New Software for Preoperative Diagnostics of Meningeal Tumor Histologic Types

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■ OBJECTIVE: **Meningeal tumors are neoplasms with different histologic manifestations of both benign and malignant types that determine the prognosis of tumor recurrence and its consistency. The risk of surgical treatment depends on the location, size, and consistency of the tumor. Magnetic resonance imaging (MRI) sequences can be used to identify the features of tumors, but these MRI characteristics are not well understood. The present study describes an advanced mathematical algorithm to analyze MRI data and distinguish histologic types of meningeal tumors before surgery.**

■ METHODS: **Forty-eight patients underwent surgical removal of meningeal brain tumor. All patients had preoperative MRI with a 1.5-T scanner. One radiologist and 2 neurosurgeons evaluated MRI histogram peaks of the whole tumor volume using the advanced computer algorithm.**

■ RESULTS: **Three specialists received the following mean value of histogram peaks: 15.99 ± 0.23 (± standard error of the mean [SEM]) for meningoteliomatous meningiomas; 21.24 ± 0.3 (±SEM) for fibroplastic meningiomas; 19.0 ± 0.28 (±SEM) for transitional meningiomas; 10.7 ± 0.27 (±SEM) for anatypical, anaplastic meningiomas, 11.03 ± 0.51 (±SEM) for primary intracranial fibrosarcomas and 25.72 ± 0.29 (±SEM) for meningeal hemangiopericytomas. A one-way analysis of variance test proved the difference between group means: $F = 70.138$, $P < 0.01$. The Tukey test and the Games-Howell test indicated that the difference between the tumor groups was significant. Mean deviation in agreement index between specialists was 0.98 ± 0.007 (±SEM).**

■ CONCLUSIONS: **The advanced algorithm proved high specificity, sensitivity, and interoperator repeatability.**

INTRODUCTION

Meningiomas are usually benign tumors arising from arachnoid cells surrounding the brain. According to a statistical report from the Central Brain Tumor Registry of the United States, the most frequent histologically diagnosed tumor is meningioma, which accounts for 35.5% of all central nervous system tumors.[1] For symptomatic meningiomas, total surgical removal is recommended. The subtypes, consistency, size, and location of meningiomas are the most important factors for total tumor resection with minimal risk of postoperative neurologic deficits.[2] Fibroplastic meningiomas are more likely to be hard-consistency tumors.[3] Little et al.[4] reported that high risk of cranial nerve deficits after petroclival meningiomas surgery depended on fibrous consistency of the tumor. Preoperative specification of meningioma subtype and consistency may thus affect surgical strategy. In several research studies, various magnetic resonance imaging (MRI) sequences have been shown to be used as consistency meningioma predictors.[2,3,5,6] However, these studies do not differentiate

Key words
- Histologic type
- Meningeal tumors
- Software for MRI

Abbreviations and Acronyms
AI: Agreement index
FA: Fractional anisotropy
HPC: Meningeal hemangiopericytomas
MRE: Magnetic resonance elastography
MRI: Magnetic resonance imaging
PIF: Primary intracranial fibrosarcoma
SEM: Standard error of the mean
TE: Echo time
TR: Repetition time

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meningiomas from other meningeal tumors. MRI characteristics of benign meningiomas do not differ significantly from meningeal hemangiopericytomas (HPCs), and primary intracranial fibrosarcomas (PIFs) mimic atypical and anaplastic meningiomas.[7-9] The present study describes the new mathematical algorithm for preoperative MRI data analysis to provide objective differentiation of histologic types of meningeal tumors and their anaplasia.

METHODS

Patient Information

The study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki and its later amendments. This study was approved by the local institutional review board. All experimental protocols in this article were approved by the ethical committee of Novosibirsk State Medical University.

The database is made up of 48 patients with meningeal tumors. Forty-seven patients were treated at the neurosurgery departments of the Railway Clinical Hospital and Meshalkin Research Institute of Circulation Pathology, Novosibirsk, Russia from 2010 to 2015. One case (no. 4) underwent meningioma removal in another hospital and was referred to our outpatient department. Histologic and immunohistochemical study of tumor tissues was performed in all cases. The 2007 World Health Organization classification of central nervous system tumors was used.[10] All patients had MRI with a 1.5-T scanner. The trial was double-blinded. One radiologist (specialist 1) and 2 neurosurgeons (specialists 2 and 3) estimated MRI of 48 patients with the new computer algorithm independently without access to the pathologic reports.

In our series of patients with meningeal tumors, we chose all patients with PIFs, HPCs, and atypical/anaplastic meningiomas. Then we randomly added cases with benign meningiomas to obtain sufficient numbers of patients in each group for statistical analysis. The inclusion criteria included thin axial slice thickness of T1-weighted images with contrast in the MRI study protocol.

MRI Study Protocol

GE Signa 1.5-T superconducting MRI (GE Healthcare, Little Chalfont, United Kingdom) was performed using a standard head coil, with a thickness of 5 mm and a layer distance of 1.5 mm, receiving spin-echo T1-weighted imaging (repetition time [TR], 400–500 milliseconds; echo time [TE], 15–30 milliseconds) and fast spin-echo T2-weighted imaging (TR, 3000–4500 milliseconds; TE, 70–120 milliseconds). Gadolinium diethylenetriamine penta-acetic acid contrast agent was adopted at a dose of 0.1 mmol/kg; injection flow rate, 3 mL/second, and scan parameter, T1-weighted imaging (TR, 30 milliseconds; TE, 9 milliseconds, slice thickness, 1.5 mm; field of view, 250 mm^2; matrix, 256 × 256).

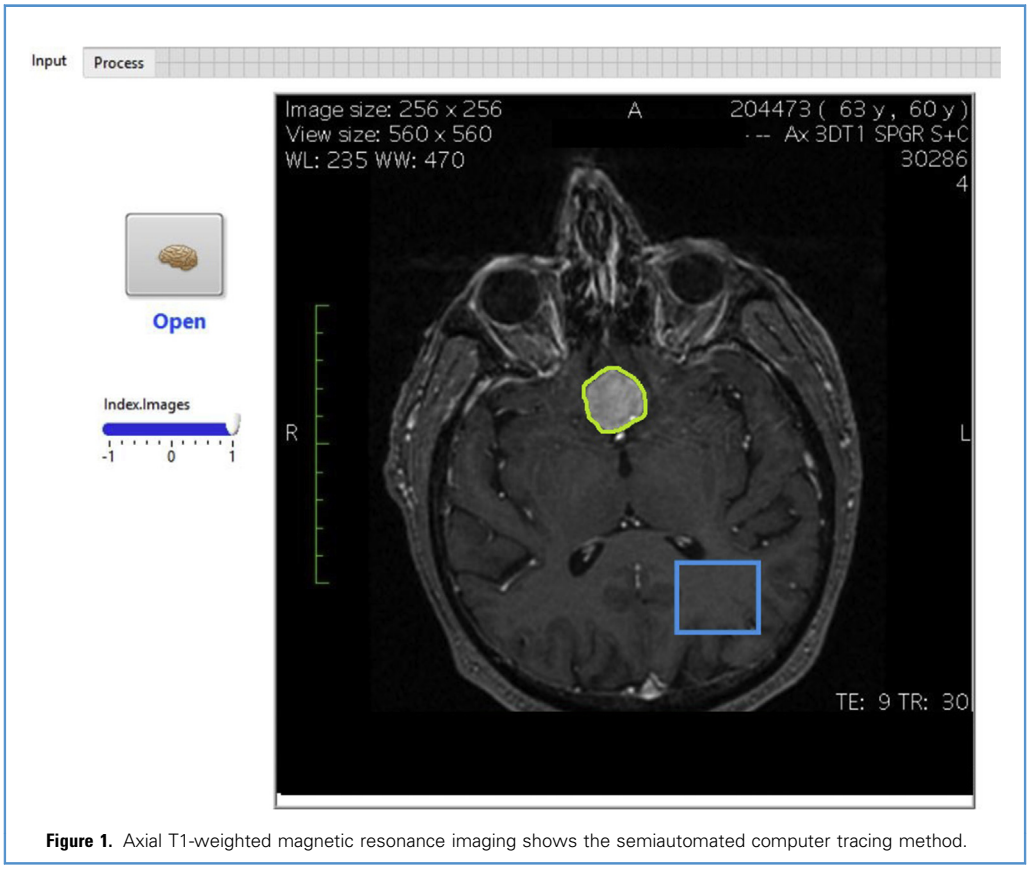

Figure 1. Axial T1-weighted magnetic resonance imaging shows the semiautomated computer tracing method.