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S Takashima, J Ikezoe, K Harada, Y Akai, S Hamada, J Arisawa, S Morimoto, N Masaki, T Kozuka and H Maeda

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Tongue Cancer: Correlation of MR Imaging and Sonography with Pathology

Shodayu Takashima[1]
Junpei Ikezoe[1]
Koushi Harada[1]
Yoshinori Akai[1]
Seiki Hamada[1]
Jun Arisawa[1]
Shizuo Morimoto[1]
Norie Masaki[1]
Takahiro Kozuka[1]
Hajime Maeda[2]

Ten patients with tongue cancer underwent both MR imaging and sonography. In seven of these patients, pathologic findings from glossectomies were correlated with MR and sonographic results. MR images of resected specimens also were obtained in two patients, and relaxation time was calculated in one of these patients. MR images (5- to 7-mm thick slices) were obtained by using a 0.1-T resistive magnet with a 128 × 256 acquisition matrix. MR and sonography had almost the same sensitivity for detecting primary-site tongue cancer. However, in the three patients with extraorgan spread of tumor, MR was superior, showing three of three cases, compared with sonography, which showed extraorgan spread in only one of the three cases.

Although MR failed in one patient to differentiate postradiation scar tissue from tumor, because of similar relaxation time of both, this imaging technique proved to be an important adjunct to the physical examination in the staging of tongue cancer.

Because the planning of treatment for tongue cancer depends on the staging of the cancer, it is important to have an accurate evaluation of the size and extent of the primary site of the tumor. Currently, various radiologic techniques, such as sonography, CT, and MR imaging are used to study neck tumors, including tongue cancer [1–5]. CT images are degraded by dental amalgams and dense bones. Although sonography is limited by artifacts caused by air and bony structures, it is widely used in the examination of tongue cancer [1, 2]. MR images are almost free of these artifacts, and they have shown superior soft-tissue contrast compared with CT scans [5–8].

This article describes the role of MR in the staging of tongue cancer and discusses whether MR could differentiate tumor from postradiation scar tissue. The findings on MR and sonography are correlated with pathologic findings in patients who have undergone surgery.

Materials and Methods

As seen in Table 1, retrospective analysis was performed in 10 patients with tongue cancer who underwent both MR and sonography. All had histologically proved squamous cell carcinoma. The patients consisted of nine women and one man, ranging in age from 23 to 73 years old (mean, 55 years). Seven of the 10 patients underwent glossectomy, and their MR images and sonographic findings were correlated with pathologic findings. Special attention was paid to the site and extent of primary tumors. In two patients, MR images of the resected specimens were obtained within 2 hr after glossectomy, and T1 and T2 values were calculated in one of these two patients.

Images were obtained on a 0.1-T resistive whole-body magnet with a 128 × 256 acquisition matrix.* T1-weighted images were obtained (in two patients) with a spin-echo (SE) sequence of 300/30/2 (TR/TE/excitations) and (in six patients) with inversion recovery (IR) sequences of 1300–1800/350–500/4 (TR range/TI range/excitations). T2-weighted images were obtained with SE sequences of 1600–1800/40–120 in all 10 patients. Multiple SE images were obtained (in two patients) with sequences of 1500/30, 60, 90, 120, 150, 180. Slice thickness

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[1] Department of Radiology, Osaka University Medical School, 1-1-50 Fukushima, Fukushima-ku, Osaka 553, Japan. Address reprint requests to S. Takashima.

[2] Department of Otorhinolaryngology, Osaka University Medical School, Osaka, Japan.

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* Asahikasei Co. Tokyo, Japan

TABLE 1: Clinical Findings of 10 Patients with Tongue Cancer

Case No.	Age	Gender	Primary Tumor	Surgery
1	23	M	T1	No
2	73	M	T2	Yes
3	62	M	T2	Yes
4	38	M	T3	Yes
5	60	M	T3	No
6	44	M	T3	Yes
7	62	M	T3	No
8	62	F	T3	Yes
9	58	M	T3	Yes
10	66	M	T4	Yes

Note.—T1 = less than or equal to 2 cm in diameter; T2 = between 2 and 4 cm in diameter; T3 = more than 4 cm in diameter; T4 = spread to bone, muscle, skin, etc.

TABLE 2: Pulse Sequences and Detection Rate of Tumors

Pulse Sequences	No. of Tumors Detected
T2-weighted SE images (1600–1800/40–120)	10/10
T1-weighted images:	
SE (300/30)	0/2
IR (1300–1800/350–500)	2/6

Note.—SE = spin echo, IR = inversion recovery.

was 5–7 mm for each image. Transverse and either sagittal or coronal images were obtained in all patients. Either a small coil or a standard head coil was used for the tongue and oropharynx. A specially designed small coil was used for the surgically resected specimens. T1 values were calculated with a combination of saturation-recovery (SR) and IR pulse sequences [9]. T2 values were calculated from a data set of eight sequential SE images [10].

Sonographic examination of the tongue was performed principally by using a real-time sector scanner with a 5-MHz transducer.† All patients were examined in the supine position with the neck hyperextended. Exploration was carried out with a submental approach.

Results

Pulse Sequences and MR Images

Table 2 summarizes the correlation between pulse sequences and the rate of detection of primary tumors in the tongue. On T2-weighted images (Figs. 1A, 2A, 3, and 4A), primary tumors had a signal intensity higher than that of normal tongue in all 10 patients, and viable tumor was indistinguishable from postradiation scar tissue in one patient. On T1-weighted SE images, tumors were as intense as normal tongue in both the patients in whom these images were obtained. On IR images (Fig. 4B), tumors appeared as a low-intensity signal in two patients; however, in the other four patients who had IR sequences, local artifacts produced by dental amalgams interfered with image interpretation. On multiple SE images (Fig. 3), mass lesions were as intense as normal tongue at TE = 30 and 60. As TE increased, tumors became recognizable as high-intensity signal in contrast with the low-intensity signal of surrounding tongue muscles; but the absolute signal intensity from all tissues decreased with a reduced signal-to-noise ratio.

Measurement of Relaxation Times

In one patient, T1 and T2 relaxation times were calculated for various sites of the resected specimen of the tongue. In this patient, preoperative MR was proved to overestimate the extent of tumor. In the preoperative examination, T2-weighted images (Figs. 5A and 5B) showed the high-intensity regions involving the left tongue as well as the tongue base, and extension of tumor into the ipsilateral tonsillar bed, pharyngeal walls, and parapharyngeal space were also demonstrated. In histopathologic findings, tumor was found at the tongue base, but the tumorlike lesion in the tongue was shown to be scar tissue from previous interstitial radiation therapy (Fig. 5C). In calculated T1 (Fig. 5D) and T2 (Fig. 5E) images of the resected specimen, the signal intensity of scar tissue was as high as that of tumor. T1 and T2 relaxation times were 357 $\pm$ 14 msec (mean $\pm$ SD) and 54 $\pm$ 2 msec for the normal tongue, 427 $\pm$ 11 msec and 90 $\pm$ 5 msec for the tumor, and 576 $\pm$ 36 msec and 117 $\pm$ 7 msec for the scar tissue, respectively.

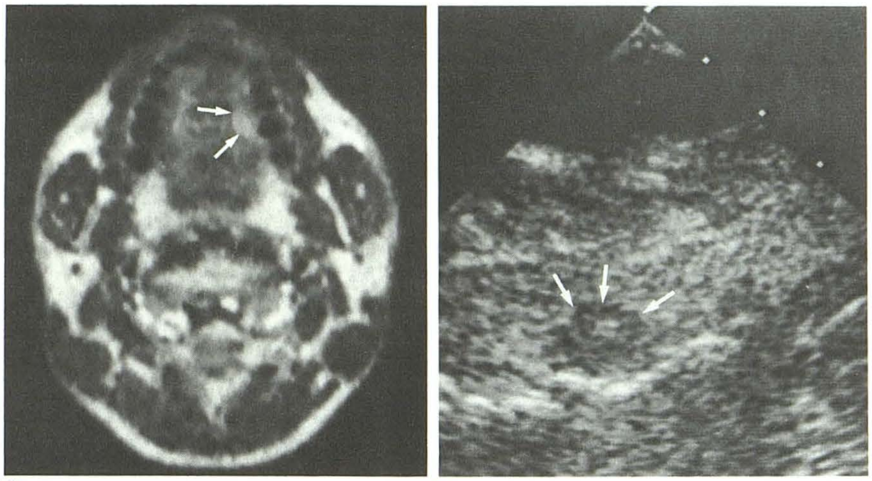
Sonographic Findings

Sonography detected nine of 10 tumors. In a false-negative patient, a 5-MHz transducer was not available, so the examination was performed with a 7.5-MHz transducer. Eight tumors were hypoechoic (Figs. 1B, 2B, and 4C). In the remaining one, an inhomogeneous echostructure with a cystic component was seen. Ulcerations were detected in five patients. Extension over the midline was found in one patient (Fig. 3C), and tumor was spread to the surrounding structures in one patient.

Correlation of MR and Sonographic Findings with Pathologic Findings

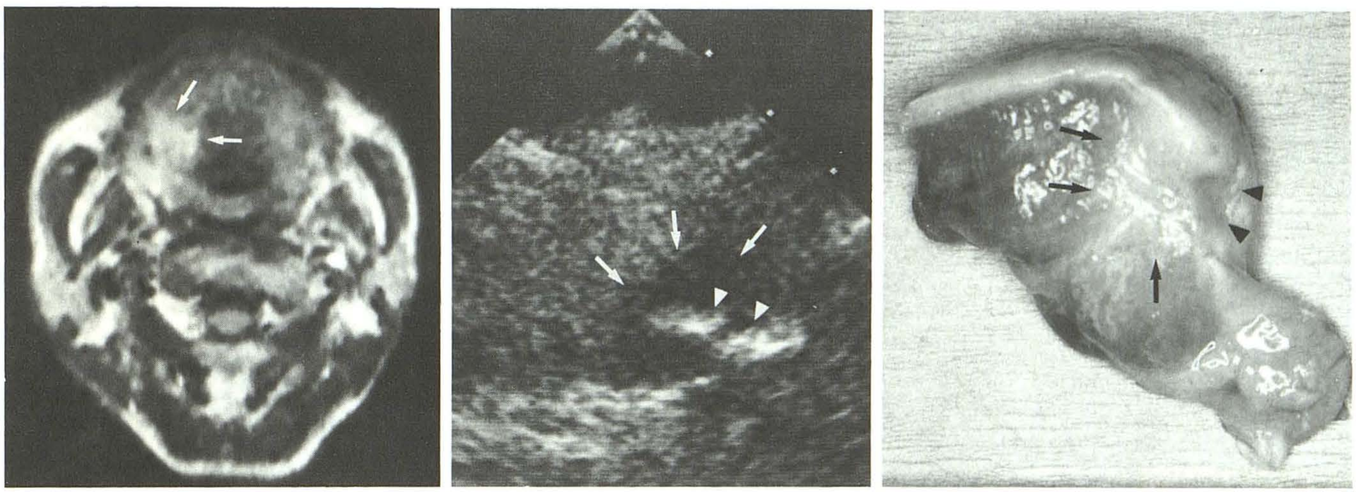
Table 3 shows the correlation between the findings on MR and sonography with the pathologic findings. In seven patients who underwent surgery, we assessed the detectability of primary tumor in the tongue, expansion over the midline, and spread outside the tongue. Sonography detected six primary tumors, whereas MR demonstrated all seven tumors. The size of the tumor was measured more precisely by sonography than by MR. In one patient, although scar tissue was falsely diagnosed as tumor by MR images, sonography correctly identified the scar tissue by its hyperechoic structure [11]. Spread over midline was depicted in one patient by both sonography and MR, which was consistent with pathologic findings. Three tumors were proved to extend outside the tongue at surgery; and the extent of the spread was accu-

† Yokogawa Co. Tokyo, Japan



A B

Fig. 1.—Patient with T1 carcinoma.
A, **Axial T2-weighted MR image (1800/90) demonstrates high signal intensity in oral cavity, left side of tongue (*arrows*).**
B, **Longitudinal sonogram (5 MHz) shows homogeneous and hypoechoic tumor (*arrows*).**



A B C

Fig. 2.—Patient with T2 carcinoma.
A, **Axial T2-weighted MR image (1800/90) shows high signal intensity confined to right side of oral tongue (*arrows*).**
B, **Longitudinal sonogram (5 MHz) depicts hypoechoic tumor (*arrows*) with a central ulceration (*arrowheads*).**
C, **Partial glossectomy was performed. Pathologic section shows tumor (*arrows*) with ulcer (*arrowheads*) in the corresponding site.**

rately estimated by MR in all three cases and by sonography in only one case. No patient in this study showed tumor spread to the mandible.

Discussion

Since a definite diagnosis of tongue cancer is obtained primarily by biopsy, the principal role of MR and sonography in this disorder is to provide an accurate staging work-up for the planning of therapy.

Small, superficial lesions are difficult to detect by sonography [2, 11], and artifacts caused by dense bones and air in the oral cavity prevent sonography from depicting mass lesions. Furthermore, the operator's skill is an important factor in the accuracy of sonographic examinations [11]. In contrast, MR images with SE sequences are not degraded by dental amalgams or by dense bones [5–8, 12]. Although ferromagnetic metals produce artifacts on MR images, the image distortion is limited to the adjacent area of the offending material, which does not influence interpretation of the whole image [5–8, 12]. T2-weighted images are best able to separate the primary tongue cancer from the surrounding normal tongue muscles, because the tumor shows long T2 relaxation time and the muscle of the normal tongue has short T2 relaxation time. In this series, MR's 100% detection sensitivity to tongue cancer in the primary site was almost the same as that of sonography (90%).

Many surgeons recommend a partial glossectomy rather than a total glossectomy for a satisfactory quality of life for

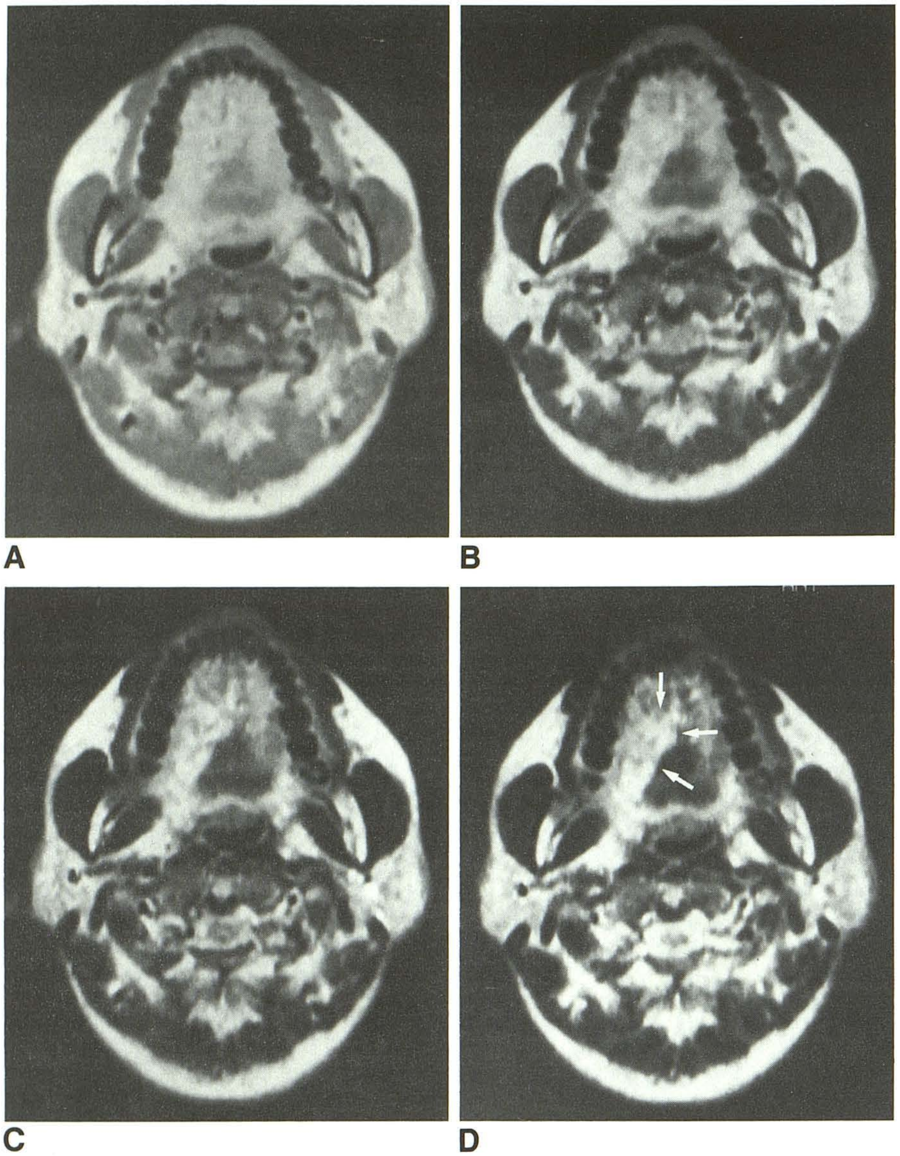


Fig. 3.—Multiple SE images (1500/30, 60, 90, 120) of patient with T3 carcinoma.

A and *B*, TE-30 (*A*) and TE-60 (*B*). Discrimination between normal tongue and tumor is difficult at these echo times.

C and *D*, TE-90 (*C*) and TE-120 (*D*). With the increase in TE, the tumor stands out as high-intensity signal in right side of tongue (*arrows* in *D*). Although tumor is adjacent to midline, it does not extend over midline. This patient underwent subtotal glossectomy and the findings on MR agreed with pathologic findings.

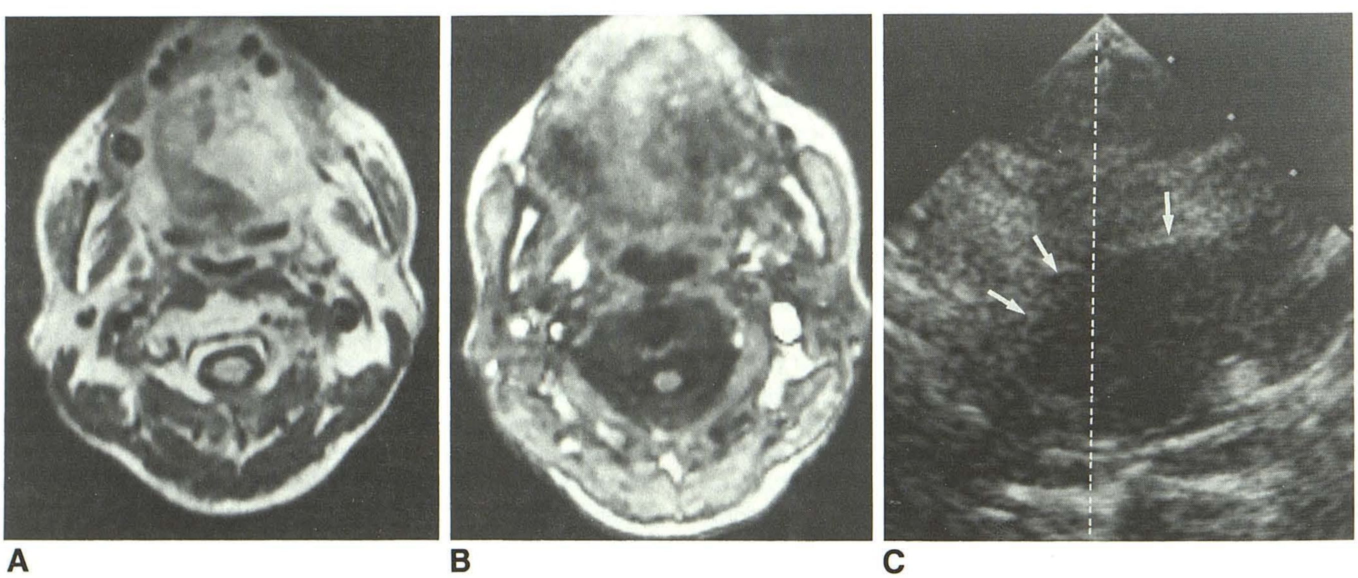


Fig. 4.—Patient with T3 carcinoma extending over the median line.

A, T2-weighted axial MR image (1600/50) shows high signal intensity in oral cavity, left side of tongue. Expansion over midline is clearly depicted.

B, IR image (1800/500) at same level demonstrates the low signal intensity corresponding in position to the high signal intensity seen in *A*.

C, Transverse sonogram (5 MHz) depicts homogeneous and hypoechoic tumor (*arrows*) that extends over median line (*dotted line*). This patient had subtotal glossectomy and the extent of tumor on MR images was confirmed by pathologic specimen.

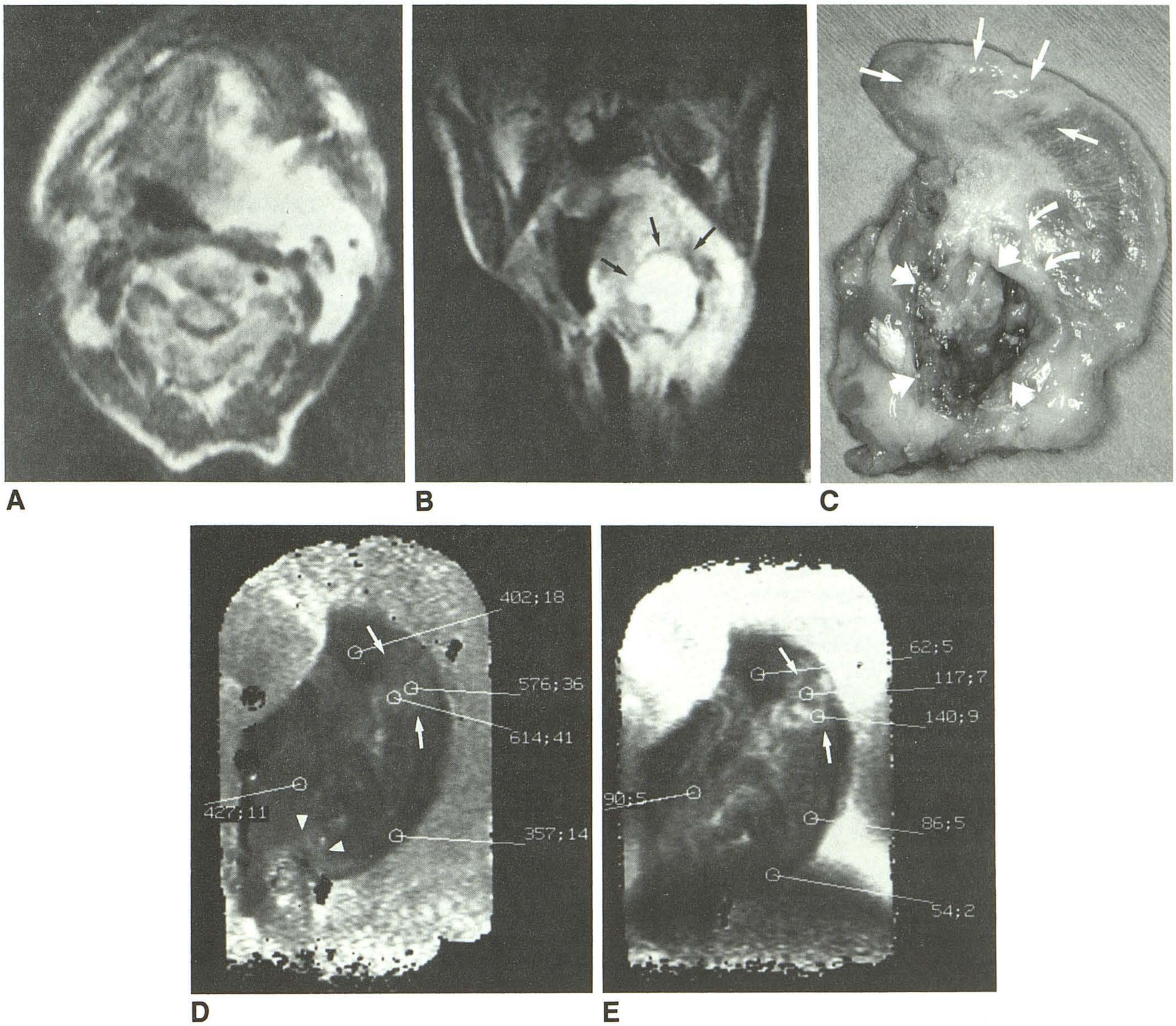


Fig. 5.—Patient with T4 carcinoma. Four months after radiation therapy with 70 Gy, tumor has regrown rapidly.

***A*, T2-weighted axial MR image (1800/110) shows high signal intensity in left side of tongue extending into tonsillar bed, soft palate, and parapharyngeal space. However, the midline is preserved.**

***B*, T2-weighted coronal MR image (1800/90) demonstrates huge mass in left side of tongue base. Pharyngeal airway is severely displaced to the right. The signal intensity of necrotic portion (*arrows*) of mass appears higher than that of surrounding areas. Left hemiglossectomy and left radical neck dissection were performed as a palliative measure.**

***C*, Resected specimen (parasagittal section) reveals pale areas in tongue (*straight arrows*) as well as in tongue base (*curved arrows*). Microscopically, tumorlike lesion in tongue was proved to be scar tissue without malignant cells. Cancer cells were identified in surrounding areas of tumor necrosis (*wide arrows*) in tongue base.**

***D*, Calculated T1 image corresponding to *C*. Signal from scar tissue (*arrows*) in tongue is as intense as that from viable tumor (*arrowheads*) in tongue base.**

***E*, Calculated T2 image corresponding to *C*. Signal intensity of scar tissue (*arrows*) is similar to that of tumor. T1 and T2 relaxation times of scar tissue were as long as those of viable tumor.**

patients with tongue cancer. Therefore, it is clinically important to determine whether the tumor has spread over the midline of the lingual septum. Sonography delineates the midline as a hyperechoic linear structure in the transverse scans [13]. However, operators occasionally take a vertical line between two geniohyoid muscles for the imaginary midline of the septum [13]. Therefore, cancer extending over the midline is sometimes incorrectly assessed by sonography [2]. In contrast, the midline is easily visualized as a linear high-intensity structure by MR, and the relationship between the tumor and the midline is recognized without difficulty [5, 12].

Tumor extending to the adjacent structures alters the treatment planning. Invasion to the larynx requires laryngectomy and/or partial pharyngectomy. When the tumor infiltrates to the mandible, surgery is preferable to radiation therapy. Sonography does not readily demonstrate tumor spread to the

TABLE 3: MR and Sonographic Findings in Correlation with Pathology ($n = 7$)

Finding	True Positive	True Negative	False Positive	False Negative
Detection of primary tumor in the tongue:				
MR	7	0	0	0
Sonography	6	0	0	1
Expansion over midline:				
MR	1	6	0	0
Sonography	1	6	0	0
Spread outside the tongue:				
MR	3	3	1	0
Sonography	1	4	0	2

preepiglottic space, epiglottis, valleculae, and pharyngeal walls [1, 2, 11, 13]. In contrast, T1-weighted MR images clearly delineate the extension of tumor into the adjacent tissues of high fat content, such as the soft palate, tonsillar bed, preepiglottic space, valleculae, and parapharyngeal space. T2-weighted images are useful for assessing tumor extension to the muscle tissues, including extrinsic tongue muscles, faucial pillars, and pharyngeal constrictor muscles. Infiltration to the mandible is demonstrated as the loss of normal low signal intensity from the cortical bone [5]. Sagittal and/or coronal MR images are very useful for depicting the three-dimensional extension of tumor [5–8, 12]. In our study, MR was more sensitive for detecting tumor extent, showing three of three cases, than was sonography, which showed extraorgan spread in only one case. However, MR has the potential to overestimate tumor extent, as it did in one of our cases, especially in patients who have received radiation therapy or surgery.

Several studies report on the ability of MR to discriminate between tumor and scar tissue in the neck region [5, 7]. One of these [7] states that T2 values of postoperative scar tissue seem to be short relative to other tissues, and the other study [5] found T2-weighted images to be useful in differentiating tumor from scar tissue in patients who had had surgery or irradiation. There is a variation in the T1 and T2 values when we compare one MR unit with another. However, the relative relationship of signal intensities in the images is more important than the absolute values. We think that the T1 and T2 data collected in our series is a useful addition to the literature because we used the same MR unit. We found that the T1 and T2 values of the tissue scarred by radiation therapy were as long as those of the tumor. Therefore, MR was unable to distinguish the scar tissue from the viable tumor. Pure scar tissue will probably have a low signal intensity on all imaging sequences because of a paucity of MR-observable protons [7]. Granulation-type tissue tends to have an intermediate-type signal because of the associated inflammatory component [7]. This may account for the misdiagnosis in our series. Further investigation should be done to confirm our results of tissue characterization by MR.

Conclusions

MR and sonography have almost the same sensitivity for detecting primary-site tongue cancer. Although sonography depicts the size of tumors more precisely than does MR, improvements in spatial resolution enable MR to demonstrate the size of tumors more exactly. MR is superior to sonography in the evaluation of extraorgan spread of tumor, since it is not hampered by artifacts produced by the mandible or dental amalgams. Despite the fact that MR may overestimate tumor extent, it plays an important role in the detection and staging of tongue cancer.

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