MR of Intraparotid Masses

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PURPOSE: To determine which MR techniques are best for identifying intraparotid masses and to assess the utility of MR for predicting specific diagnosis. **METHODS:** A retrospective review of 31 intraparotid masses was performed. Lesion conspicuity and signal intensity characteristics were evaluated by objectively measured regions of interest and by subjective visual review. **RESULTS:** The T1-weighted images produced the highest lesion conspicuity in 25 of 31 masses. All the masses were easily detected as hypointense lesions on the T1-weighted scans with good or excellent conspicuity; on the T2-weighted images nine lesions appeared isointense to the normal parotid tissue, including six malignancies. Gadolinium-enhanced images were not helpful for identifying the intraparotid masses. Warthin tumors and malignancies tended to be hypointense or low in conspicuity on T2-weighted images. **CONCLUSIONS:** The T1-weighted images were best for detecting parotid masses. The T2-weighted images may help in limiting a differential diagnosis, but a specific diagnosis cannot be made without biopsy.

Index terms: Parotid gland, magnetic resonance; Parotid gland, neoplasms; Parotid gland, cysts; Magnetic resonance, comparative studies

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The literature on the evaluation of parotid masses has grown rapidly. Many previous studies have suggested that magnetic resonance (MR) imaging is the modality of choice for evaluating painless parotid masses (1–3). At the same time, MR imaging applications have been expanding with the introduction of new pulse sequences, imaging techniques, and contrast agents (4). We reviewed our experience with pathologically proved intraparotid masses to assess which pulse sequences produced the best lesion conspicuity against the background of the normal parotid gland.

Several authors have analyzed the ability of signal intensity characteristics of parotid masses to suggest the histopathology of a lesion, but there are numerous contradictions in the literature (1, 4–8). Therefore, we reviewed the signal intensity patterns of the parotid masses using objective criteria.

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Methods

A retrospective review of MR examinations in all patients with pathologically proved intraparotid masses was performed over a 4-year period, November 1987 to November 1991. Thirty-one masses in 29 patients were evaluated (Table 1). All were pathologically proved by resection or needle biopsy.

All scans were performed on a 1.5-T Signa unit (General Electric Medical Systems, Milwaukee, WI). Multiple planes were imaged, but the standard plane was axial. T1-Weighted pulse sequences were obtained in all cases using a spin-echo (SE) technique (400–800/11–25/2) (repetition time/echo time/excitations). Twenty-four of the masses were imaged with the standard SE sequences (2000–3500/18–35, 80–90) to obtain proton density and T2-weighted images. In seven cases a fast SE technique (3000–3500/80–90) was used, and only T2-weighted images were obtained. Chemical fat saturation was performed in six of these cases (Table 1). The fast SE pulse sequence is a modification of a rapid acquisition relaxation enhanced sequence (9).

Fat-suppressed unenhanced T1-weighted images were obtained in seven cases. Sixteen patients received intravenous gadopentetate dimeglumine (Magnevist, Berlex Laboratories, Wayne, NJ) at a dose of 0.1 mmol/kg. Postcontrast T1-weighted images without and with fat suppression were performed in eight and 13 cases, respectively. In five cases both were obtained. The fat-suppressed images were obtained with an SE sequence and/or a

spoiled gradient-echo sequence (40–55/5–11, 40° flip angle).

The images were obtained using either an anterior-posterior neck surface coil or a quadrature head coil. Section thicknesses were 3 to 5 mm, and the matrix sizes were 256 × 192 or 256 × 128.

From the magnetic tapes or optical disks, regions of interest were measured through nonhemorrhagic areas within the parotid mass and within a normal portion of the surrounding ipsilateral parotid gland. The largest possible region of interest that could be applied to both the normal gland and the mass was used. If the gland was completely replaced by the lesion, the contralateral parotid gland was measured for comparison. Background noise values were subtracted. The measured signal intensity difference was defined as the difference between the signal intensity measurement of the parotid lesion and the normal parotid tissue. Therefore, a positive signal intensity difference corresponds to a hyperintense mass; a negative value corresponds to a hypointense mass relative to the surrounding normal gland. The greater the measured signal intensity difference is from zero, the greater the conspicuity of the lesion.

A subjective evaluation of lesion conspicuity and signal intensity was also performed by a radiologist experienced in head and neck imaging. The lesions were graded for signal intensity characteristics and assigned a value from 1 to 5 (1 = very hypointense, 2 = slightly hypointense, 3 = isointense, 4 = slightly hyperintense, and 5 = very hyperintense). Values of 1 or 5 were considered excellent conspicuity, and values of 2 or 4 were considered good conspicuity. From this, a subjective visual evaluation of which pulse sequence was best for identifying the mass was obtained. A comparison of the subjectively determined conspicuity and the objectively measured conspicuity was performed. The subjective and objective assessments of the relative signal intensity of the masses were also compared.

TABLE 1: Measured signal intensity differences

	T1-Weighted	PD	T2-Weighted
Pleomorphic adenomas			
1	−33	22	**36**
2	**−84**	44	72
3	**−240**	112	223
4	**−290**	−14	30
5	−58	57	**103**
6	**−276**	95	208
7	−60	36	**61**
8	**−69**	24	46
9	**−94**		63[a]
Warthin tumors			
1	−67	**−89**	−3
2	**−77**	−71	−21
3	**−17**	−12	−3
4	**−40**	−35	−15
5	**−65**	−23	−59
6	**−124**	−107	−22
7	**−109**		39[a]
8	**−112**		84[a]
9	**−83**		−3[b]
Squamous cell carcinoma			
1	**−20**	−7	−4
2	**−127**	−54	0
3	**−143**	−122	−28
4	**−81**	3	−34
5	**−185**	−23	19
Poorly differentiated adenocarcinoma			
1	**−202**		−152[a]
2	**−78**		−5[b]
Cyst	**−314**	−97	222
Mucoepidermoid carcinoma	**−467**	−92	−29
Melanoma metastasis	**−217**	−20	53
Poorly differentiated carcinoma arising in a pleomorphic adenoma	−91	**−214**	−68
Human immunodeficiency virus lymphoepithelial neoplasm	−71	117	**273**
Lymphoma	**−44**		37[a]

Note.—Bold type = highest conspicuity sequence for a given lesion. Negative signal intensity difference means the lesion was hypointense relative to the normal gland. PD indicates proton density.

[a] T2-Weighted image obtained with fat-suppressed fast SE technique.

[b] Fast SE technique without fat suppression.

Results

Objective Measurements

Table 1 lists the measured signal intensity differences for each pulse sequence.

The T1-weighted images had the highest signal intensity differences in 25 of 31 cases (81%) (Fig 1). The T2-weighted signal intensity differences were the highest in only four cases (of which three were pleomorphic adenomas), and the proton density-weighted values were highest in only two masses (Table 2).

In all 31 masses the lesions could be easily detected on the T1-weighted images. The mean T1-weighted measured signal difference was 127; the minimum was 17. The mean T2-weighted signal intensity difference was 65 with a minimum of 0. On the T2-weighted images six lesions had very low conspicuity, with measurements of less than or equal to 5.

Pleomorphic adenomas often had high signal intensity differences on both the T1-weighted and T2-weighted images, but the majority (six of the nine lesions) were still best detected on the T1-weighted images (Fig 2).

The Warthin tumors and squamous cell carcinomas were best detected on the T1-weighted images in 13 out of 14 cases (Figs 1 and 3). On the T2-weighted images, many of the Warthin tumors and squamous cell carcinomas had very low signal intensity differences and were barely

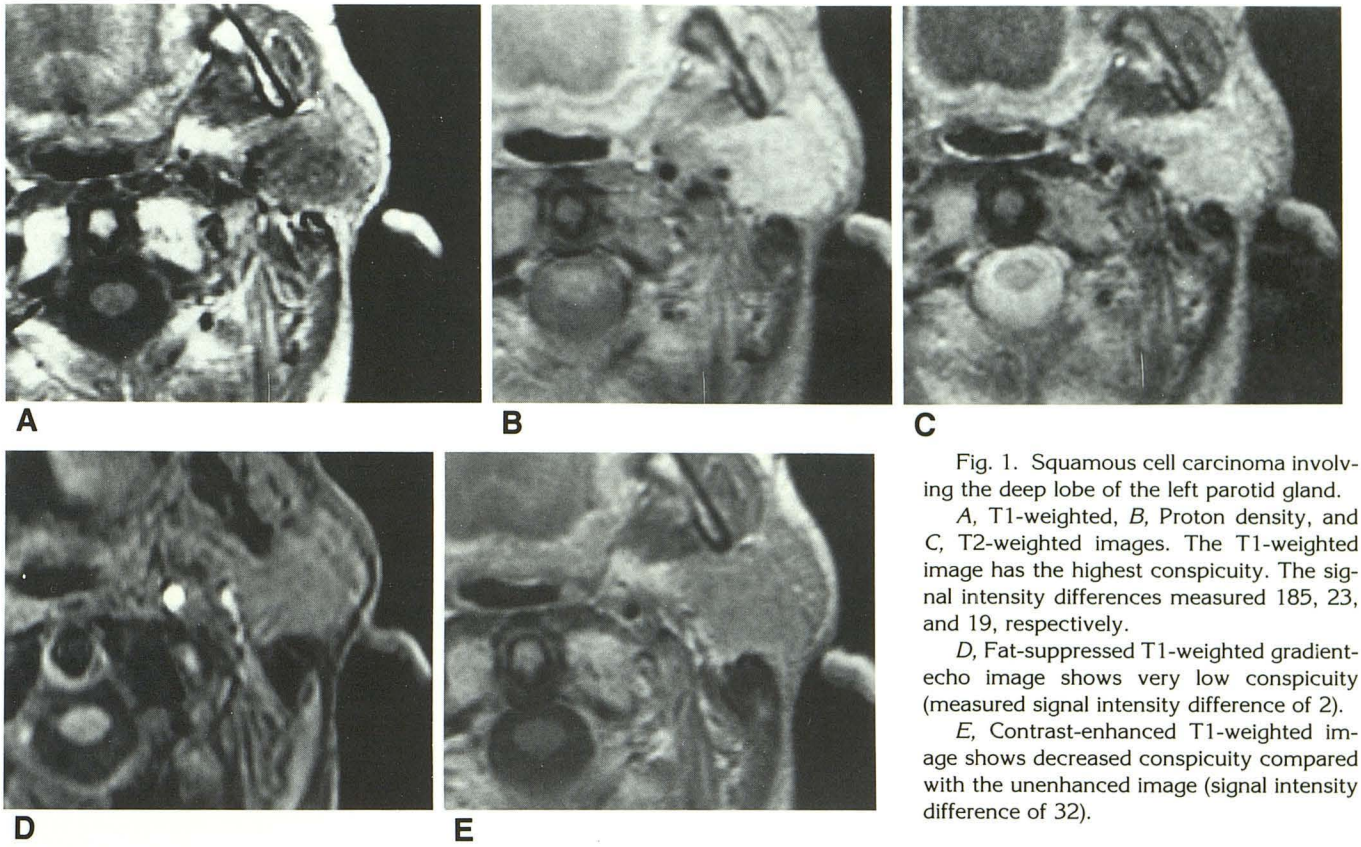


Fig. 1. Squamous cell carcinoma involving the deep lobe of the left parotid gland.

A, T1-weighted, *B,* Proton density, and *C,* T2-weighted images. The T1-weighted image has the highest conspicuity. The signal intensity differences measured 185, 23, and 19, respectively.

D, Fat-suppressed T1-weighted gradient-echo image shows very low conspicuity (measured signal intensity difference of 2).

E, Contrast-enhanced T1-weighted image shows decreased conspicuity compared with the unenhanced image (signal intensity difference of 32).

TABLE 2: Objectively measured best unenhanced sequence for detecting the parotid masses

Mass Type (n)	Number of Masses Best Detected by Each Pulse Sequence		
	T1-Weighted	PD	T2-Weighted
Pleomorphic adenoma (9)	6		3
Warthin (9)	8	1	
Squamous cell carcinoma (5)	5		
Poorly differentiated adenocarcinoma (2)	2		
Other			
Cyst	1		
Mucoepidermoid carcinoma	1		
Metastatic melanoma	1		
Poorly differentiated carcinoma arising in a pleomorphic adenoma		1	
Human immunodeficiency virus lymphoepithelial neoplasm			1
Lymphoma	1		
Total (31)	25	2	4

Note.—PD indicates proton density.

detectable in five cases (with measured signal differences ≤5).

Fat-suppressed, unenhanced T1-weighted images were not found to be helpful for identifying the masses. In six of seven cases the signal intensity differences dramatically decreased after fat suppression (mean decrease from 146 to 65) (Fig 1D).

Gadolinium enhancement was not very helpful for identifying the parotid masses (Table 3). The unenhanced images were still best at identifying the masses in 11 out of 16 cases. In only one of eight nonfat-suppressed and in only four of 13 fat-suppressed cases did the contrast-enhanced images best identify the masses (Fig 1e). In all five cases in which both sequences were ob-

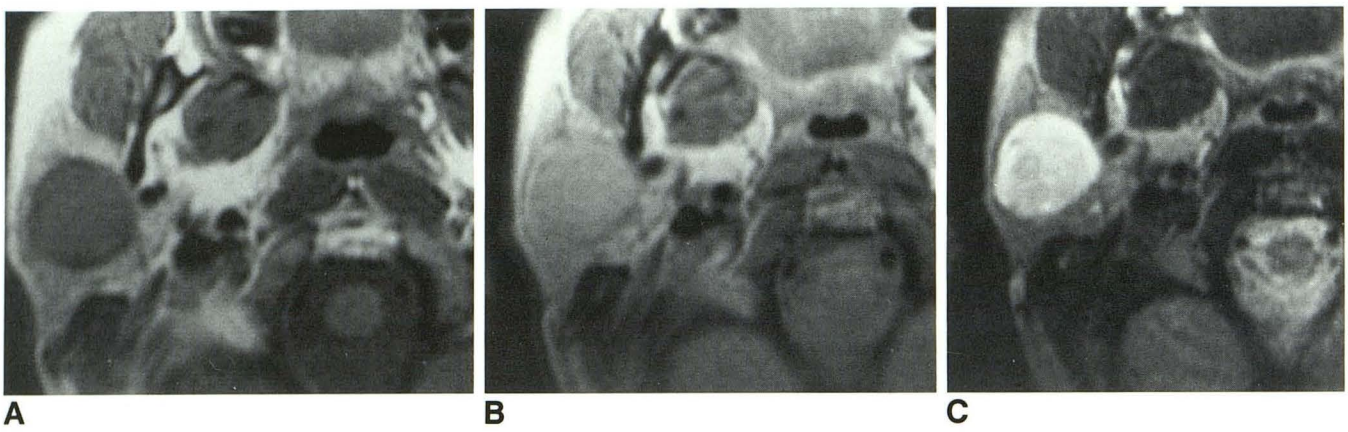
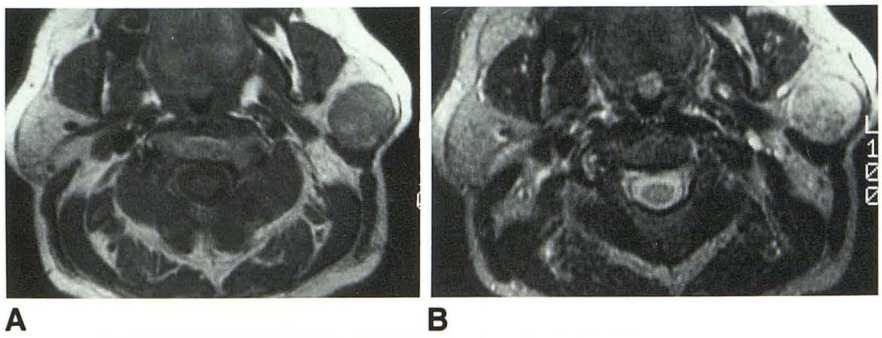


Fig. 2. Pleomorphic adenoma with high conspicuity on both T1-weighted and T2-weighted images.
A, T1-weighted image with measured signal intensity difference of 60.
B, Proton density-weighted image with measured signal intensity difference of 36.
C, T2-weighted image with measured signal intensity difference of 61.

Fig. 3. Warthin tumor with very low conspicuity on the T2-weighted image and high conspicuity on the T1-weighted image.
A, T1-weighted image with a measured signal intensity difference of 67.
B, T2-weighted image with a measured signal intensity difference of 3. Note the heterogeneity of the mass.



tained, the fat-suppressed contrast-enhanced images had increased conspicuity over the nonfat-suppressed contrast-enhanced images, with the mean signal intensity difference increasing from 56 to 135.

Subjective Measurements

On the subjective, visual analysis of relative lesion conspicuity, the T1-weighted images were found to be the best for identifying the masses in 15 cases (Table 4). All lesions showed excellent (20 lesions) or good (11 lesions) conspicuity on the T1-weighted scans, and none were judged isointense (low conspicuity). Four masses were best identified on the T2- or proton density-weighted images. In the remaining 12 cases, the T1-weighted images were felt to be equal in their ability to detect the lesions compared with either the proton density (three cases) or the T2-weighted images (10 cases), with one case having all three sequences equal in conspicuity. In no case was the proton density scan the sole best sequence for identifying a mass. On the proton density-weighted images, 13 lesions showed excellent or good conspicuity, and 12 had low conspicuity. For the T2-weighted images, 22 had excellent or good conspicuity, and nine had low conspicuity.

In 30 of 31 cases the subjective and objective determinations of conspicuity agreed about whether the T1-weighted scan was better than or equal to the T2-weighted scan for visualization of the masses.

Signal Intensity Characteristics and Histology

On the T1-weighted images all 31 of the masses were hypointense compared with the normal parotid gland tissue. This was found on both subjective visual assessment and by measured regions of interest.

All nine of the pleomorphic adenomas were hyperintense compared with the surrounding gland on the T2-weighted images, with a mean signal intensity difference of +94 (range +30 to +208) (Fig 2C). On the subjective analysis, all the pleomorphic adenomas were characterized as

TABLE 3: Objectively measured best sequence for detecting parotid masses in those receiving contrast enhancement

Mass Type (n)	Number of Masses Best Detected by Each Pulse Sequence			
	T1-Weighted	PD	T2-Weighted	+ Gadolinium
Pleomorphic adenoma (4)	1		1	2
Warthin (5)	4			1
Squamous cell carcinoma (2)	2			
Poorly differentiated adenocarcinoma (2)				2
Other				
Metastatic melanoma	1			
Poorly differentiated carcinoma arising in a pleomorphic adenoma		1		
Lymphoma	1			
Total (16)	9	1	1	5

Note.—PD indicates proton density.

TABLE 4: Subjectively determined best sequence for detecting the parotid masses

Mass Type (n)	Number of Masses Best Detected by Each Pulse Sequence (by Visual Assessment)		
	T1-Weighted	PD or T2-Weighted	T1-Weighted and T2-Weighted/PD Equal
Pleomorphic adenoma (9)	1	3	5
Warthin (9)	5		4
Squamous cell carcinoma	4		1
Poorly differentiated adenocarcinoma	1		1
Other			
Cyst			1
Mucoepidermoid carcinoma	1		
Metastatic melanoma	1		
Poorly differentiated carcinoma arising in a pleomorphic adenoma	1		
Human immunodeficiency virus lymphoepithelial neoplasm		1	
Lymphoma	1		
Total (31)	15	4	12

Note.—PD indicates proton density.

very hyperintense, except one, which was slightly hyperintense on the T2-weighted scans.

All seven Warthin tumors were hypointense to normal parotid tissue on the nonfat-suppressed T2-weighted images, with a range from −3 to −59 (Fig 3B). The mean signal intensity difference was small (−18) for these lesions. By visual review, four were judged slightly hypointense, and three were considered isointense. Two Warthin tumors were imaged with a fat-suppressed fast SE technique, and both of these masses measured higher intensity than the normal gland. By subjective review both were characterized as slightly hyperintense.

Four of the five squamous cell carcinomas had negative measured signal intensity differences: one measured 0; one measured positive on the T2-weighted scans. On subjective visual review, two lesions were slightly hypointense, two were isointense, and one was slightly hyperintense (Fig 1C).

Both of the poorly differentiated adenocarcinomas were imaged with a fat-suppressed fast SE T2-weighted pulse sequence. On subjective visual review, one lesion was very hypointense (measured conspicuity value = −152); one was isointense (−5).

The melanoma metastasis, lymphoma, and the poorly differentiated carcinoma subjectively appeared isointense, and the cyst and the human immunodeficiency virus lymphoepithelial neoplasm were subjectively very hyperintense on T2-weighted scans.

In 21 of the 31 cases the subjective and objective determinations of the lesions' relative signal intensity on the T2-weighted scans were in agreement. In eight cases, the T2-weighted images were subjectively classified as isointense, but measured signal intensity differences could be assigned (−3, −15, −3, 19, −5, 53, −68, and 37). In only two cases, a mucoepidermoid carcinoma and a squamous cell carcinoma, was there disagreement about the relative signal intensity of the mass by the subjective versus the objective criteria. Both of these lesions were considered slightly hyperintense by the subjective reviewer but had negative measured signal intensity differences. Both of these lesions were classified as heterogeneous, and this may have contributed to this discrepancy. Six of the nine Warthin tumors, one squamous cell carcinoma, and one mucoepidermoid carcinoma were considered heterogeneous on T2-weighted images.

Discussion

The goal of an MR examination is to define a lesion's extent rapidly and accurately and to suggest a possible histologic diagnosis. As recent studies have suggested, the specificity of MR in diagnosing parotid masses is low, as many lesions have similar signal intensity patterns (1, 4, 5, 7). Additionally, different lesions of the same histopathologic diagnosis (eg, Warthin tumors, mucoepidermoid carcinoma, and adenoid cystic carcinoma) may have different signal-intensity features. Because of this we believe that detecting masses and defining their extent, not predicting histology, remains the primary function of the MR examination. This project set out to determine: 1) which pulse sequences are the most useful for the detection of intraparotid masses; 2) the value of intravenous contrast material for this effort; 3) the value of measuring lesion intensity; and 4) the ability of signal intensity patterns to predict a specific diagnosis. By using measured regions of interest, we hoped to remove some of the subjectivity from this process and to add a measure of quantitation.

Optimal Pulse Sequences

We found that parotid mass conspicuity is optimal on the T1-weighted images. This held true for both the subjective visual examination and measured regions of interest. All masses could be easily identified on the T1-weighted images, whereas nine of 31 lesions were isointense on T2-weighted images, including six malignancies. Casselman and Mancuso reported similar findings (1). These results are not surprising, because the normal fat in the parotid gland provides a bright background against the low signal intensity of the mass on the T1-weighted images. None of Casselman and Mancuso's lesions was isointense on the T1-weighted images, but two of 25 were isointense on T2-weighted images (1).

We found that fat suppression usually decreased lesion conspicuity on the unenhanced T1-weighted images but increased lesion conspicuity on the enhanced images. This occurred because without fat suppression enhancing lesions will simulate the intensity of the fatty parotid.

The proton density-weighted images were of the least value for both lesion identification and characterization. With conventional SE imaging, these images are obtained without any additional time expenditure. However, with the introduction of new pulse sequences, such as fast SE, these images now take additional time, and it is important to determine whether they are worthwhile. In our opinion, the proton density-weighted images do not add to the evaluation of parotid masses, and they can be omitted.

In fast SE imaging it has been found that fat, including that in the parotid, tends to be brighter on the T2-weighted images than with conventional SE imaging (9). Our very limited experience suggests that the fat-suppressed fast SE technique may alter the relative signal intensity of a mass compared with a conventional SE T2-weighted image. This demonstrates one of the potential problems of generalizing previously described lesion characteristics to new pulse sequences. Our only cases of hyperintense Warthin tumors were with the fat-suppressed fast SE technique. However, our numbers are very small, and we have no cases imaged with both pulse sequences for direct comparison.

Role of Gadolinium

We did not find gadolinium to be helpful for the identification of the masses. Vogl et el did not recommend gadolinium for routine imaging of the parotid gland but found it helpful for identifying the facial nerve and main duct, for delineating tumorous lesions, and for evaluating postoperative fibrosis. They also found the gadolin-

ium-enhanced images to be the most useful for distinguishing benign lesions from malignant lesions, with ill-defined borders being the most important signs of aggressive growth (4). We believe the borders of a mass are best evaluated on the nonenhanced T1-weighted scans. Work by Robinson et al found gadolinium useful for perineural spread of tumor, intracranial spread of tumor, and for improved tumor-muscle contrast (10).

Role of Measuring Intensity Values

By using measured regions of interest to compare lesion conspicuity and relative signal intensity, we hoped to reduce some of the subjectivity involved in visually evaluating these features. Certain potential pitfalls exist using this technique. First, the regions of interest must be chosen to be representative of the overall lesion. If the lesion is heterogeneous, small changes in the position of the region of interest can alter the measured values and their standard deviation severely. This may be caused by either the inherent nature of the lesion or technical factors such as shading from a surface coil or inhomogeneous or incomplete fat suppression. On the other hand, visual grading of lesion conspicuity or intensity also has potential sources of error. Small changes in windowing can alter the visually apparent conspicuity of a lesion dramatically.

Windowing becomes a practical problem when evaluating parotid masses. If the person filming a case is not windowing the scans for the ranges within the parotid gland, the mass may be obscured despite a moderately high signal intensity difference.

We had hoped that we would be able to correlate the measured signal intensity differences with the subjective, visual assessment of lesion signal intensity to quantitate our ability to visually assess the lesions. However, we found that the numerical values cannot be compared from one case to another, as there is a great variation in receiver and transmission gain, surface coil placement, and other technical factors, such that the measured numbers are not consistent from one case to another. However, within an individual case, comparing the measured numbers was useful for relative conspicuity between the different imaging sequences.

In this study, measured regions of interest served as a tool for quantifying lesion conspicuity and determining relative signal intensity. However, we did not find the measurements necessary or particularly helpful for evaluating clinical cases. In the vast majority of the cases the visual assessment of a lesion matched its measured characteristics. Also, the measured values did not add to the specificity of arriving at a diagnosis. The measured values do point out that subjectively grading a lesion as hypo- or hyperintense, as is common in the radiologic literature, is a simplistic and error-prone analysis of a lesion. Eight cases labeled isointense subjectively were not so on measured values, and two cases labeled hyperintense were in fact hypointense when measured.

Signal Intensity Analysis

All of the parotid masses were hypointense on the T1-weighted images. This finding agrees with multiple prior studies (1, 2, 5, 6, 8). Therefore, only the long-repetition time images and postcontrast images can be useful in any attempt to discriminate different histopathologic types of lesions.

We found that Warthin tumors, squamous cell carcinomas, and other primary parotid malignancies tended to be hypointense compared with the normal parotid tissue and were often low in conspicuity on the conventional SE T2-weighted images. However, a definitive diagnosis was not possible without biopsy, and our case numbers were small. Of the 11 malignant lesions we imaged, six were isointense, three were hypointense, and two were hyperintense. Various authors have reported different findings, some of which agreed with our findings. Som and Biller reported that high-grade parotid malignancies have low signal intensity on T1-weighted and T2-weighted images and that this presumably reflects a lack of serous and mucinous products, a high mitotic ratio, and a high nuclear to cytoplasmic ratio (5). Sigal et al reported on 27 adenoid cystic carcinomas, and six of the 27 lesions were high in signal intensity on T2-weighted scans (6). Freling et al studied 30 malignant parotid masses, and on T2-weighted images they found that only five of the 30 were hypointense (8).

All seven of the Warthin tumors reported herein with conventional SE technique showed either an isointense or slightly hypointense pattern. Our experience parallels that of Vogl et al, who found the T2 relaxation times for their three Warthin tumors to be equal to the normal gland (4). On the other hand, Som and Biller reported that benign tumors (including three Warthin tu-

mors) and low-grade malignancies had high signal intensity on T2-weighted images (5).

We found that six of nine Warthin tumors and two of the malignancies were heterogeneous on the T2-weighted images. None of the other benign lesions were heterogeneous. Swartz et al reported that four of their six Warthin tumors were heterogeneous on T2-weighted scans (11), and Freling et al found 23 of 30 malignant parotid masses to be inhomogeneous on T2-weighted images (8).

Summary

In conclusion, we found that the T1-weighted images produced the highest lesion conspicuity in most parotid masses, and that some masses, including malignancies, could be very low in conspicuity and appear isointense on proton density- and/or T2-weighted images. The T2-weighted images may help in the ranking of a differential diagnosis, but a specific diagnosis cannot be made, and biopsy is required for histopathologic diagnosis (7). Most benign lesions, except Warthin tumors, tend to be hyperintense and highly conspicuous. Unenhanced fat-suppressed T1-weighted scans and proton density-weighted images were not helpful for identifying the masses, but fat suppression increased conspicuity on the contrast-enhanced images. Gadolinium was not necessary for identifying the intraparotid masses; all masses were easily seen on unenhanced scans.

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