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Editorial

Transforming Education in Orthopedic and Trauma Surgery: Integration of Extended Reality

Transformando la educación en cirugía ortopédica y traumatológica: Integración de la realidad extendida

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The integration of Extended Reality (XR) technologies, encompassing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), is increasingly transforming medical education. These technologies are revolutionizing the way future surgeons are trained and educated, immersive learning experiences that were previously unimaginable.

Relevance of XR in Medical Education

Providing an appropriate balance between theoretical and practical training in medical education has been a constant challenge.[1–3] Student exposure to and practice of procedures depends on multiple factors, including the prevalence of the pathology, location, and length of the rotation, student's personal motivation, and their relationship with their instructor.[4] Traditional Medical-surgical education, based on Halsted's "master-apprentice" model (see one, do one, teach one)[5] and practice on physical or cadaveric simulators, is being complemented and, in some cases, replaced by XR tools. These technologies provide an immersive learning experience in a three-dimensional (3D) digital environment, allowing students to interact with simulated cases, generating active, accessible training that is considerably more economical than other medical simulation methods in the long term.[6,7] For example, VR offers simulations where users can practice surgical techniques with immediate feedback and without risk to patients, while AR overlays digital elements with crucial information directly into the user's field of view during a procedure, facilitating real-time decision-making.

Impact on Learning

XR has been positioned as an academic tool that improves theoretical, practical, and spatial knowledge,[8,9] critical thinking,[10] memorization of steps to complete a procedure, motor skills,[11–14] attitude, and commitment to learning,[8,15,16] even as much or more than a traditional medical simulation.[17] In addition, it offers the opportunity to train in techniques that are not performed in the institution or region in which residents work, offering an opportunity for developing countries. For these reasons, the simulation of orthopedic and trauma surgery procedures in XR is being formally integrated into training programs.[18,19] The application of XR allows for more equitable access to high-quality education. Residents can practice repeatedly in controlled and safe environments, which is crucial in a discipline where skill and precision are essential.[20]

Challenges

While XR simulation offers the advantages mentioned above, its implementation is not without challenges. These include the initial cost of the equipment and the necessary infrastructure, as well as the choice of one or more specialized software that meets the needs of the academic program. It is also important to consider that current technology, while immersive, is still unable to generate a 100% realistic scenario, especially due to shortcomings in haptic feedback. However, there are already XR simulations that incorporate this technology, demonstrating its improvements in the learning process.[21,22] Moreover, technology drives continuous

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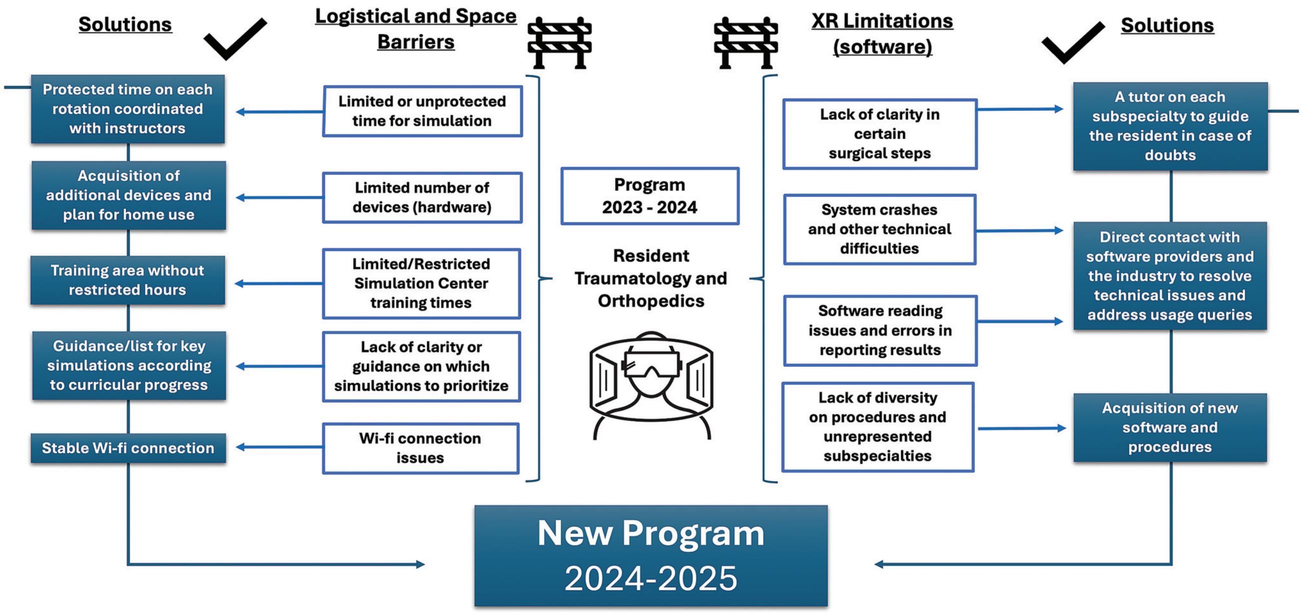

Fig. 1 Challenges encountered and proposed solutions to the integration of simulation with XR in a orthopedic and trauma surgery training program.

improvement as it constantly evolves and adapts to address new needs and challenges. Simultaneously, as this evolution takes place, its costs tend to decrease.[23] Finally, any teaching intervention and innovation can lead to resistance among users and hinder their integration,[24] therefore, a progressive insertion that considers continuous measurement and analysis of the difficulties encountered is of utmost importance.

Local Experience

XR simulation has been formally integrated into our training program. During the pilot implementation, XR training showed that more than 90% of residents reported that this tool is beneficial to them, allowing them to better understand and apply their knowledge and recommend it as an entertaining way to learn. 91% were confident that through simulation they were acquiring knowledge that allows them to perform in a real clinical scenario. Confidence to act as first surgeon and assistant for the trained procedures increased from 9% to 50% and 55% to 92% before training and after the last session, respectively. As challenges, elements like those reported in the literature were identified,[19] particularly logistics, physical space and technology, solutions were proposed for each of them (►**Figure 1**). Once the solutions began to be implemented and with 546 simulations carried out, user satisfaction increased from an average Net Promoter Score of 38 to 48.

Conclusion

XR is becoming established as an essential tool in medical education, particularly in orthopedic and trauma surgery. It is crucial that educational institutions and healthcare professionals recognize these technologies, not just as adjuncts but as an integral part of medical training. Future research should focus on refining these technologies and assessing their long-term impact on the quality of medical care. We invite academics and those responsible for orthopedic and trauma surgery training. In the country to explore and implement these tools in their programs. The promise of XR lies not only in improving the technical skills of future surgeons, but in transforming continuing medical education to meet the challenges of the future and provide the best care to our patients.

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