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Normal Contrast Enhancement of Extraocular Muscles: Fat-Suppressed MR Findings

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PURPOSE: To evaluate contrast enhancement of normal extraocular muscles in the orbit. **METHODS:** Noncontrast and contrast-enhanced T1-weighted images of the orbit were acquired using a fat-suppression MR technique in eight patients with no orbital disease. Contrast enhancement of 64 extraocular muscles was evaluated and compared with that of 16 temporal muscles. **RESULTS:** Compared with temporal muscles, all extraocular muscles markedly enhanced after administration of contrast material. **CONCLUSIONS:** Because normal extraocular muscles enhanced markedly with contrast material, more attention should be paid to these muscles when using contrast-enhanced, fat-suppressed T1-weighted MR imaging to evaluate pathologic conditions.

Index terms: Orbits, magnetic resonance; Fat, magnetic resonance; Muscles, magnetic resonance

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Extraocular muscles are involved in hyperthyroidism, sarcoidosis, inflammatory pseudotumor, and benign and malignant tumors, all of which are evaluated with the use of computed tomography and magnetic resonance (MR) imaging (1–7). Since these pathologic conditions in the orbit usually enhance after injection of contrast material and exhibit a high signal intensity similar to that of fat, a fat-suppression technique is useful for emphasizing the enhancing pathologic tissues bordered by the orbital fat tissue (4, 5, 8). The purpose of this study was to assess contrast enhancement of normal extraocular muscles in the orbit using fat-suppressed T1-weighted MR imaging.

Subjects and Methods

We obtained MR images of normal orbits of eight subjects (three men and five women) ranging in age from 25 to 66 years (average, 50 years). This group consisted of three patients with cerebral infarctions, three patients with postoperative brain tumors (Rathke's cyst, glioblastoma multiforme, and chemodectoma), and two patients with brain tumors (suspected prolactinoma and meningioma).

MR studies were performed on a 1.5-T unit with a quadranture head coil. Coronal T1-weighted images with fat suppression were acquired using the following parameters: 300/16/0.75–1 (repetition time/echo time/excitations), 256 × 192–256 matrix, a 21- to 24-cm field of view, and a 5-mm section thickness with a 2.5-mm gap. The acquisition time was 1 minute, 4 seconds. Fat suppression was obtained by using the chemical-shift selective saturation method developed by Haase et al (9). Contrast-enhanced MR images were obtained immediately after administration of 0.2 mL/kg gadopentetate dimeglumine. The imaging setting—such as sequence parameters, transmit and receive attenuation, pixel size, section position, scale factor, and window width and level—were all identical before and after administration of contrast material.

Contrast enhancement of extraocular muscles in the orbit was assessed by two reviewers, and agreement was reached by consensus. Since noncontrast, fat-suppressed T1-weighted images failed to delineate the accurate margins of the extraocular muscles, the signal intensity quantitation of these muscles was not available for this study. Instead, a three-step grading system was used to evaluate contrast enhancement of extraocular muscles: grade 0, muscle showed no definite enhancement; grade 1, between grades 0 and 2; grade 2, muscle enhanced as markedly as nasal mucosa. Noncontrast and contrast-enhanced fat-suppressed T1-weighted images of the extraocular muscles were studied, and the extent of contrast enhancement was evaluated according to this sys-

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tem. For comparison, temporal muscles were also assessed by means of this grading system.

Results

Inferior rectus and inferior oblique muscles were excluded from this study, since a magnetic inhomogeneity artifact from the maxillary sinus was found on the orbital floor (Fig 1A and B). Thus, 64 extraocular muscles (ie, medial rectus, lateral rectus, superior oblique, and superior rectus in both orbits in eight subjects) were analyzed together with 16 temporal muscles in the same subjects.

The extraocular muscles enhanced markedly after injection of contrast material in all cases, whereas temporal muscles exhibited no or slight enhancement (Fig 1C and D). On the basis of the grading system described above, the extraocular muscles had an average score of 1.95 (±0.27), whereas temporal muscles had an average score of 0.438 (±0.128) (Table). The scores of contrast enhancement of extraocular muscles were significantly higher than those of temporal muscles using the unpaired Student's *t* test ($P < .001$).

Discussion

The advantages of MR imaging for investigating the orbit include multiplanar capability, excellent soft-tissue contrast, and lack of ionizing radiation (1, 2). Conventional T1-weighted images detect the lesions in the orbit but cannot be used for their diagnosis, since most lesions are isointense with muscle (1, 2, 5). Images obtained with the fat-suppression technique are useful for depicting pathologic tissues in the head and neck region, since these lesions often show high intensity similar to that of adjacent fat on fast spin-echo T2-weighted and contrast-enhanced T1-weighted images (1, 4, 5, 10). In

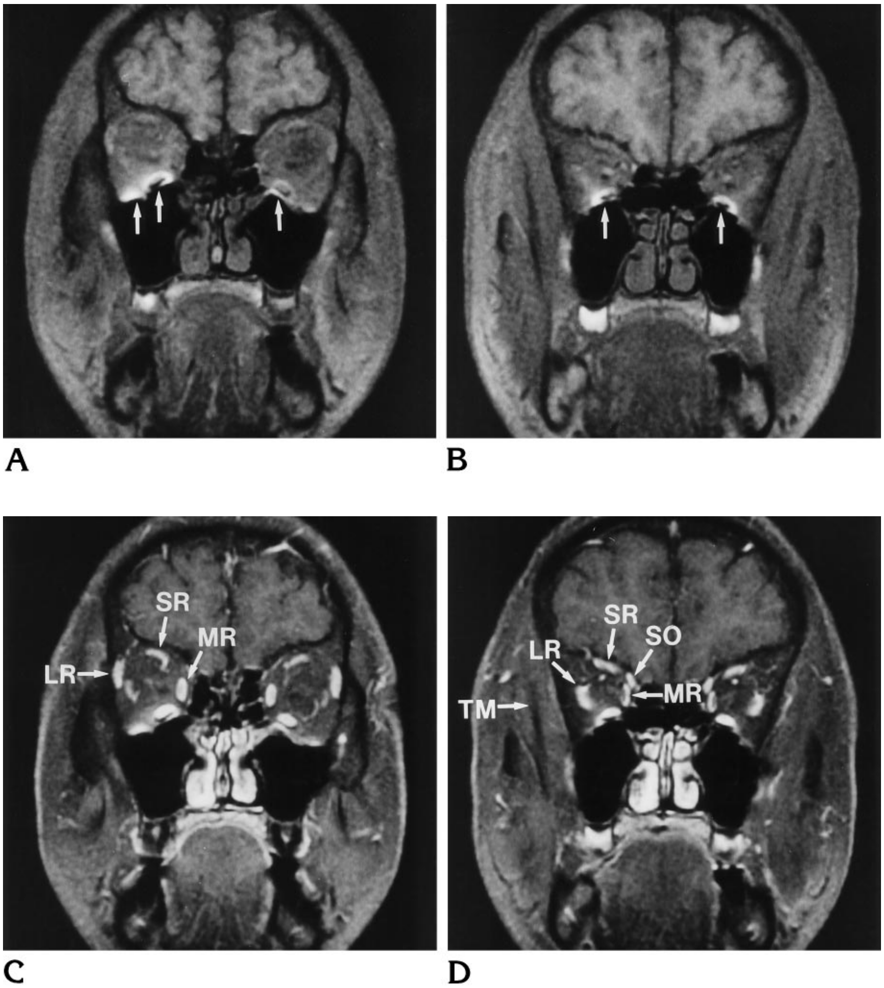

Fig 1. Case 4: 50-year-old man with cerebral infarction.

A and *B*, Noncontrast fat-suppressed T1-weighted images fail to depict the margins of extraocular muscles. A magnetic inhomogeneity artifact from the maxillary sinus is observed on the orbital floor (*arrow*).

C and *D*, Contrast-enhanced, fat-suppressed T1-weighted images show marked enhancement of the superior rectus (*SR*), superior oblique (*SO*), medial rectus (*MR*), and lateral rectus (*LR*) muscles (grade 2). Temporal muscles (*TM*) show no definite enhancement (grade 0). The sections in *C* and *D* are identical to those in *A* and *B*, respectively.

Evaluation of contrast enhancement of extraocular muscles

Disease	Patient	Extraocular Muscles								Temporal Muscle	
	Age, y/Sex	R SR	L SR	R SO	L SO	R MR	L MR	R LR	L LR	L	R
Rathke cyst, po	25/F	2	1	2	2	2	2	2	2	0	0
Glioblastoma, po	26/F	2	2	2	2	2	2	2	2	0	0
Prolactinoma, su	47/F	2	2	2	2	2	2	2	2	0	0
Cerebral infarct	50/M	2	2	2	2	2	2	2	2	0	0
Cerebral infarct	59/M	2	2	2	2	2	2	2	2	1	1
Chemodectoma, po	62/F	2	2	2	2	2	2	2	2	0	1
Cerebral infarct	63/M	2	2	2	1	2	2	2	1	1	1
Meningioma, su	66/F	2	2	2	2	2	2	2	2	1	1
Average score		1.95 ± 0.27								0.438 ± 0.128	

Note.—Po indicates postoperative; su, suspected; SR, superior rectus muscle; SO, superior oblique muscle; MR, medial rectus muscle; and LR, lateral rectus muscle. Grading system: 0, no enhancement; 1, between 0 and 2; 2, enhancement like nasal mucosa. The average score of extraocular muscles (1.95) is significantly higher than that of temporal muscles (0.438) at $P < .001$ using the unpaired Student's t test.

addition, contrast-enhanced, fat-suppressed T1-weighted images are of great value for demonstrating the margins, vascularity, and necrosis of inflammatory and tumoral processes in the orbit (4, 5). Although such lesions as hyperthyroidism, sarcoidosis, inflammatory pseudotumor, and metastatic carcinomas occasionally involve extraocular muscles (1, 2, 5–7), the normal contrast enhancement of extraocular muscles has not been discussed in detail.

This study confirmed the marked contrast enhancement of normal extraocular muscles. Although Jackson et al (6) reported that conventional T1-weighted images do not show enhancement of these muscles, no quantitative analysis was performed in their study. Our results suggest that the contrast enhancement of extraocular muscles was less obvious because of the high signal of the contiguous fat on conventional T1-weighted images, that the fat-suppression technique emphasized this enhancement, and that these muscles definitely enhanced as compared with temporal muscles in the same sections. The causes of contrast enhancement of extraocular muscles were not investigated in this study. Woodlief (11) using electron microscopy, demonstrated the appearance of large arteries and bundles of capillaries in the extraocular muscles. This finding is consistent with the rich blood supply to the muscles. Our results also suggest high blood flow to extraocular muscles, perhaps relating to the rapid and frequent contraction of the muscles associated with eye movements.

Our findings should encourage further study of the differences in enhancement between normal and pathologic extraocular muscles. To detect abnormalities and enlargement of the extraocular muscles, contrast-enhanced conventional T1-weighted images and measurements of T2 relaxation times of muscles are also needed (1–3, 6). Our results also showed that the magnetic inhomogeneity artifact that accompanies the fat-suppression technique (10) obscures the inferior rectus and inferior oblique muscles, which are often involved by hyperthyroidism (3).

In conclusion, normal extraocular muscles showed enhancement on contrast-enhanced, fat-suppressed T1-weighted MR images. Pulse sequences must be carefully optimized when investigating orbital pathologic lesions involving the extraocular muscles.

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