Traditional robot-assisted surgery, which relies on conventional mechanical mechanisms, has certain drawbacks, including friction, backlash, and the need for lubricants. In contrast, compliant mechanisms utilizing flexure joints can achieve the desired motion while minimizing the disadvantages associated with movable joints. This research introduces a novel approach to address the issues prevalent in robot-assisted surgery. Our device incorporates flexure joints to enhance movement and eliminate complications posed by traditional movable joints. The primary focus of this study is on designing, analyzing, and validating a flexible remote center-of-motion (RCM) mechanism intended for robot-assisted surgery. SolidWorks was used for modeling of the proposed mechanism with different configurations of joints arrangement, and finite element analysis (FEA) was performed using ANSYS to evaluate and compare different design iterations in terms of RCM point drift in X and Y axis. Experimental Results show that the optimized design keeps the RCM point drift within acceptable microsurgical limits, with measured displacements of 1.02 mm along the x-axis and 2.07 mm along the y-axis. These results highlight the potential of compliant mechanism to improve the accuracy and safety of robot-assisted microsurgical procedures and point to a significant improvement over current mechanism.