Tumors of the Parotid Gland: MR Imaging Characteristics of Various Histologic Types

OBJECTIVE. The purpose of this investigation was to study the MR imaging characteristics of various histologic types of parotid gland tumors in order to determine if MR findings can be used to categorize these tumors.

MATERIAL AND METHODS. We retrospectively studied the MR images and pathologic findings in 20 patients with a variety of tumors of the parotid gland. Fat-suppressed T1-weighted images, T2-weighted images, and contrast-enhanced fat-suppressed T1-weighted images were acquired with a 1.5-T MR imager and an anterior neck coil.

RESULTS. Carcinomas ($n = 5$) were characterized by infiltration into the muscles along the surface of the mandible and by contrast enhancement. Warthin's tumors ($n = 4$) showed areas of different signal intensity on T2-weighted images and did not enhance after injection of contrast material. Pleomorphic adenomas ($n = 11$) showed enhancement after injection of contrast material but did not infiltrate the muscles.

CONCLUSION. Our findings suggest that MR characteristics are helpful in categorizing parotid gland tumors according to histologic type.

Attempts have been made to correlate MR imaging findings and histologic types of parotid gland tumors [1–11], but the success has generally been limited. On the basis of low signal intensity on T1- and T2-weighted MR images, Som and Biller [5] were able to differentiate high-grade malignant tumors from other tumors of the parotid gland. However, most tumors in the parotid gland are either benign or low-grade malignant neoplasms, and differentiating these more common lesions is difficult because most have low signal intensity on T1-weighted images and high signal intensity on T2-weighted images [5, 7, 10].

In our clinical work with MR imaging of parotid gland tumors, we have used contrast-enhanced fat-suppressed T1-weighted images in addition to unenhanced T1- and T2-weighted images. We found that MR characteristics such as contrast enhancement, invasion into the adjacent structures, and signal intensity on the T2-weighted images are different in various types of tumors. The purpose of this study was to identify MR imaging characteristics of various histologic types of parotid gland tumors.

Materials and Methods

The study was based on 20 patients with histologically verified tumors of the parotid gland who had MR imaging between January 1988 and August 1993. Sixteen patients had tumor removal or open biopsy, and four patients had fine-needle aspiration biopsy. The group consisted of 11 men and nine women 24–77 years old (mean, 49 years). This series of parotid gland tumors included 11 pleomorphic adenomas (Fig. 1), five carcinomas (Fig. 2), and four Warthin's tumors (Fig. 3). These 20 patients constitute all patients at our institution who had MR imaging of the parotid gland and a histologically verified tumor of the parotid gland during the study period. Follow-up studies after radiation therapy or surgery were not part of this investigation.
Fig. 1.—Pleomorphic adenoma.
A, Proton density-weighted (5000/1) MR image shows capsule (arrows) around lesion.
B, T2-weighted (5000/102) MR image shows high signal intensity of lesion (arrows).
C and D, T1-weighted MR images (600/12) obtained before (C) and after (D) injection of contrast material show dramatic enhancement of lesion (arrows) after injection.
E, Coronal contrast-enhanced fat-suppressed T1-weighted (600/12) MR image shows lesion (arrows) in midpart of parotid gland.

MR images were obtained with one of two 1.5-T MR systems and an anterior neck coil. Five types of images were obtained. On the basis of anatomic findings on a sagittal localizing image (2800/102/1 [TR/TE/number of signal averages]), we obtained unenhanced axial proton density-weighted (5000/19/1), T2-weighted (5000/80/1), and fat-suppressed T1-weighted (600/11/2) images in all patients. The fat-suppression technique used was the standard supplied by the software of the General Electric MR scanner. After IV administration of gadopentetate dimeglumine (Magnevist, 0.2 ml/kg; Berlex Laboratories, Wayne, NJ), axial and coronal fat-suppressed T1-weighted (600/11/2) images were obtained in 16 patients. For proton density-weighted and T2-weighted images, sections were 5 mm thick and extended from the anterior skull base to the clavicles. For T1-weighted images, sections were 3 mm thick and covered the parotid gland and adjacent structures. The interslice gap was 2 mm for T2-weighted images and 0.5 or 1.0 mm for T1-weighted images. In a few patients in the beginning of the study, we used regular spin-echo (SE) technique, but as the fast spin-echo (FSE) technique [12, 13] became available, it was used.

The MR images were evaluated by two authors who knew the histologic diagnosis. The first task was to identify imaging characteristics of parotid gland tumors and the second was to determine the prevalences of these characteristics by histologic type of tumors.

Histologic preparation included staining with hematoxylin and eosin. A 21- to 23-gauge needle was used for fine-needle aspiration biopsy. The aspirated material was stained with Diff-Quik [14] and Papanicolaou’s stain.

Results

The prevalences of MR imaging characteristics of various types of parotid gland tumors are given in Table 1. The pleomorphic adenomas enhanced after injection of contrast material, had high signal intensity on T2-weighted images (one exception), and, in most cases, had a clearly visible capsule. The average maximal cross-sectional diameter of the pleomorphic adenomas was 2.1 cm (range, 1.0–5.4 cm).
Fig. 2.—Adenoid cystic carcinoma.
A, Axial fast-spin-echo proton density–weighted (3000/19) MR image shows large lesion (arrows) in left parotid gland. Difference in signal intensity of lesion in lateral and medial aspects of gland is related to drop-off of signal associated with use of surface coil.
B, T2-weighted (3000/90) MR image shows lesion (arrows) with intermediate signal.
C, Fat-suppressed T1-weighted (900/12) MR image shows tumor (T) is isointense with parenchyma of gland.
D, Fat-suppressed T1-weighted (900/12) MR image obtained after injection of contrast medium shows dramatic enhancement of tumor (arrows). E, Coronal T1-weighted (900/12) MR image shows evidence of tumor invasion into masseter muscle (long arrows) and perineural spread along fifth cranial nerve (short arrows) and into foramen ovale. Histologic examination showed tumor involvement up to foramen ovale but no involvement of dura.

The five carcinomas included two adenoid cystic carcinomas, one mucoepidermoid carcinoma, one adenocarcinoma, and one poorly differentiated carcinoma. The average maximal cross-sectional diameter of the carcinomas was 4.3 cm (range, 2.2–5.5 cm). The carcinomas enhanced after injection of contrast material (Table 1). MR images showed the tumors infiltrating the masseter muscle in three of the five cases (Fig. 2E) and the medial or lateral pterygoid muscles in three cases. Thus, one carcinoma infiltrated more than one muscle. Typically, the infiltration was along the surface of the ramus of the mandible. This MR feature was not observed in pleomorphic adenomas. On T2-weighted images, three of five carcinomas had intermediate signal intensity; this also differentiated them from pleomorphic adenomas, which generally had high signal intensity on T2-weighted images. One adenoid cystic carcinoma showed perineural extension along the fifth cranial nerve. At surgery, tumor invasion up to the foramen ovale was found, providing good correlation with the enhancing thickened nerve seen on coronal MR images (Fig. 2E). No tumor invasion into the dura was found. Three of the carcinomas involved the portion of the parotid gland medial to the ramus of the mandible.

None of the four Warthin’s tumors enhanced with contrast material (Table 1). This feature differentiated Warthin’s tumors from the pleomorphic adenomas and the carcinomas. Separate parts of the tumors had different signal intensities on proton density–weighted and T2-weighted images. Thus, the tumor extent on proton density–weighted images (Fig. 3A) appeared different from that seen on T2-weighted images (Fig. 3B) in all the Warthin’s tumors. This finding was supportive rather than definitive for Warthin’s tumor; it was also seen in a few of the other tumors. One patient had three
Fig. 3.—Warthin's tumor.
A, Proton density–weighted (2000/30) MR image shows a 1-cm lesion (arrow) in superficial aspect of left parotid gland.
B, T2-weighted (2000/80) MR image shows areas of different signal intensity in tumor. Tumor appears larger (arrows) than on proton density–weighted image (A).
C, T1-weighted (1000/20) MR image obtained after injection of contrast material shows no enhancement of tumor (arrow) in midpart of parotid gland.
D, T1-weighted (1000/20) MR image obtained after injection of contrast material shows no enhancement of tumor (arrows) in midpart of parotid gland.

TABLE 1: MR Characteristics of Tumors of the Parotid Gland

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pleomorphic Adenoma (n = 11)</th>
<th>Carcinoma (n = 5)</th>
<th>Warthin's Tumor (n = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancement with contrast material</td>
<td>9/9a</td>
<td>3/3a</td>
<td>0</td>
</tr>
<tr>
<td>Bilateral lesions</td>
<td>0</td>
<td>0</td>
<td>1/4</td>
</tr>
<tr>
<td>Infiltrating muscle along surface of bone</td>
<td>0</td>
<td>5/5</td>
<td>0</td>
</tr>
<tr>
<td>Different signal intensities on T2-weighted images in different parts of the tumor</td>
<td>3/9a</td>
<td>2/5</td>
<td>4/4</td>
</tr>
<tr>
<td>Intermediate signal intensity on T2-weighted images</td>
<td>1/9a</td>
<td>3/5</td>
<td>2/4</td>
</tr>
<tr>
<td>High signal intensity on T2-weighted images</td>
<td>8/9a</td>
<td>2/5</td>
<td>2/4</td>
</tr>
<tr>
<td>High signal intensity on proton density–weighted images</td>
<td>1/9a</td>
<td>0</td>
<td>2/4</td>
</tr>
<tr>
<td>Clearly visible capsule</td>
<td>7/11</td>
<td>1/5</td>
<td>2/4</td>
</tr>
<tr>
<td>Diffuse enlargement of gland without local mass</td>
<td>1/11</td>
<td>2/5</td>
<td>0</td>
</tr>
</tbody>
</table>

*Numbers are different because two patients did not have all types of MR images.

**Discussion**

MR imaging is a part of the workup for parotid gland tumors at many institutions. It supplements the information from clinical examination and aspiration biopsy. MR examination is valuable for assessment of the extent of the tumor and its relationship to adjacent structures. Biopsy is the gold standard for histologic characterization of tumors, and MR imaging cannot replace a histologic diagnosis. However, with multiple pulse sequences, contrast enhancement, and fat suppression, it may be possible to differentiate the most common tumors of the parotid gland.

Invasion of the muscles of mastication appears to be associated with carcinomas. It was not seen in pleomorphic adenomas or Warthin's tumors. Invasion, as a characteristic of a malignant tumor, has been reported by others also [8,
10]. Typically, the invasion occurs along the surface of the ramus of the mandible into the masseter muscle. Invasion of the muscle was the main characteristic used to differentiate carcinomas from pleomorphic adenomas. Pleomorphic adenomas compressed the muscle toward the ramus instead of invading it. Another characteristic used to differentiate pleomorphic adenomas from carcinomas was signal intensity on T2-weighted images. Carcinomas more often had an intermediate to low signal intensity on T2-weighted images, whereas pleomorphic adenomas generally had high signal intensity on these images. The finding of low signal intensity on T2-weighted images of high-grade malignant tumors is in accordance with an earlier study [5]. The presence of a capsule, seen as a thin line of low signal intensity surrounding the tumor, was detected in several of the pleomorphic adenomas but rarely in the carcinomas. Finally, perineural extension was seen in one of the adenoid cystic carcinomas; this is a characteristic feature of this tumor [15].

Warthin's tumors were characterized by the absence of enhancement with contrast material. This is in agreement with previous observations [4, 8, 10, 11]. Warthin's tumors can be bilateral. Although seen in only one case, bilaterality is strongly suggestive of a Warthin's tumor, and thus it is worthwhile to routinely image both parotid glands. The differential diagnosis of bilateral nonenhancing lesions includes lymphop epithelial hyperplasia and cyst formation associated with HIV infection. The differential diagnosis of unilateral nonenhancing lesions includes a necrotic lymph node and, less likely, a cyst of the first branchial cleft. In the latter, the clinical history should be most valuable for differentiation.

The average size of the carcinomas (4.3 cm) was greater than that of the pleomorphic adenomas (2.1 cm); however, the size of the lesion was not a reliable marker for distinguishing pleomorphic adenomas from carcinomas. The purpose of the study was not to calculate the sensitivity or specificity of MR imaging for detection of tumors of the parotid gland but to determine and illustrate the imaging characteristics when multiple MR imaging sequences are used. For this reason, the study was not blinded, but instead the pathologic findings were known when the MR images were analyzed. In future studies, the sensitivity and specificity of MR imaging of the parotid gland tumor should be tested. On the basis of our findings, we developed an algorithm for interpretation of MR images of parotid gland tumors (Fig. 4). In practical work, the steps indicated by yes and no in the algorithm will not be absolute; overlap between the different tumors will occur. Some of the smaller carcinomas will be mistaken for pleomorphic adenomas, and some of the larger pleomorphic adenomas will have a more aggressive appearance and will be thought to be carcinomas. Future research should apply this algorithm to a larger series of parotid gland tumors and establish the probability of each diagnostic step. This way the algorithm could be refined and form a base for better understanding of MR imaging characteristics of parotid gland tumors.

The parotid gland has a high fat content and has high signal intensity on T1-weighted images. With contrast enhancement, the signal is even higher, and this might obscure small enhancing lesions, as pointed out by Swartz et al. [6]. With fat suppression, we found the signal from the normal gland parenchyma to be greatly decreased, and therefore the differentiation of an enhancing lesion was substantially improved. We found fat suppression with contrast enhancement valuable for imaging parotid gland tumors. This technique is now

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Fig. 4.—Algorithm for MR assessment of parotid gland tumors.
used routinely because differentiation of tumor from normal gland is clearly easier on fat-suppressed images than on other images. The fat-suppressed images obtained before injection of contrast material were of only limited diagnostic value and were essentially used as a baseline for assessment of the degree of enhancement. This is in accordance with previous studies [16], which showed that fat suppression without contrast material usually decreases lesion conspicuity. Once MR imaging of parotid gland lesions is more common, unenhanced fat-suppressed imaging can be deleted from the routine protocol. In our more recent MR protocol for parotid gland tumors, unenhanced fat-suppressed T1-weighted images have been deleted. Proton density–weighted images or T1-weighted images without fat suppression are used to delineate the anatomy. In our experience, proton density–weighted images are often superior to T1-weighted images for assessment of the capsule. Thus, a protocol for MR imaging of parotid gland lesions consists of four imaging sequences in addition to a sagittal localizing image. The most important images are axial T2-weighted images and axial and coronal contrast-enhanced fat-suppressed images. To obtain optimal delineation of a tumor, we use 3-mm sections through the gland with a gap of 0.5 or 1.0 mm between sections. This allows evaluation of the tumor margins as well as the relationship of the tumor to the ramus of the mandible, muscles of mastication, and retromandibular vein. We use a 5-mm slice thickness for T2-weighted axial images in order to be able to cover the upper part of the neck as well. In our clinical work, we have replaced the regular SE technique with the FSE MR imaging technique [12, 13]. We agree with others [17, 18] that the FSE technique is preferable for imaging lesions of the neck. The signal intensity on FSE T2-weighted images especially is superior to the intensity on conventional SE T2-weighted images. The first echo of the FSE images appears slightly more fuzzy than that of the regular SE images, but the better signal-to-noise ratio on T2-weighted images clearly outweighs this disadvantage. We do not think that changing from conventional SE to FSE images influenced our results in a significant way, because parotid gland tumors have similar features on both types of images. The lateral element of the neck coil overlay the parotid gland, and this explains the high signal from the gland and the tissue lateral to the gland on some of the images. In our more recent experience with an improved anterior neck coil, this disadvantage has been eliminated to a large extent.

We were unable to detect the facial nerve consistently; therefore, it was frequently difficult to tell if a small tumor involved the deep portion of the gland. In many cases, we saw a linear structure with low signal intensity running horizontally in the vicinity of the retromandibular vein. With only minimal improvement of the soft-tissue resolution and signal-to-noise ratio, we should be able to detect the facial nerve in the parotid gland more consistently. For the larger tumors in which the tumor extended medial to the retromandibular vein and medial to the ramus, without question, the deep portion was involved. Frequently, the size of the larger tumors was underestimated on the basis of findings at clinical examination.

In conclusion, the findings of this study suggest that MR characteristics are helpful in characterizing parotid gland tumors according to histologic type.

REFERENCES