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Paragangliomas of the Jugular Bulb and Carotid Body: MR Imaging with Short Sequences and Gd-DTPA Enhancement

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Twenty-six patients with glomus jugulare (16), glomus tympanicum (three), or carotid glomus (seven) tumors were examined with contrast-enhanced CT scans and MR scans without and with Gd-DTPA. MR and CT scans had similar sensitivities, but the enhanced MR scans were diagnostically more specific than either CT or nonenhanced MR. Dynamic MR scanning permitted measurement of the degree of Gd-DTPA enhancement over time.

We recommend contrast-enhanced MR with short sequences and a dynamic approach in patients with suspected carotid, tympanic, and jugular paragangliomas.

Before the introduction of MR imaging, the radiologic diagnosis of glomus tumors was based on CT findings [1–3]. MR imaging shows some advantages over CT in the diagnosis of lesions in the skull base and surrounding structures. Our experience indicates that these advantages are particularly evident in patients with suspected carotid, tympanic, and jugular paragangliomas. The following is a discussion of the diagnostic value of MR imaging of glomus tumors, particularly with short sequences and with the paramagnetic contrast medium Gd-DTPA.

Subjects and Methods

Twenty-six patients examined with MR and CT are included in this study. When clinical symptoms indicated a lesion in the middle ear or neck, prospective MR and CT were performed. Patients lacking objective clinical findings were excluded from the study. CT was performed with a Somatom DRH scanner* before and, except in five patients, after injection of a nonionic contrast agent.

MR examinations were carried out on a 0.35-T (seven cases) and later on a 1.0-T (19 cases) unit. In 16 patients with suspected jugular bulb tumors, the standard head coil was used. For suspected masses in the neck, a specially constructed Helmholz coil was used to improve the signal-to-noise ratio. Axial images with a 5-mm slice thickness were obtained by using a long, 1600/30, 90 (TR/first-echo TE, second echo TE), and a short, 500/30 (TR/TE), spin-echo sequence. Eighteen patients were examined with the fast imaging technique. The time dependence of the Gd-DTPA enhancement was recorded by repeating the same slice eight times, one image every 30 sec. A 40° flip-angle sequence, 30/12, was used with acquisition times of 7 sec each, beginning at the time of bolus injection of Gd-DTPA. The enhancement/time ratio was analyzed and used for differential diagnosis. Similar to the denseness/time profile in dynamic CT, the enhancement/time ratio described the variation of the intensity of the region of interest vs time [3, 4].

There were 16 paragangliomas of the jugular bulb, three glomus tympanicum tumors, and seven tumors in the neck. A subjective evaluation system was developed to analyze our results (Table 1). Three categories of assessment were developed. The first category dealt with the quality of the MR images, with a range of grades from satisfactory (grade 1) to optimal (grade 3). Satisfactory image quality was defined as allowing anatomic display and recognition of tumor masses 5.0 mm in diameter. Good image quality was defined as allowing clear delineation of the tumor. Optimal information was defined as offering not only clear

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display of the anatomy and tumor delineation but also information on tissue necrosis and vascularity of the neoplasm.

The second category of assessment dealt with the use of Gd-DTPA. The post–Gd-DTPA image quality was deemed satisfactory (grade 1) if modest improvement was attained in comparison with nonenhanced images, good (grade 2) if significant tumor enhancement allowed better delineation of tumor extent, and optimal (grade 3) if mucosal structures and vascularity could be visualized in detail. The third category of assessment dealt with the results of CT and the comparison of MR and CT.

TABLE 1: MR and CT Assessments of Glomus Tumors

Tumor Type	Rating[a]			MR vs CT[b]
	Nonenhanced MR	Gd-DTPA MR	CT	
Glomus jugulare (n = 16)	2	3	2	+
Glomus tympanicum (n = 3)	2	3	3	0
Glomus caroticum (n = 7)	3	3	2	+

[a] 3 = optimal; 2 = good; 1 = satisfactory.
[b] + = MR superior to CT; 0 = MR equal to CT; − = MR inferior to CT.

Results

The results of the MR studies and other examinations were divided between tumors in the skull base and neck.

Glomus Jugulare and Glomus Tympanicum Tumors

We found 16 glomus jugulare tumors. The clinical symptoms associated with paragangliomas were unilateral "deafness," tinnitus, pulsation, vertigo, and pain. Paralysis of cranial nerves VII, IX, and XI was evident in some.

The MR study was done before and after IV injection of Gd-DTPA. In tumors smaller than 1.5 cm, nonenhanced MR was not able to delineate masses in three of five cases. In all paragangliomas we found a remarkable increase in signal intensity in the first 60 sec after injection. Maximum signal intensity in tumor tissue was found after 150 sec with an enhancement factor of 1.8; after this peak, the intensity diminished gradually until the end of measurement at 360 sec. We attribute this to the "washout effect" of the highly vascularized tumor tissue.

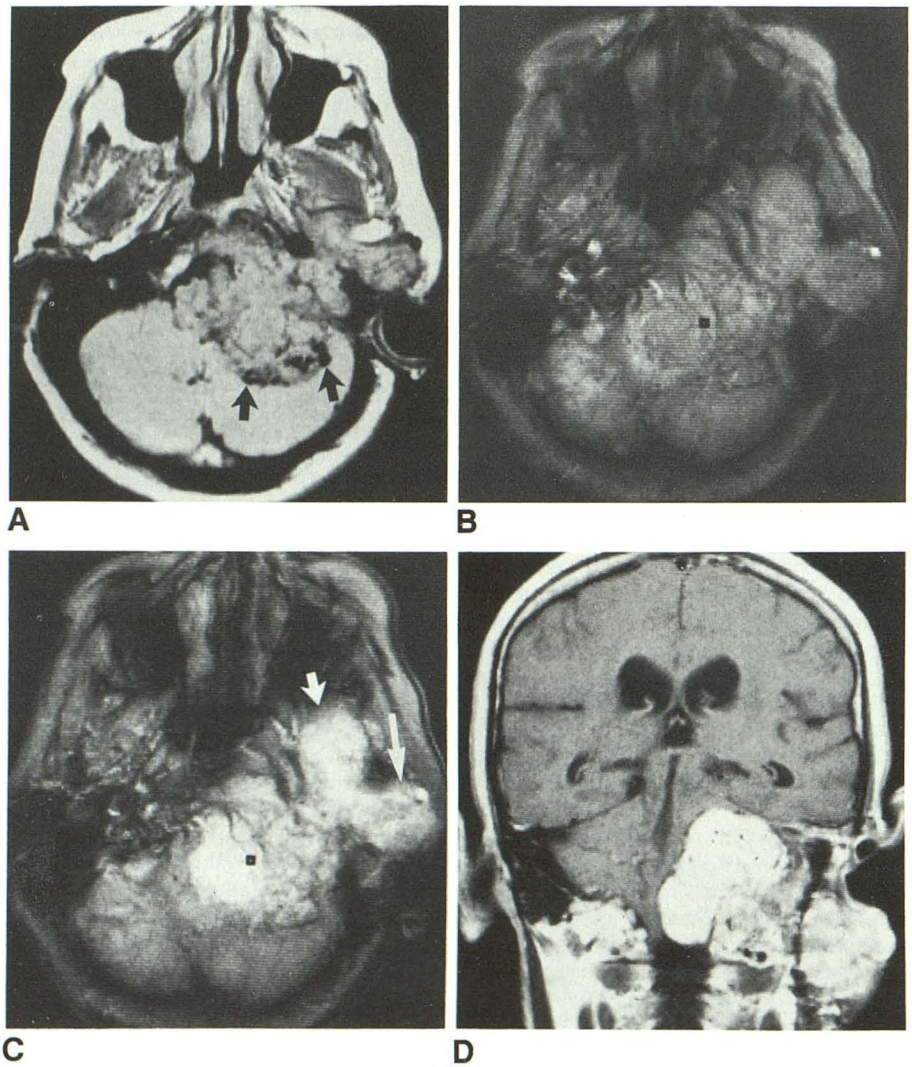

Fig. 1.—Large glomus jugulare tumor with intracranial involvement and bony erosion.

***A*, Axial plain MR image, 500/30, shows mass in left temporal bone and posterior fossa extending across midline. Large veins (*arrows*) are seen on surface of tumor.**

***B*, Nonenhanced FLASH (fast scan) image, 30/12, 40° flip angle.**

***C*, Gd-DTPA–enhanced FLASH image, 30/12, 40° flip angle, shows marked enhancement of tumor. Extent into infratemporal fossa (*short arrow*) and parotid area (*long arrow*) is appreciated.**

***D*, Coronal Gd-DTPA image, 500/28, shows displacement of brainstem, bony erosion from large enhanced mass, and parotid involvement.**

The T1-weighted sequence (500/30) was carried out after completion of the fast imaging technique. Enhancement with Gd-DTPA increased the signal intensity to 205% in tumor tissue, 132% in muscles, and 119% in fatty tissue. In 16 patients with glomus jugulare or glomus tympanicum tumors this led to significant additional information; only in three patients with very large tumors were no additional facts discovered (Table 1).

In analyzing the results of MR and CT, diagnostic reliability, completeness of the topographic description, and histologic diagnosis were compared. MR was superior in 13 patients with paragangliomas and equal to CT in three. Especially in tumors eroding the skull base (Figs. 1 and 2), in tumors with surrounding edema, and in very small tumors (Figs. 3 and 4), contrast-enhanced MR demonstrated its value.

Glomus Caroticum Tumors

Nonenhanced MR imaging was sufficient in six patients with glomus caroticum tumors, but information improved further after application of Gd-DTPA. Because it provided better soft-tissue contrast, MR was superior to CT. MR was able to demarcate the tumor from the carotid bifurcation as well as from surrounding structures (Fig. 5). The characteristic vascularity of the tumors could be partly seen on nonenhanced MR, but was seen better on the early postinjection

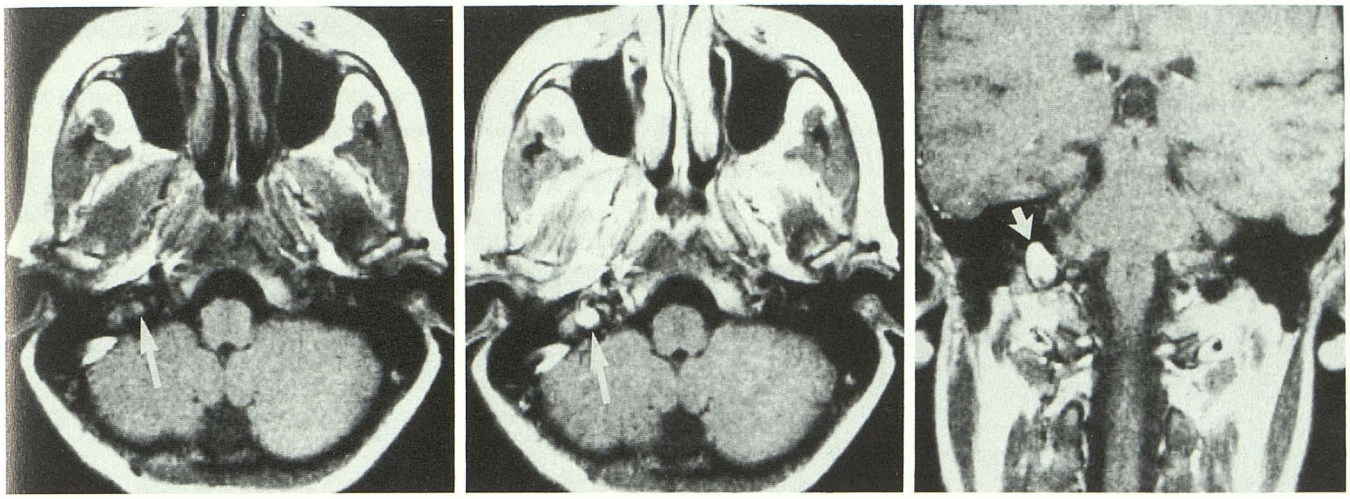

Fig. 2.—Small glomus jugulare tumor on right.
***A*, Nonenhanced axial image, 500/28, shows mass (*arrow*) in temporal bone measuring 1 × 1.5 cm in diameter. Lesion shows medium signal intensity.**
***B*, Gd-DTPA–enhanced axial image, 500/28, shows increase in signal intensity of mass (*arrow*) and optimum contrast in relation to surrounding tissues.**
***C*, Gd-DTPA–enhanced coronal image, 500/28, shows hyperintense mass (*arrow*).**

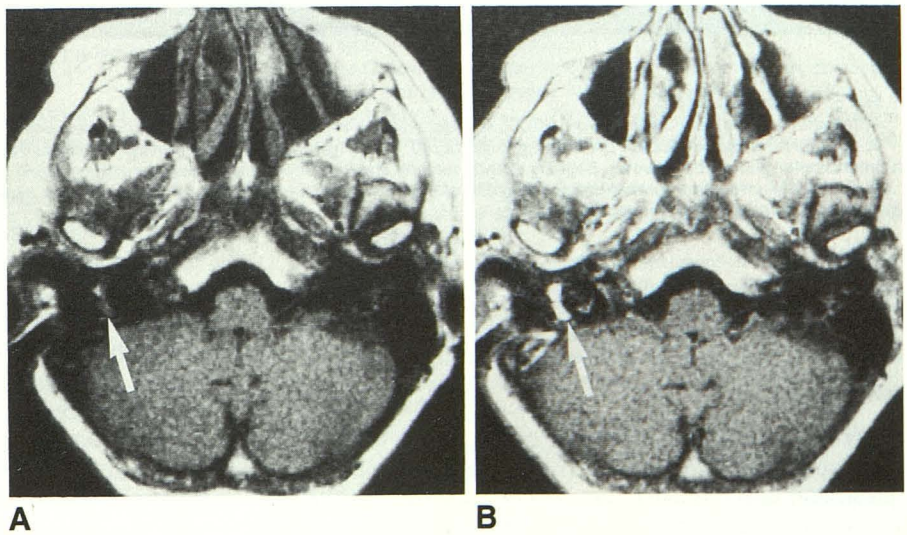

Fig. 3.—Recurrent tumor of glomus tympanicum after radiation therapy.
***A*, Nonenhanced axial image, 500/28, shows very small lesion (*arrow*) of intermediate signal intensity in mesotympanum.**
***B*, Gd-DTPA–enhanced axial image, 500/28, shows marked increase in signal intensity in glomus tympanicum tumor (*arrow*), which measures 11 × 3 mm.**

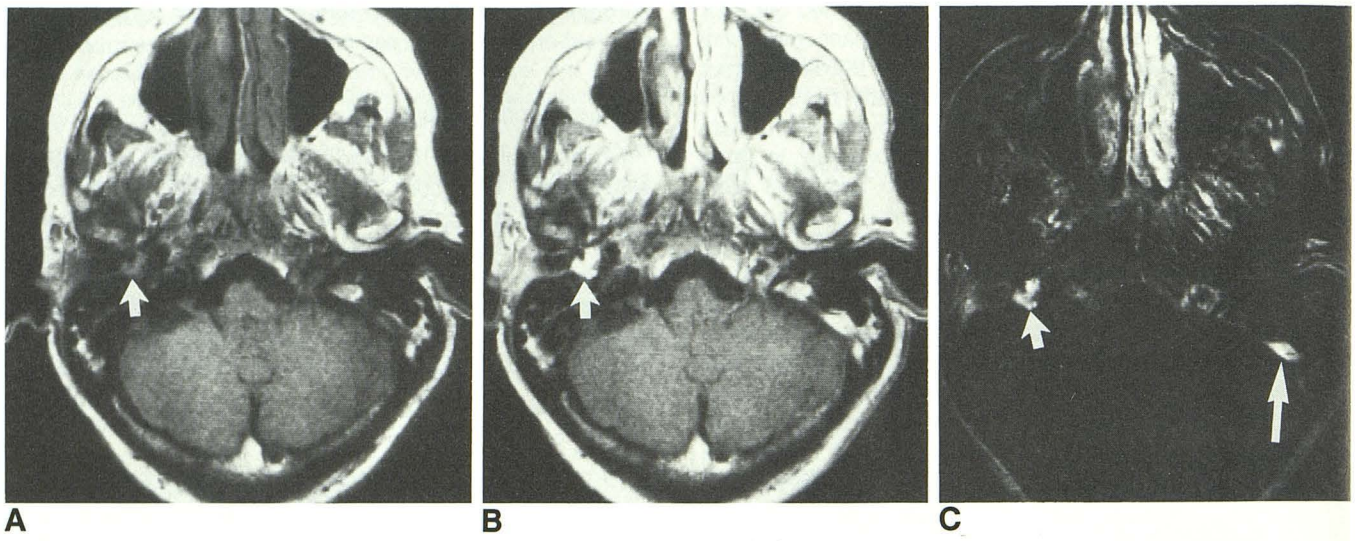

Fig. 4.—Glomus tympanicum tumor on right side.
A, Nonenhanced axial image, 500/28. Medial end of external auditory canal is obstructed by tumor (*arrow*) growing from middle ear.
B, Gd-DTPA–enhanced axial image, 500/28, shows marked enhancement of tumor (*arrow*).
C, Image obtained after subtracting *A* from *B*. Enhanced structures are glomus tympanicum tumor (*short arrow*), transverse sinus (*long arrow*), and nasal mucosa and turbinates.

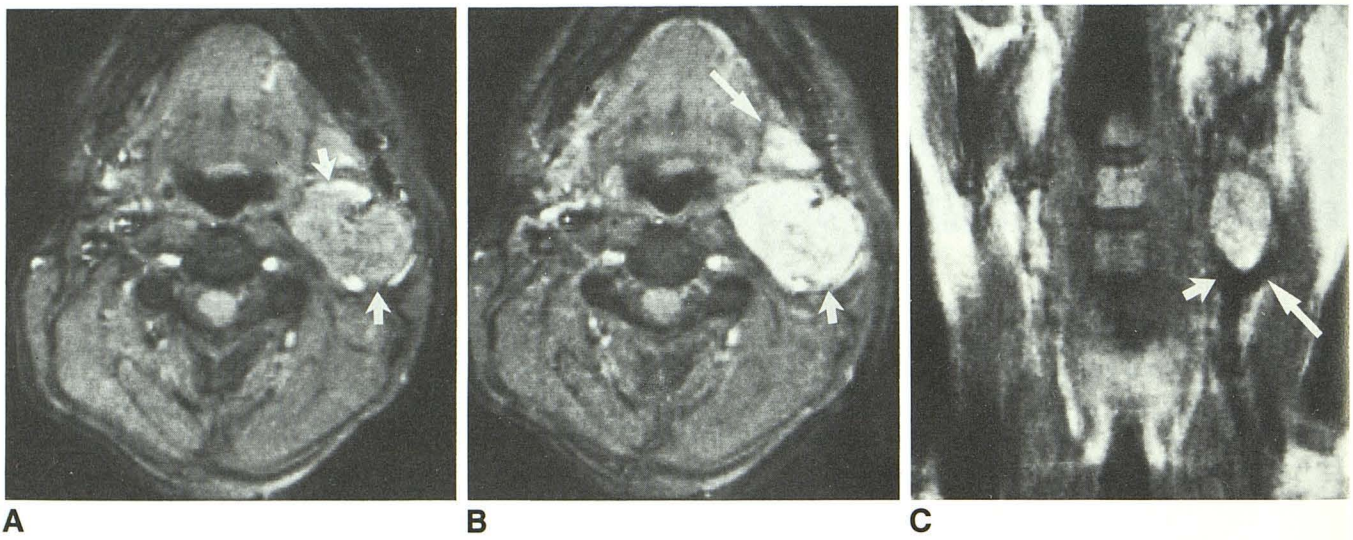

Fig. 5.—Glomus caroticum tumor.
A, Nonenhanced axial FLASH image, 30/12, 40° flip angle, shows large mass of heterogeneous intensity in carotid sheath (*arrows*).
B, Gd-DTPA–enhanced axial FLASH image, 30/12, 40° flip angle, shows homogeneous increase in signal intensity in glomus tumor (*short arrow*) and submandibular gland (*long arrow*). Salivary glands usually show marked enhancement.
C, Gd-DTPA–enhanced coronal image, 1600/30, provides optimum localization of tumor. Inferior aspect of mass is delineated by external (*long arrow*) and internal (*short arrow*) carotid artery.

sequences of the fast imaging technique. The signal/time pattern in one case is shown in Figure 6.

Discussion

Glomus tumors arise from paraganglia, which exist in various places in the human body. The precapillary arteriovenous shunts and nonchromaffin cells are characteristic of the histologic appearance of these tumors. Although glomus tissue is found in different locations in the body, the histology and functions are the same [1, 5–7]. In the literature these tumors are called either chemodectomas, paragangliomas, or glomus tumors. Characteristic signs are their slow progression and the mostly benign, nonmetastatic growth. We did not find metastatic spread in our patients, but it is described in the literature [7, 8].

CT with thin slices and contrast enhancement so far has been the method of choice to diagnose glomus tumors and

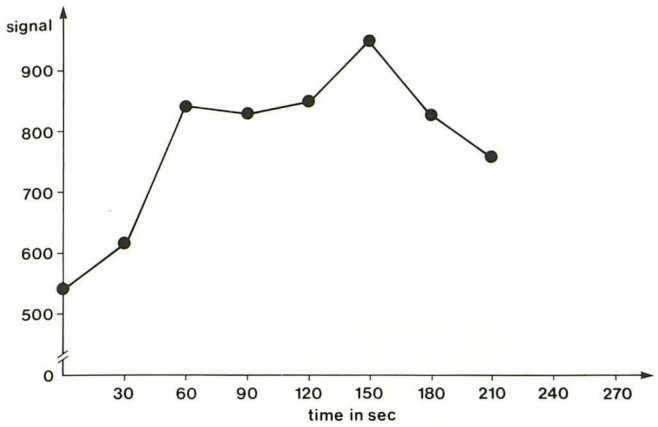

Fig. 6.—Enhancement/time profile typical of glomus caroticum tumor. Signal intensity was measured every 30 sec.

their growth in the skull base. Before the introduction of CT the preoperative diagnosis of glomus tumors was based on selective angiography [5, 7].

Coronal CT scanning is desirable and is recommended by various authors [1, 3, 5, 9–11]. Contrary to the findings of Larson et al. [1], our CT investigations with a high-resolution technique have yielded lower sensitivity and also lower specificity. The diagnosis of small tumors, especially those found at the glomus tympanicum without bone erosion, proved to be difficult, especially the differentiation from inflammatory changes.

MR as a new imaging tool shows some advantages for the diagnosis of lesions in the skull base and surrounding structures. In comparison with CT, MR provides superb soft-tissue contrast as well as soft-tissue/bone differentiation [12, 13]. This and the flow phenomenon are two reasons for the superiority of MR.

Generally, in the conventional spin-echo techniques, flowing blood has a low signal intensity; therefore, the lumina of vessels are easily distinguished from surrounding tissue [13, 14]. By using thin slices and individually adapted head or surface coils with a high signal-to-noise ratio, the carotid artery and the jugular bulb and vein are easily identified on nonenhanced MR. MR enables demonstration of even smaller vessels within the tumor [12].

The advantages of noninvasive investigation are forfeited when the contrast medium Gd-DTPA is used; however, MR with Gd-DTPA is considerably less invasive than angiography. The paramagnetic contrast medium helps to differentiate inflammatory lesions from tumors in the tympanum and mastoid. In our series, inflammatory lesions showed a significantly lower enhancement by Gd-DTPA than tumors did. Even more important is the use of Gd-DTPA for detecting tumors of the glomus jugulare and tympanicum with a diameter of 5 mm or less.

As in dynamic CT, it is possible to measure an enhancement/time pattern with the fast imaging technique. Short exposure sequences (gradient-echo sequences) repeated in a standardized pattern allow measurement of the degree of enhancement as well as its time dependence. Typically, paragangliomas show a take-up immediately after injection of the paramagnetic contrast medium, and a gradual decrease until the end of measurement at 7 min. Peak enhancement is reached after approximately 150 sec. This enhancement/time pattern with the washout effect helps to differentiate paragangliomas from meningiomas and neuromas.

MR of the glomus caroticum offers the same advantages described for skull-base glomus tumors. However, because these lesions may be difficult to detect clinically, an imaging study is of particular importance. The possibility of multiplanar imaging and the high soft-tissue contrast make MR the primary diagnostic tool when a carotid body tumor is suspected [15]. MR is able to define the position of the common, external, and internal carotid arteries. Carotid body tumors 5 mm in diameter can be identified by MR, while CT examination with iodine contrast medium only allows detection of carotid glomus tumors greater than 8 mm in diameter.

In conclusion, our experience has shown the advantages of MR in patients with suspected carotid, tympanic, and jugular paragangliomas. For the detection of glomus tumors in the head and neck area, the use of contrast-enhanced MR including short sequences and a dynamic imaging approach is recommended.

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