

Review Article

Opportunities for Remote Surgeon-to-Surgeon Education : A Novel Use Case for Immersive Virtual Reality

Danny Goel, M.D.^{1a}, Omar Rahman^{2b}, Derek Ochiai^c, George Athwal^{3d}, Joaquin Sanchez-Sotelo^{4e}, Scott Sigman^{5f},

a A practicing surgeon and surgical educator, Dr. Danny Goel currently practices in the Vancouver, B.C. area and also serves on the University of British Columbia's Faculty of Medicine in the Department of Orthopedic Surgery. He received his medical degree from the University of Manitoba, pursued his residency training in orthopedic surgery at the University of Calgary, and completed fellowship training in shoulder surgery at the University of Western Ontario and Harvard University. Dr. Goel has co-authored more than 30 publications, and is widely sought as a presenter on surgical techniques.

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b Dr. Omar Rahman is a fellowship-trained orthopedic surgeon who focuses on both operative and non-operative management of sports-related injuries, musculoskeletal injuries, and arthritis. Dr. Rahman graduated from Georgetown University with a Bachelor of Science in Biology while minoring in Economics. He received his Doctor of Medicine from Georgetown University School of Medicine and concurrently obtained his Master of Business Administration from Georgetown University's McDonough School of Business. He completed his orthopedic surgery residency training at Lenox Hill Hospital-Northwell Health in New York City, where he served as Chief Resident during his final year. He then went on to the world-renowned Kerlan-Jobe Orthopedic Clinic in Los Angeles to complete his sports medicine & shoulder surgery fellowship, where he was part of the medical staff for the Los Angeles Dodgers, Anaheim Ducks, Los Angeles Angels, Los Angeles Galaxy, Pepperdine University, and many local junior colleges and high schools, while training under Drs. Neal ElAttrache, Bert Mandelbaum, and John Itamura. Dr. Rahman's clinical research focuses on orthopedic innovations and emerging surgical technologies. His business endeavors are concentrated on entrepreneurship and venture capital. In addition to his work experience at healthcare consulting firms, he has assisted numerous healthcare and medical device startups in clinical assessment and advisory roles.

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c Dr. Derek Ochiai, FAAOS, FAANA, is a board certified orthopaedic surgeon specializing in hip arthroscopy and hip preservation. He is a graduate of Cornell University and Case Western Reserve University School of Medicine. He did his orthopaedic residency at Albany Medical Center and fellowship at the Nirschl/Georgetown Sportsmedicine Fellowship. He currently practices at the Nirschl Orthopaedic Center in Arlington, VA. He is a member of ISHA, AANA, and AOSSM, along with being on the editorial board of Arthroscopy Journal. He has lectured and taught surgeons worldwide on techniques in hip arthroscopy. He is passionate about improving the safety, efficacy, and availability of advanced arthroscopic techniques.

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d Dr. George Athwal is a shoulder and elbow surgeon that practices in London, Ontario, Canada.

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e Dr. Sanchez-Sotelo practices as Consultant in the Department of Orthopedic Surgery at Mayo Clinic. He is also appointed as Professor at Mayo College of Medicine. He serves as Division Chair of Shoulder and Elbow Surgery, and Medical Director for Communications and Marketing for the Department of Orthopedic Surgery. He has been presented the Mayo Clinic Teacher of the Year Award on two separate occasions and has received other awards in the past, including the Mark B. Coventry, Melvin Post, MidAmerica Orthopedic Association, Knee Society, ISOLS 2019, ICSES 2019, AAOS Achievement's Awards, Course Director for Best Mayo Clinic Course (2017 and 2021), Digital Educator of the Year at Mayo Clinic 2021, ASES Morrey Award in 2024 and Pauwels Medal in 2024. Dr. Joaquin Sanchez-Sotelo MD PhD was born in Madrid, Spain. He graduated as Medical Doctor from Universidad Autonoma de Madrid, and obtained the #1 position in the Spanish National Exam for Medical Graduates. Dr. Sanchez-Sotelo completed his Residency in Orthopedic Surgery at Hospital Universitario La Paz and his PhD Program at Universidad Autonoma de Madrid. He was then selected for a fellowship position at Mayo Clinic and completed a two-year program in adult reconstruction. Dr. Sanchez-Sotelo has published over 450 articles in the peer-reviewed literature in addition to over 50 book chapters. He is co-editor of the most widely read textbook on elbow surgery, "The Elbow and Its Disorders". Dr. Sanchez-Sotelo has also published Mayo Clinic Principles of Shoulder Surgery. He is actively involved in the design of implants for joint replacement, shoulder sports medicine, and fracture fixation. Dr. Sanchez-Sotelo serves as course co-director for the Mayo Clinic Annual Elbow Course "Teach the teachers", the AO of NorthAmerica Sports Course on Shoulder Tendon Transfers and Complex Rotator Cuff Tears, and the International Advanced Course on Elbow Surgery (IACES). He has presented his research in numerous occasions at national and international meetings.

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Shariff K. Bishai^{6g}, Jon Warner^{7h}, Phil Williams⁸ⁱ, Ryan Lohre^{9j}, Laurie Hiemstra^{10k}

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^f Dr. Scott Sigman is a national and internationally recognized leader in Opioid Sparing Surgery. He is an Orthopedic Surgeon that specializes in the knee and shoulder. He has been in clinical practice for over 25 years and is a leader in professional education, medical device development, and has numerous peer reviewed publications. He is the team physician at UMASS Lowell. He is a member of Governor Bakers Commission to establish a pain management access program in the Commonwealth of Massachusetts. He did his sports medicine fellowship at the prestigious Kerlan Jobe Clinic in Los Angeles. His Opioid Sparing leadership propelled him to become a Fellow of the Worlds Society on Sports and Exercise Medicine, and most recently has had the honor of becoming a Fellow of the Royal College of Surgeons in Ireland. In addition, to his clinical responsibilities Dr. Sigman is the Chief Medical Officer for OrthoLazer Orthopedic Laser Centers. The OrthoLazer franchise was developed to provide an alternative treatment option for acute and chronic pain to help combat the Opioid crisis. Dr. Sigman is also the host of the popular The Ortho Show podcast. Dr. Sigman's TEDx talk on the evolution of the Opioid Crisis has been well received.

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^g Dr. Shariff K. Bishai, DO, MS is a shoulder and sports medicine specialist dual board certified in Orthopaedic Surgery and Sports Medicine. He is an Associate Professor for Michigan State University College of Osteopathic Medicine, an Assistant Professor for Oakland University William Beaumont School of Medicine, and a former Professor for the Detroit Medical Center Sports Medicine Fellowship. He presently works in Troy, MI and is the founder of the Detroit Orthopaedic Institute.

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^h Dr. Jon Warner is currently Professor of Orthopedics at Massachusetts General Hospital and Harvard Medical School and a Graduate of Harvard Business School. He has been a practicing orthopedic surgeon for 35 years.

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ⁱ Dr. Phillip Williams, MD is a board-certified orthopedic surgeon specializing in sports medicine in the Joseph Barnhart Department of Orthopedic Surgery at Baylor Medicine. Dr. Williams earned an undergraduate degree in Political Science at Yale while competing on the track & field team. Afterward, he attended Harvard Medical School, followed by an orthopedic surgery residency at Hospital for Surgery in New York. Dr. Williams completed additional training in Sports Medicine that included a fellowship at Cedars-Sinai Kerlan-Jobe Institute, where he had the opportunity to assist in the care of several professional sports teams, including the Los Angeles Lakers, Los Angeles Dodgers, Los Angeles Kings, Anaheim Ducks, Los Angeles Sparks, and the Los Angeles Galaxy. His clinical and research interests include ACL injury and prevention, joint preservation, biologics, and rotator cuff conditions. He utilizes novel techniques and innovations to relieve pain, restore function, and confidently return patients to their desired activities.

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^j Dr. Ryan Lohre is an orthopaedic shoulder, scapula, and elbow surgeon practicing at Massachusetts General Hospital. He is an Assistant Professor of Orthopaedic Surgery at Harvard Medical School. He is an instructor of both residents and fellows in the Shoulder and Sports Medicine department. Dr. Lohre is a co-founder and director of the Massachusetts General Hospital Scapula Program, an international referral center for complex scapular pathology. His research focuses on clinical outcomes of shoulder girdle reconstruction, novel arthroscopic techniques, and incorporating technology including virtual reality into training and practice.

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^k Dr. Laurie Hiemstra is a Fellowship trained orthopaedic surgeon working in Banff, Canada. She holds Clinical Professor appointment at the University of Calgary. The clinical and research program in Banff is focused on knee ligament injury, prevention of secondary injury, rehabilitation and surgical outcomes with an emphasis on ACL injury and reconstruction and patellofemoral instability. Laurie is on the Board of Directors of the Patellofemoral Foundation, Banff Sport Medicine Foundation, and the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS). Laurie has published over 80 peer-reviewed pa-

¹ Orthopedic Surgery, University of British Columbia, ² Orthopedics, Cedars-Sinai Kerlan-Jobe Institute, ³ Orthopedics, Western University, ⁴ Orthopedics, Mayo Clinic, ⁵ Orthopedics, Orthopedic Surgical Associates, ⁶ Orthopedics, Detroit Orthopedic Institute, ⁷ Orthopedics, Massachusetts General Hospital, ⁸ Orthopedics, Baylor University Medical Center, ⁹ Massachusetts General Hospital, MD, ¹⁰ Orthopedics, Banff Sports Medicine

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The integration of immersive virtual reality (IVR) in orthopedic surgery offers a platform for surgeon-to-surgeon collaboration. This paper explores a new use case of IVR-based collaboration among orthopedic surgeons, focusing on three key areas: surgical training, procedural planning, and remote peer to peer collaboration. Immersive virtual reality enables surgeons to engage in immersive, interactive environments where complex anatomical structures and surgical techniques can be visualized in three dimensions. This fosters more efficient communication, precise surgical planning, shared learning experiences and an opportunity to enhance 3D visual spatial intelligence.

This case study highlights how surgeons in different geographic locations can collaborate, sharing knowledge and expertise in real time without the constraints of physical presence. This connectivity provides a platform for skill acquisition, and the practice of surgical techniques while creating an opportunity for a mentor to educate a remote learner. Moreover, IVR facilitates the rehearsal of a procedure, potentially contributing to improved patient outcomes by reducing errors and enhancing preoperative planning and education.

In the context of orthopedic surgery, the ability to virtually simulate surgeries in a collaborative setting represents a novel advancement. IVR also allows for the customization of surgical scenarios, providing surgeons with repeated exposure to common and rare, complex cases, thus broadening their experience base. By supporting a connected surgical community, IVR-based surgeon-to-surgeon collaboration has the potential to create opportunities for educators and learners to connect and learn in a meaningful manner.

INTRODUCTION

In the evolving landscape of medical education, immersive virtual reality (IVR) has arisen as a new tool, which demonstrates the potential of impacting traditional learning and teaching methods. The conventional approach to surgical training often relies heavily on cadaveric demonstrations and assisting in live surgery with incremental autonomy under expert guidance. While these tools are invaluable, they present certain limitations. Access to cadavers can be difficult due to logistical and financial reasons. Other limitations of cadaveric experiences include variation in quality, absent mirroring of the actual operative experience including set up, normal anatomy, radiation exposure when

using a C-arm, and a time gap between cadaveric practice and real-time surgical execution in the operating room. Furthermore, the nuances of surgical technique – the subtle maneuvers and adjustments that can make a difference during surgery may be difficult to appreciate through conventional teaching methods.

Immersive virtual reality technology seeks to address these challenges by providing a learning environment that attempts to replicate the real-world OR experience while adding additional opportunities not available in current models of simulation. This technology allows surgeons to engage in two modes of hands-on practice either as an individual user or through a multiuser shared experience. A multi-user experience using IVR enables the real time ‘presence’ of a mentor from anywhere in the world by con-

pers and is a national and international speaker. Laurie obtained her Medical Degree from the Memorial University of Newfoundland, completed an orthopaedic residency at the University of Manitoba, and a Clinical Fellowship in Orthopedic Sport Medicine at the University of Western Ontario. She also attained a PhD in Neuromuscular Physiology. Laurie has worked as an Orthopaedic Surgeon at Banff Sport Medicine since 2005. Her clinical focus is on patellofemoral instability and ACL reconstruction. Dr. Hiemstra has a keen interest in gender diversity and inclusion in orthopaedic surgery. She is a founding member of the International Orthopaedic Diversity Alliance (IODA) and Women in Orthopaedics Worldwide (WOW). She is the 2nd Pr.

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**Video 1**URL: <https://www.youtube.com/embed/4GLQO2Hro0g>

necting to the internet. This virtual mentorship attempts to replicate the experience of standing next to an expert surgeon, providing the ability to observe, perform, learn, and receive real-time feedback on surgical techniques in a virtual space.

Many expert surgeons, despite their busy clinical and research schedules, share a strong passion for education. However, their ability to offer in-person training to a learner is limited by the demands of cost, time, and logistics. These educators are often invited to provide hands-on teaching at their own facilities, visit other institutions, or participate in courses. While this traditional method is valuable, it lacks scalability and cannot be repeated multiple times throughout the year. This presents a substantial barrier to expanding the reach of their expertise and enhancing the education of others.

The limitations of current educational models also affect the broader healthcare community beyond surgeons and surgical trainees. Without scalable solutions, there are fewer opportunities for professionals to develop the skills necessary to better support their patients. The value of in-person learning experiences, especially with an expert present, offers a unique perspective. The ability to interact, ask questions in real time, and observe techniques first-hand provides an experience that may impact growth and knowledge retention.

Remote Surgeon-to-Surgeon (S2S) collaboration using IVR presents a novel educational opportunity. Remote S2S collaboration offers an effective and scalable model, enabling expert educators to extend their reach beyond geographical boundaries. All authors involved in this case study have conducted successful S2S collaborations between themselves (Please see [Video 1](#) below) within North America and between other surgeons (Please see [Video 1B](#)) in regions including Europe, Latin America, Asia-Pacific, the Middle East, and North Africa. By leveraging this innovative method, these educators were able to provide real-time, impactful guidance for surgery across orthopedic various orthopedic procedures without the need for physical presence.

**Video 1B**URL: <https://www.youtube.com/embed/LAOSlogjWh4>

This case study highlights the potential impact of remote S2S collaboration on surgical education, focusing on one of the authors' experiences. It demonstrates how this approach may overcome the traditional barriers of time and cost but also enables surgeons to deliver an enriched, interactive learning experience. In doing so, it helps enhance the education of healthcare professionals in varying geographical regions.

In this case study, Dr. Derek Ochiai, an orthopedic surgeon sub-specializing in hip arthroscopy, independently mentored Dr. Philip Williams and Dr. Omar Rahman, both early career surgeons specializing in hip arthroscopy, using IVR technology. From his home office in Virginia, Dr. Ochiai guides and instructs Dr. Williams in Texas and Dr. Rahman in California, despite their geographical location. This narrative delves into their experiences, challenges encountered, and impact of IVR on their surgical training. By highlighting the insights gained from Dr. Williams' and Dr. Rahman's separate one-on-one interactions with Dr. Ochiai, this article illustrates how IVR may afford a novel platform for surgical education but is also creating a more connected and collaborative future in surgical training.

BACKGROUND

Dr. Derek Ochiai is an orthopedic surgeon who specializes in hip arthroscopy. Recognizing the complexities and steep learning curve (Hoppe, de, Simunovic, et al. 2014) associated with this technique, identifying novel methods of sharing knowledge and expertise is important.

Dr. Philip Williams (Texas) and Dr. Omar Rahman (California) are both early career surgeons interested in offering hip arthroscopy to their local patients. During their orthopedic training, both physicians independently completed fellowship training in sports medicine at the Kerlan-Jobe Orthopaedic Clinic, an institution known for high case volume and case complexity, including hip arthroscopy.

While their fellowship training afforded them a solid foundation in hip arthroscopy, the early years of practice as

a sports medicine surgeon bring in a variety of cases. Building a hip arthroscopy practice is particularly challenging due to the lower incidence of cases compared to knee and shoulder arthroscopy. It also takes time to establish a presence in such a niche field of sports medicine, particularly when the understanding of hip sports pathology continues to rapidly evolve. This can lead to potentially substantial lag time between hip arthroscopy cases, which poses a challenge for early career surgeons interested in building their reputation in the community while maintaining surgical proficiency. IVR may provide the opportunity to bridge this gap, allowing surgeons to maintain their surgical skill set during periods of lower-case volume in hip arthroscopy or other new procedures. By offering continuous practice in a risk-free setting, IVR offers surgeons the ability to maintain their technical skills.

THE NEED FOR INNOVATION

The conventional approach to learning hip arthroscopy involves observing live surgeries, practicing on cadavers, and performing procedures in a supervised fashion. While effective, these methods come with limitations such as the availability of cadavers, ethical concerns, and the inherent risks of learning on live patients.

In addition to these concerns, there are systemic challenges for continued surgeon education after the completion of residency and fellowship training. One barrier is limited access to expert mentorship, particularly in niche sub-specialties such as hip arthroscopy or during the release of new medical device products. Surgeons are often limited to seeking technical advice from their close colleagues and partners within their practice or travel to courses occasionally on their own expense or at the expense of a medical device company. Geographical disparities further compound this issue, since surgeons practicing in community hospitals or rural settings may not have access to continued training in complex procedures commonly offered in urban areas. This problem has downstream impact to patients residing in these areas who may need complex procedures and may have to travel to other centers to obtain specialized treatment.

Many surgical conferences offer private cadaveric sessions with expert surgeons. Although beneficial, these sessions are often at an additional expense on top of the conference fee and are limited to a small number of attendees due to physical and budgetary constraints. Moreover, these sessions typically allow for a single procedure per cadaver, leaving little opportunity for hands-on practice by all surgeon learners. The time away from surgical practice and the associated costs of surgical conferences further restrict the availability and frequency to continued surgical education.

Because of these challenges, Dr. Ochiai decided to integrate IVR into surgeon-to-surgeon education to improve health equity by improving educational access and reducing costs. By incorporating IVR, Dr. Ochiai not only enhances the learning experience, but also reduces the cost for both the surgeon and the medical device companies that typically sponsor cadaveric training sessions. The ability to per-



Video 2

URL: <https://www.youtube.com/embed/ueVPoBpiqS4>

form these experiences virtually minimizes the limitations of physical space, time, and cost, thereby allowing more surgeons to benefit from the expertise of leading surgeons in complex procedures. This shift in approach to continued training not only provides immediate benefits, but also opens a significant opportunity for a more accessible and equitable future in surgical education.

IMPLEMENTING IMMERSIVE VIRTUAL REALITY

Dr. Ochiai partnered with an IVR company (PrecisionOS®, Vancouver, BC) specializing in medical simulations. This IVR system provides an immersive and interactive environment, replicating the anatomy and surgical scenarios in a digital 3D environment (Lohre, Bois, Pollock, et al. 2020; Lohre et al. 2020; Feeley et al. 2021). Early data demonstrates that this technology has also been shown to be equivalent to physical simulators (Rahman, Kunze, Yao, et al. 2024) and a cadaveric experience (Crockatt et al. 2023). For this particular case, developed in concert with expert hip surgeons, also includes a new concept enhancing the educational experience known as multisensory feedback (MSF™). It permits the freedom to make mistakes while reinforcing difficult to teach three-dimensional (3D) visual spatial concepts enabling Dr. Ochiai to experiment and teach the specific nuances with which he operates in the real world (Please see [Video 2](#) below). This in combination, provided a teaching environment that Dr. Ochiai could take advantage of while educating the surgeon learners remotely. The feedback through this MSF approach combining haptics, vibration, enhanced visual cues, and auditory feedback allows users to feel fully immersed in a 3D environment while attempting to recreate the OR experience. Given this experience, Dr. Ochiai could focus on several of the critical aspects of hip arthroscopy, including properly addressing the most common cause of revision surgery, CAM lesion resection (Mehta, Chamberlin, Marx, et al. 2018; Hoppe, de, Simunovic, et al. 2014).

THE TRAINING PROCESS

1. ORIENTATION AND INITIAL ASSESSMENT

The training began with two independent orientation sessions where Drs. Williams and Rahman were introduced to the IVR setup. The physicians donned the IVR headset and were guided through the virtual environment, familiarizing themselves with the controls and interfaces. This orientation was organized through the help of the IVR medical education team. Dr. Ochiai assessed their baseline skills by observing initial attempts at navigating the virtual hip joint and performing basic maneuvers.

2. STEP-BY-STEP GUIDANCE

In collaboration with the IVR medical education team, Dr. Ochiai designed a curriculum that highlighted the hip arthroscopy procedure into manageable and essential parts of the procedure. With Dr. Ochiai in his home in Virginia, two independent sessions were organized with Dr. Williams in Texas, and Dr. Rahman in California. A multiuser experience was set up where a PIN code was shared between the participants to join a virtual collaboration session. Digital representations (avatars) of Dr. Williams, Dr. Rahman, and Dr. Ochiai were created, with each avatar standing next to the other, allowing them to communicate and gesture virtually in real-time. (Please See [Video 2](#))

Each session focused on specific aspects that were relevant to the surgeon learners, such as portal placement, diagnostic arthroscopy, and handling of common pathologies, such as addressing the CAM lesion and subsequent resection. Within the IVR environment, Dr. Ochiai navigated through the virtual environment while being able to pause and provide real-time demonstration and feedback which Dr. Williams and Rahman could then practice repeatedly. The total time for the experience was two hours each for both surgeon learners. In Dr. Williams' session, there was additional discussion on portal placement and how subtle changes in the position of the hip can be used for specific hip pathology such as femoroplasty versus acetabuloplasty ((Please See [Video 2](#)). In Dr. Rahman's session, there was a focus on patient positioning such as post versus post-less positioning and the optimal position of the fluoroscopy machine relative to the operating table to appreciate the 3D anatomy of the femoral head-neck junction.

3. SIMULATED COMPLICATIONS

During the remote multi-user educational experience, Dr. Ochiai introduced simulated complications into the training. Specifically, Dr. Ochiai over- and under-resected the CAM lesion to demonstrate how that would look on the fluoroscopic images. Dr. Ochiai also removed the virtual femur bone out of the body to demonstrate how the resection looked directly on the bone relative to the fluoroscopic images. The intention here was to expose a nuance of CAM resection and the visual appearance of this on fluoroscopy in both states (under and over resection). In Dr. Williams' session, Dr. Ochiai demonstrated a systematic approach for

a revision hip arthroscopy case including portal placement, under-resection of a CAM lesion and the benefits of a particular medical device to overcome this challenge.

4. PROGRESS TRACKING AND FEEDBACK

During their independent use of the IVR system before and after their mentoring session with Dr. Ochiai, the system tracked Dr. Williams's and Dr. Rahman's progress. Performance data measured and recorded included the time taken for each step, precision of movements, number of images taken, percentage of CAM lesion resected, inadvertent damage to the femoral head with the arthroscope, limb traction time, and overall surgical efficiency. Dr. Williams and Dr. Rahman reviewed these metrics after each session, highlighting areas for improvement. This data-driven approach was utilized to tailor to the specific needs of each surgeon.

CHALLENGES FACED

Despite all these advantages, the integration of IVR was not without challenges. Initially, Dr. Williams experienced that there is a learning curve in adapting to the IVR controls and maneuvering in a 3D world with digital tools. Dr. Williams was able to acclimate stating: "It took me a few minutes and attempts to manipulate the instruments and move around the simulated OR smoothly. "I became a little more comfortable during the session, but it was still a challenge to access some areas in the hip safely, which I think was actually the point and was similar to a real hip." Similarly, Dr. Rahman encountered challenges in translating some of the haptic feedback into real-world actions, particularly when the virtual environment did not perfectly mimic the tactile feedback experienced in live hip arthroscopy. Dr. Rahman specifically noted the value of repeatedly practicing difficult maneuvers in a virtual environment to build muscle memory and "know where your hands are in space."

OUTCOMES AND BENEFITS

1. ENHANCED SKILL ACQUISITION

Over the course of several days of independent practice, Dr. Williams' and Dr. Rahman's skills and IVR performance metrics improved. The repetitive practice using IVR allowed them to refine their techniques without the pressure of performing on live patients. Their ability in identifying and addressing common hip pathologies increased, while increasing their 3D spatial intelligence as it related to CAM resection and visualizing it by using the digital C-arm. The ability to remove the virtual hip bone from the virtual patient afforded a unique opportunity in understanding the complexity of hip bony anatomy.

2. INCREASED CONFIDENCE

Dr. Williams and Dr. Rahman self-reported that the immersive experience increased their confidence. By the time they

transitioned to performing surgeries on real patients, they had attempted to manage numerous simulated scenarios in IVR, reducing their anxiety in the operating room. Dr. Williams stated: “I did another practice IVR session the day before my first hip scope. During the case, I felt familiar with navigating the joint. It was still a challenge; however, I did feel more confident and comfortable with the procedure overall. The case progressed well, and the patient did great.” Dr. Rahman noted: “Every second counts, especially in hip arthroscopy with traction time and operating within a tight arthroscopic space. IVR training allowed me to enhance my dexterity and technical efficiency to minimize any wasted movements. Through repeated practice in a virtual environment, I refined my technique, ensuring each step was precise and purposeful, ultimately leading to reduced operative times.”

REFLECTIONS AND FUTURE DIRECTIONS

Drs. Ochiai, Williams, and Rahman acknowledged the impact of IVR on surgical education. Dr. Ochiai noted that the ability to provide immediate feedback and the data-driven insights were valuable. He also noted that teaching in a virtual OR allows for real time exchange of ideas and thoughts, cued by the procedure itself, but in a comfortable and no-risk environment. Finally, being able to highlight surgical errors deliberately was a valuable way to educate on a complex procedure. Dr. Williams and Dr. Rahman appreciated the opportunity to learn at their own pace and the reduction in stress when transitioning to live surgeries.

CONCLUSION

This case series between Dr. Ochiai with Dr. Williams and Dr. Rahman, highlights a unique and novel use case of immersive virtual reality. By providing a safe, immersive, and interactive learning environment, IVR bridges the gap between theory and practice in an interactive way which simulates the operative experience. Without traveling and the opportunity cost of leaving practice to engage with an educator, Drs. Williams and Rahman experienced no disruption in their clinical practice but reported a benefit from the expertise of Dr. Ochiai. Having a digital replica of what one would encounter in an actual OR, from patient set up to the manipulation of the hip and inserting portals is the major benefit of this operative experience. Enhancing skill acquisition, judgment, improving 3D visual spatial intelligence, through deliberate practice in a no-risk environment has the potential to improve patient care (Spiker, Arthroscopy 2024). As this technology continues to advance, the integration of IVR in medical education may provide a series of new opportunities for trainees, surgeons in practice and surgeon educators worldwide.

CONFLICTS OF INTEREST

The following authors have a conflict of interest with PrecisionOS Ochiai, D, Sigman, S., Bishai, S., Sanchez-Sotelo, J., Athwal, GS., Warner, J.J.P., Hiemstra, L and Goel, D.P.

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