Prominent Dural Enhancement Adjacent to Nonmeningiomatous Malignant Lesions on Contrast-Enhanced MR Images

Prominent dural enhancement was noted in 10 (16%) of 61 superficial malignant intracranial tumors studied with contrast-enhanced MR imaging during a 2-year period. Included were six glioblastomas, three parenchymal metastases, and one case of dural metastasis. Seven patients had surgery. In four, there was extensive leptomeningeal invasion in the center of the lesion. In two of these lesions there was firm attachment of the center of the tumor to the dura, but without dural invasion despite extensive external carotid artery supply to the tumor in one case. In two cases the overlying dura was normal, and there was no leptomeningeal tumoral invasion. In the case of dural metastasis, huge nodular lesions were present along the inner aspect of the dura. In none of the cases did prominent dural enhancement adjacent to the tumor correspond with tumoral invasion or extension to the dura.

Prominent dural enhancement on contrast-enhanced MR images appears to be much less frequent in malignant tumor than in meningioma, where it is seen in up to 60% of the cases. We believe this finding is more likely to represent reactive changes of the dura than tumoral invasion.

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Prominent dural enhancement with tail-like thickening of the dura adjacent to meningioma on contrast-enhanced MR images has received considerable attention in the recent neuroradiologic literature [1-4]. The sign has been considered a highly specific feature of meningiomas [3, 4]. We describe prominent dural enhancement adjacent to nine malignant nonmeningiomatous lesions and one dural metastasis.

Materials and Methods

In a retrospective study, we reviewed 306 malignant tumoral lesions, either metastases or malignant gliomas, studied by contrast-enhanced MR imaging between July 1988 and October 1990. Of these, 36 glioblastomas and 25 metastatic lesions were superficially located and showed a broad-based attachment to the dural surface.

MR was performed on a superconductive system operating at 1.5 T (Siemens, Magnetom). Axial T1-weighted, 600–800/15–22/2 (TR/TE/excitations), and T2-weighted (2500–3000/90) images and coronal and sagittal T1-weighted images were acquired after IV injection of gadopentetate dimeglumine (Magnevist, Schering, Germany) or Gd-DOTA (Dotarem, Guerbet, France) at a dose of 0.1 mmol/kg.

All studies were reviewed for the presence of prominent dural enhancement adjacent to the tumors, with evidence of dural tail or flare sign by three independent observers. The presence of prominent dural enhancement was diagnosed as proposed by Aoki et al. [4]:

1. linear enhancement was present along the dura mater originating from and extending outward from the tumor margin
2. enhancement was greater than elsewhere along the dura
3. findings were present in two different imaging planes
4. there was agreement among three observers.
The malignant tumors showing prominent dural enhancement included six glioblastomas, three metastatic lesions (a bronchial carcinoma, a mediastinal adenocarcinoma, and a carcinoma of unknown primary site), and one dural metastasis from a nasopharyngeal carcinoma.

The MR findings were compared with the surgical and anatomopathologic findings, which were available in seven cases.

Results

Prominent dural enhancement adjacent to a malignant tumor was found in 10 of the 306 cases examined. This accounts for 3% of all lesions, or 16% of the tumors adjacent to the surface of the brain. In five cases this dural enhancement tapered away from the tumor in a dural tail-like manner. In the five others, the transition between the tumor and the enhancing dura was abrupt.

Surgical confirmation of the nature of the lesion was available in five glioblastomas, one parenchymal metastasis, and the dural metastasis. In the three cases without surgical confirmation, proof of the malignant nature of the lesion was provided by the clinical evolution: death followed MR diagnosis at 1, 3, and 5 months, respectively. In one case of metastasis, additional proof of the nonmeningiomatous nature of the lesion was provided by the absence of a lesion on MR, performed 6 months earlier.

At surgery, the overlying dura appeared normal in two of seven cases without evidence of invasion of dura or leptomeninges. In the case of dural metastases, at surgery huge nodular lesions were present at the inner aspect of the dura with tail-like extension to the surrounding dura. No further surgery was performed in this patient because of the poor prognosis (Fig. 1).

In two patients, at surgery the tumor abutted the dura, resembling meningioma. In one of these patients, an emergency biopsy during surgery pointed to meningioma. Final anatomopathologic diagnosis was glioblastoma with leptomeningeal but no dural invasion (Fig. 2).

In the other patient, at surgery and anatomopathologic examination the glioblastoma showed extensive leptomeningeal invasion and was adherent to the dura mater, but did not invade it. In the vicinity of the tumor, the dura was normal without any evidence of tumoral extension. In this patient there was definite external carotid artery supply to the tumor from the middle meningeal artery (Fig. 3). Anatomopathologic examination showed normal dura (Figs. 3C and 3D).

In the remaining two patients (one case of glioblastoma and one of metastasis), the tumor at surgery was not adherent to the dura, and the overlying dura showed no macro- or microscopic changes. In both these cases there was extensive leptomeningeal invasion by the tumor (Figs. 4 and 5). In all cases, the dura in the vicinity of the tumor appeared normal.

Discussion

Prominent dural enhancement adjacent to meningioma on contrast-enhanced MR images has been noted by several authors in the recent neuroradiologic literature [1-4] and was called dural thickening [1], dural tail [3], or flare sign [4]. In meningioma, this thickened, enhanced dura mater mostly tapers away from the tumor mass like a tail.

We reported that this thickened dura corresponded to direct tumoral extension [1], while others found meningothelial nodules in the samples taken from the enhanced dura around the tumor [3]. Therefore, in these cases the dural tail might be essential for surgical planning to prevent or reduce regional recurrences of meningiomas [1, 3]. However, in the majority of the cases, the dura is enhanced far beyond the neoplastic infiltration or shows no tumoral extension at all, so that the pathologic enhancement of dura adjacent to meningioma after administration of contrast material could represent reaction to the meningioma [2-4], although these changes are not seen on pathologic specimens.

In our preliminary report about dural thickening in meningioma [1], we suggested that this sign might distinguish atypical meningiomas from other lesions. Goldsher et al. [3] described this dural tail in up to 60% of cranial meningiomas. In order to assess the differential diagnostic value of this finding, they examined 17 superficially located gliomas and 17 metastatic lesions that abutted the dural surface. In their series, these cases of superficial tumors failed to show dural enhancement, although in one case of glioma a linear enhancing structure
was seen in one plane in one section. In our retrospective review of malignant intracranial tumors we demonstrated dural enhancement in one case of dural metastasis, six glioblastomas, and three metastases. The reason for the discrepancy between the findings of Goldsher et al. and ours is not clear. It cannot be determined how many of the patients with superficial malignant tumors in their series were examined on the 0.5-T system, but spatial resolution might definitely play a role.

In five cases this dural enhancement could not be differentiated from the dural tail seen in meningiomas. In the case of dural metastasis, this finding is not surprising, since the lesions were based on the inner surface of the dura and tapered out toward normal dura. One of the other cases of metastasis of mediastinal adenocarcinoma (Fig. 6) might in part have represented dural metastasis.

In five of our cases that were surgically proved, there was extensive invasion of the leptomeninges. Therefore, the enhancement of pathologic or tumoral tissue within the invaded leptomeninges might be responsible for the abnormal enhancement along the dura. In two cases the lesion was firmly attached to the dura. These features of superficial glioblastomas are well known by pathologists [5]. Superficially placed glioblastomas are known to penetrate the adjacent meninges with a high rate of frequency and the localized infiltration of the leptomeninges is often followed by firm union to the dura. Therefore, at first inspection, glioblastoma can mimic a meningioma, as was the case in one of our patients. The fibroblastic reaction originating from the meninges can even be confusing at biopsy [5].

It is also well known by pathologists that the dura is resistant to penetration by glioblastoma, so that penetration of the lumen of the dural venous sinuses or of bone is exceptional [5]. In our series, despite extensive leptomeningeal invasion in five cases, with firm attachment to the dura in two cases, there was no invasion of the dura; rather, the tumor extended to the inner surface of the dura.

Meningeal invasion is known to produce external carotid artery supply to malignant tumors, so an erroneous angiographic diagnosis of meningioma is possible [6, 7]. In one of our patients, there was extensive middle meningeal artery supply to the tumor. With the dural enhancement in the vicinity
of the tumor on contrast-enhanced MR images, this strongly suggested meningioma. Nevertheless, at anatomopathologic examination, there were no signs of dural invasion. This is in contrast to the findings of others [6, 7], who found dural invasion in all cases with angiographic evidence of meningeal blood supply.

The most important result of our study is that in none of the operated cases did the dura in the vicinity of the tumor show any sign of tumoral extension. In the most severe case of dural attachment, with external carotid artery supply to the tumor, anatomopathologic examination of the dura in the vicinity of the tumor showed no signs of invasion. While we have not documented it by pathologic examination, prominent dural enhancement adjacent to malignant lesions may represent reactive changes of the dura rather than tumoral invasion.

REFERENCES
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