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3D TOF MRA: role in evaluation of intracranial aneurysms following embolization with platinum coils

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Several patients with intracranial aneurysms at our hospital have recently been treated with embolization of the aneurysm itself with detachable platinum coils. This has been done as part of a multicenter trial of GDC platinum coils. We report our experience in the follow-up of these patients with magnetic resonance (MR) after the embolization procedure. We present several illustrative cases and discuss the information that can be gained from the spin-echo images, the magnetic resonance angiography (MRA) source data, and the maximum intensity projection (MIP) reconstructions. We also examine the relative merits and limitations of MR in this role including thrombus formation, susceptibility artifact, and estimation of size and morphology of the aneurysms. We discuss the role of MRA in the planning of the embolization procedure.

Keywords: magnetic resonance imaging, angiography, aneurysms, embolization.

CASE REPORTS

Patient 1

A 42-year-old woman presented with recurrent left-hemisphere infarcts. Digital subtraction angiogram (DSA) demonstrated a large elongated saccular aneurysm of the extracranial internal carotid artery (Fig. 1a). The neck of this aneurysm was wide. Due to the high cervical position of the lesion, the patient was referred for endovascular treatment of the aneurysm.

Two platinum coils were placed within the fundus of the aneurysm. At the end of the procedure, the aneurysm was largely occluded, but a significant neck to the lesion remained into which one loop of the platinum coil projected. An incomplete embolization was achieved as a nondetachable coil system was used and placement of a further coil would have potentially jeopardized the parent vessel. The GDC coil system was not available at the time of the procedure; however, the coil material was identical to that used for the GDC system. The internal carotid artery remained patent at the end of the procedure.

Magnetic resonance (MR) imaging was performed for assessment 20 months later. On both the MRA source data (Fig. 1b) and the maximum intensity projection (MIP) reconstructions (Fig. 1c), the neck of the aneurysm is seen to remain patent, but the distal two-thirds of the lumen had been occluded. In addition, flow in the carotid artery distal to the aneurysm was visualized. Circle of Willis magnetic resonance angiography (MRA) demonstrated the intracranial vessels to be normal.

Patient 2

This 45-year-old man presented with a subarachnoid hemorrhage from a large left middle cerebral artery aneurysm. He underwent three separate embolization procedures over the next year.

After the first embolization, spin-echo (SE) axial T_2-weighted scans showed the left middle cerebral aneurysm with a complex signal intensity pattern (Fig. 2a) with a peripheral low signal related to mural calcification, lamellated hyperintensity in keeping with subacute thrombi, and a central area of mixed but essentially low signal which could be related to the platinum GDC coil ball or a flow void.

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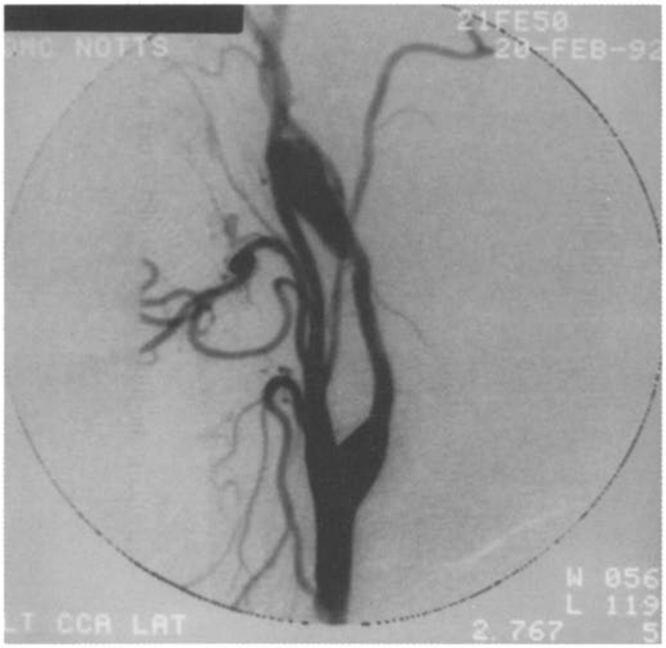
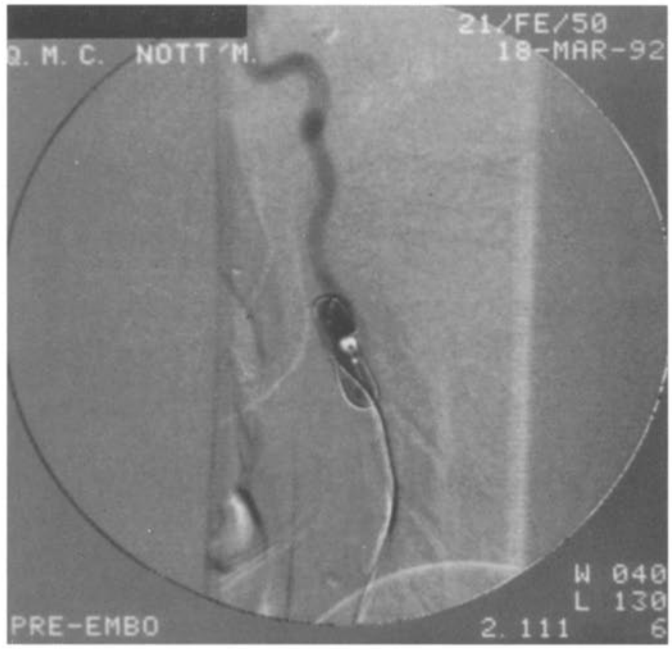


(a)



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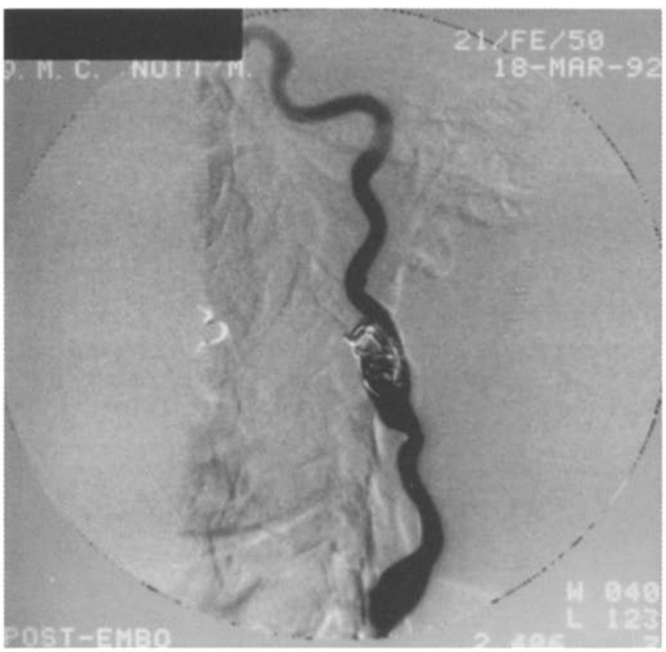


(c)

(d)

Fig. 1. A 42-year-old woman who presented with recurrent left hemisphere infarcts (Patient 1). (a) DSA demonstrates the large elongated saccular aneurysm of the extracranial internal carotid artery. (b) DSA during embolization of the aneurysm with GDC coils. (c) DSA at the end of the procedure showing occlusion of the majority of the aneurysm and patency of the distal internal carotid artery. (d) MRA source data demonstrating flow in the neck of the aneurysm.

(e)

Fig. 1. (e) MIPed reconstruction shows the neck of the aneurysm to be patent but the distal two-thirds of the lumen had been occluded. Also, flow in the carotid artery distal to the aneurysm is visualized.

MRA acquired at the same time showed flow within the residual pouch and patency of the distal vessels, although the signal was attenuated (compared to the right) due to slow flow and saturation effects.

After the second embolization, SE images demonstrated more thrombi in the aneurysm, but the aneurysm has continued to enlarge.

The third embolization further occluded the aneurysm; however, a small residual pouch was deliberately left, as M2 vessels emanated from it. There was good concordance between the MRA and conventional X-ray angiogram; however, difficulty in separating thrombi from flow in large aneurysms with MIPed MRA images was experienced in this case (Fig. 2b). High signal from methemoglobin on gradient recalled echo (GE) images is incorporated into the reconstructed MIPed images. Phase contrast angiography would be very useful in distinguishing the subacute thrombi from flow in large aneurysms.

Patient 3

This 52-year-old woman presented with a subarachnoid hemorrhage. Conventional angiography at the time demonstrated a large aneurysm at the origin of

(a)

(b)

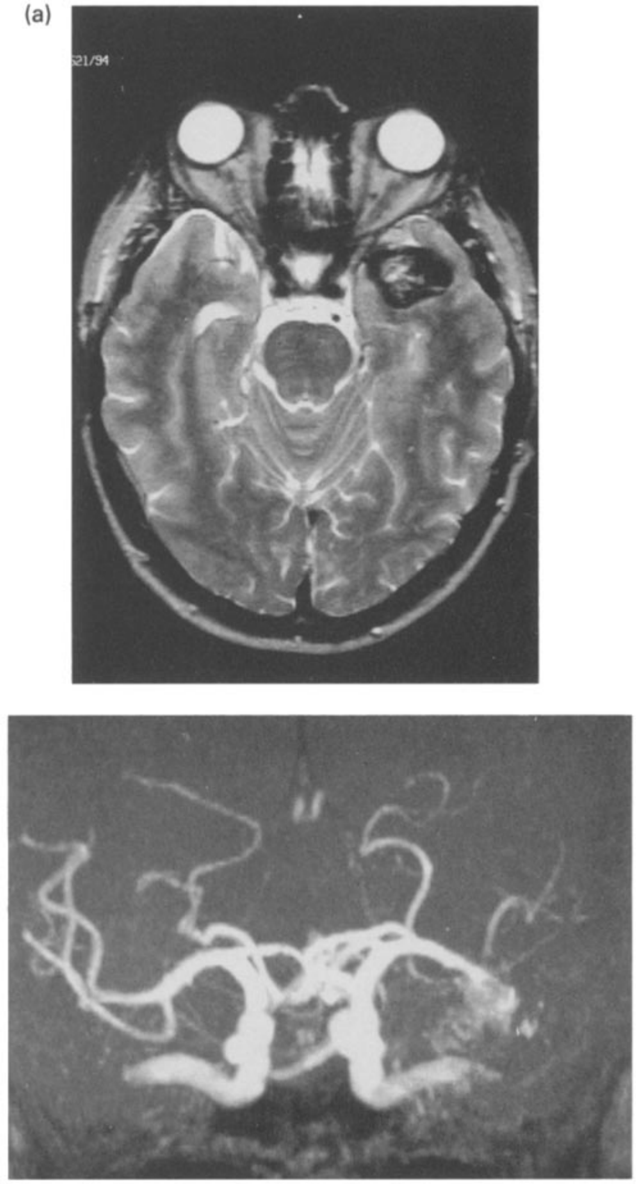


Fig. 2. A 45-year-old man who presented with a subarachnoid hemorrhage from a large left middle cerebral artery aneurysm. He underwent three separate embolization procedures over the next year (Patient 2). (a) Following embolization, axial T_2-weighted scans showed the left middle cerebral aneurysm with a complex signal intensity pattern with peripheral low signal related to mural calcification, hyperintensity in keeping with subacute thrombi and centrally low signal which could be related to the platinum GDC coil balls or might represent a flow void. (b) MRA after the third and final embolization. Difficulty in separating thrombi from flow in large aneurysms was experienced in this case. High signal from met hemoglobin on gradient-echo images is incorporated into the reconstructed MIPped images.

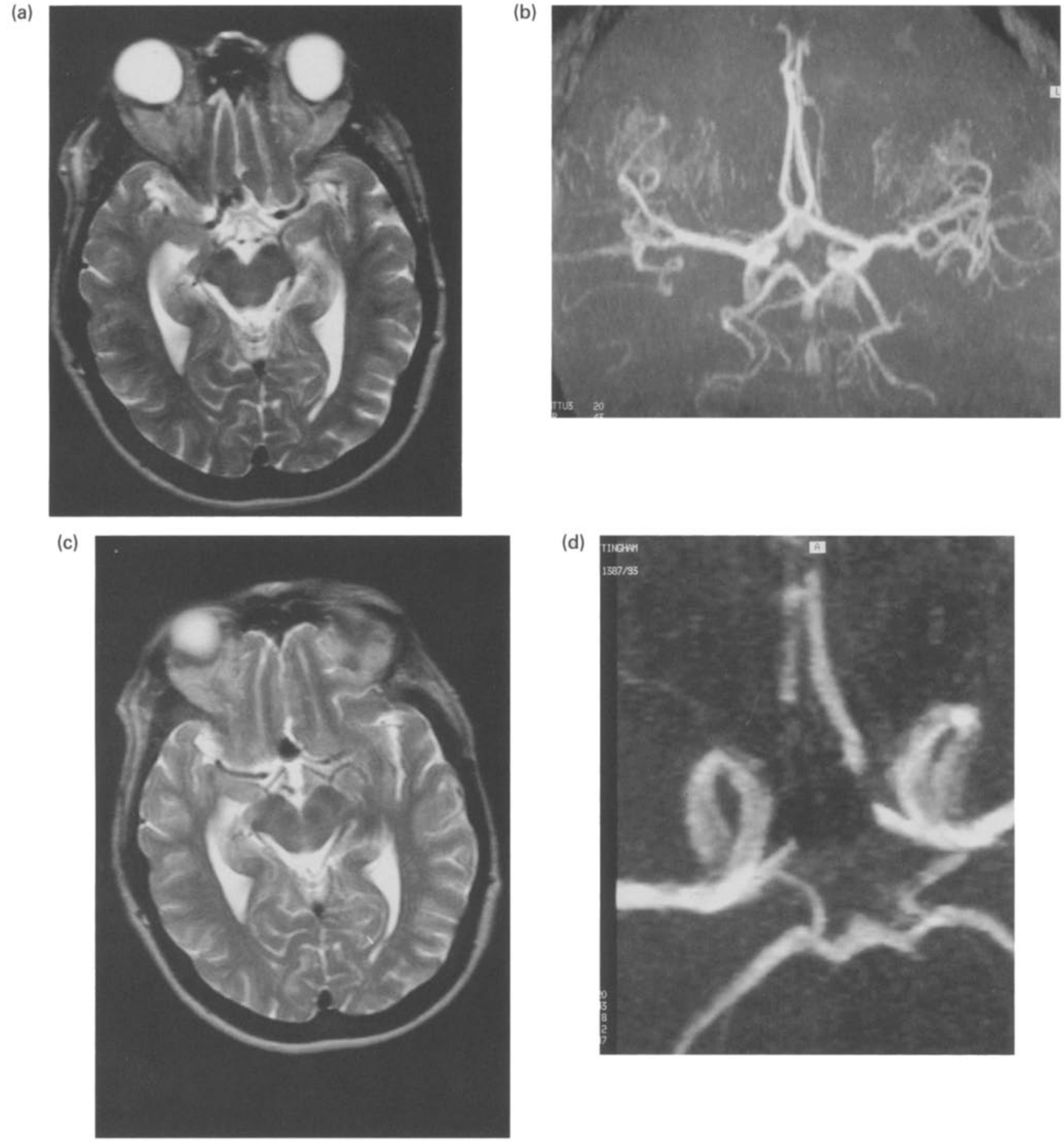


Fig. 3. A 52-year-old woman with a large aneurysm at the origin of the left anterior cerebral artery (Patient 3). (a) Prior to embolization, spin-echo images demonstrate the aneurysm which contains some thrombi (high signal). (b) Prior to embolization, MRA MIPed images demonstrate the aneurysm to contain flowing blood. (c) Postembolization, spin-echo images demonstrate dense loss of signal from the aneurysm (susceptibility effect). (d) Postembolization MRA shows nonvisualization of the parent vessels due to the susceptibility effect of the coils.

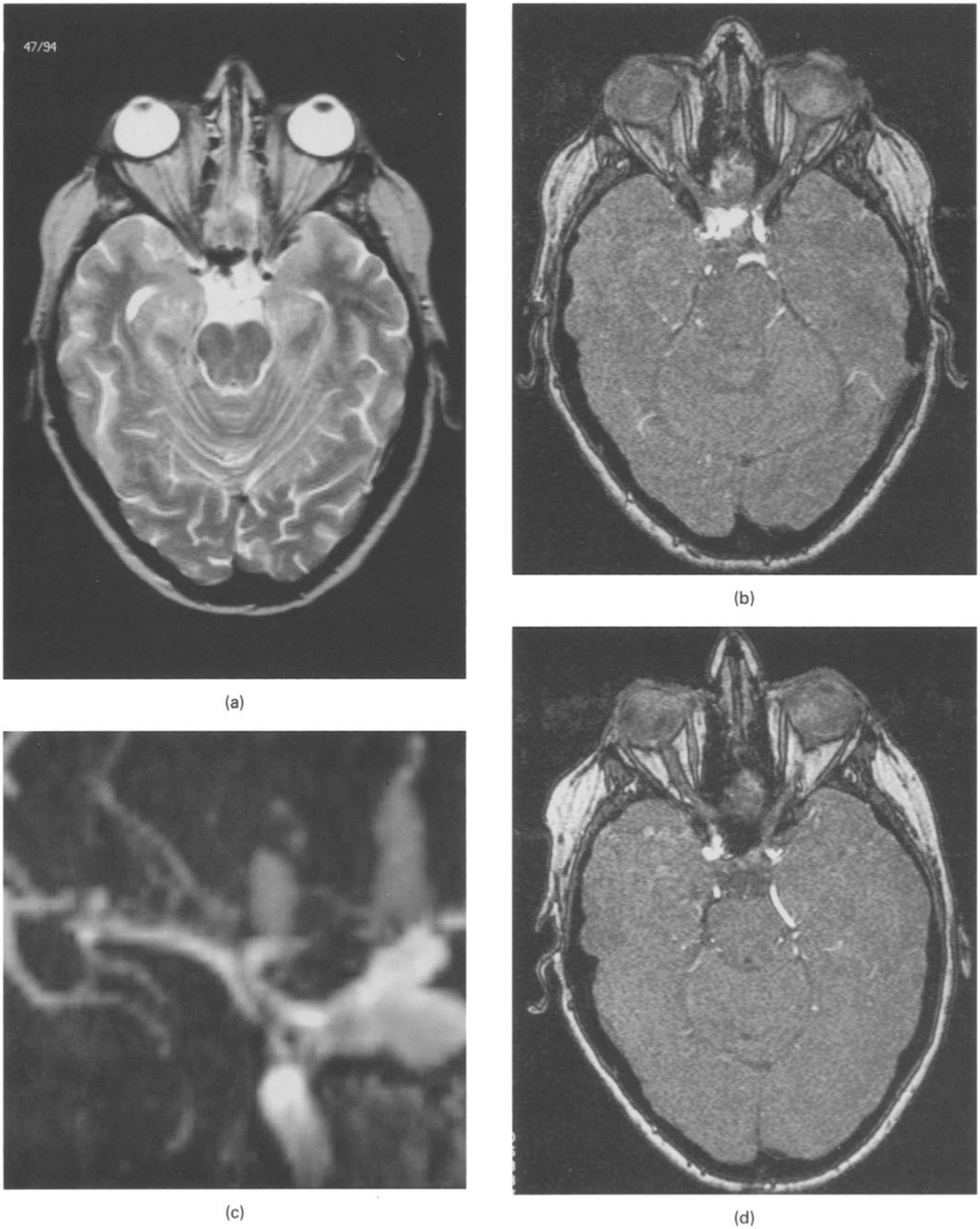


Fig. 4. A 50-year-old woman with a large aneurysm at the origin of the right ophthalmic artery (Patient 4). (a) Spin-echo images demonstrate the aneurysm. (b) Prior to embolization, MRA source images demonstrate the aneurysm to contain flowing blood. (c) Prior to embolization, MRA MIPed images demonstrate a bilobed aneurysm with hematoma superiorly. (d) Postembolization, MRA source images show no flow in the aneurysm. (Continued on page 332.)

(e)

Fig. 4. (e) Postembolization, flow in a small residual pouch is seen on MRA MIPed images, but the aneurysm is largely occluded.

the left anterior cerebral artery. This was subsequently wrapped at surgery.

Eight months later, the aneurysm was assessed with MR. The spin-echo images demonstrated the aca aneurysm to contain some high-signal thrombi (Fig. 3a). The MRA sequence demonstrated flow within the aneurysm (Fig. 3b). These images allowed assessment of size and morphology, enabling an appropriate choice of coils and approach.

On the same day, embolization was undertaken using three GDC coils with almost complete obliteration of the aneurysmal sac. Two days later, assessment by MRA showed a low signal in the aneurysm on both T_1 and T_2 spin-echo sequences (Fig. 3c). This could possibly have represented a flow void, but the dense loss of signal indicates a susceptibility artifact from the platinum coils. The postembolization MRA (Fig. 3d) demonstrated loss of signal in the region of the aneurysm and the parent vessel due to the susceptibility artifact from the platinum coil mass, but the distal aca was visualized and the proximal segment was presumed to be patent.

Patient 4

A 50-year-old woman presented with a subarachnoid hemorrhage. Conventional angiography demonstrated a large aneurysm at the origin of the right ophthalmic artery. Two weeks later, MRA was performed to assess the aneurysm. MRA source data confirmed flow within the lumen (Fig. 4b). The reconstructed images demonstrated a bilobed aneurysm with hematoma superiorly (Fig. 4c). Four days later, embolization with six GDC coils caused almost complete obliteration of the aneurysm.

Flow in a small residual pouch is seen on both the MRA source data (Fig. 4d) and the MIPed reconstructions (Fig. 4e), but the aneurysm remained largely occluded. Measurements of the aneurysmal size were made from the MIPed images.

Patient 5

This 54-year-old woman had a giant basilar artery tip aneurysm, and bilateral middle cerebral artery aneurysms demonstrated on conventional arteriography.

She was treated with embolization in which tungsten spiral microcoils and platinum coils were inserted into the basilar tip aneurysm. Later, computer tomography (CT) showed densely packed coils, producing a severe radial artifact and was not useful. The spin-echo coronal sequence clearly demonstrated a large aneurysm burrowing into the brainstem (Fig. 5a). Spin-echo images also demonstrated extensive changes in the surrounding diencephalic structures and posterior internal capsule on the left side, probably representing a combination of edema and ischemia.

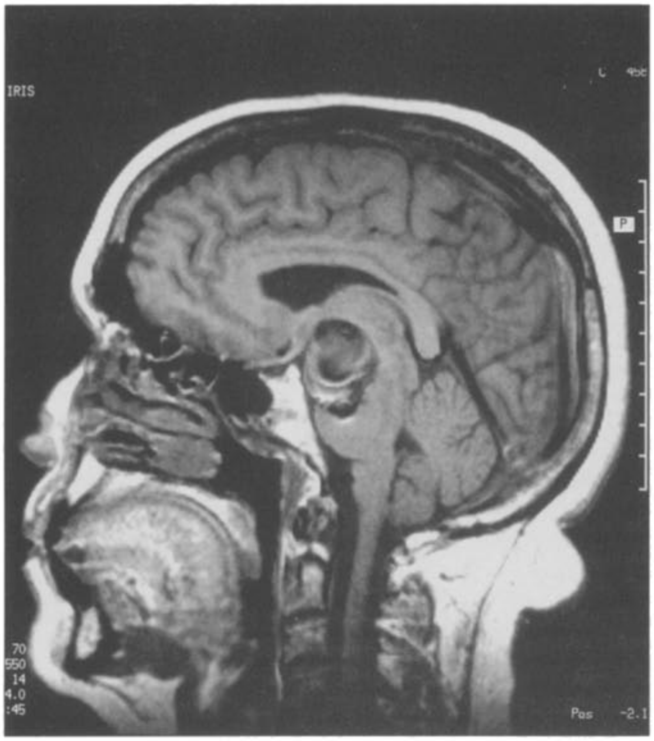
MR angiography demonstrated a persistent residual pouch and gave some evidence of the internal flow dynamics (Fig. 5b). It also demonstrated the bilateral moderate-sized middle cerebral artery aneurysm.

Phase ghosting was helpful in this case, as it established pulsatility of the aneurysm (Fig. 5c).

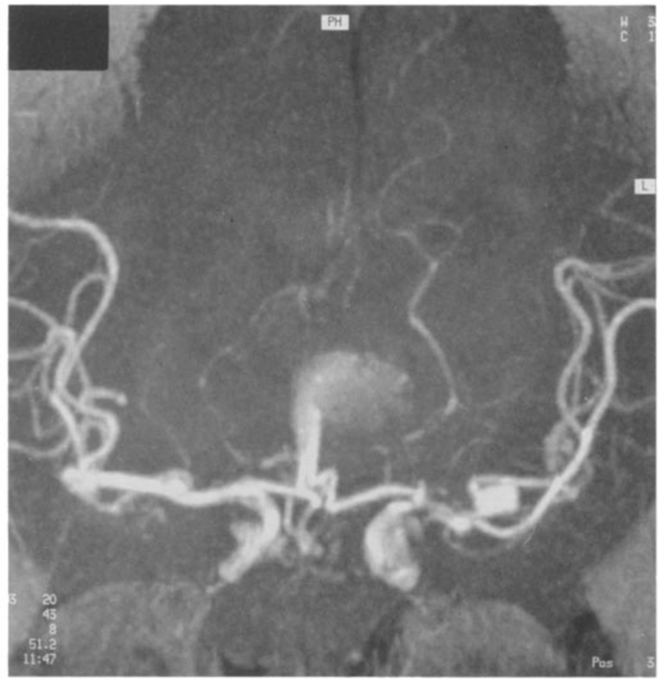
This incompletely embolized aneurysm continued to grow and subsequently ruptured with the death of the patient.

DISCUSSION

The use of three-dimensional time-of-flight (3D TOF) MR angiography in the evaluation of intracranial



(a)



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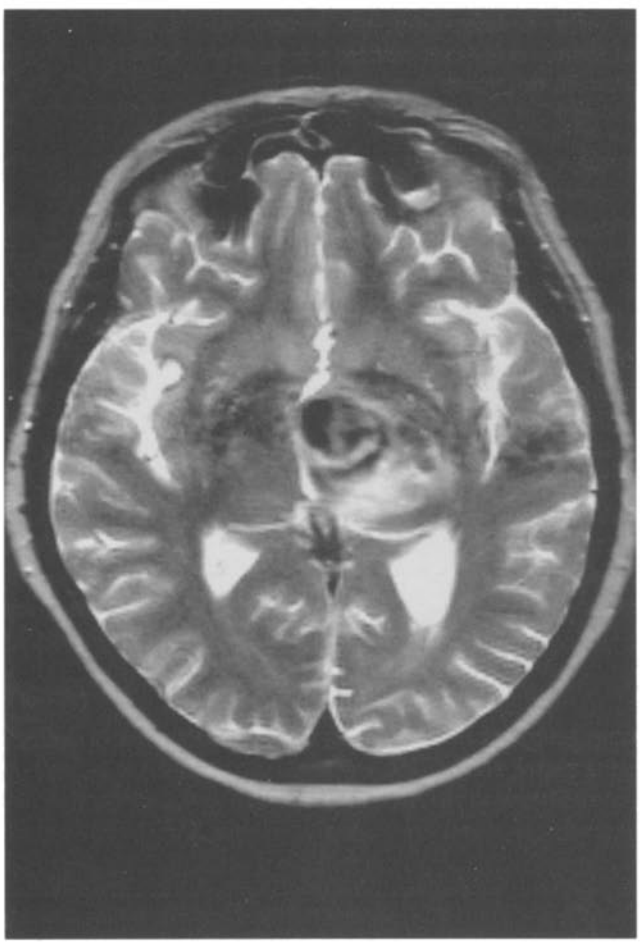

(c)

Fig. 5. A 54-year-old woman with a giant basilar artery tip aneurysm and bilateral middle cerebral artery aneurysms (Patient 5). (a) Spin-echo coronal sequences demonstrate a large aneurysm burrowing into the brainstem. (b) Phase ghosting establishes pulsatility of the aneurysm. (c) MRA MIPed demonstrates a persistent residual pouch and shows the internal flow dynamics.

aneurysms treated by endovascular balloon occlusion has been previously reported [1]. To our knowledge, this is the first report of MRA of platinum microcoils in cerebral aneurysms. All patients were imaged using a Siemen's 1.5-T Magnetom scanner. The MR angiography sequence used has the following parameters: TR = 43, TE = 8, flip angle = 20, field of view = 200, slice thickness = 52 mm, matrix = 256 × 512 oversampled, number of acquisitions = 1, acquisition time = 11 min 47 s).

The platinum coils produce an area of signal loss on SE images which could be mistaken for a flow void. Signal loss due to susceptibility artifacts from platinum coils is qualitatively different from a flow void from which it can be distinguished (patient 3). However, the susceptibility artifact is also small, as predicted by *in vitro* and *in vivo* experimental studies [2].

The 3D MRA TOF sequence is sensitive to paramagnetic substances and these will appear as bright objects in the MIP reconstructions. Therefore, a subacute thrombus produces high-signal simulating flow on TOF images. This problem has been previously described [3]. Phase contrast techniques would be useful to overcome the T_1 shortening effect of methaemoglobin on MIPed images and demonstrate more clearly residual slow flow in large aneurysms.

Platinum emboli in the cerebral hemispheres as a complication of this procedure has been reported in a recent communication to the FDA. We reviewed all the spin-echo images for evidence of platinum emboli, but none was detected.

CONCLUSION

MRA is a quick outpatient, serial noninvasive monitoring technique in the evaluation of cerebral aneurysms which have been embolized with platinum coils. MRA has the advantages of not requiring a general anesthetic, no radiation burden, and increased comfort, which is important in those patients who need repeated examinations. Platinum coils did not cause a clinically significant susceptibility problem.

MRA also has an important role in the planning of the embolization procedure. External and internal dimensions of aneurysms may be demonstrated and this helps in the selection of coil size and selecting the approach to the aneurysm.

Problems with MRA include limited spatial resolution, degradation due to motion artifact, high-signal subacute thrombi simulating flow on GR images, and slow flow leading to saturation effects and reduced signal.

REFERENCES

1. Tsuruda JS, Sevick RJ, Halbach VV (1992) Three-dimensional time-of-flight MR angiography in the evaluation of intracranial aneurysms treated by endovascular balloon occlusion. *Am J Nucl Reson* **13**(4): 1129–1136.
2. Marshall MW, Teitelbaum GP, Kim HS, Marshall MW, Teitelbaum GP, Kim HS, Deveikis J (1991) Ferromagnetism and magnetic resonance artefacts of platinum embolization microcoils. *Cardiovasc Intervent Radiol* **14**(3): 163–166.
3. Strother CM, Eldevik P, Kikuchi Y, Graves V, Partington C, Merlis A (1989) Thrombus formation and structure and the evolution of mass effect in intracranial aneurysms treated by balloon embolization: emphasis on MR findings. *Am J Nucl Reson* **10**(4): 787.