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Transcranial puncture through the parietal and mastoid foramina for the treatment of dural fistulas

Report of four cases

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✓In this report the authors describe the endovascular treatment of dural arteriovenous fistulas (DAVFs) through transcranial puncture of the feeding arteries. Four patients had DAVFs that were fed by occipital arteries (OAs) that supplied blood to the intracranial meningeal arteries via the transcranial branches and coursed through the parietal and mastoid foramina. Due to the excessive tortuosity of the OA, conventional endovascular navigation had failed in all cases. Transcranial puncture of the meningeal feeding arteries was performed through the parietal or mastoid foramen, allowing navigation with a microcatheter until the level of the shunts. Complete cure of the DAVF was attained in all patients after injection of acrylic glue.

KEY WORDS • dural arteriovenous fistula • cerebral hemorrhage • meningeal artery • therapeutic embolization

DURAL arteriovenous fistulas can be successfully treated using surgery or embolization. The goal of embolization is occlusion of the primary draining vein. This may be achieved either by retrograde navigation in the veins and placement of coils or antegrade navigation in the arteries and injection of glue. In both cases, a microcatheter must be navigated close to the shunts. If the microcatheter remains far away from the shunts, injection of glue becomes more hazardous. The risk of diffusion of the glue into unaffected branches is increased, and the ability to occlude the fistula is reduced. We describe an original technique of direct transcranial puncture of the meningeal arteries through the parietal or mastoid foramen in cases in which conventional arterial navigation failed. This method allows close access to the arteriovenous shunts and subsequent cure of the DAVF.

Case Reports

Case 1

This 52-year-old man presented with a Djindjian–Merland Type III DAVF after he had suffered an SAH. The fistula was located at the inferior edge of the falx cerebri and was exclusively fed by the right OA (Fig. 1A). The OA supplied blood to the meningeal feeding arteries via a transcranial anastomosis coursing through the parietal foramen (Fig. 1B). The DAVF drained through deep veins, one of which harbored an aneurysm. Given that distal navigation in the tortuous OA did not seem possible, catheterization was not attempted. A cranial CT scan showed the precise location of the transcranial course (Fig. 1C). Transcranial puncture of the OA was achieved under fluoroscopic guidance. An axial projection was used to locate the site of puncture and adjust the angulation of the needle (Fig. 1D). The transcranial course was also identified on a lateral projection so that the inner table of the cranial vault could be visualized and too distal a placement of the needle could be avoided (Fig. 1E). After selective puncture of the transcranial artery, a microcatheter (Vasco 10, Balt) was navigated through the intravenous catheter (Terumo Corp.) in the meningeal artery close to the shunts (Fig. 1F). Injection of a mixture of 20% of acrylic glue (Glubran 2, GEM Srl) and 80% of Lipiodol (Lipiodol Ultra-Fluid, Guerbet) allowed occlusion of the primary draining vein and complete resolution of the DAVF (Fig. 1G and H).

Case 2

This 76-year-old woman experienced an episode of confusion due to swelling of the right occipital lobe in relation to venous outflow impairment. Magnetic resonance imaging revealed a DAVF, which was fed by both MMAs and a

Abbreviations used in this paper: CT = computed tomography; DAVF = dural arteriovenous fistula; MMA = middle meningeal artery; OA = occipital artery; PMA = posterior meningeal artery; SAH = subarachnoid hemorrhage.

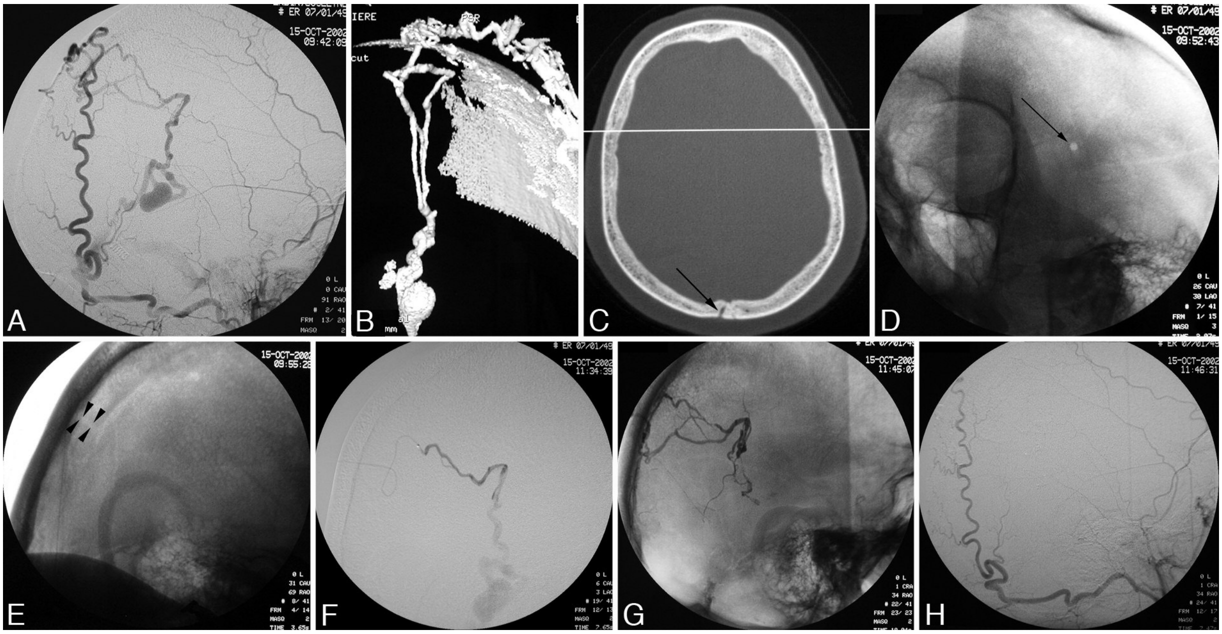

FIG. 1. Case 1. Angiograms (A, B, and D–H) and CT scan (C). A: Lateral view of the right external carotid artery (ECA) showing a DAVF of the inferior edge of the falx cerebri, fed exclusively by the right OA. B: A 3D angiogram of the right ECA showing the transcranial course of the anastomotic vessel joining the OA to the intracranial feeding arteries of the fistula. C: A CT scan showing the course of the parietal foramen *(arrow)*. D: Unsubtracted axial view of the parietal foramen showing the puncture site *(arrow)*. E: Lateral view of the parietal foramen showing precise delineation of its lateral margins *(arrowheads)* as well as the inner and outer table of the skull. F: Image showing injection through the microcatheter after puncture of the parietal foramen and navigation with a microcatheter through the needle. G: View showing the cast of glue after embolization. The feeding arteries and the primary draining vein have been occluded. H: Image demonstrating the injection into the right ECA, confirming cure of the DAVF.

PMA arising from the left OA. The shunts were located in the occipital region close to the superior sagittal sinus. There was a single primary draining vein that harbored an aneurysm and supplied blood to numerous cortical veins (Fig. 2A). Retrograde navigation in the veins did not seem achievable, and embolization was attempted via the arterial route. Distal catheterization of both MMAs was attempted but failed due to the extreme tortuosity of the vessels (Fig. 2B). Acrylic glue (Glubran 2, GEM Srl) with a high dilution of Lipiodol was injected in both MMAs, but the glue could not reach the level of the shunts, leaving the DAVF patent. The third feeding vessel was a PMA fed by a tortuous OA but with a straight intracranial course (Fig. 2C). Direct puncture of the transcranial artery in the mastoid foramen was achieved. The exact location of the mastoid foramen (Fig. 2D) was checked by rotation of the C-arm fluoroscope. The mastoid foramen was punctured with an 18-gauge needle under fluoroscopic guidance, and an Echelon 10 microcatheter (EV3 MTI) was navigated through the needle in the posterior MMA and brought to the level of the shunts (Fig. 2E). Injection of diluted acrylic glue allowed occlusion of the primary draining vein and cure of the fistula (Fig. 2F and G).

Case 3

A vein of Galen DAVF was incidentally discovered in this 35-year-old man after he had experienced an SAH. The malformation was fed by the bilateral PMAs and MMAs, by meningeal branches arising from the internal carotid arteries, and by meningeal branches supplied by arteries of the scalp through a transcranial anastomosis coursing in the parietal foramen. Endovascular treatment was achieved using a combined arterial–venous approach to occlude the vein of Galen. A microcatheter was navigated into the vein of Galen, and the vein was progressively packed with detachable coils. Despite this procedure, the DAVF remained patent. Occlusion of the main feeding vessels arising from the OAs was therefore attempted. Distal navigation through these arteries could not be achieved due to excessive tortuosity. Using an 18-gauge intravenous catheter, direct puncture of the transcranial artery coursing through the parietal foramen was achieved. A microcatheter was navigated through the intravenous catheter up to the shunts, allowing injection of acrylic glue in the fistulas and complete cure of the DAVF.

Case 4

A DAVF was found in this 61-year-old man who presented with a left perimesencephalic hematoma associated with an SAH. The fistulas were located at the free edge of the tentorium cerebelli on the right side and drained into a perimesencephalic vein injecting numerous bilateral cortical veins. The main vessel to the DAVF was the right PMA arising from the OA. Distal catheterization of the PMA was attempted through the groin and failed. Direct puncture of the PMA in its transcranial course in the mastoid foramen was therefore achieved with an 18-gauge intravenous catheter. Further navigation with a microcatheter (Echelon 10, EV3 MTI) through the intravenous catheter enabled close access to the shunts and cure of the fistula with acrylic glue.

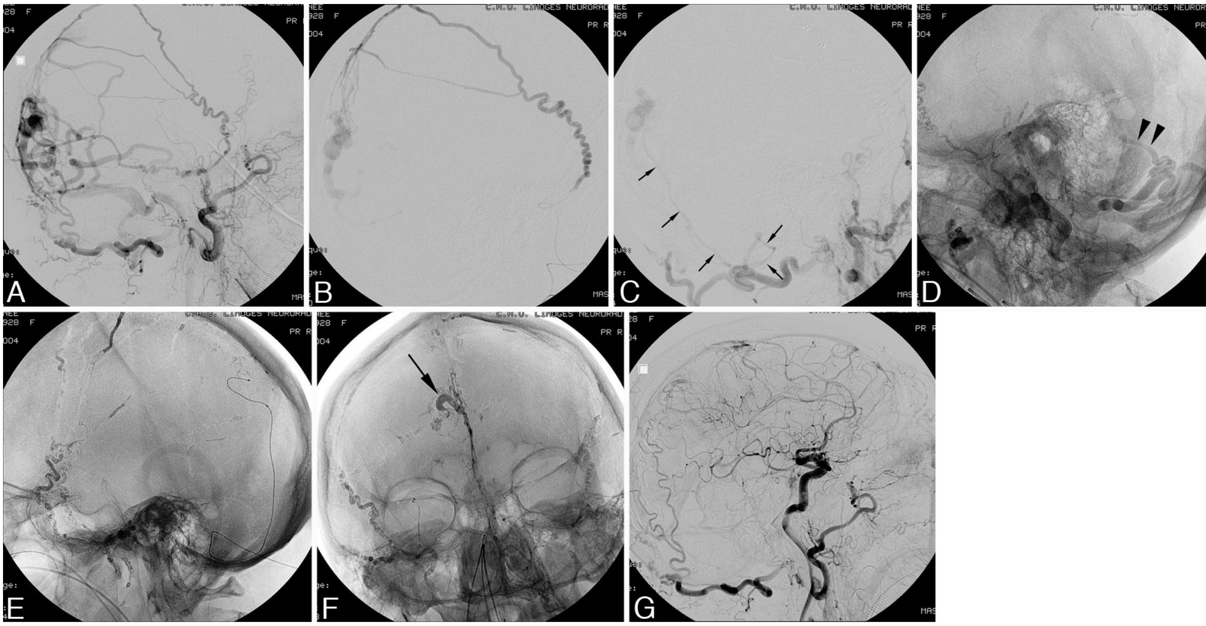

FIG. 2. Case 2. Angiograms. A: Lateral view of the injection in the right ECA showing an occipital DAVF fed by the MMA and draining into cortical veins. B: Lateral projection of the left MMA. The course is too tortuous to allow navigation with a microcatheter. C: Image showing the left ECA after proximal embolization of the MMA. The DAVF is fed by a PMA with a straight intracranial course *(arrows)* arising from the OA. D: Oblique projection delineating the transcranial course *(arrowheads)*. E: View showing the catheterization of the PMA through the intravenous catheter until the distal tip of the catheter has reached the shunts. F: Unsubtracted image of the skull after injection of glue, showing the cast of glue in the primary vein of drainage *(arrow)*. G: Lateral projection of the right ECA showing complete cure of the DAVF.

Discussion

Dural arteriovenous fistulas with cortical venous reflux are associated with a high rate of morbidity (10.4% annually).[12] Definite cure of the DAVF is achieved by occlusion of the primary draining vein, which may be achieved by endovascular treatment or surgery. The vein can be occluded by placement of coils after retrograde venous navigation[3] or injection of a liquid adhesive from the artery into the vein. To allow sufficient injection of glue, the tip of the microcatheter must be navigated as close as possible to the shunts. The microcatheter may not be navigated close to the shunts when the feeding arteries follow a highly tortuous course, as in our patients. In such a situation, endovascular occlusion of the DAVF may sometimes be achieved by obtaining a flow-arrest condition.[9] However, the flow cannot always be arrested.

In our patients, the extracranial segments of the feeding arteries followed a tortuous course making endovascular navigation impossible, whereas the intracranial segments followed a straight course. Direct puncture of the transcranial anastomosis was therefore the only way to access the straight segments of the feeding arteries and allow further navigation with a microcatheter. This enabled injection of glue under optimal conditions leading to occlusion of the primary draining vein and successful treatment of the DAVF in all patients.

Direct puncture techniques have already been used in situations in which endovascular navigation could not be performed.[8] These techniques have been used for the treatment of DAVFs in a variety of vessels and channels including the following: the dural sinus after craniotomy,[7] the superior ophthalmic vein after surgical exposure,[1] the cavernous sinus via the foramen rotundum,[6] and the OAs in their extracranial course.[5] To our knowledge, direct puncture of intracranial arteries through the parietal or mastoid foramen with subsequent intracranial navigation has not been reported.

Small parietal foramina are normal defects in the cranial vault and are located close to the midline on the parietal bone. These defects are 1 to 2 mm in diameter and occur in 60 to 70% of adults.[10] They are rarely enlarged, representing an anomaly of ossification of the parietal bone.[2] Small parietal foramina may contain vessels, either emissary veins connecting the superior sagittal sinus to occipital veins[11] or arteries, providing an anastomosis between meningeal arteries and the OA.[4] Similarly, the mastoid foramina are normal defects in the cranial vault that often contain an anastomosis between the OA and the PMA. In DAVFs, the arterial anastomosis is enlarged and supplies blood to the entire foramen. Therefore, puncture of the foramen allows access to the artery.

Nonetheless a few caveats must be heeded when using this technique. The foramen must have a diameter large enough to allow placement of a needle. The diameter may not be large enough if the malformation comprises multiple transcranial feeding arteries instead of a single anastomotic vessel. There may also be a risk of extradural hematoma in cases in which the needle is placed too distally, causing intracranial perforation of the meningeal artery. Such complications did not occur in our patients because caution was taken to optimally visualize the foramen before puncture. The axial view of the foramen showed the place of puncture. The lateral view showed the limit of progression of the needle that must remain outside the inner table of the skull. Acrylic glue was also available and ready to inject in case of vessel perforation.

Conclusions

Transcranial puncture through the parietal or mastoid foramen is an extension of endovascular techniques that may allow successful treatment of DAVFs through endovascular means even if the feeding vessels cannot be accessed by conventional endovascular navigation.

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