Virtual Reality for Patient-Specific, Multidisciplinary Planning of Complex Orthopaedic Oncological Surgery

Yusra Kassim Al Mosuli[1], Jorge Cabrolier, Kevin Smit, Patrick James Villeneuve, Philippe Tran Nhut Phan, Hesham Abdelbary, Teresa Flaxman, Dan La Russa, Kawan S Rakhra[2], Joel Michael Werier
[1]The Ottawa Hospital Research Institute, [2]The Ottawa Hosp

INTRODUCTION: Surgical planning is essential for complex oncology cases. Current imaging regimens include 2D planar CT and MRI, multiplanar reformations, and 3D surface enhanced series. Virtual Reality (VR) visualization and planning is a dynamic, immersive experience offering enhanced understanding of complex anatomical relationships, the ability to manipulate and layer the 3D models with 2D images, and allows simultaneous engagement across remote sites. This pilot describes our experience with the 3D VR planning system.

METHODS: Ten patients with complex anatomic sarcomas of the spine, pelvis and chest wall were included. The 3D models were generated from diagnostic CT and MR imaging using 3D modeling tools while noting the length of time and cost to prepare cases. The VR system was also validated for model and measurement accuracy via direct comparisons with a reference system, and for overall ease of use and clinical utility. The Dice-Sørensen Coefficient (DSC) was used to score similarity of models generated in VR to those made in the reference platform.

RESULTS: On multidisciplinary debrief, each case reviewed in VR provided added information to the surgical team compared to standard imaging. This included better understanding of the tumor margins and relationships to critical structures and, in 3 cases, modified surgical approach. The platform supported multiple reviewers sharing the same VR environment and allowed for dynamic changes to 2D and 3D visualizations. The mean time to prepare cases was 70 minutes (range 25 -90) dependent on number of anatomical structures to be modeled, representing a mean cost per case of $233 USD (range $85 -$300). DSC values for 3D structures created in VR were 0.97 or higher, confirming geometric accuracy of models relative to a reference system. Measurements of length, cross-sectional area, and angle on clinical CT scans were within 0.22 mm (0.3%), 0.16 mm2 (0.02%), and 0.04 deg (0.07%) or less of expected results, respectively. Lastly, predefined usability tests were conducted by 15 volunteer end-users, all of whom yielded accurate measurements and reported high confidence in their use of the platform.

DISCUSSION AND CONCLUSION:

VR planning of complex multidisciplinary cases is feasible and cost effective providing enhanced appreciation of complex anatomical relationships.