# Transarterial Embolization of a Direct Carotid Cavernous Fistula with Guglielmi Detachable Coils

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**Summary: Four patients underwent transarterial embolization of a carotid-cavernous fistula with Guglielmi detachable coils; in three cases as the initial form of treatment and in one case after treatment via transarterial balloon embolization failed. The fistulas were 2 to 3 mm in diameter on pretreatment angiograms. Complete obliteration was achieved in two patients; in the other two, minimal residual flow remained immediately after embolization but disappeared by follow-up angiography. One to four coils were used to occlude the fistulas. The internal carotid artery remained patent in all patients, and there were no complications.**

**Index terms: Fistula, carotid cavernous; Interventional instruments, coils**

Direct carotid cavernous fistulas are commonly treated via the transarterial endovascular approach with detachable balloons (1–6). In cases of technical failure, transvenous embolization with detachable balloons, standard platinum coils, liquid adhesives, or particulate agents, such as silk sutures, are usually the next treatment option, although this is not always possible because of a lack of vascular access (7–9).

Guglielmi detachable coils (GDCs) have been introduced as a method for treating aneurysms that are difficult to manage surgically (10, 11). We report our early experience with transarterial embolization of carotid cavernous fistulas with GDCs.

## Patients and Methods

We report the findings in four patients treated with GDCs (Target Therapeutics, San Jose, Calif) for carotid cavernous fistula between September 1994 and March 1995 (Table). The embolizations were performed in three hospitals by different physicians. Fistulas occurred after penetrating trauma in one patient and after blunt head injury in another. Two fistulas were spontaneous, and one of these was found in association with an intracavernous aneurysm. The fistulas manifested with pulse-synchronous bruit (n = 4), proptosis (n = 4), retroorbital pain (n = 3), conjunctival congestion (n = 3), diplopia (n = 1), elevated ocular pressure to more than 30 mm Hg (n = 1), and vertigo (n = 1). The interval between trauma (or appearance of the symptoms) and treatment varied from 15 days to 27 weeks (mean, 12 weeks).

Each procedure was performed via the percutaneous transfemoral approach. Three patients were under local anesthesia and one patient was under general anesthesia. The fistulas measured 2 to 3 mm in diameter on pretreatment angiograms. Mild steal with nearly normal visualization of the ipsilateral hemispheric arteries was seen in two patients and moderate steal with near equal flow though the fistula and toward the ipsilateral hemisphere was present in the other two. The fistula was located in the C5 segment of the cavernous internal carotid artery in three patients and in the C3 segment in one patient (case 3). The venous drainage was toward the ipsilateral superior ophthalmic vein (n = 4), the inferior petrosal sinus (n = 3), the inferior ophthalmic vein (n = 1), the cortical veins (n = 1), the pterygoid plexus (n = 1), and the contralateral cavernous sinus (n = 2).

Embolization was attempted after diagnostic arteriography to delineate the fistula and the draining venous pathways. In three patients, embolization of the carotid cavernous fistula with GDCs was the first line of treatment. In one patient (case 1) it was attempted after transarterial balloon embolization failed. Systemic anticoagulation was achieved by administering an intravenous bolus of heparin (5000 IU). A 5F or 6F guiding catheter was then placed into the proximal internal carotid artery. A GDC Tracker-10 catheter with a 0.010-in flexible tip wire (both from Target Therapeutics) was navigated with roadmapping techniques through the fistula into the cavernous sinus. The spaces between the guidewire and the GDC Tracker catheter as well as the spaces between the two catheters

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**Four patients treated with GDCs**

| | Case | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Patients | | | | |
| Age, y/Sex | 52/F | 26/F | 35/F | 45/F |
| Cause of fistula | Blunt trauma | Penetrating trauma | Aneurysm | Spontaneous |
| Size of fistula, mm | 2 | 2 | 2 | 3 |
| Location of fistula | C5 | C5 | C3 | C5 |
| Steal | Moderate | Mild | Mild | Moderate |
| Methods | | | | |
| No. of procedures | 1 | 1 | 2 | 1 |
| Delivery catheter | Tracker-10 | Tracker-10 | Tracker-10 | Tracker-10 |
| No. of coils | 4 | 4 | 2* | 3 |
| First coil | 3 mm /8 cm | 4 mm /10 cm | 3 mm /8 cm | 4 mm /10 cm |
| Second coil | 2 mm /8 cm | 4 mm /10 cm | 5 mm /15 cm* | 3 mm /8 cm |
| Third coil | 5 mm /15 cm | 4 mm /10 cm | . . . | 3 mm /6 cm |
| Fourth coil | 5 mm /15 cm | 3 mm /15 cm | . . . | . . . |
| Detachment times | | | | |
| First coil | 2.48 | 2.34 | 1.50 | 2.08 |
| Second coil | 3.08 | 5.48 | 2.20* | 2.21 |
| Third coil | 5.48 | 10.04 | . . . | 2.58 |
| Fourth coil | 8.13 | 13.06 | . . . | . . . |
| Initial result | Complete occlusion | Partial occlusion | Complete occlusion | Partial occlusion |
| Angiographic follow-up | . . . | Complete occlusion | . . . | Complete occlusion |

* The second coil was placed in the aneurysm.

and the introducer sheath and the guiding catheter were perfused continuously with heparinized saline. Selective angiograms were obtained through the Tracker catheter once it was positioned in the cavernous sinus. After the position of the catheter tip was secured in the cavernous sinus, GDCs were introduced through the microcatheter into the cavernous sinus. The location of the tip of the Tracker catheter and patency of the internal carotid artery were periodically checked with fluoroscopy and angiography during the procedure.

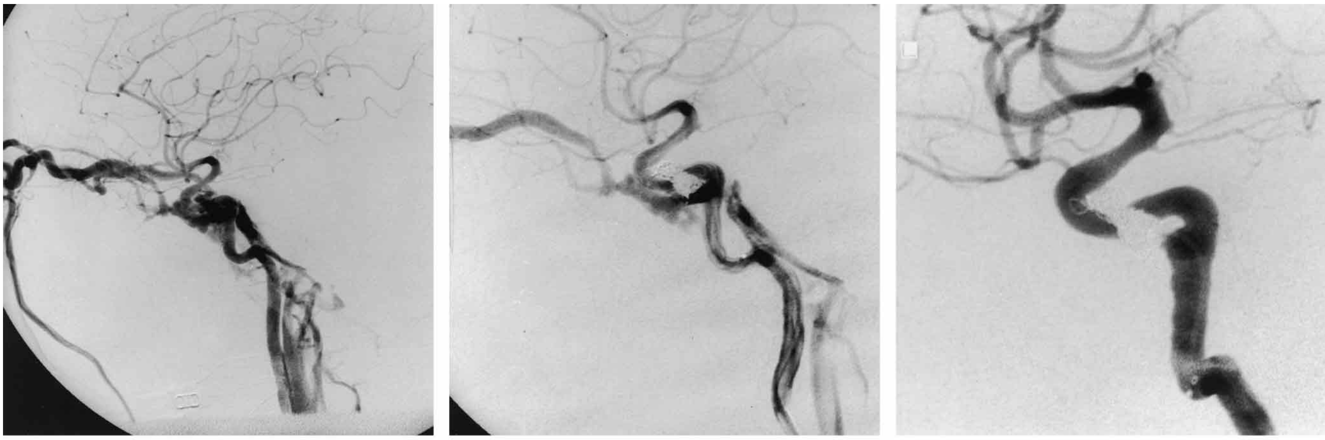
## Results

A summary of the four patients treated with GDCs is presented in the Table. The first coil chosen was larger than the diameter of the fistulous connection and at least as large as the adjacent cavernous sinus. Complete closure of the fistula was achieved during the initial treatment in two patients (Fig 1) whereas minimal residual flow remained in the other two (Fig 2). In both patients with subtotal occlusion, the procedure was interrupted because further thrombotic progress was expected. Unintentional recoiling of the microcatheter into the internal carotid artery occurred in three patients.

The detachment times for the coils varied from 1 minute 50 seconds to 13 minutes 6 seconds (mean, 4 minutes 51 seconds). There were no immediate or late complications. Follow-up angiograms, obtained after 5 weeks and 2 weeks, respectively, in the two patients who initially had subtotal obliteration of the fistula, showed complete obliteration of the fistula in both cases. All but one patient made a full clinical recovery. After 7 months, one patient (case 2) still had occasional diplopia related to injury of the third cranial nerve, which was consequent to the initial injury, not the result of the GDC treatment.

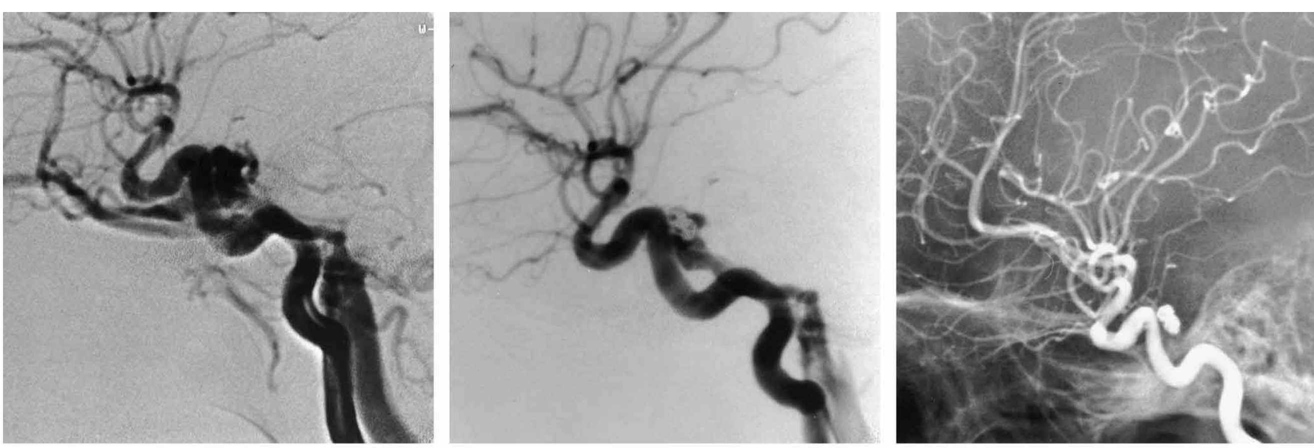
## Discussion

Embolization via the transarterial approach with detachable balloons is presently considered the method of choice for the treatment of most single-hole carotid cavernous fistulas (5, 6). However, technical difficulties are not uncommon, and transarterial balloon embolization fails in 5% to 10% of cases (8, 12). Failure occurs because the fistula orifice may be too small to allow entry, the venous compartment of the fistulous communication may be too small to allow balloon inflation, or sharp margins of bony fractures or foreign bodies may rupture the balloon during inflation. In some patients who have subtotal occlusion after initial balloon embolization, navigation of additional balloons into the fistula is unsuccessful owing to



A B C

Fig 1. Case 1. Lateral subtraction angiogram of the ipsilateral internal carotid artery (*A*) shows a carotid cavernous fistula. Subtotal occlusion of the fistula is seen after detachment of four GDCs (*B*). In an attempt to place an additional coil, the microcatheter recoiled in the internal carotid artery and the coil had to be withdrawn without detachment. A subsequent subtraction angiogram shows complete obliteration of the residual fistula (*C*). There is slight dilatation of the internal carotid artery at the site of the fistula.



A B C

Fig 2. Case 2. Lateral subtraction angiogram of the carotid cavernous fistula (*A*). After placement of four GDCs, a moderate residual fistula remains (*B*). After 15 minutes, the flow through the fistula was minimal and the procedure was terminated. A follow-up angiogram 5 weeks later shows complete obliteration of the fistula (*C*).

the presence of balloons partially blocking the fistula orifice.

While transvenous techniques can be used to treat some of these patients, venous routes are not always accessible. The use of standard platinum coils alone or in combination with balloons or silk-suture embolization has been reported in the treatment of direct carotid-cavernous fistulas (9, 13). Technical pitfalls associated with embolization done with these coils include the impossibility of easy retrieval, the relative stiffness of the coils, the risk of perforation, and the difficulty of packing them tightly. Moreover, complete obliteration of the fistula may be difficult to achieve, and there is a risk of impingement on the parent vessel and possible distal coil migration.

Guglielmi et al (14) recently reported a case of a carotid cavernous fistula and another case of a vertebrovertebral fistula, both with small fistulous communications, that were treated successfully with GDCs via the transarterial approach. Advantages of using electrodetachable platinum coils are the ability to control their placement and to easily retrieve, reposition, or exchange them, if necessary (15). It is also technically easier to guide a microcatheter/microguidewire combination through a small fistula than it is a balloon. Therefore, failure of a balloon to enter the fistula should not be considered a contraindication but rather an indication to attempt embolization with GDCs. In the case of fistulas at a sharp angle to the parent artery, it may be necessary to curve the tip of the microcatheter with steam. A disadvantage of the GDC is its cost: a single GDC costs $550, versus $35 to $70 for a complex fibered coil.

In our cases, one to four coils were used to occlude the fistulous connection. Partial obliteration of an aneurysm was achieved in one case; however, our experience suggests that subtotal occlusion of a fistula may not indicate failure, because progression of thrombosis is likely to occur. Heparinization was not reversed during or at the end of the procedure and appears to be unnecessary. The procedure can be continued on a subsequent occasion if the residual fistula remains open.

GDCs are very pliable and adapt to the shape of the cavernous sinus without producing a significant mass effect on the intracavernous cranial nerves (15). It is also unlikely that embolization of a carotid cavernous fistula with GDCs will cause any significant inflammatory response that could aggravate the neurologic symptoms of the patients. However, secondary thrombosis may be produced with abrupt closure when giant aneurysms are obliterated with balloons or coils. The possibility of detachment without traction helps to prevent mechanical trauma in the surrounding structures (15). The risk of perforation should be insignificant when the proper technique is used.

An intracavernous venogram should be obtained to verify that the microcatheter is positioned properly and to accurately delineate the cavernous sinus. We believe that the occluding coils should be placed as close to the fistula orifice as possible, leading to a better anatomic result and decreasing the risk of migration. Also, fewer coils are needed if the fistula can be blocked at its orifice. In one case, we could probably have obtained an even better anatomic result if the first coils had been slightly larger and had been placed closer to the fistulous connection (Fig 1). While placement of the coils close to the fistula orifice is desirable, it is associated with a higher risk of coil displacement into the parent artery. The risk that the microcatheter will recoil increases toward the end of the procedure, when the fistulous connection becomes more tightly packed. A carotid angiogram before detachment through the guiding catheter may be obtained to document the proper position of the coil and the patency of the internal carotid artery. This is less often necessary if the roadmapping technique is used when introducing the coil.

Care should be taken not to occlude the draining pathways. Occlusion of the venous outflow may redirect the flow into the remaining pathways, aggravating ocular symptoms (superior ophthalmic vein) or hemorrhage (cortical drainage). Migration of coils to the lungs may occur as a result of dilatation of venous outflow pathways and venous sinuses if the coil does not remain stationary close to the fistula. Choosing the proper coil size is essential, as too small a coil may migrate distally and too large a coil may fail to assume its desired configuration. Choice of an appropriate coil size is based on the diameter of the cavernous sinus and on the size of the fistula. In small and medium-sized fistulas ($<$3 mm), the first coil should be at least the size of the diameter of the cavernous sinus (and larger than the fistula). We tried to select a first coil that was slightly larger than the cavernous sinus adjacent to the fistula, whereas subsequent coils, if needed, were smaller in diameter. This policy resulted in proper coil stability in all our cases.

Slight residual flow through the fistula does not appear to be a definite indication to place more coils. In both our patients who had minimal residual flow at the termination of the procedure, the small residual fistula had closed completely by follow-up angiography. After a significant reduction of flow, the gradual spontaneous progression of thrombosis can sometimes be documented angiographically (Fig 2). In patients with subtotal occlusion initially, follow-up angiograms should be obtained to document complete obliteration of the fistula.

We have no experience in treating large, high-flow fistulas with GDCs. The soft platinum coils exert little force on the surrounding structures and might be more easily displaced in a high-flow fistula. When a cavernous sinus is notably dilated and variable in dimensions, closure of the fistula close to the orifice may be difficult or impossible. The procedure will also take more time, because more coils are needed to occlude the fistula. GDCs appear to be appropriate for treating small to medium-sized carotid cavernous fistulas ($<$3 mm).

We have not used GDCs together with other embolic materials. However, we think that transarterial or transvenous embolization with

GDCs could be attempted in selected cases of residual fistula after balloon embolization if the fistula does not close spontaneously and the placement of additional balloons is considered difficult or fails.

In this series, all the patients were treated with GDCs via the transarterial route with excellent results. We find it a logical approach for use in appropriate fistulas or after transarterial balloon embolization has failed. We have no experience with embolization of carotid cavernous fistulas with GDCs via the transvenous approach. We believe that in most patients the transvenous approach should be attempted as a secondary route if the transarterial approach fails.

In conclusion, small and medium-sized fistulas (<3 mm) that are not high flow may be amenable to treatment with GDCs.

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