The characterization of meningioma in magnetization transfer technique

Ayumi Okumura, M.D., Katsunobu Takenaka, M.D., PH.D., Yasuaki Nishimura, M.D., PH.D., Noboru Sakai, M.D., PH.D., Kazuo Kuwata, M.D., PH.D*., Seiichi Era, M.D., PH.D*.
Departments of Neurosurgery and *Physiology, Gifu University School of Medicine, Gifu, Japan

While MR imaging in brain tumors is tending toward the evaluation of biological tissue characterization, there is a little report regarding physical constitutional features, which is important for operating surgeon. Magnetization transfer (MT) between water protons and the semi-solid or solid components of tissue protons has provided a relatively new feature in clinical MR imaging. Not only has the technique of MT applied to the evaluation of tissue morphology, but it has also provided a semi-quantitative method of non invasive tissue characterization based on the physico-chemical properties of macromolecules and water. We previously examined the optimization of clinical MT using bovine serum albumin (BSA) to understand the intermolecular interaction of protein (1) In the study reported here, we applied the clinical MT sequence to evaluate the histological and constitutional features of intracranial meningioma.

Materials and Methods

Histological and constitutional features of meningioma

Sixteen meningiomas were examined. All of the tumors that were removed surgically, via inner decompression, had a diameter of greater than 2 cm. The relationship between the MT effect and histological features of the tumors was evaluated. Still more, the relationship between the MT effect and the constitutional feature of the tumors, as observed on surgical resection was evaluated. The constitutional feature of the tumors included two classifications: soft tumors those were removed easily using a standard suction tube or special instrument; Cavitron ultrasonic aspirator (SVS-205, Aloka LSD, Tokyo, Japan), set at less than 50% of full power (soft tumor group), and sticky or hard tumors those were removed by a Cavitron ultrasonic aspirator set at over 50% of full power (hard tumor group).

Determination of MTR in patients

A 1.5-tesla MR, Signa clinical imaging system, a unit equipped with software at the 5.3 level (GE Medical Systems, Milwaukee, USA), was used with a quadrature head coil. The MR imaging protocol was as follows: spoiled gradient recalled acquisition (SPGR) in a two-dimensional mode, TR 50 msec, TE 5 msec, flip angle 30 degree, section thickness 5mm with a 2 mm intersection gap. The matrix was 256 x 192, and the section thickness was 5 mm. The MT single cycle sinc pulse had a duration of 18 msec and utilized waveform area that was 10 times greater than that of a 90 degree spin-echo pulse, using 1000 Hz offset frequency, previously optimized[6]. Images were acquired both with and without the MT pulse using the same slice, receive attenuation and transmit attenuation parameters. We evaluated the MT effect using MT ratio (MTR) ($MTR = 1 - Ms / Mo$, where Ms is the intensity of the signal that was obtained with the MT pulse, and Mo is the intensity of the signal that was obtained without the MT pulse). The MT was performed in the patients of brain tumor, all of whom provided informed consent documents. All patients were initially imaged using a conventional MR imaging technique. Before injection of gadopentetate dimeglumine, the sequences both with and without the 1000 Hz offset RF pulse were performed. The specific absorption rates were well below the safety limits. The signal intensity measurements were carried out at particular regions of interest (ROI), which comprised a circle with an area of 46 mm^2, or 52 pixels. The signal intensity was measured in five homogeneously enhanced regions within the area of the tumor and averaged in order to correct for regional field inhomogeneties and the partial-volume effect. The calculated MTRs in each group were compared using an unpaired one-tailed Student's *t*-test, assuming a normal distribution within each group. The level of statistical significance was set at $p<0.05$.

Results

The mean value and standard deviation for MTRs of meningioma, was 0.31 ± 0.04 (n=16). The MTR (0.31) of meningiomas was significantly lower than that of normal brain tissue (white matter; 0.48, gray matter; 0.40). The mean values and standard deviations for MTRs of fibrous type and meningothelial type were 0.32 ± 0.03 (n=8) and 0.29 ± 0.04 (n=7), respectivity. The MTR of fibrous type was higher than that of meningothelial type, but that was no stastical significance.

Before examining the relationship between MTR and physical consistency of tumors, we performed to suck various concentration BSA solutions and gels placed into the tubes by using a surgical suction tube. While 10, 15 and 20 % solutions of BSA (MTR = 0.03, 0.10, 0.16, respectivity) and 10% imcomplete gel (MTR = 0.23) were easily sucked up into a surgical tube, 15 and 20 % BSA gels (MTR = 0.34, 0.36, respectivity), which were tough gels, could not be sucked. As for the constitutional feature of the brain tumors, the MTRs of the soft tumor group (0.22 ± 0.03, n = 6) were significantly lower than those of the hard tumor group (0.36 ± 0.04, n = 9) ($p<0.05$).

Discussion

The MTR of meningiomas was significantly higher than that of the other tumors, as was also reported previously (1) . In Lundbom's article (2), collagen content in meningiomas correlated with the observed MTR (as collagen content rose, so did MTRs, presumably because collagen has high crosslinking, which results in greater bound water interaction.). However, in our study, the difference in MTR between fibrous type and meningotheliomatous was not significantly observed. Although the quantitative collagen content should be correlated with MTR in addition to histological findings, interestingly, there was a statistically significant difference regading the physical consistency at surgery while the MTR in meningioma was not correlated with histology. For neurosurgical operations of brain tumors that are located at the skull base, knowledge of tumor consistency prior to exploration may influence surgical planning. Only a few studies have dealt with possible correlation between the physical consistency of tumors and their images. Carpeggiani et al (3)., reported correlation between the physical consistency and signal intensity of T_2-weighted MR images of intracranial meningiomas. However, it was difficult to perform a quantitative image analysis of tumor consistency. In this paper, we divided the tumors into two classes according to the surgical instruments used and evaluated tumor consistency with the MT technique. MT is relatively sensitive to the constitutional features of tumors and could be expressed quantitatively as the MTR. Therefore, MT technique might be able to offer profitable information for surgeons. More experimental studies are required to develop the pulsed MT technique for the research into the functional or biochemical aspects of the central nervous system.

References

1. Okumura A, Kuwata K, Takenaka, K, Nishimura Y, Shirakami S, Sakai N, Hayashi T, Era S. Pulsed off-resonance magnetization transfer for brain tumor in patients. Neurol Res 1998; **20**: 313-319
2. Lundbom N. Determination of magnetization transfer contrast in tissue: an MR imaging study of brain tumors. AJR 1992; **159:** 1279-85
3. Carpeggiani P, Crisi G, Trevisan C. MRI of intracranial meningiomas:correlations with histology and physical consistency. Neuroradiology 1993; **35:** 532-536