Purpose: Real-time sub-millimeter head motion compensation during frameless SRS delivery has the potential to achieve the accuracy of frame-based SRS while being significantly less invasive. Previously, we demonstrated real-time 6D head motion monitoring using an optical camera, however, at the time we were limited to only 3D (x-y-z) of head motion correction due to mechanical restrictions of the head platform. In this work we investigate the feasibility of using a compact 6D robotic Stewart platform (hexapod) placed under the patient's head to perform both translational and rotational motion compensation in real-time. Benefits of a hexapod approach over a conventional serial kinematics stage include less flex, compactness, high force to weight ratio, and fast response times.

Methods: A hexapod is a parallel robotics device consisting of two platforms connected by six linear actuators oriented at particular angles. To provide accurate motion in 6D, the desired position of the top platform (head) was ascertained using inverse kinematics. MATLAB was used to simulate the six actuator positions for performing motion along x-y-z-phi-theta-psi. Prior recorded 6D human volunteer head motion data was used as an input for simulation of motion compensation. Six Firgelli L12-P linear servo actuators, together with a PCI-7344 motion controller and Labview software, were used for initial construction of a hexapod prototype.

Results: The necessary actuator lengths over time were computed for this data, simulating the required 6D movement of the hexapod for motion correction. Simulations on previously collected volunteer data indicate a hexapod system is capable of responding to subject head motion with corrections of precise movements, and solutions to the linear system can be computed at near real-time speeds.

Conclusions: Based on simulated results, it was successfully demonstrated that a hexapod device can compensate for small patient head motions along all six degrees of freedom.