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An analysis of the accuracy of the CyberKnife: a robotic frameless stereotactic radiosurgical system.

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OBJECTIVE: The use of stereotactic radiosurgical systems to treat intracranial and extracranial tumors and other lesions requires a high degree of accuracy in target identification and localization. The purpose of this study was to evaluate the total system accuracy of the CyberKnife (Accuray, Inc., Sunnyvale, CA), a frameless, image-guided, stereotactic radiosurgery system.

METHODS: Clinically relevant accuracy or application accuracy of the CyberKnife radiosurgery system is based on 1) the beam delivery accuracy, which combines the robot and the camera image tracking system, and 2) target localization accuracy, which combines computed tomographic (CT) imaging and treatment planning. Clinically relevant accuracy can be measured by delivering a radiation dose to phantoms, in which the target is defined on a set of CT images using all components of the CyberKnife system, including the treatment planning software, the robot, the camera tracking system, and the linear accelerator. Clinically relevant accuracy was measured in head phantoms loaded with packs of radiochromic film. The accuracy measured is the displacement of the dose contours from the treatment plan to that measured in the radiosurgically exposed phantom.

RESULTS: Measurements of mean errors of the second-generation CyberKnife system at Stanford University Medical Center, installed in 2001, ranged from 0.7 mm for a CT slice thickness of 0.625 mm to 1.97 mm for a CT slice thickness of 3.75 mm.

CONCLUSION: The frameless, image-guided, second-generation CyberKnife radiosurgery system has a clinically relevant accuracy of 1.1 +/- 0.3 mm when CT slice thicknesses of 1.25 mm are used. CyberKnife precision is comparable to published localization errors in current frame-based radiosurgical systems.

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