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REVIEW ARTICLE

Mixed Reality and Augmented Reality in Shoulder Arthroplasty: A Literature Review

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ABSTRACT

Background: Reversed shoulder arthroplasty is considered a treatment choice for arthritis and irreparable/massive cuff-tears. The accurate placement of the glenoid baseplate, particularly the positioning of the central peg or screw as well as the inclination and version has been considered critical in reducing implant related intra- and postoperative complications. While the implant positioning and position of the screws can be planned preoperatively on three-dimensional imaging modalities, the lack of intraoperative access to the information and the visual monitoring of variations achieved in the surgery can lead to low reproducibility. The ongoing innovation in the reality technologies aim to improve the accuracy and precision in implantation of the components with a hypothesis that it improves the implant survivorship and the outcomes.

Aims: This review aims to provide an overview on the currently available mixed and augmented reality technologies in shoulder arthroplasty, their differences, and potential future applications in shoulder arthroplasty.

Methods: For this literature review, all relevant published reports were found via searches in Medline (PubMed) database using the following medical subject headings (MeSH) terms: "virtual reality" or "augmented reality" or "mixed reality" with "orthopedics" or "orthopedic surgery." Additional searches were carried out using the same key words in other databases including Ovid, Science Direct, SpringerLink, and Google Scholar, finding further relevant titles.

Results: The systematic search query resulted in 61 articles of which 8 articles met the inclusion and exclusion criteria. Two out of 3 clinical studies were published by the same group of authors, whereas 1 study elaborated a technical note of the application of navigated augmented reality technology in reversed shoulder arthroplasty. Among the remaining 5 (non-clinical) studies, 3 studies were feasibility studies while 1 study used the navigated augmented reality technology over 12 cadaveric scapulae. The remaining 1 study was a proof-of-concept study over saw bone models based on the CT scans of one single patient.

Conclusions: This study gives the clarity between mixed and augmented reality that have been interchangeably used in the literature. We believe that the inclusion of mixed reality and augmented reality technology can enhance the precision during surgery, potentially reducing implant related complications and revision rates. However, further studies evaluating the radiographic parameters on implant-positioning, surgical, functional, and patient reported outcomes of this technology are called for its global acceptance.

Keywords: Mixed reality, augmented reality, reversed shoulder arthroplasty, HoloLens, cuff tear arthropathy

Introduction

The research and implementation of innovative technologies in total joint replacement has engrossed attention in the last decades. After the introduction of minimally invasive surgery (MIS), computer assisted orthopedic surgery and robot assisted surgery; computer navigation has become a compelling tool for accurate positioning of implants.[1-3] The implantation systems, implant designs and surgical techniques are being continuously studied and improved.

Conventionally, the imaging modalities in orthopedic surgery have been classified as offline (those performed prior to surgery and after surgery, e.g., X-rays, MRI, CT scans) and online (those performed during surgery). The online two-dimensional imaging has proved to enhance the accuracy of a surgery, requiring video monitors, having the potential disadvantage of overlapping structures and increased radiation exposure. It has led to the need of online three-dimensional imaging. Hence, there appeared a need of three-dimensional imaging to be introduced from preoperative stages to intraoperative stages.[4]

The increase in life expectancy in general, and the substantial increase in the varied indications in the ageing population, has resulted in the globally increased use and acceptance of total shoulder arthroplasty as standard of treatment.[5,6] Initially, reversed shoulder arthroplasty was indicated in patients with severe stages of rotator cuff arthropathy. Nowadays, it has become a treatment option in the management of massive irreparable rotator cuff tears, primary fracture management of complex proximal humerus fractures, failed osteosyntheses, post-traumatic shoulder arthritis, osteoarthritis of the shoulder in geriatric patients etc.[7] The encouraging results (functional and surgical) of reversed shoulder arthroplasty have revolutionized shoulder care, and have led to an improvement of the long-term survival and the function of the prostheses.

Accurate implant positioning has been the top priority amongst shoulder surgeons to reduce implant related intra- and postoperative complications. To be more precise, drilling of the central screw/peg position and orientation has been considered the critical step with a neutral version and neutral to slight inferior inclination being considered the best baseplate position.[8-10] Especially in patients with severe glenoid deformation, severe bony defects, or poor bone quality as well as in complex revision cases, the best positioning of the baseplate is challenging due to limited intraoperative visibility and orientation. Malpositioning of the baseplate can lead to inferior scapular notching, loosening of the components, instability, and unfavorable clinical and functional outcomes.[11]

The market leaders have invested their stakes in computer navigation systems and patient specific implantation and instrumentation (PSI). Both these systems can be used to achieve optimal component/baseplate positioning. However, with the exponential growth in the computing powers and imaging technology, the advent of reality technologies has opened new horizons from diagnosis to treatment in shoulder care.

Basic concepts technologies

The artificial technologies allow a better understanding of the patient anatomy, thus increasing the precision and safety of the procedures. The studies on reality imaging have been first presented in literature by Milgram and Kishino in 1994, when they published a detail continuum to elaborate the ways to combine virtual and real worlds to create a unique experience for the user.[12]

A. Virtual reality

The virtual reality technology, first coined by Jaron Linier in 1986, has been implemented in the field of clinical medicine from the entertainment industry.[13,14] The later evolution has been based on the unique property to replicate the scenarios and environments by visually immersing the user in a completely artificial computer-generated environment. The virtual reality technology available in market currently, uses the combination of three-dimensional rendering computer, a head mounted display and controllers with position tracker, further extending by a step to haptic feedback to recreate a sense of touch, vibration, and motion.[13] The virtual reality applications used in the field of orthopedic surgery are broadly classified in low-fidelity and high-fidelity formats. The low-fidelity formats replicate single- or multi-tasking with limitations of interactivity, visual presentation or available commands or contents. On the other hand, the high-fidelity virtual reality recreates greater immersion, replicating clinical and surgical scenarios and tasks that are more interactive, visually appealing and content specific.[15] Most of the virtual reality advances are capable of providing the freedom of movement through a virtual environment. Well, still in early days these applications are limited to preoperative planning, patient education, practical training of specific surgical techniques with the goal of improving the procedural skills in resident training. It can also support the patient specific preoperative simulation of patient's anatomy.[16,17] There is no place for virtual reality during the operative procedure itself.

B. Augmented reality

Various studies have assessed the worth of augmented reality in orthopedic surgery.[18-20] Its concept was suggested by Azuma et al.[21] as a variant of virtual reality. The augmented reality assisted surgical intervention was suggested by Kelly et al.[22] in 1982, where they superimposed the tumor outlines from preoperative CT data into the view of a surgical microscope rigidly attached to a stereotactic frame. In augmented reality systems, the patient's anatomy is presented to the operating surgeon in a more elaborated format. In contrast to virtual reality, augmented reality allows the user to see the real world with virtual images superimposed upon it, thus supplementing the reality with computer-generated sensory impression, enhancing the patient's anatomy to the surgeon.[23] It enables the operating surgeon to have the preoperative information superimposed over the surgical field. The virtual content is generated from the preoperative CT or MRI scans and visualized to the surgeon next to the surgical field over a monitor or over an optical see-through head mounted display or smart glasses without a screen that forces the surgeon to look away from the surgical field. The basic elements of the augmented reality system are the position tracking system, a display device, and the corresponding system control software.[19] The registration phase (first step) can be marker based[24] or marker less (surface registration introduced by Liebmann et al.[20] as a radiation free approach with intraoperative surface digitization and navigation) or through the augmented image intensifier[21]. The accuracy of the procedure depends on the precision of the registration phase. The next step is the tracking phase, which provides the exact orientation of the organ during the surgical procedure. The registration and tracking phase are followed by the presentation phase (third step), in which the elaborated anatomy is displayed over the screens, head mounted displays or projectors. The currently available headsets in market are the Google Glass, Microsoft HoloLens, and Madic Leap, in which the preoperative information is displayed in real time on a small screen in front of a user's eye. Augmented reality has been reliably used for preoperative planning, intraoperative guidance, and resident training. The recent developments provide the enhanced freedom of control with hand gestures.[26] In augmented reality systems, the surgeon cannot interact with or manipulate the displayed images.

C. Mixed reality

While augmented reality enables specific devices to fuse digital images to physical models and to limitedly interact with both, the mixed reality technology like augmented reality technology permits the same along with a deeper perception in virtual mode. It includes the digital display overlay combined with interactive projected holograms. An added advantage of mixed reality is that it offers more accuracy in performance of interventions, thus leading to an upgrade in the quality of treatment and outcomes of the procedures. The user sees the real world while changing the digital information generated by the device having enhanced freedom of control over digital content with response to verbal commands and hand gestures.[27]

Extended reality is the recently coined term used broadly to describe the immersive technologies of virtual reality, augmented reality, and mixed reality under one single umbrella.[28]

The literature has used the terms augmented reality and mixed reality interchangeably. The aim of this review is to define the reality techniques with clarity in the field of shoulder arthroplasty. We also aim to elaborate the future possibilities in the development of reality technologies used for obtaining precise implant positioning in the patients.

Methods

Search strategy

For this literature review, all relevant published reports were found via searches of Medline (PubMed), Google scholar database and Cochrane Database of Systemic Reviews. These databases were queried for publications using the combinations of following medical subject headings (MeSH) terms: "augmented reality" or "mixed reality" and "shoulder arthroplasty" or "shoulder replacement" or "total shoulder arthroplasty" or "reversed shoulder arthroplasty." Additional searches were carried out using the same key words in other databases including Ovid, Science Direct, and SpringerLink, finding further relevant titles since the start of the databases up to 31st July 2022. No limit was set about year of publication. During the title screening, only abstracts that included the application of augmented reality and mixed reality were included. The full text of the manuscripts was reviewed if adequate information was provided by the title and abstract. The studies evaluating the application of reality technologies in trauma surgery, spine surgery, total knee arthroplasty, total hip arthroplasty, oncology, total elbow arthroplasty and arthroscopy were excluded from the study. Case series, case reports, technical notes, cadaveric studies, feasibility studies and reviews were included in the study.

Inclusion and exclusion criteria

Any original study in which augmented reality or mixed reality technology were applied in clinical and preclinical settings were included in this study. The type of system, its application, pearls and pitfalls in the technique and the accuracy and precision findings were recorded. Exclusion criteria were commentary reports, letters to the editor, commentaries, book chapters, abstracts from scientific meetings, unpublished reports, and studies with no details on the augmented reality or mixed reality system reported.

Results

The search query resulted in 61 abstracts that were examined if they fulfilled the inclusion criteria, related to application of augmented reality or mixed reality technology in shoulder arthroplasty. Following elimination of duplicate articles, only 8 articles met the inclusion criteria and were included in the final analysis.[4,29-35] Amongst them, 3 studies were clinical studies, which included one case series and 2 other studies illustrating a technical note of the surgery performed.[4,29,30]

Gregory et al.[29] published an international case series of 13 patients, reporting the surgeon's experience using HoloLens, while the same group also published the proof-of-concept over one single patient using HoloLens.[4] There was no collaboration between the head mounted display and the navigation system in this technical report. J Tomas Rojas et al.[30] published a technical note using HoloLens and the collaborated navigation system over a single patient. The system required standardized CT scans with three-dimensional reconstruction, three-dimensional preoperative planning, optional use of a headset and navigation system for performing reversed shoulder arthroplasty.

Kriechling et al.[31] conducted a feasibility study over three-dimensional models of 10 human scapulae which were printed from CT data and a hologram of the planned guidewire that was projected onto these three-dimensional models. The central guide wire was placed with the help of navigation, another CT imaging was recorded, and the three-dimensional model was superimposed with the preoperative planning to analyze the deviation from the planned guidewire. They reported a mean deviation of the trajectory of 2.7° ± 1.3° and a mean deviation of the entry point of 2.3 mm (about 0.09 inch) ± 1.1 mm (about 0.04 inch). The same group of authors reproduced the same study on cadaveric specimens.[33] After obtaining CT images of 12 human cadaver shoulders, a reversed shoulder arthroplasty baseplate positioning was three-dimensionally planned, and an augmented reality hologram was superimposed using the head mounted display Microsoft HoloLens. Then, the shoulders were CT scanned a second time, postoperatively, to evaluate the deviation from the planning, reporting a mean deviation of the trajectory of 3.8° ± 1.7° and a mean deviation of the entry point of 3.5 mm (about 0.14 inch) ± 1.7 mm (about 0.07 inch). A similar study based on a navigation technology of augmented reality through a head mounted display was reported by Schlueter-Brust et al.[32]. The authors in their feasibility study, explored an augmented reality system for the positioning of the glenoid baseplate. Like the study by Rojas et al.[30], this system also needed a standardized CT protocol, with three-dimensional reconstruction, three-dimensional planning, and the use of a commercial headset, to conduct augmented reality assisted K-wire placement in the glenoid. The outcome was measured using a high-resolution laser scanner on the patient specific three-dimensional printed bone. In this proof-of-concept study, the discrepancy between the planned and the achieved glenoid entry point and guidewire orientation was approximately 3 mm (about 0.12 inch) with a mean angulation error of 5°.

Table 1:

Authors	Patients/ Cadavers/ Sawbones	Type of study	Supporting device AR/Assisted AR/MR	Results
Clinical Studies				
Thomas Gregory et al.[29]	13 surgeries	Multicenter international case series and surgeon's experience	HoloLens	100% surgeons were very satisfied to satisfied. 94.1% would continue to use mixed reality headset
J. Tomás Rojas et al.[30]	1 patient	Technical note	HoloLens and collaborated computer navigation system	Satisfactory implant positioning
Thomas Gregory et al.[4]	1 patient	Proof of concept and technical note	HoloLens No collaboration between mixed reality headset and navigation system	Adequate positioning of the implant No postoperative complications
Feasibility studies/Saw bone studies/Cadaver studies				
Kriechling et al.[31]	10 three-dimensionally printed scapulae	Feasibility study for guidewire positioning	HoloLens 1 Navigation - surface marking with fiducial markers (Used only for the K-wire placement)	Mean deviation of the entry point 2.3 mm ± 1.1 mm Mean deviation of the planned trajectory 2.7° ± 1.3°
Schlueter-Brust et al.[32]	9 saw bones on 1 patient's CT	Proof of concept for glenoid entry point for RSA	HoloLens 2	Mean entry point error of 2.3 mm (comparable to conventional techniques) Orientational error of 2.7° (lower)
Kriechling et al. (Cadaveric study)[33]	12 cadaveric scapulae	Cadaveric study for baseplate positioning in reversed shoulder arthroplasty	HoloLens 1 Navigation - surface marking with fiducial markers	Mean deviation of the entry point 3.5 mm ± 1.7 mm Mean deviation of the planned trajectory 3.8° ± 1.7°
Wenhao Gu et al.[34]	-	Feasibility study	Microsoft HoloLens 1	-
Julien Berhouet et al.[35]	1 3D reconstructed scapula	Feasibility study	-	Adequate orientation of the scapula and glenoid was obtained. It was possible to identify and view the location on the glenoid.

Discussion

The exponential growth in the computing powers and imaging technology has transformed the global health systems and revolutionized patient care from diagnosis to treatment. The reality technologies are applied in orthopedics as an effort to improve the surgical precision, surgical outcomes and to reduce complications. There has been widespread adoption of augmented reality technology in spine surgery with preposition to the complex anatomy and the potential risk of iatrogenic injury during instrumentation, with promising results.[36-42] Encouraging results have also been published in the fields of corrective osteotomies, trauma surgery and tumor surgeries increasing the precision and lowering the radiation exposure.[42-44]

While two- and three-dimensional preoperative planning still remains crucial for precise positioning of the glenoid components, the limited exposure, severe glenoid deformities and the limited intraoperative three-dimensional orientation of the scapula may hinder the accurate positioning of the glenoid component.[45-47] To reduce these deficiencies, computer navigation[48,49], mixed reality[4], navigated augmented reality systems[50] and patient specific implantation and instrumentation (PSI)[51] were introduced in shoulder arthroplasty. While PSI takes a longer preoperative processing time (4-6 weeks) and is more expensive, the mixed reality and navigated augmented reality systems prove to be beneficial, less expensive, and literature confirms a better placement of baseplate screws intraoperatively.[4,31-33]

The mixed reality technology in the form of navigated augmented reality systems and head mounted displays allows a more detailed transfer of a preoperative plan into the surgical procedure.[27] The preoperative plan that is presented on the head mounted display glasses can be validated and improved with intraoperative referencing and registration of the patient's anatomy. In contrast to augmented reality and PSI, mixed reality technologies provide instant and real-time feedback to the operating surgeon about the placement of the central screw of the glenoid baseplate. The orientation of the glenoid face in reference to the coronoid process provides the exact orientation of the scapula in 3 dimensions, despite a limited exposure. When compared to the classical procedures, the introduction of mixed reality headsets along with navigation will improve the efficiency of the surgeon and optimize the outcomes for the patient, without reducing the safety of the procedure. The three-dimensional holograms orient the surgeon with the exact location of the vital neuromuscular structures in real time. This in return, will help increasing the safety of the procedure, and will in the same time be time saving and help to improve the accuracy in component positioning.[27]

In routine surgeries, the surgical field is visible and accessible only to the main surgeon and his/her assistant. The surgeon's view of the surgical field can be projected to a screen and can be made accessible to people at distant site. This can provide constant feedback and can be an efficient tool in education. The usage of head mounted displays allows the surgeon to obtain the preoperative planning in his field of vision, while keeping the focus in the surgical field. He can gain access to the three-dimensional holograms related to the patient's imaging and to the surgical technique. With the use of navigated augmented reality technology, the surgeon can confirm the preoperative planning in real time over the patient's anatomy, while staying in the sterile surgical field. He can also still gain the opinions and advice from colleagues and the company representatives about implantation and instrumentation. This was shown by Gregory et al.[4] in the very first clinical study that implemented the complete usage of immersive and collaborative aspects in shoulder surgery. In their proof-of-concept publication, they operated an 80-year-old patient with navigated, augmented reality assisted reversed total shoulder arthroplasty. The surgeon's field of vision was shared with 4 other surgeons at distant places in USA and UK who were able to share their opinion through Skype while the surgeon was in the operating field.

Schlueter-Brust et al.[32] in their proof-of-concept publication found that the addition of preoperative three-dimensional planning increased the overall time required by approximately 5 minutes. This however provided a very vital three-dimensional information about the patient's anatomy, adequate orientation, better visualization, and possibility of obtaining a three-dimensional printed haptic model for patient counselling and added value in surgical education and training.

The mixed reality and augmented reality technologies were able to show the quantitative improvement in entry point positioning and K-wire trajectory while placing the central guide wire for the baseplate. The mean postoperative errors in the published literature using standard instrumentation techniques were 7.1° (range 3.5° - 11.2°), the mean postoperative inclination errors were 8.45° (range 2.8° - 11.7°), and the mean postoperative positional offset errors were 2.6 mm (range 1.7 mm - 3.4 mm) compared with the preoperative plans.[52]

The study by Schlueter-Brust et al.[32] reported an average entry point error of 2.3 mm (about 0.09 inch) which was comparable to one of the existing studies in the literature. However, they reported a lower orientation error which the authors attributed to the automated registration method based on surface scanning of the glenoid. The authors were successful in feasibly showing the replication of the preoperative CT based plan in their lab-based study. Berhouet et al.[35] described the application of augmented reality to display a three-dimensional reconstruction of the glenoid and the adjacent scapula in total shoulder arthroplasty using a head mounted display without navigation.

The improved efficiency of the surgery does not come at an extra burden to the surgeon. The head mounted displays are light weight with approximately 579 grams, and their use do not cause any pain or tiredness. This was confirmed by Schlueter-Brust et al.[32], who stated that the headsets were comfortable and did not induce any fatigue. However, the time needed for K-wire insertion increased by 3 minutes which was attributed to the manual alignment of the holographic referee anatomy to the phantom scapula. The display, image quality and image stability were described as favorable, and not causing motion sickness. Regarding communicating with distant colleagues in videoconferencing, there was no cut off and the consistency of interaction as well as the safety was assured. Finally, the battery support of 5.5 hours was sufficient for most of the surgical procedures.[4]

Though all these interesting results have been reported by few clinical studies, the application of augmented reality and mixed reality systems in shoulder arthroplasty needs to be fully explored and thoroughly understood. The placement of a glenoid baseplate and the central screw/guide wire has only been investigated in few studies over few patients, cadaveric scapulae, or bone models to evaluate the feasibility and proof of concept as well as to study the accuracy and precision of the augmented reality systems as such. However, for the widespread adoption and application of this novel technology further studies are required investigating various technical challenges, possible complications, radiographic parameters etc. The long-term surgical and functional outcomes of the operated patients must be followed up for accepting the reality technologies assisted with navigation as new state of the art in shoulder arthroplasty. Finally, more valuable data and prospective randomized controlled studies are needed to support this innovative technology for optimization of the precision in implant positioning.

To summarize, besides various other innovative technologies (including PSI, computer assisted surgery and robotics), augmented reality and mixed reality technologies show promising results according to current literature, raising the faith that these novel techniques will significantly enhance implant survivorship and improve clinical and functional outcomes in shoulder arthroplasty. However, these modalities can easily follow the Scott`s parabola of surgical techniques[53], especially when the costs incurred in the installation are not supported by the gain in better clinical outcomes.

There were multiple limitations to this study. The limited quality and type of available studies (few patients, technical notes, cadaver and saw bone model studies) does neither allow to reach a clear conclusion about the efficacy of the technology nor to properly compare it to other technologies. There has been a great diversity in the published literature about the devices used for navigation, clinical and preclinical settings leading to inability to analyze them statistically. The sparse number of clinical studies with different devices and different outcomes on a small number of patients attributes to the currently limited diffusion of the technology among shoulder surgeons. The devices used for augmented reality are often different and limited to pilot studies. So, current literature does not provide a clear and objective conclusion on any individual device. Finally, most of these published reports were industry funded, leading to potential selection, performance, and publication bias. Hence, we advocate a cautious interpretation of the results.

As we strive forwards in search of precision, despite the limitations, the readers should also learn that augmented reality and mixed reality systems provide real time information of the orientation and constant feedback during the placement of a glenoid component, matched with the preoperative planning. The head mounted displays inarguably provide the best access to preoperative planning to the surgeon. Moreover, they also provide distant inputs to the surgeon without having to leave the sterile field. The advantages and disadvantages have been summarized in Table 2. Finally, the results published in the literature keep the stake holders interested in further development of these technologies with a constant goal to improve the surgical and functional outcomes and survivorship of the implant.

Table 2:

Advantages and Disadvantages of Navigation	
Advantages	• Real time information of the K-wire or central screw placement, the base plate positioning and orientation, length of the screws, the target bone for the purchase of the screws and final glenoid implants is provided as per the preoperative planning. • The use of headsets allows the operating surgeon to keep his focus in the surgical field. • Distant help can be obtained from colleagues as well as from company representatives. • Trackers used for navigation are easy to position. • The calibration by the navigated system can validate the preoperative planning with a real time registration process. • Central screw placement and hold of the screws can precisely be determined with the help of the navigation system. • The size of the baseplate, inclination, trajectory of the central screw and peripheral screws, the size of the bone graft can be predetermined in preoperative planning with the use of a three-dimensional planning software.
Disadvantages	• Trackers used for a navigation system add extra costs. • Theoretical risk of coracoid fracture • Increased exposure, theoretical increase in incidence of bleeding and infection • Increased instrumentation and number of surgical steps • Exposure to radiation preoperatively for additional CT sequences

Table 3:

Tips, Tricks and Pitfalls
Tips and Tricks
• Precise preoperative planning approved by the software, agreed by the surgeon, and communicated with the team is important for the uninterrupted flow of surgery. • Release of the posterior, anterior and inferior capsule, and long head of triceps for complete exposure of the glenoid. Release of superior fibers of the pectoralis major muscle for improving the exposure when needed. • The K-wires for trackers holders must be directed to base of coracoid for secure fixation. • Avoid putting these pins too medial and too deep. • Infra-red trackers must be aligned with the camera. • In cases with glenoid bone loss, the lateralization is performed with bone graft from the humeral head. In such cases the long peg base plate should be used.
Pitfalls
• Loose pins/trackers can hinder the accuracy of registration. • Insufficient soft tissue release can lead to inadequate exposure and compromise the instrumentation and implantation process.

Conclusion

The reality technologies have promisingly shown to visualize the preoperative planning in real time. They have efficiently proven the implementation of the preoperative planning into the surgery, and the improvement in accuracy and precision of the component placement in shoulder arthroplasty. The teleconferencing and obtaining distant help from colleagues and company representatives, can surely be considered as a boost to telemedicine in the future. The gap between the research and its wide application is primarily attributed to the limited diffusion of the technology amongst surgeons, the costs of the reality technologies, disparity in the available devices and limited clinical studies.

With further research and implementation, the reality technologies will provide an interesting prospect with a diversity in potential applications not only in shoulder surgery but in orthopedic surgery in general.

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