Quantification of intraoperative displacement of deep structures in neurosurgery using 3D ultrasound

Abstract

Image-guided neurosurgery directed by a preoperative imaging study, such as MRI or CT, can be very accurate provided no significant changes occur during surgery. A variety of factors are known to affect brain tissue movement and are not reflected in the preoperative images used for guidance. In a previous study we have quantified the amount of displacement that can be expected during neurosurgery for cortical features1 and found it to be on the order of 1 cm, predominantly in the direction of gravity. In this study we investigated the displacement of deep structures using a hand-held ultrasound scanhead whose position and attitude in space were monitored with a 3D magnetic tracker2. In another study3 we have found that using a stylus rigidly coupled to our 3D tracker we were able to locate a point with an overall error of 1.36 mm ± 1.67 mm (n=39). When coupling our tracker to an ultrasound scanhead, we found that we could locate features appearing on ultrasound images with an error of 2.96 mm ± 1.85 mm (n=58). To conduct this study we reconstructed features appearing in sequences of 2D ultrasound images in 3D. By using image sequences acquired at the beginning and end of surgery, and which encompassed the same features, we were able to determine the amount of shift taking place subcortically based on the relative position of the same features.