Intraoperative margin detection and grading of human meningioma using a handheld visible resonance Raman analyzer and machine learning

Binlin Wu
Southern Connecticut State University, United States

Meningiomas are the most common brain neoplasms that account for about 36.6% of all central nervous system (CNS) tumors. The extent of resection and the tumor grade are the two most important factors that affect the recurrence rate. Total surgical resection is the most effective solution for symptomatic meningiomas. Tumor margin identification is critical in a neurosurgery, however, often times challenging for neurosurgeons. New techniques for accurate and rapid intraoperative identification of negative margins from different grades of tumors are desired. Here we report for the first time the preliminary results to evaluate an optical analyzer (VRR-LRRTM Model# LRR2000) based on visible resonance Raman (VRR) technique with 532nm excitation for identifying meningioma margins and grades intraoperatively. The observations of the preliminary analysis include the following. The intensity ratio of VRR peaks of protein to fatty acid (2934/2888cm-1) decreased with the increase of meningioma grade. The ratio of VRR peaks of phosphorylated protein to amid I (1588/1639cm-1) decreased for the higher grade of meningioma. Three RR vibration modes at 1378cm-1, 3174 cm-1, and 3224cm-1 which were related to the molecular vibrational bands of oxy-hemeprotein, amide B and amide A protein significantly changed in peak intensities in meningioma tissues compared to the normal tissue. The changes in the intensities of VRR modes of carotenoids at 1156cm-1 and 1524cm-1 were also found in the meningioma boundary and disappeared in the tumors. These Raman peak changes may be used as the markers for intraoperative meningioma margin detection and grading. The accuracy for distinguishing meningioma margins and different grades using support vector machines (SVMs) was about 70% based on Raman peaks of key biomolecules and principal component analysis (PCA).