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## Dashed Hopes for MR Imaging of the Head and Neck: The Power of the Needle<sup>1</sup>

WHEN magnetic resonance (MR) imaging was introduced to diagnostic radiologists in the early 1980s, there were great expectations that this new modality would be the panacea that would eliminate the "nonspecific" imaging report. It was hoped that the frequent disclaimers of "clinical correlation required" or "advise biopsy if clinically indicated" could be eliminated. Radiologists believed that MR imaging would unlock the door to histologic specificity if only the flip angles, repetition times (TRs), and echo times (TEs) were manipulated just right to obtain the optimum pulse sequence.

MR imaging was first widely implemented in the brain. Neuroradiologists ultimately found that, although MR imaging was exquisitely sensitive in detection of intracranial abnormality, the histologic specificity that one hoped for was not realized. High signal intensity on T2-weighted images was the norm for inflammatory, infectious, neoplastic, vasculopathic, and traumatic injuries to the brain. Low signal intensity on T1-weighted images, which indicates increased water content, was also stereotypical of the response of the brain to a variety of insults. Occasionally, when areas of high signal intensity were present on T1-weighted images, one was able to suggest the content of the lesion: fat, hemorrhagic blood, or lesions with high protein content. Areas of low signal intensity within lesions on T2-weighted images indicated blood, ferromagnetic ions, inspissated secretions, or "highly cellular" neoplasms. For the detection of calcification, computed tomography (CT) was more sensitive than MR imaging and often directed the radiologist to a more

specific histologic diagnosis (ie, oligodendroglioma, ependymoma, craniopharyngioma—tumors that often calcify).

While enhancement with gadolinium also increased the sensitivity of MR imaging to intracranial abnormality, the presence of enhancing lesions on MR images contributed little to the differential diagnosis of enhancing masses on CT scans. For example, in the presence of a ring-enhancing tumor, one continued to face the quandary of a differential diagnosis that included abscesses, neoplasms, demyelinating disorders, or hemorrhagic-ischemic lesions. Pathologic specificity still eluded MR imaging.

In head and neck imaging, early investigators were eager to credit MR imaging with greater histopathologic precision than perhaps was warranted. The initial enthusiasm for the capacity of MR imaging to enable a limited differential diagnosis was based on signal intensity characteristics on T2-weighted images. It was reported that, because of their higher water content, inflammatory lesions tended to have higher signal intensity on T2-weighted images than neoplastic lesions. In an excellent study by Som et al, MR imaging was used to distinguish sinonasal tumors from inflammatory lesions in 113 patients (1). Som et al found that 95% of sinonasal tumors had intermediate signal intensity on T2-weighted images, whereas only 5% had high signal intensity on T2-weighted images. On the other hand, inflammatory lesions had high signal intensity in all cases. This was followed by a report that high-grade malignant tumors of the salivary glands had lower signal intensity on T2-weighted images than benign or low-grade malignant tumors (2).

The belief that a lesion with high signal intensity on T2-weighted images was either inflammatory or benign was promulgated (1-4). In a similar manner, lesions with low signal intensity on T2-weighted images were believed to portend a high-grade malignancy with a highly cellular stroma and poor prognosis. These generalizations were based on published reports of relatively small studies. Radiologists should learn from past mistakes. The lack of statistical power in radiology articles has created falsely high expectations of new technologies (ie, intravenous digital subtraction angiography) in the past.

It is within this context that we must evaluate the articles by Sigal et al (5) and Meyers et al (6) in the current issue of *Radiology*. Sigal and associates studied the

possibility that low signal intensity on T2-weighted images corresponds to highly cellular (solid) variants of adenoid cystic carcinomas with poor prognoses and that high-signal-intensity lesions correlate with poorly cellular (tubular) subtypes with good prognoses (5). The correlation described by the kappa statistic was only fair, and their Table 1 shows that absolute concordance of signal intensity and pathologic grade occurred in only 10 of 25 cases (40%). Even when tumors with low signal intensity and those with intermediate signal intensity were grouped together, signal intensity correlated with pathologic grade in only 17 of 25 tumors (68%). To suggest that this discrepancy should be dismissed because of sampling error at pathologic examination is dubious, especially in cases in which the entire tumor was surgically removed. A good match between grade of tumor and T2-weighted signal intensity simply does not exist, and one would be mistaken to believe otherwise. Furthermore, the match between signal intensity and prognosis is far from reliable.

Nevertheless, two lessons are derived from the article by Sigal et al:

1. An aggressive relentless malignancy, adenoid cystic carcinoma may have high or low signal intensity on T2-weighted images.
2. MR imaging is nonspecific in the differentiation of adenoid cystic carcinoma from other tumors, thereby underscoring the requirement for biopsy or fine-needle aspiration of salivary gland tumors.

The article by Meyers et al is important also for pointing out that an aggressive sarcoma can have very high signal intensity on long TR/TE MR images (6). In 16 of the 17 patients with chondrosarcoma, the predominant signal intensity was very high on T2-weighted images despite the fact that chondrosarcomas may have matrix mineralization and high nucleus:cytoplasm ratios (7). This finding has also been noted in other reports of chondrosarcomas (and chordomas) of the skull base (8,9).

Other aggressive malignancies have been reported to have high signal intensity on T2-weighted images. A study of rhabdomyosarcomas of the head and neck demonstrated high signal intensity on T2-weighted images in all 13 cases (10). Salivary gland tumors of cell types other than adenoid cystic carcinoma have also been bright on long TR/TE MR images (11).

Head and neck imagers have also found

**Index terms:** Editorials • Head and neck neoplasms, 12.381, 264.3751 • Magnetic resonance (MR), tissue characterization, 23.3751, 264.373, 264.3751 • Sarcoma, 12.3211 • Skull, MR, 12.1214 • Skull, primary neoplasms, 12.3211

*Radiology* 1992; 184:25-26

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See also the articles by Sigal et al (pp 95-101) and Meyers et al (103-108) in this issue.

that the generalization that benign neoplastic lesions of the head and neck are high in signal intensity on T2-weighted images may be fallacious. Benign schwannomas that contain high levels of Antoni A tissue may have low signal intensity on T2-weighted images because of the more cellular, less myxoid content of the schwannoma tissue. Similarly, Warthin tumors of the salivary glands have been proved to have signal intensity lower than that of fat and neighboring parotid tissue in the majority of cases (11-13). Within the sinonasal cavity, inverted papillomas, a benign neoplastic process of the lateral nasal wall, may have intermediate to low signal intensity that can completely simulate squamous cell carcinoma (4). This is particularly troublesome with inverted papillomas because squamous cell carcinoma, also low to intermediate in signal intensity, coexists with inverted papillomas in 10%-15% of cases. Desmoid tumors (14), meningiomas (15), and benign odontogenic tumors (3) may all show low intensity on long TR/TE MR images.

Some neoplasms of the head and neck may have high or low signal intensity, depending on histologic subtypes. The article by Sigal et al (5) describes adenoid cystic carcinoma, but variable signal intensity has also been described in Hodgkin and non-Hodgkin lymphomas and leukemias (chloromas) on T2-weighted images (16,17). Neoplasms with a propensity for necrosis may also show variable signal intensity.

Some inflammatory tissues may have low signal intensity on T2-weighted images. Whenever sarcoidosis or Sjögren syndrome affects the salivary glands, the lesions are usually intermediate in T2-weighted signal intensity. Radiation-induced sialadenitis and sialolithiasis show low signal intensity in affected salivary glands as well (2). In the sinonasal cavity (possibly because of the presence of paramagnetic iron or manganese ions), fungal infections are often dark on T2-weighted images (18). Amyloid deposits (in amyloidosis) (19), postoperative fibrosis (11,20), granulation tissue (20), pseudotumor of the orbit (21) and cavernous sinus (22) (Tolosa-Hunt syndrome), rheumatoid pannus (23), and cholesteatomas of the middle ear (20) may be dark to intermediate in signal intensity on T2-weighted images.

Little success has been achieved in differentiation of inflammatory from neoplastic infiltration of lymph nodes except with the use of size, shape, and the presence of central nodal necrosis or extracapsular spread. Various researchers have studied T1 and T2 values of lymph nodes to determine whether high or low signal intensity on T1- or T2-weighted images might suggest neoplastic infiltration rather than inflammatory enlargement (24-27). No conclusive evidence has been found. In addition, unfortunately, necrosis within a lymph node may cause high signal intensity on T2-weighted images; in a simplistic evaluation of the lymph nodes, such signal intensity might suggest in-

flammatory enlargement. Thus, head and neck radiologists must still hedge their bets whenever they evaluate lymph nodes with MR imaging.

Enhancement patterns on MR images may be helpful in limited instances. Benign and malignant neoplasms of the head and neck may enhance homogeneously, heterogeneously, or not at all. While some rely on a peripheral pattern of contrast enhancement on MR images to suggest inflammatory lesions in the sinonasal cavity (28), our experience has been that fungal infections associated with polyposis may demonstrate either a solid or a mixed solid and peripheral enhancement pattern. Inverting papillomas enhance in a solid fashion (3). Both inflammatory and neoplastic lymph nodes enhance (27). Thus, the presence of enhancement may fail to clarify matters whenever one attempts to limit a confusing differential diagnosis.

In summary, there was early enthusiasm over the possibility that MR imaging would ultimately eliminate the need for biopsies or aspirations of lesions in the head and neck by virtue of histologic specificity, but this expectation has not been fully realized. High signal intensity on T2-weighted images does not necessarily mean a favorable diagnosis, nor is low signal intensity necessarily the kiss of death. Hedge your bets. The use of MR imaging in head and neck radiology has paralleled its evolution in the central nervous system: Its greatest value remains in the detection and mapping of lesions rather than in histologic specificity. As MR imaging has matured with the imaging community, head and neck imagers have developed even greater respect for the importance of a biopsy needle and a pathologist for the final diagnosis. ■

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