Journal of Clinical Neuroscience 42 (2017) 182–185

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Tools and techniques

Comparison of 3D TOF MR angiographic accuracy in predicting Raymond grade of flow-diverted versus coiled intracranial aneurysms

Tamar R. Binyamin [a], Brian C. Dahlin [b], Ben Waldau [a,*]

[a] Department of Neurological Surgery, University of California, Davis, Sacramento, CA 95811, United States
[b] Department of Radiology, University of California, Davis, Sacramento, CA 95811, United States

ARTICLE INFO

Article history:
Received 18 September 2016
Accepted 5 March 2017

Keywords:
3D MRA TOF
DSA
Pipeline Embolization Device
Coiling
Accuracy
Sensitivity

ABSTRACT

The accuracy of 3D time of Flight Magnetic Resonance Angiography (TOF MRA) has been studied extensively for following coiled intracranial aneurysms. It is used by many clinicians for non-invasive follow-up because of its adequate sensitivity in predicting aneurysmal recanalization compared to diagnostic cerebral angiography. The data on the accuracy of 3D TOF MRA for the Pipeline™ Embolization Device (PED) are sparse. In a retrospective chart review, we compared the accuracy of 3D TOF MRA of PED to coil embolization at our institution. 3D TOF MRA had a lower sensitivity and positive predictive value in detecting aneurysmal filling in PED-treated versus coiled aneurysms (57% versus 87% and 80% versus 100%, respectively). Analysis of discrepancies between conventional diagnostic angiography and 3D TOF MRA revealed that 3D TOF MRA was inaccurate in the setting of small residual necks and slow residual filling of the dome with fluid–fluid layers. Therefore, contrasted studies such as contrast-enhanced MRA may be preferred for non-invasively following PED-treated aneurysms to increase accuracy.

1. Introduction

Endovascular coil embolization of both ruptured and unruptured intracranial aneurysms has been proven an effective and safe modality of treatment [1]. Follow-up of previously coiled aneurysms is mandatory, due to the subsequent risks of coil compaction, recanalization and aneurysmal re-growth [2,3]. Conventional catheter based angiography has been considered the gold standard for following coiled intracranial aneurysms [4].

Catheter-based digital subtraction angiography (DSA) for routine follow up carries a small risk of stroke, vessel dissection, contrast-induced nephrotoxicity and access site complications and requires a short hospital stay [5,6]. MR Angiography, specifically 3D-Time of Flight (TOF) imaging, is therefore well established for following coiled intracranial aneurysms instead of conventional diagnostic angiography [7].

Additional devices including the Pipeline™ Embolization Device (PED, Covidien, Irvine, California) have been introduced for the treatment of broad-necked anterior circulation aneurysms which are located proximal to the PCOM artery. However, little is known about the sensitivity and specificity of MR 3D TOF in predicting recanalization of aneurysms treated with PED compared to coiling.

In this study, we sought to evaluate the accuracy of 3D TOF MRA in predicting the Raymond grade recanalization of previously flow-diverted aneurysms and compare it to accuracy of coiled aneurysms at our institution.

2. Materials and methods

The institutional review board (IRB) of the University California, Davis approved the study (IRB #954988-1).

MRAs were obtained on 1.5 and 3 Tesla scanners (GE Medical Systems, Milwaukee, Wisconsin, USA). Maximal Intensity Projections were used for 3D-TOF images. The field of view was 20–24 cm. Slice thickness was either 1.4 mm with an acquisition matrix size of 384 × 224 and 0.7 spacing or 1.6 mm with an acquisition matrix of 320 × 256 and 0.8 spacing. The number of excitations (NEX) were 1, echo train length (ETL) 1 and flip angle 20 degrees. Digital subtraction angiograms were performed on a dedicated biplane neuro-angiographic suite, Siemens Artis Zee or Siemens Neurostar prior to 2011. (Siemens AG, Munich, Germany).

Between the years of January 2014 – September 2016, we identified 23 patients with a total of 26 aneurysms who had a total of 24 Pipeline™ Embolization Devices placed for flow diversion embolization. In 11 of these patients, 13 follow-up diagnostic

* Corresponding author at: University of California Davis Medical Center, Department of Neurological Surgery, 4860 Y Street, Suite 3740, Sacramento, CA 95811, United States. Fax: +1 916 703 5368.
E-mail address: bwaldau@ucdavis.edu (B. Waldau).

http://dx.doi.org/10.1016/j.jocn.2017.03.009
0967-5868/

angiograms with concurrent MRAs were available for analysis of 13 aneurysms. For comparison, we identified 28 coiled patients with 30 post coiling MRAs which were followed by a diagnostic angiogram and imaging of the treated aneurysm. Patients' names, medical record numbers, study accession numbers, sex, age, aneurysm location, rupture status, presence of stent and type, recanalization status on official radiologist MRA read, and Raymond grade of recanalization on MRA brain and catheter angiogram were recorded. Staff neuroradiologists who were blinded to the results of angiograms performed the official readings of the MRAs. Results were also analyzed by the non-blinded authors to verify accuracy of the interpretation of the neuroradiologist.

3. Results

The patients' average age in the flow diversion group was 54 ± 9.9 years (Table 1). All but one of the identified patients were women, and all of the aneurysms were unruptured. The most common aneurysm undergoing flow diversion embolization were PCOM aneurysms (38%), followed by superior hypophyseal artery aneurysms (31%). All of the patients had a follow-up diagnostic angiogram approximately six months following flow diversion embolization along with an MRA around the same time (average time difference of 28 days between the two studies).

Considering conventional diagnostic angiography as the gold standard, 3D TOF MRA had a sensitivity of 57%, specificity of 88%, positive predictive value of 80% and negative predictive value of 70% when the blinded interpretations of the radiologists were analyzed (Table 2). There were four discrepancies between MRA and DSA in the blinded analysis which all were confirmed to be valid on non-blinded review. Analysis of these discrepancies revealed that in three out of four cases, a small residual neck was misinterpreted (Raymond grade 2 versus Raymond grade 1). In two of these cases, 1.5 Tesla MRA units failed to appreciate a small residual neck while in one case the MRA falsely identified a residual neck in a previously coiled and subsequently flow-diverted aneurysm. In one case, the MRA of a 3 Tesla unit failed to identify residual filling of the dome (Raymond grade 3 versus Raymond grade 1). This aneurysm had stagnant flow into its dome with a fluid–fluid layer which was not seen on 3D TOF MRA (Fig. 1). MRA and DSA were performed on the same day in this patient 6 months after flow diversion embolization.

Average age of patients in the coiling group was 52 ± 9.8 years (Table 3). Five patients were male, 23 female. Twelve aneurysms were unruptured. Nine aneurysms underwent stent-assisted coiling. Most aneurysms were located at the posterior communicating artery (43%), followed by the anterior communicating artery (14%). An average of 71 days elapsed between the MRA and the DSA.

The blinded neuroradiologists made a decision on the recanalization status in 27 of the 30 MRAs of coiled aneurysms (Table 4). In 24 of these 27 MRAs (89%), the neuroradiologist correctly predicted the Raymond grade of the aneurysm on the diagnostic angiogram. The sensitivity of the blinded neuroradiologist in detecting the correct Raymond grade of recanalization was 20/23 (87%), the specificity 4/4 (100%). The positive predictive value of the blinded neuroradiologist was 20/20 (100%), the negative predictive value 4/7 (57%). In the case of the three false predictions, the delay between MRA and angiogram was 3, 122 and 124 days. The coil mass had not compacted in these cases compared to the initial coiling, based on the initial procedural and follow-up diagnostic angiographic studies.

Table 1
Demographics of patients who underwent flow diversion embolization PCOM: Posterior communicating artery, MCA: Middle cerebral artery.

Patient age	55.4 ± 9.9 years
Patient sex	1/10 (10%) male
Aneurysm rupture status	13/13 (100%) unruptured
Aneurysm location	PCOM 5/13 (38%); Superior hypophyseal 4/13 (31%); Ophthalmic 2/13 (15%); MCA 1/13 (8%); Cavernous 1/13 (8%)
Device	Pipeline® Embolization Device
Average days between MRA and angiogram	28 ± 33 days

Table 2
Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of blinded interpretation of MR angiography to assess for residual filling of flow-diverted aneurysms.

	Angiogram positive	Angiogram negative	
MRA positive	4	1	PPV: 4/5 (80%)
MRA negative	3	7	NPV: 7/10 (70%)
	Sensitivity: 4/7 (57%)	Specificity: 7/8 (88%)	

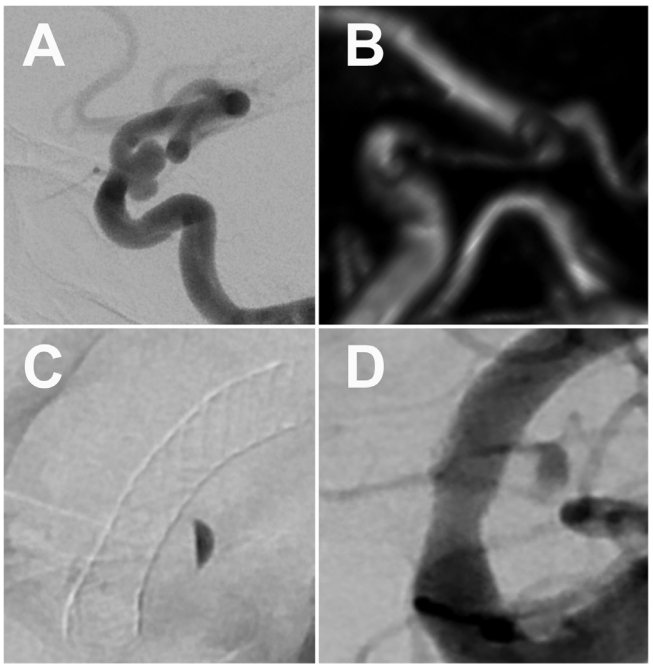

Fig. 1. Digital subtraction angiography (DSA) of the right internal carotid artery shows a right superior hypophyseal artery aneurysm (A). Six-months follow-up 3D MRA TOF does not show residual flow in the aneurysm neither on 3D reconstruction (B) nor on source imaging (data not shown). Follow-up DSA on the same day however reveals slow residual filling of the superior dome of the aneurysm with a fluid–fluid layer in the late venous (C) and arterial phases (D) of the injection.

Table 3
Demographics of patients undergoing coil embolization PCOM: Posterior communicating artery, ACOM: Anterior communicating artery, ICA: Internal carotid artery.

Patient age	52 ± 9.8 years
Patient sex	5/28 (18%) male
Aneurysm rupture status	17/28 (61%) ruptured
Aneurysm location	PCOM 12/28 (43%); ACOM 4/28 (14%); cavernous, ophthalmic, superior hypophyseal each 2/28 (7%); basilar tip, vertebrobasilar fenestration, supraclinoid, terminal ICA, pericallosal each 1/28 (4%)
Stent deployment	Neuroform 8/30 (27%), Enterprise 1/30 (3%)
Average days between MRA and angiogram	71 ± 102 days