Augmented Reality for Sarcoma Surgery - the Future is Here

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Significance and Hypothesis or Techniques

Complex spine tumor resections require precise spatial understanding of distorted anatomy near critical neural and vascular structures. Conventional navigation systems provide valuable guidance but remain limited by the need to shift attention away from the operative field and by challenges in translating 2D imaging into real time 3D decision making. Augmented reality offers the ability to project patient specific imaging directly into the surgical field at true scale. We propose that augmented reality integration improves intraoperative anatomical understanding, enhances preoperative planning including incision design and trajectory selection, and increases surgical precision during complex spine resections. The goal of this study is to present three highly complex spine cases to illustrate the feasibility and added value of augmented reality in planning and execution.

Innovation

This work demonstrates the use of real time augmented reality overlays registered to patient anatomy during complex spine surgery. The innovation lies in the seamless integration of imaging with direct visualization, allowing the surgeon to perceive deep anatomical relationships without diverting focus from the operative field. Additional novelty includes the use of augmented reality during the earliest stages of the procedure to guide incision placement and optimize surgical approach, as well as its role in refining preoperative planning through immersive review of patient specific anatomy.

Approach Materials and Methods

Three cases of complex spine resection are presented. These include a case of malignant peripheral nerve sheet tumor, myxofibrosarcoma invading bone and giant cell tumor of the spine. Preoperative imaging was used to create 3D reconstructions, registered intraoperatively using an augmented reality platform aligned to patient landmarks. The surgeon visualized superimposed structures including vertebrae, tumor margins, and critical adjacent anatomy in real time. Augmented reality was used for preoperative planning and intraoperative incision planning, exposure, and verification of resection.

Results

All three cases demonstrated successful integration of augmented reality without disruption of workflow. The surgeon reported improved confidence in identifying anatomical boundaries and planning surgical corridors. Incision placement and exposure were optimized based on projected anatomy, reducing unnecessary dissection. Complete resections were achieved in all cases with preservation of critical structures. Figure 1 provides intraoperative views demonstrating augmented overlays of each case. No technology related complications were observed.

Discussion and Impact

Augmented reality enhances spatial understanding and real time correlation between imaging and anatomy in complex spine and sarcoma surgery. It supports more precise planning and execution, with potential to improve safety, efficiency, and operative time. Visualization at true scale reduces cognitive load and may shorten the learning curve. This series highlights its role as a complement to existing navigation systems from incision through resection. Future work will include integration of instrument navigation overlays and precision studies to quantify accuracy and validate clinical impact.

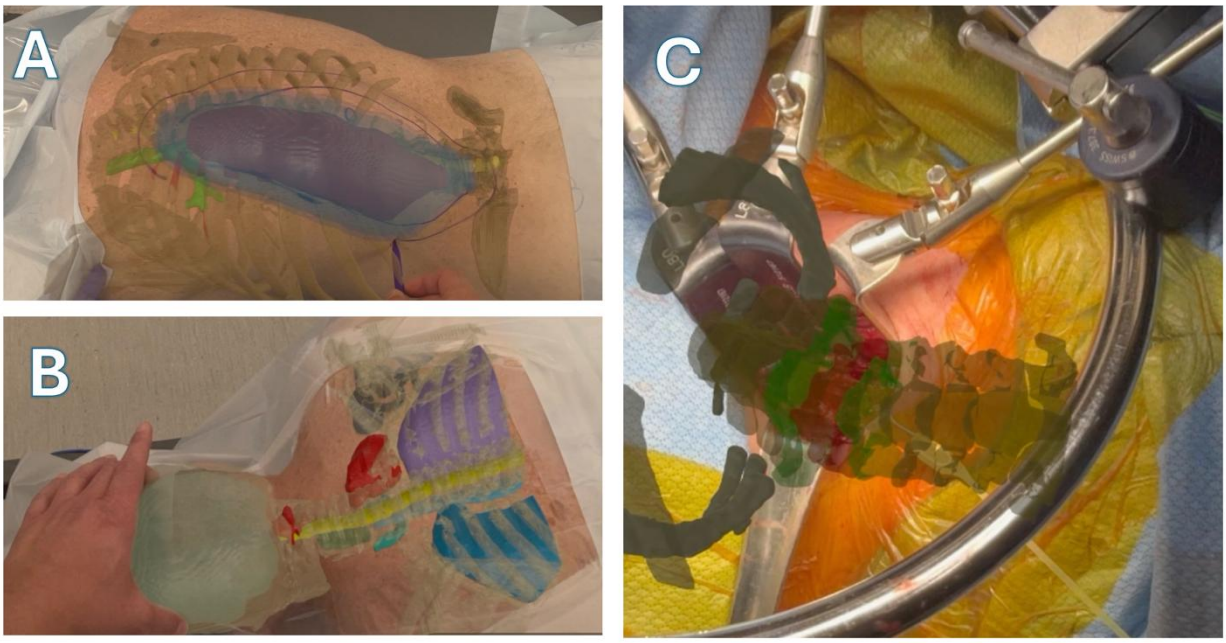

Figure 1. A: Pre-incision overlay of large 9 level en-bloc sarcoma in the Thoraco-Lumbar Spine. B: Pre-incision overlay of a patient with two MPNSTs in the cervical spine. C: Post-incision overlay of GCT of the cervical spine.