Digital Rotational Radiography in Neuroradiology

M. Schumacher,[1] K. Kutluk, and D. Ott

Different angiographic techniques (e.g., multiple oblique views, angiotomography, and magnification angiography) have been proposed to improve the diagnosis of cerebral vascular malformations and occlusive diseases. However, these methods are either time-consuming or necessitate repeated injections of contrast medium. The common goals of all these techniques are (1) to achieve a documentation of the lesion, free of other superimposing structures, and (2) to provide a three-dimensional image of the lesion. Cornelis et al. [1] first proposed an angiographic rotation technique to overcome these problems. Later, Voigt et al. [2] and Thron and Voigt [3] introduced it into clinical use. In these studies, however, difficulties in exposure time were not solved and subtraction films were not available. This article reports a new technique with improved DSA equipment [4], which allows exact automatic exposure control of two pictures per second, subtraction technique, and applicability to myelography.

Subjects and Methods

Between April 1986 and January 1988, 36 patients were examined. Diseases studied included vascular stenoses, aneurysms of the supraaortic and cerebral vessels, and arteriovenous malformations (AVMs). In one patient with postoperative meningocele, rotational myelography revealed details not apparent on conventional myelography.

In all cases, the tube-camera unit* was rotated 70° around the isocentrically placed region of interest within about 10 sec. The posteroanterior and lateral views were not taken, as they were shown by the initial routine angiography. During the maneuver, a film speed of two pictures/sec was found to be sufficient. Exposure time was 340 msec/image, with a dose rate of 400 μR/image. Evaluations with three exposures/sec did not yield better results. The rotation around the 70° sector was short enough to allow the contrast volume to be kept to the acceptable amount of 13 ml. This resulted in an injection velocity that provided continuous arterial contrast filling. In the beginning of our study, only nonsubtracted films were available (Figs. 1 and 2). Later, a modified technique was used: after a 70° rotational series from posteroanterior to lateral, the moving direction was immediately reversed and contrast medium was injected. The data of the initial rotational series were taken as individual subtraction masks in order to provide good subtraction pictures (Fig. 3). Using the same exposure time, there was no increase in signal/noise ratio. In some cases pixel shifting was necessary to optimize the subtraction. To estimate the effect of motion, resolution value was measured by a 50 μm Pb-plate consisting of 0.6–5 line pairs/mm. The plate was isocentrically placed. Measurement was performed with a two-image/sec rate. Resolution under static conditions was 1.2 line pairs/mm, whereas the value decreased to 1.0 line pairs/mm because of motion during rotation. A faster rotation speed of the angioscope is now available (upgrade version of Angioskop), enabling the contrast medium to be restricted to 10 ml and to rotate through an 80° sector.

Results and Discussion

Cornelis et al. [1] first described a method of examining intracranial aneurysms by rotational multiple sequence radiography with a 70-mm camera rotated at high speed through 90° or 180° at four films/sec and with injection of 12 ml of contrast medium. Twenty films were usually obtained with an angle difference of about 5° between each, making them suitable for stereoscopy. Voigt and co-workers [2] performed a rotational cerebral radiographic technique with a 70-mm camera in model studies of the plain skull and cerebrovascular system. Their aim was to assess the various diagnostic possibilities of a radiographic technique in which all required special projections were obtained not by the usual positional changes of the patient's head, but by the rotation of a roentgen tube around a centered target. They examined intracranial calcifications, foreign bodies, and abnormalities of the calvaria with an exposure frequency of six/sec.

The superior diagnostic value of this rotation technique in the visualization of arteriosclerotic lesions, aneurysms, arteriovenous angiomas, or fistulas has also been pointed out [3]. Although rotational angiography can also be helpful in identifying AVM feeders, only the first images of the scene are useful, since later ones are superimposed by veins because of the high flow.

In our study, we used the additional subtraction technique that was not possible in the previous studies described above. The use of the subtraction technique with rotational angiography combined the advantages of both methods and was of additional benefit in about 30% of the patients, compared with nonsubtracted images (Fig. 3).

* Angioskop A33 (Siemens Corp., Erlangen, W. Germany) image intensifier SIRECON 33 HN-triplex, input image 9 in.

Received April 12, 1988; accepted after revision September 13,1988.

[1]All authors: Section of Neuroradiology, University of Freiburg, Hauptstr. 5, D-7800, Freiburg, Federal Republic of Germany. Address reprint requests to M. Schumacher.

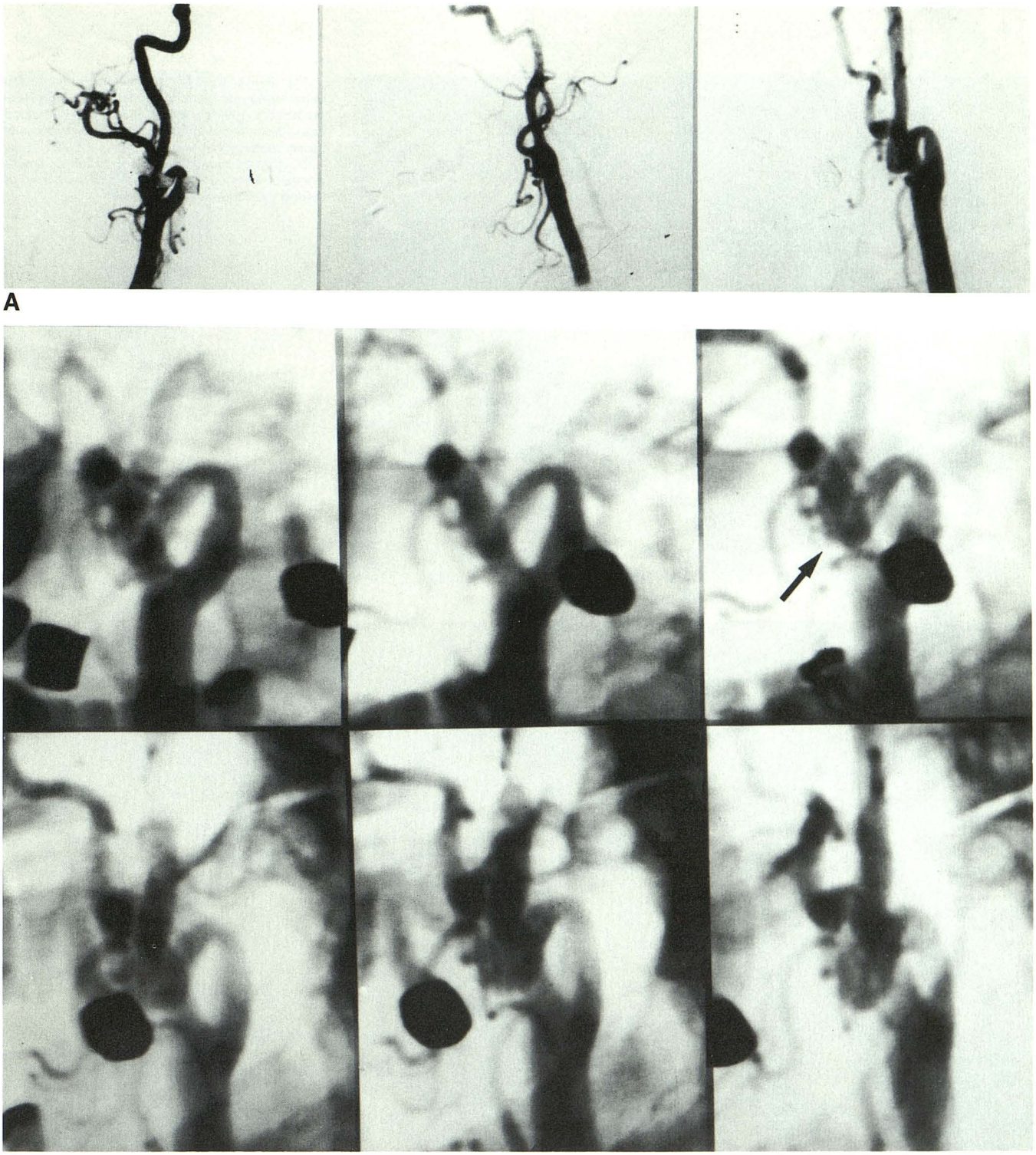
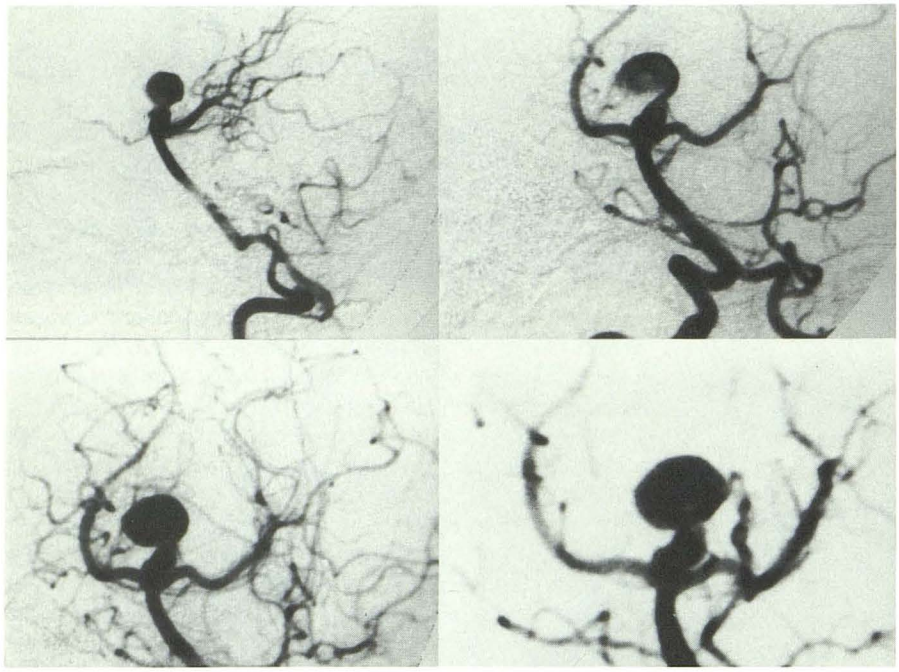
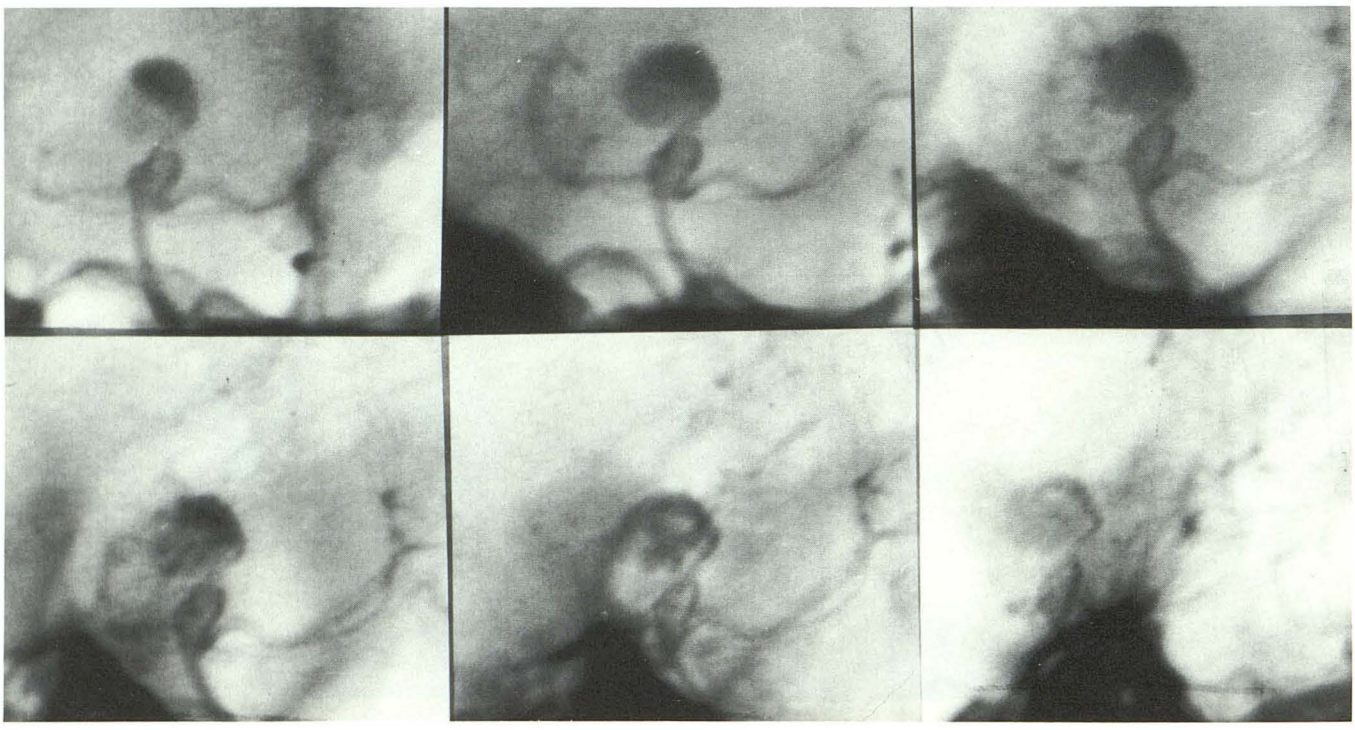


Fig. 1.—*A*, Conventional digital angiograms in different positions do not allow differentiation of vessel loop with or without stenosis. *B*, Nonsubtracted rotational angiograms show clearly the vessel loop without any stenosis (*arrow*).



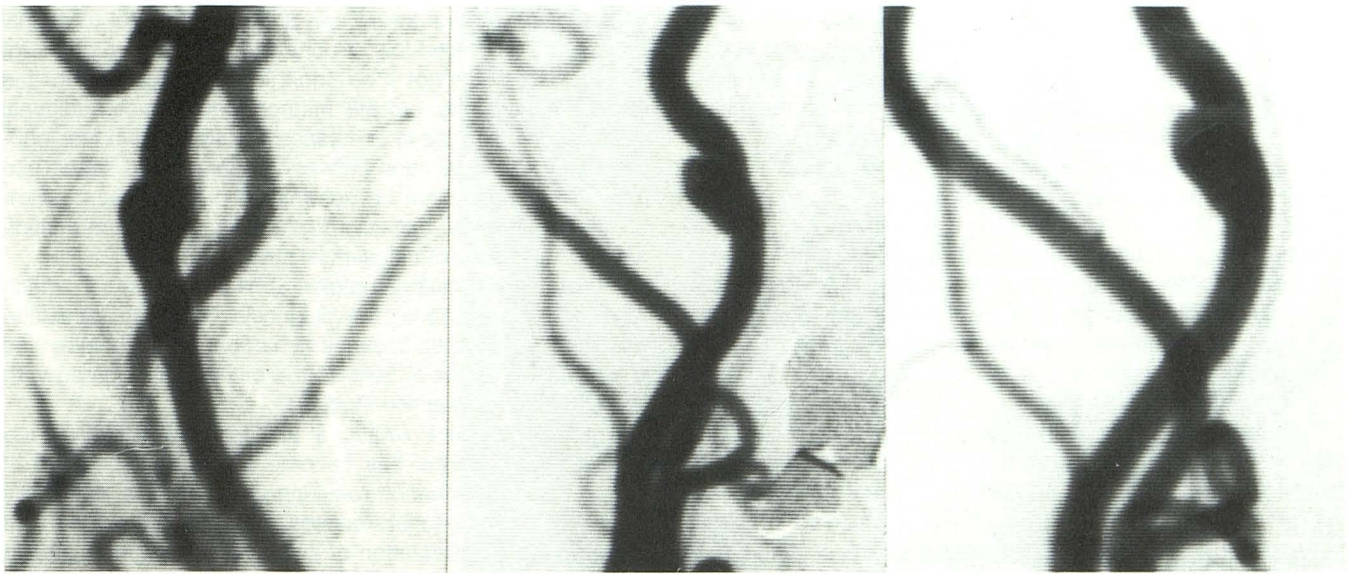
A



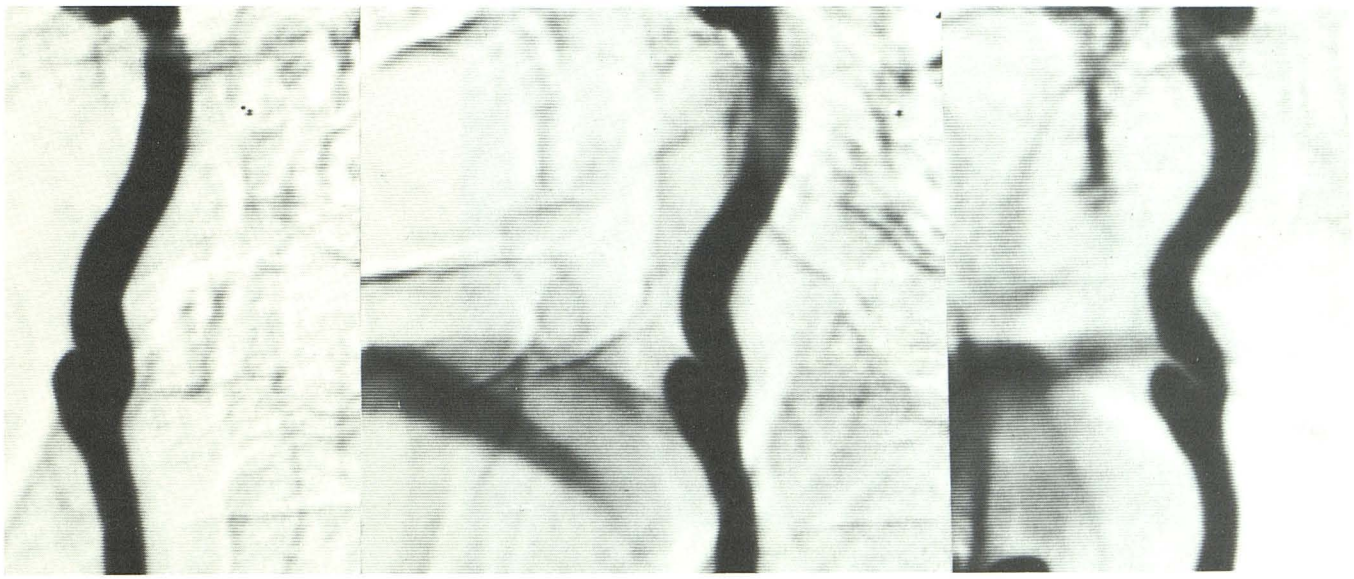
B

Fig. 2.—*A*, Conventional digital angiograms show aneurysm in top of basilar artery in several projections, giving the impression that the lesion has a large distal spherical part and a proximal broad communicating neck.

***B*, Nonsubtracted digital rotational angiograms identifying the proximal part as a loop of the left posterior cerebral artery.**



A



B

Fig. 3.—*A*, A clear differentiation between loop and dissection is not possible with conventional digital angiograms of left carotid artery, even with multiple views.

***B*, Subtracted digital rotational angiograms show lesion to be a dissection.**

The lesions demonstrated by the digital rotational technique were cerebral vascular stenoses, dissections, aneurysms, AVMs, and one postoperative meningocele. Some examples of investigations of our patients are described below.

In one of our first cases (not involving the subtraction technique), even when we used three different projections on digital carotid angiography, we could not assess what direction the coiling loop took and whether an additional stenosis existed. With the use of rotational angiography, on the other hand, we could determine that the internal carotid artery was not superimposed by other vessel loops and a narrowing of the vessel could be excluded (Fig. 1).

The rotational technique is of special value for a distinct preoperative evaluation of cerebral aneurysms; that is, to answer the surgeons' questions concerning type, origin, localization, neck direction, and neighboring vessels of the aneurysm. The initial visualization of the top of the basilar aneurysm in one patient (Fig. 2) did not provide enough information even in oblique views. Only rotational angiography showed such details as a small long neck, a long ascending loop of the left posterior cerebral artery in close contact with the neck of the aneurysm, and slight spasm of the posterior cerebral artery. These features were all confirmed by surgery.

With the modified technique described above, continuously changing projections in rotational digital subtraction images revealed more details, as shown in a case with dissection of the carotid artery, in which the normal digital subtraction angiogram gave reason to doubt whether the structure was a loop or a dissection (Fig. 3). In another patient, conventional digital angiography suggested an aneurysm of the A2 part of the anterior cerebral artery, but subtracted digital rotational angiography revealed this structure to be a vessel loop (Fig. 4). Myelography is not a common field of application for the rotational technique, but this method may provide additional details, such as it did in one case of postoperative meningocele. The communication between subarachnoid space and meningocele could not be determined precisely by conventional myelography, but was displayed in one of the multidirectional views of rotational myelography (Fig. 5).

We obtained rotational angiographs in all cases in which there was doubt about the diagnosis. Although resolution was slightly degraded because of motion, the technique was of significant benefit in 50% of the patients, compared with routine digital subtraction studies.

In our department, rotational angiography employing the subtraction technique has become a routine procedure in every diagnostic situation requiring oblique views, especially in aneurysms and arterial stenoses. No other method provides as complete a visualization of small vascular lesions after a single injection of contrast medium in one examination series.

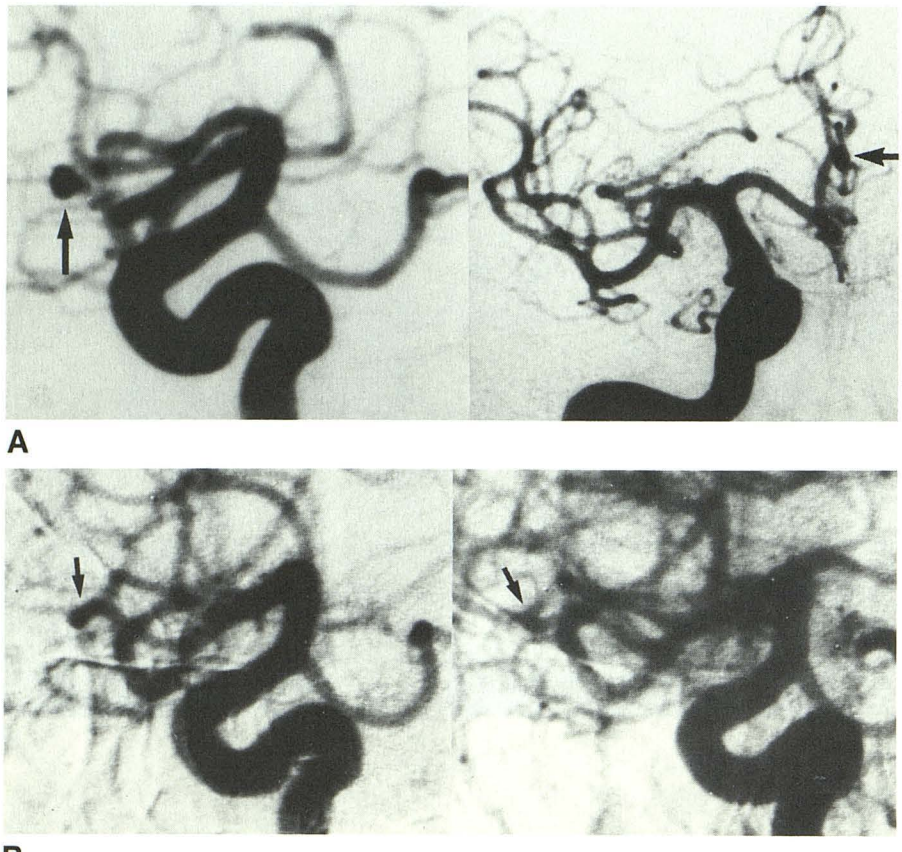


Fig. 4.—*A*, Conventional digital angiograms suggest an aneurysm of the A2 part of the anterior cerebral artery (*arrows*).
***B*, Subtracted digital rotational angiograms reveal a vessel loop (*arrows*).**

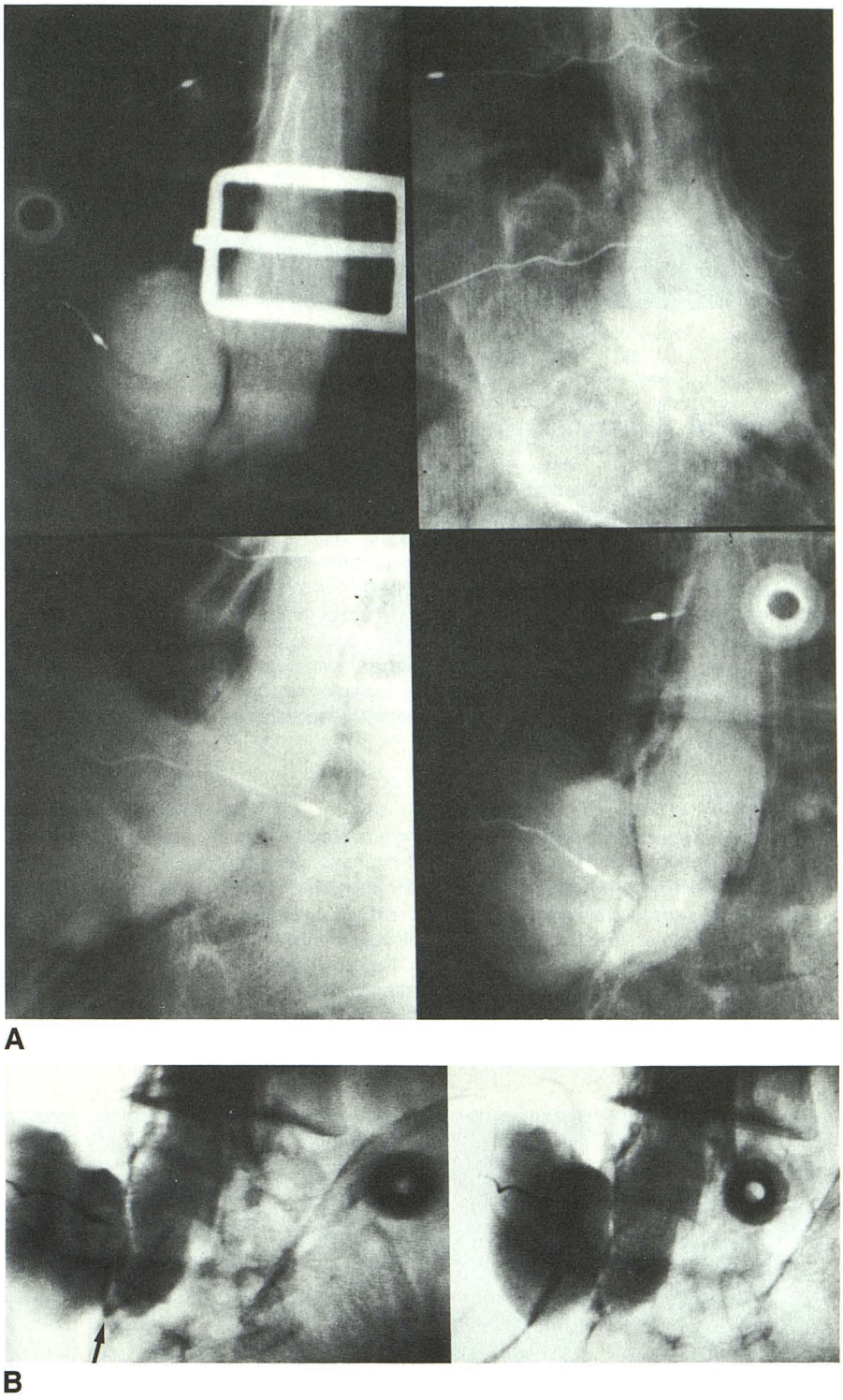


Fig. 5.—*A*, Conventional myelograms: postoperative meningocele.
***B*, Rotational myelograms show communication between dural sac and meningocele (*arrow*).**

REFERENCES

1. Cornelis G, Bellet A, Van Eygen B, Roisin PH, Libon E. Rotational multiple sequence roentgenography of intracranial aneurysms. *Acta Radiol* **1972**;13:74–76
2. Voigt K, Stoeter P, Petersen D. Rotational cerebral roentgenography. Evaluation of the technical procedure and diagnostic application with model studies. *Neuroradiology* **1975**;10:95–100
3. Thron A, Voigt K. Rotational cerebral angiography: procedure and value. *AJNR* **1983**;4:289–291
4. Schumacher M. Digital rotational angiography in cerebral vascular diseases. Presented at the VIth European Congress of Radiology, Lissabon, **1987**