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# Follow up MR-angiography of intracranial aneurysms treated with Guglielmi Detachable Coils

Badanie tętniaków mózgu za pomocą angiografii MR, leczonych spiralami GDC

Wojciech Poncyljusz<sup>1</sup>, Adam Zapaśnik<sup>2</sup>, Aleksander Falkowski<sup>3</sup>, Leszek Sagan<sup>4</sup>, Zygmunt Domański<sup>1</sup>

- <sup>1</sup> Department of Diagnostic Imaging and Interventional Radiology Pomeraniam Academy of Medicine in Szczecin, Poland
- <sup>2</sup> Department of Radiology Medical University, Gdańsk, Poland
- <sup>3</sup> Department of General and Dental Radiology Pomeraniam Academy of Medicine in Szczecin, Poland
- <sup>4</sup> Department of Neurosurgery Pomeraniam Academy of Medicine in Szczecin, Poland

# **Summary**

**Background:** 

The purpose of this study was to compare the digital subtraction angiography (DSA) with the magnetic resonance angiography (MRA) in the evaluation of intracranial aneurysms embolized with Guglielmi Detachable Coils (GDC) and to assess the 3D TOF MRA source data, maximum intensity projection (MIP) and the 3D isosurface reconstruction.

Material/Methods:

MRA and DSA were performed in 28 patients with 32 aneurysms treated by GDC (12 men - 43% and 16 women - 57%, age range 38-62) as a part of a routine protocol. Images were assessed for parent and branch artery flow, the presence of neck and suck recurrence and aneurysm regrowth.

**Conclusion:** 

There was a relatively strong correlation for all these features when 3D isosurface MRA and source data were compared with DSA. The correlation between MIP MRA and DSA was less robust. Additional confidence can be obtained by performing plain films of the skull to demonstrate change in coil ball configuration. MRA did not visualize residual aneurysm neck in 2 cases. MRA is promising but cannot substitute DSA in evaluation of GDC treated aneurysms.

key words:

intracranial aneurysms • magnetic resonance angiography • embolization • Guglielmi Detachable Coils

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## **Background**

The treatment of patients with cerebral aneurysms by endovascular techniques is becoming increasingly important [1]. Three dimensional time-of-flight (TOF) magnetic resonance angiography (3D TOF MRA) is now readily accepted as a non-invasive screening tool for familiar aneurysmal disease [2] and has been used as an alternative to DSA (digital subtraction angiography) in the surgical management of aneurysmal subarachnoid haemorrhage [3]. MRA in patients treated with GDC is safe, imparts no radiation dose and provides acceptable image quality [4]. DSA is still most relevant for detecting intracranial aneurysms and for follow-up evaluation after vascular and neurosurgical procedures [3]. However, this method is invasive and exposes both patients

and operators to ionizing radiation. The advantages of MRA include shorter time of examinations and lower costs compared to DSA. MRA in patients after embolization should visualize the arteries with their branches, the aneurysm neck or remnant and residual flow within the interstices of a coil ball mesh. There must also be good correlation with conventional angiography for diagnostic credibility. The aim of the paper was to verify the hypothesis that 3D TOF-MR angiography could replace the DSA in evaluating aneurysms in patients after embolization with GDC.

#### **Material and Methods**

MRA and DSA were performed in 28 patients with 32 aneurysms treated by GDC (12 men 43% and 16 women - 57%;

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age range – 38–62) as a part of a routine protocol. All patients presented with aneurysmal subarachnoid haemorrhage (SAH) and were treated in the same day or day after SAH. Both examinations were completed in one day. MRA was carried out on a 1.5 T scanner (Picker) using a single slice 2D sagittal angiogram and a 3D TOF MRA acquisition sequence and the following parameters: TR 42 ms, TE – 6.71 ms, field of view – 23 cm, matrix – 512×512, in two cases using 256×256 matrix and than 512×512, flip angle – 90°. DSA studies were performed on a Siemens fluoroscopy unit with a 1024×1024 matrix using a standard projections and working projections to clearly define the aneurysm neck. DSA was a standard used for evaluating MR which was analysed by two radiologists. MR examinations were assessed

using a specialised workstation and standard software for viewing of multi-planner reformatted images (MPR) and generation of maximum intensity projection (MIP) and 3D isosurface rendered images. The axial source data (SD) and multi-planar reformatted images (MPR) were viewed first, followed by the MIP and 3D isosurface rendered MR angiograms. Review of MRAs on the workstation allowed images to be viewed at variable window settings reducing errors due to inappropriate windowing. Generation of MIP, surface extraction and 3D rendering images took about 10–15 minutes to perform. The images were studied using the 5-grade scale evaluating the diagnostic features of DSA and MRA and their correlation: (1/non-diagnostic, 2/weak, 3/acceptable, 4/good, 5/very good) against the DSA appearance; more-

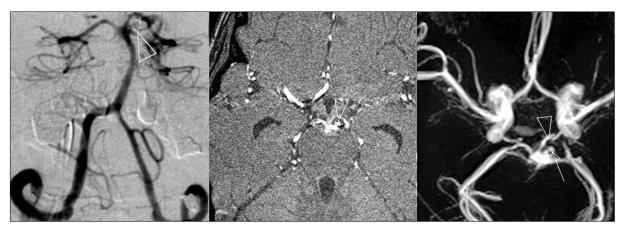


Figure 1. Coiled small aneurysm visible below the superior cerebellar artery with evidence of recurrence is seen on DSA (A), TOF MPR MRA(B) and TOF MIP MRA(C). On TOF MPR MRA central high signal is seen (arrow) and represents flow.

Rycina 1. Maty zembolizowany tętniak poniżej tętnicy móżdżkowej z cechami rekanalizacji widoczny jest w DSA (A), rekonstrukcji MPR TOF MRA(B) i rekonstrukcji MIP TOF MRA(C).

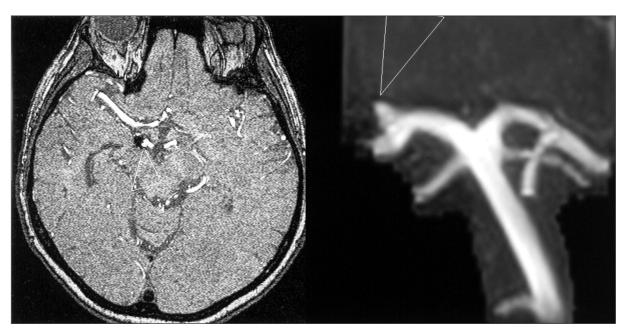


Figure 2. Right posterior cerebellar artery aneurysm with evidence of the flow in the aneurysmal neck and partially sac is seen on TOF MPR MRA(A) and TOF MIP MRA(B).

Rycina 2. Tętniak prawej tetnicy móżdżkowej tylnej z cechami przepływu w szyi i częściowo w worku tętniaka widoczny jest na rekonstrukcji MPR TOF MRA(A) i rekonstrukcji MIP TOF MRA(B).



Figure 3. Right middle cerebral artery aneurysm with evidence of recurrence is seen on DSA (A), TOF MPR MRA(B) and TOF MIP MRA(C). On TOF MPR MRA central high signal is seen (arrow) and represents flow.

Rycina 3.Tętniak tętnicy środkowej mózgu z cechami rekanalizacji widoczny jest w DSA (A), rekonstrukcji MPR TOF MRA(B).



Figure 4. Source image in TOF angiography. High signal rim artefact around the coiled basilar tip aneurysm is seen.

Pucing 4. Obrazy pionzaphyczona angiografii TOF, Wokół

**Rycina 4.** Obrazy nieprzetworzone angiografii TOF. Wokół zembolizowanego tętniaka tętnicy podstawnej mózgu widoczny jest artefakt wysokiego sygnału.

over the flow in the embolized artery, its branches and the aneurysm neck was examined together with the circulation between the coil loops. A similar 5 point score was then used to determine the overall MRA correlation with the DSA. The results were classified anatomically using the scheme modified by Roy et al. [5] 1/complete occlusion, 2/the remaining aneurysm neck, 3/ aneurysm recurrence or unsatisfactory embolization.

#### Results

The aneurysms were located in the following arteries: internal carotid -13 (41%), basilar -14 (44%), vertebral -1 (3%), posterior cerebral -1 (3%), superior cerebellar artery -1 (3%), medial cerebral artery -1 (3%), posterior inferior cerebellar artery -1 (3%); their sizes ranged from 3 to 12 mm, neck diameter- 0.5-6 mm. Mean follow-up angiography range from 2 to 18 months post GDC embolisation. In DSA 8/32 cases (25%) the neck flow was observed, in 11/32 (34%) the flow between the coil loops was found and in 20/32 (62.5%) there was no flow in the embolized aneurysm. By comparing the MRA and DSA findings the neck or coil flow was showed and a correlation between the examinations was found to be: very good in 21/32 aneurysms (65,62%), good in 6/32 (18,75%), acceptable in 3/32 (9,37%), weak and non-diagnostic in 2/32 (6,25%).

The unprocessed and MPR images were the best ones to evaluate the remaining flow between the coils (Figure1,2,3). Small artefacts of high signal from flowing blood with the coils were visible on some images around aneurysms, however they did not affect their quality. Minimal artefact due to the presence of the coil ball mesh was seen in most MRA studies. This thin, crescentic high-signal artefact, which was consistently seen around the coil ball signal void on the source data images (Figure 4), could easily be separated from flowing blood.

Minor degrees of coil ball compaction at the neck of an aneurysm were often difficult to assess on SD/MPR. Selecting the correct orthogonal plane to detect a small bulge in the parent vessel was often not possible. This was also difficult to assess on DSA because of the presence of a coil ball mesh. Surface-rendered 3D reconstruction showed this to best effect, because of its ability to detect a step in the lu-

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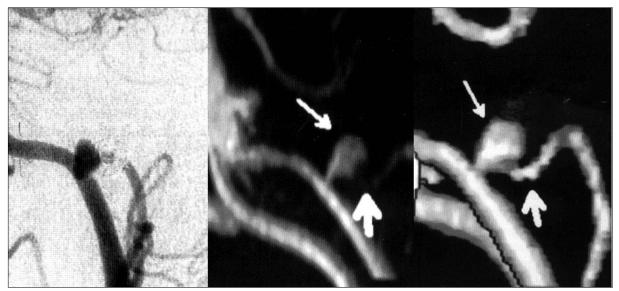


Figure 5. Remnant left posterior inferior cerebellar artery aneurysm (small arrows) is seen on DSA (A), TOF MIP MRA(B) and TOF 3D MRA(C). 3D MRA better depicted wide aneurysm neck and origin of the artery than MIP MRA (big arrows).

Rycina 5. Pozostała część tętniaka tętnicy móżdżkowej dolnej ( mała strzałka) jest widoczna w DSA (A), rekonstrukcji MIR TOF MRA(B) i rekonstrukcji 3D TOF MRA(C). Rekonstrukcja 3D TOF MRA lepiej pokazała szyję tętniaka i początek odejścia tętnicy w porównaniu do rekonstrukcji MIP MRA (duża strzałka).

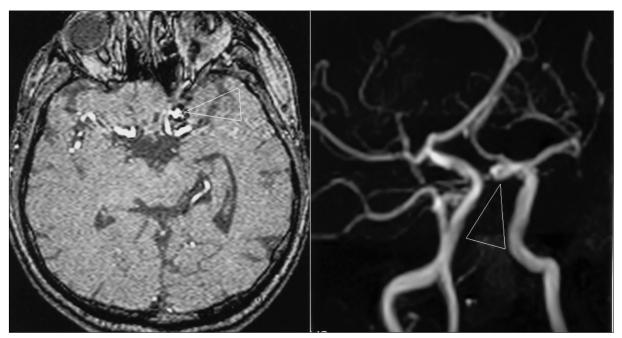


Figure 6. Left carotid cerebral artery aneurysm with evidence of recurrence is seen on TOF MPR MRA(A) and TOF MIP MRA(B) matrix 216×216; quality of the image is worse than on 512×512 matrix.

Rycina 6. Tętniak tętnicy szyjnej wewnętrznej lewej z cechami rekanalizacji widoczny jest na rekonstrukcji MPR TOF MRA(A) i rekonstrukcji MIP TOF MRA(B) o matrycy 216×216. Jakość obrazu jest gorsza w porównaniu z matrycą 512×512.

men of the vessel. High signal when seen was assumed to represent flow rather than thrombus because of the prolonged time interval between treatment and follow-up. This was confirmed on DSA. Misinterpretation of thrombus as flow did not happen in any of our cases.

Parent, branch vessels or neck could usually be demonstrated by combining all MR modalities. If a parent vessel or neck could not be seen with one modality, it could usually be seen with a different modality (Figure 5). When there was discontinuity of a vessel, but flow was seen distal to the point of discontinuity, patency was assumed.

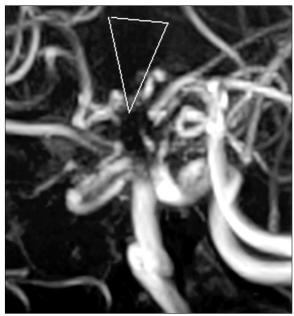


Figure 7. Patient after embolization of 3 aneurysms on internal carotid arteries. Entire loss of the signal in vessels is seen at the base of the terminal part of ICA- TOF MIP MRA.

Rycina 7. Pacjent po embolizacji 3 tętniaków na tętnicach szyjnych.
Całkowita utrata sygnału w obrębie części końcowej tętnicy
szyjnej wewnętrznej jest widoczna w rekonstrukcji MIP TOF
MRA.

MIP MRA scored poorly in all categories when compared to the modalities of source data/MPR and 3D isosurface rendering, but particularly in defining the presence or absence of residual neck. In several cases a halo of high signal was seen at the neck around a recurrent area of aneurysm filling. Despite variations in window setting this halo persisted and correlated poorly with IA DSA. Subjectively, aneurysmal remnants were undersized on MIP MRA, presumably due to underrepresentation of slow flow. This was consistent throughout a range of window settings. This problem was not seen with SD. Other problems with MIP images are due to lack of depth and poor spatial perception. Excessive background noise also degrades images at lower window settings. Setting the lower matrix caused Significant loss of diagnostic image quality (Figure6).

In five patients obscuration or narrowing of the parent and branch vessels created difficulties in interpretation. Significant signal loss of the parent vessel was seen at the base of the terminal ICA aneurysm, but not the basilar tip aneurysm (Figure 7).

## **Discussion**

Embolization is fully accepted as one of the two techniques used to treat cerebral aneurysms. Although the anatomical results of endovascular treatment seem to be less satisfactory than the effects of neurosurgical procedures [5], the long-term follow-up results concerning permanent neck occlusion and complete and permanent filling of the aneurysm sac with coils are unknown. Therefore, the long-term clinical and angiographical follow-up of patients after em-

bolization is necessary. DSA is a method of choice of evaluating the recurrences of aneurysms, however the method is invasive and exposes patients and radiologists to ionizing radiation, which may result in various complications [6,7]. Since such long-term follow-up examinations are required (to evaluate morbidity and mortality rates) a non-invasive technique should be worked out.

CT angiography an is the technique showing high sensitivity and specificity in the diagnosis of aneurysms, however artefacts caused by embolized coils do not allow to use it after embolization [8,9].

Since the diagnostic value of MRA for the diagnosis of cerebral aneurysms is very high [7–11] and the first studies assessing its usefulness after embolization very promising [6,12,13], we decided to verify the hypothesis that MRA might replace DSA in such cases.

Many authors have demonstrated the diagnostic accuracy of MRA in the prospective detection of intracranial aneurysms (11), and in aneurysm detection after SAH. There have been fewer studies documenting the utility of MRA in post GDC follow-up [12,14,15]. Safety should be of primary concern with a potential risk of heat generation due to current flow induced in a metallic object by alternating magnetic fields that may produce thermal damage to surrounding tissue. In vitro studies on the Guglielmi platinum coils have, however, documented no temperature rise when placed in a 1.5-T field using [4].

The image quality is the basic condition of evaluation and requires high homogeneity of the magnetic field [1]. Metals may cause various disturbances resulting from the magnetic field distortion, however tungsten and platinum coils caused only a slight, peripheral, hyperintensive artefact which was observed in some examinations (16); it was easy to differentiate it from the real flow signal, especially with 3D reconstruction [12].

All post-processing algorithms inevitably incur some degree of data reduction [17] and can be viewed in isolation from the source data. We have demonstrated that review of source data increases confidence in interpretation of MRA images presented in a reconstructed format. We would strongly recommend, therefore, that whatever post-processing algorithm is used it should not be interpreted in isolation without reference to source data. This is particularly important when viewing 3D isosurface rendered images which uses an operator defined threshold. Inappropriate thresholding may result in the inclusion of background noise in the processed image [7] or exclusion of important residual flow within the aneurysm. Source image review is also not a necessary pre-requisite for MIP MRA generation and viewing, but this reconstruction technique does have recognised limitations [18]. A single MIP image lacks depth and this can lead to problems of orientation. Because the MIP grey scale is derived from the composite value of all the pixels along an imaging plane, smaller structures may be assigned inappropriately low signal intensity. The signal intensity of flow must exceed the maximum signal from the background plus noise or it cannot be recognised as flow [19]. For this reason small neck remnants or branch Original Article Pol J Radiol, 2003; 68(2):

vessels may go undetected. Background noise on MIP images can also become a problem on lower window settings.

All arteries relevant for embolization could have been evaluated with the combination of all MRA reconstructions used. In cases of small aneurysms, evaluation of the coil 'packing' in the aneurysm neck was extremely difficult on SD and MPR images and in the conventional angiography. The combination of all possible MRA reconstuctions, i.e. SD/MPR, MIP and 3D highly correlates with DSA [12]. In each case the remaining flow in the aneurysm neck or sac was clearly defined.

Problems with residual haemoglobin degradation products producing high background signal were not seen in our patient group. This is due to the fact that imaging is being performed some time after the ictus and also because of the relatively rapid removal of these products from the subarachnoid space.

In the early evaluation, it was possible to decide whether the high signal within the aneurysm resulted from the flow or a new thrombus; in the late evaluation a high signal always corresponds to recanalization [12]. A potential possibility of differentiating the slowly flowing blood and inverting the spins in the TOF technique is provided by the use of a contrast medium to shorten T1, however the costs increase [3,20,21] The use of ultrafast TR techniques to reduce the time of data canvassing to < 1 minute may eliminate the saturation effect [17].

In conclusion, 3D TOF MRA appears to have a useful role in the long-term surveillance of patients treated with GDC for intracerebral aneurysm disease. We have shown the importance of reviewing the source data and multi-planar reformats of this data and strongly recommend that MIP images are not looked at in isolation. MRA provides sufficient information concerning morphology of the coils in the aneurysm sac although it should be accompanied by typical skull X-rays which give additional, valuable data as the coil position is an important prognostic factor of aneurysm recurrence. Those X-ray pictures are helpful in overall evaluation. The combination of all possible MRA reconstuctions: SD/MPR, MIP and 3D highly correlates with DSA. MRA did not visualize residual aneurysm neck in 2 cases. MRA is promising but cannot substitute DSA in evaluation of GDC treated aneurysms.

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