ (cadaver)} - T_{iVR\ (cadaver)})}{T_{iVR\ (simulated)}}$$

$$CER = \frac{TER}{Cost_{(iVR)} / Cost_{(non\text{-}iVR)}}$$



$$Cost_{(iVR)} / Cost_{(non\text{-}iVR)}$$

Conclusions

- iVR & non-iVR training in hip arthroscopy are welcomed tools by orthopaedic trainees
- iVR had **similar effectiveness** in transfer-of-skill compared to non-iVR
- iVR **8x more cost-effective** than non-iVR with **132x cost difference**
- **Portability, Efficacy, and Cost-Effectiveness of iVR** may be beneficial in future of arthroscopic education

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