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Correlating Imaging Features of Intracranial Meningioma with Intraoperative Findings

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ABSTRACT

Introduction: Intracranial meningiomas are the most common extra-axial brain neoplasm with surgical resection the treatment of choice in most cases. Preoperative Imaging of these tumors can help in prediction of intraoperative features such as consistency and parenchymal adhesion and aid in preoperative planning.

Materials & Methods: Our study included 27 patients with preoperative diagnosis of meningioma who prospectively underwent surgery in Dr. Firoozgar hospital. MRI features were evaluated by radiology resident and intraoperative findings were recorded by attending neurosurgeon. The findings were then compared to find significant correlation.

Results: Meningiomas arising from anterior clinoid process and sphenoid wing and tumors with less than 50% visible rim in FLAIR sequence were more likely to have moderate or severe adhesion to surrounding parenchyma ($p<0.05$). Tumors with T2 signal to cortex ratio of less than 1.05 were more likely to have hard or very hard consistency ($p<0.05$). This cut-off had 100% specificity and 36% sensitivity.

Conclusion: Our study shows that preoperative imaging features of meningiomas are correlated with intraoperative consistency and adhesion of tumors which can aid in preoperative planning.

Keywords
Meningioma, tumor consistency, MRI, tumor-brain adhesion
Mesh Terms: Meningioma, magnetic resonance imaging, neurosurgical procedures

Introduction

Intracranial meningiomas are the most common extra-axial brain neoplasm with surgical resection the treatment of choice in most cases (1, 2). However not all meningiomas can get total excision as many of these tumors have adhesions or neurovascular encasement (1). In these cases preoperative evaluation of tumor properties such as tumor size, consistency, and degree of adhesion to brain parenchyma can guide the surgeon to choose the best surgical technique and predict post-operative complications and risk of long-term recurrence (3-6).

Even benign meningiomas with no adhesion or neurovascular encasement can be excised with variable techniques including sharp dissection, ultrasonic aspirator or endoscopy, based on tumor consistency which requires pre-op planning for proper surgical instrument preparation (7). In this study we try to correlate pre-operative imaging findings with intra-operative findings of the neurosurgeon to find the most reliable predictors of tumor consistency and adhesion.

Material and Method

27 patients were included in the study who underwent resection of cranial meningioma in Firoozgar General Hospital, Tehran, Iran, from 2017 to 2019. Patients with intraosseous or en-plaque meningiomas, tumors with size of less than 2 cm^3 and recurrent meningiomas were excluded from the study.

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Pre-operative magnetic resonance imaging (MRI) studies were performed using Philips Intera 1.5T MRI Scanner. Routine brain tumor protocol was used including axial T1-weighted imaging (T1WI), axial, coronal, and sagittal T2-weighted imaging (T2WI), axial fluid-attenuated inversion recovery (FLAIR), axial diffusion-weighted (DWI), and axial, coronal and sagittal contrast-enhanced T1-weighted sequences. The radiologist was blinded to the intraoperative grading.

Tumor size was calculated using three largest diameters in perpendicular planes using T1 post-contrast images. The meningioma signal on all sequences were obtained by averaging three measurements with region of interest (ROI) of at least 5 mm^2. In heterogeneous meningiomas, measurements were done from homogenous areas. Cortical signals were also measured with similar technique. Diffusion was recorded qualitatively as high, iso, or low signal on DWI sequence compared with the cortex. Peritumoral edema was evaluated in T2WI and FLAIR sequences.

Tumor margins were evaluated in all sequences and its sharpness was graded as nonvisible tumor margin, visible margin in less than 50% of tumor periphery, visible margin more than 50% of tumor periphery, and 100% visible margin around the tumor. Areas of tumor not in contact with brain parenchyma, such as dural or tentorial attachment, were not included in grading of margin visibility. Visible cerebrospinal fluid (CSF) rim around the tumor was graded with the same method. There is a list of all features evaluated in pre-operative MRI in Table 1.

Intraoperative assessment of tumor consistency and adhesion was performed prospectively by the attendant neurosurgeon or chief neurosurgery resident. Consistency grading was done using a scale developed by Zada et al. (Table 2). Adhesion of the tumor to surrounding tissues was described as “no adhesion”, “mild adhesion with arachnoid preservation”, “moderate adhesion with exposure of brain parenchyma during tumor resection”, and “severe adhesion needing parenchymal resection”.

Data analysis was performed using IBM SPSS statistics 23. The main tests used were Fisher's exact test and non-parametrical tests like Mann-Whitney U test.

Results

Twenty-two female and five male patients were included with ages from 28 to 79. Twenty-four meningioma were in supratentorial location and three meningiomas were located infratentorially. Table 3 shows the exact location of tumors.

Tumors measured 1-147 cm^3 with a mean volume of 36.4 cm^3. Six meningiomas (22.2%) had cystic or necrotic regions and 10 had flow voids (37%). None of the tumors had hemorrhagic or lipid contents. Eighteen (66.7%) tumors presented thickened adjacent dura or dural tail, of which only 2 (7.4%) were nodular and the rest were smooth. Surrounding edema was detected in 15 (65.6%) meningiomas with mean diameter of 10.7 mm (0-55 mm).

Cases were graded intraoperatively for tumor consistency and adhesion (Tables 4 and 5). Two meningiomas (7.4%) were severely heterogeneous which had mild adhesion and soft or very soft consistency. Three meningiomas were infratentorial which were hard and had no adhesion. Six out of seven meningiomas (85%) with no adhesion, had hard or very hard consistency.

Meningiomas that originated from anterior clinoid process or sphenoid wing were more likely to have moderate to severe parenchymal adhesion ($p<0/05$). Having less than 50% visible rim in FLAIR sequence was also correlated with moderate to severe adhesion with a likelihood ratio (LR) of 7.1 ($p<0.05$). no significant correlation was found between tumor size, tumor signal and enhancement pattern, and presence of cystic components with parenchymal adhesion.

Analysis of consistency data showed that mean age of patients with soft and very soft meningiomas ware significantly higher than patient with moderate to very hard meningiomas ($p<0.05$). It also showed that all tumors with T2 signal ratio of less than 1.05 (n=5) had hard or very hard consistency. The likelihood ratio of hard or very hard consistency for T2 signal ratio of less than 1.05 was 7.2 ($p<0.05$) with 100% specificity and 36% sensitivity. Tha data failed to show an overall linear correlation between T2 signal ratio and consistency score.

All patients had a returned informed consent for participation in the study. The study was approved by National Research Ethics Committee of Islamic Republic of Iran.

Discussion

Several studies have evaluated association between imaging patterns of meningioma and surgical findings. They have chosen different classifications and techniques for imaging characterization and also for intraoperative grading of adhesion and consistency. In our study, we tried to use more quantitative and reproducible methods.

Many studies have categorized meningioma consistency as Hard and soft (4, 8-15). In our study we used Zada classification for tumor consistency. Zada and associates in 2013, proposed a grading system for reliable and reproducible grading of meningioma consistency, from 1 (extremely soft) to 5 (extremely hard) based on the need for mechanical debulking and capsule foldability. Their proposed classification system showed good interobserver agreement (16).

Enokizono et al. classified rim pattern of intracranial meningiomas into 4 grades by their extent from 0 (no rim visible) to 3 (rim visible over most of the tumor-brain interface) both in nonenhanced and contrast-enhanced 3D FLAIR. They then correlated rim pattern with tumor size, grade of peritumoral edema, pial supply, grade of tumor-brain adhesion, and histological findings. They found direct association between rim pattern in nonenhanced MRI with surgical cleavability. Furthermore, despite significant correlation between rim pattern in contrast-enhanced MRI with pial supply, it could not be used for prediction of tumor-brain adhesion or histological tumor grades (17).

Shiroishi et al in 2016 conducted a systematic review on prediction of meningioma consistency using preoperative imaging. They realized that many studies found correlation between tumor consistency and T2 signal, however, few studies used quantitative signal measurement, and those that have found significant correlation, have not mentioned the accuracy of the results. They also found out that most studies have not been able to show significant correlation between T1 signal and consistency (18).

In our study, we suggested T2 signal ratio of less than 1.05 for prediction of hard or very hard tumors. In 2015 Watanabe and associates suggested the same cut-off for differentiation of hard and soft tumors with 89% sensitivity and 76% specificity (19). In another study in 2016, Smith and coworkers suggested cut-off of 1.41 with 81.9% sensitivity and 84.8% specificity using T2 ratio of tumor to middle cerebellar peduncles (11).

The limitations of our study were small sample volume and unavailability of newer imaging techniques such as apparent diffusion coefficient (ADC) value, MR spectroscopy, and functional MRI. We suggest that future studies also use prospective method with similar quantitative measures and give cut-offs for use in clinical practice.

Conclusion

Our study shows that preoperative imaging features of meningiomas are correlated with intraoperative consistency and adhesion of tumors which can aid in preoperative planning.T2WI of intracranial meningiomas may be helpful for prediction of intraoperative consistency. Low T2 signal especially T2 signal ratio of tumor to cortex less than 1.05 seems to be correlated with hard consistency.

Hard intracranial meningiomas seem to have less adhesion to adjacent brain parenchyma and intracranial meningiomas with less than 50% visible rim in FLAIR sequence are more likely to have moderate to severe parenchymal adhesion. These information can aid in prediction of intracranial meningioma consistency and adhesion for better operative planning.

Name of the institution where the work was done: Radiology Department, Firoozgar General Hospital, Iran University of Medical Sciences, Tehran, Iran

Conflict of interests:

There is no conflict of interest for this study

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