Use of Preoperative MRI to Predict Vestibular Schwannoma Intraoperative Consistency and Facial Nerve Outcome

William R. Copeland¹ Jason M. Hoover¹ Jonathan M. Morris² Colin L. W. Driscoll^{1,3} Michael J. Link^{1,3}

¹ Departments of Neurologic Surgery, Mayo Clinic, Rochester, Minnesota, United States

² Department of Radiology, Mayo Clinic, Rochester, Minnesota, United States

³ Department of Otorhinolaryngology, Mayo Clinic, Rochester, Minnesota, United States

Address for correspondence Michael J. Link, MD, Mayo Clinic, Department of Neurologic Surgery, Room 8-209, Gonda Building, 200 First Street SW, Rochester, Minnesota, United States (e-mail: link.michael@mayo.edu).

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Abstract

Objectives We sought to identify if preoperative schwannoma magnetic resonance imaging (MRI) intensities might predict intraoperative consistency. We then determined whether consistency correlated with facial nerve outcomes.

Design Operative reports from 2000 to 2010 were searched for tumor description as either *soft* and/or *suckable* or *firm* and/or *fibrous*. Preoperative T1 and T2 sequences were then reviewed to identify intensities relative to gray matter. Facial nerve function was recorded at the time of most recent follow-up.

Results Forty-six patients were included. No tumors were T1 hyperintense. Soft and firm schwannomas were equally likely to be T1 hypointense. On T2 sequences, however, soft schwannomas were more likely to be hyperintense (88% versus 14%, $p < 0.005$) whereas firm schwannomas were more likely to be hypointense (86% versus 6%, $p < 0.005$). There was a tendency for firm schwannomas to have worse facial nerve outcomes (43% versus 19%, $p = 0.14$).

Conclusions Prediction of vestibular schwannoma intraoperative consistency based on T2 intensity seems promising. Furthermore, though not statistically significant, in this small pilot study firm schwannomas tended to have worse facial nerve outcomes. This potential ability to predict consistency and its correlation with facial nerve outcome may assist the surgeon in preoperative planning and patient counseling, though further data needs to be accumulated.

Keywords

- ▶ vestibular schwannoma
- ▶ acoustic neuroma
- ▶ facial nerve outcome
- ▶ tumor consistency
- ▶ magnetic resonance imaging

Introduction

Numerous predictors of facial nerve function following surgical resection of vestibular schwannomas have been proposed.^{1,2} Most uniformly agreed upon is the correlation between increasing size and worse outcome. One factor discussed less frequently is the intraoperative consistency of the tumor. Some have suggested that a firm, avascular

consistency leads to a more favorable facial nerve outcome.³

Previous attempts have been made to correlate preoperative magnetic resonance imaging (MRI) characteristics to histologic features of meningiomas.^{4,5} Similarly, some have sought to correlate imaging characteristics to intraoperative meningioma consistency.^{6,7} To our knowledge, however, no attempt to determine if there is an association between

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Fig. 1 Preoperative noncontrast magnetic resonance imaging. Left, T1 sequence showing hypointense tumor. Middle, T2 sequence showing hyperintense tumor. Right, T2 sequence showing hypointense tumor.

preoperative MRI findings and tumor consistency has been made with regards to vestibular schwannomas.

Our objective with this report was twofold. First, we sought to identify if preoperative tumor MRI T1 and T2 intensities might predict intraoperative tumor consistency. Second, we attempted to determine whether intraoperative consistency correlated with facial nerve outcomes.

Design

Surgical reports from operations performed at our institution by the senior authors (CLD, MJL) from 2000 to 2010 were reviewed for surgeon description of the schwannoma as *soft* and/or *suckable* or *firm* and/or *fibrous*. Cases were selected if the neuro-otologist and neurosurgeon both independently described the tumor as such. Thereby, only tumors that were felt to be at the extremes of softness or firmness were analyzed. Preoperative noncontrast MRI T1 and T2 sequences were then retrospectively reviewed to characterize signal intensities relative to gray matter. These were classified as either hypointense, isointense, or hyperintense (►Fig. 1). Facial nerve function using the House-Brackmann scale was recorded at the time of most recent follow-up.⁸

Exclusion criteria included lack of electronic preoperative MRI, lack of surgeon description of tumor consistency, a solely intracanalicular tumor location (as this can make characterizing tumor intensity somewhat difficult on MRI), prior surgical or radiation treatment, and finally age less than 18 years or diagnosis of neurofibromatosis type 2, as these

latter two groups are unique populations that may have different tumor characteristics and behavior (e.g., more adherent or invasive). Noncontrast images were chosen, as there tends to be much less heterogeneity in the enhancement pattern of vestibular schwannomas, making enhancement less ideal to use as a predictor of tumor consistency.

Statistical analysis was performed using JMP software (SAS Institute Inc., Cary, North Carolina, USA).

Results

Three hundred fifty-six surgical reports were reviewed. Forty-six patients were included in the final analysis, 32 with soft schwannomas and 14 with firm schwannomas. ►Table 1 shows baseline demographics of the two groups. Of note, the groups were well matched with regards to size. No patient underwent a middle fossa approach.

On preoperative MRI, none of the schwannomas were T1 hyperintense. Soft and firm tumors were equally likely to be T1 hypointense (►Table 2, 9/14 firm versus 21/32 soft, or 64% of each group). The remaining tumors were T1 isointense. On T2 sequences, soft schwannomas were much more likely to be hyperintense (►Table 2, 88% versus 14%, *p* < 0.005), whereas firm schwannomas were much more likely to be hypointense (►Table 2, 86% vs 6%, *p* < 0.005). No firm tumors, and only two soft tumors, were T2 isointense.

There was a tendency for firm schwannomas to have poor facial nerve outcomes, with 6 of the 14 tumors exhibiting postoperative nerve function of House-Brackmann grade 3 or

Table 1 Demographics of included patients

	Firm (14 pts)	Soft (32 pts)	<i>P</i> value
Gender, female, no. (%)	7 (50%)	16 (50%)	1.00
Mean age (y)	47	56	0.03 ¹
Mean maximum cisternal diameter (cm)	2.7	2.8	0.72
Translabyrinthine approach, No (%)	2 (14%)	14 (44%)	0.09
Gross/near total resection, No. (%)	11 (79%)	19 (59%)	0.32

¹Statistically significant, *P* < 0.05.

Table 2 MRI correlation with consistency

	Firm	Soft	P value
T1 hyperintense	0 (0%)	0 (0%)	1.00
T1 hypointense	9 (64%)	21 (64%)	1.00
T1 isointense	5 (36%)	11 (36%)	1.00
T2 hyperintense	2 (14%)	28 (88%)	<0.005 ¹
T2 hypointense	12 (86%)	2 (6%)	<0.005 ¹
T2 isointense	0 (0%)	2 (6%)	1.00

Abbreviation: MRI, magnetic resonance imaging.

¹Statistically significant, $P < 0.05$.

worse, compared with 6 of the 32 soft tumors (►Table 3, 43% versus 19%, $p = 0.14$). Univariate analysis of predictors of facial nerve outcome demonstrated only median follow-up to be statistically significant, with longer follow-up correlating with poor outcome (►Table 4, median of 31 months with poor outcome versus 6 months with good outcome, $p = 0.01$). Of interest, size was not a statistically significant predictor of facial nerve outcome ($p = 0.22$).

Discussion

We hypothesized that—as others have suggested³—a firm tumor consistency would lend to a better facial nerve outcome due to factors such as a more easily identifiable plane of dissection, less adherence of the tumor to the facial nerve, and a less vascular nature of the tumor itself. Contrary to this, however, our results suggested that in fact firm tumors tended to have worse outcomes, albeit this was not statistically significant. We do not intend to overemphasize this trend, however, it was unexpected. The reason for this is unclear, but we could conceive several possible factors. Given the apparent ease of dissection aided by a favorable plane, the extent of resection may be pushed farther, as was the tendency in our series (►Table 1, 79% of firm tumors had a gross or near total resection versus 59% of soft tumors, $p = 0.32$). Perhaps a firm consistency requires more manipulation of the tumor itself, with resultant strain on the facial nerve. Also, the fibrous stroma of the tumor may limit the ability of its vasculature to coagulate, requiring more aggressive bipolar cautery, thereby transmitting more heat to the facial nerve. Of note, we excluded purely intracanalicular tumors, of which firm tumors are typically easier to deliver from the internal auditory canal than soft, friable tumors. Finally, the median follow-up for the firm group was only 7 months, and some patients may yet have improvement in

their facial nerve function, making the nonsignificant difference in facial nerve outcome compared with soft tumors even less so as follow-up continues.

Although certainly there can be improvement in facial function with time, in our series median follow-up was in fact the only statistically significant predictor of facial nerve outcome, with longer follow-up actually associated with poor facial nerve outcome (►Table 3). Presumably, this reflects bias secondary to being a tertiary referral center. Patients with a good outcome are not asked to return for a formal outpatient follow-up consultation after the routine three-month postoperative visit but may have surveillance imaging performed by their home physician and sent for our review. Conversely, patients with a poor outcome are seen in follow-up more frequently, and for a longer period of time, to assess nerve recovery and manage any complications that may ensue from facial weakness.

Among the remaining predictors of facial nerve outcome that were analyzed, firm consistency was most strongly predictive of a poor outcome, though this did not reach statistical significance (►Table 3, $p = 0.09$). Presumably, size was not a statistically significant predictor simply as a result of our small cohort.

Although prediction of vestibular schwannoma consistency based on T1 intensity does not appear reliable, prediction based on T2 intensity seems promising. Soft schwannomas tend to be hyperintense on T2 sequences, whereas firm schwannomas tend to be hypointense. Undoubtedly not all tumors will be wholly of one consistency, but rather have both components or more likely be somewhere between the two, making classification difficult. Similarly, not all will be either uniformly hyperintense or hypointense on T2 sequencing. However, when a patient has a clearly hypointense tumor on preoperative imaging, the surgeon may counsel that patient more carefully with regards to the risk to the facial nerve, or at least be more mindful of that risk during surgery, recalling some of the possible causative factors mentioned above. Currently, though, we would not plan to alter our goals of surgery based on the preoperative imaging signal intensity.

Critiques of our results include those of any small, retrospective study. In addition, there is an obvious subjective nature to classifying tumor intensity on MRI, as well as consistency at the time of surgery. It is possible that certain imaging software would allow a more objective measure of

Table 3 Facial nerve outcome

	Firm	Soft	P value
Median follow-up (mths)	7	15	0.40
House-Brackmann grade 3 or worse	6 (43%)	6 (19%)	0.14

Table 4 Predictors of facial nerve outcome

	Good (34 pts)	Poor (12 pts)	P value
Gender, female, no (%)	16 (47%)	7 (58%)	0.50
Mean age (yrs)	54	51	0.42
Mean maximum cisternal diameter (cm)	2.6	3.0	0.22
Translabrynthine approach	11 (32%)	5 (42%)	0.56
Gross/near total resection	21 (62%)	9 (75%)	0.41
Firm consistency	6 (18%)	6 (50%)	0.09
Median follow-up (m)	6	31	0.01 ¹

¹Statistically significant, $P < 0.05$.

signal intensity. Similarly, one could include histopathologic analysis to better characterize tumor makeup, allowing perhaps for a more unbiased measure of tumor consistency.

Conclusions

Prediction of vestibular schwannoma intraoperative consistency based on T2 intensity seems promising. Furthermore, though not statistically significant, in this small pilot study firm schwannomas tended to have worse facial nerve outcomes. This potential ability to predict consistency and its correlation with facial nerve outcome may assist the surgeon in preoperative planning and patient counseling, though further data needs to be accumulated.

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