

3D-FIESTA Magnetic Resonance Angiography Fusion Imaging of Distal Segment of Occluded Middle Cerebral Artery

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Abstract

Middle cerebral artery (MCA) occlusion was examined with basi-parallel anatomical scanning (BPAS) using three-dimensional fast imaging employing steady-state acquisition (3D-FIESTA), and 3D-FIESTA and magnetic resonance angiography (MRA) fusion images were created. We expected that an incidence of hemorrhagic complications due to vessel perforations would be decreased by obtaining vascular information beyond the occlusion and thus acute endovascular revascularization could be performed using such techniques. We performed revascularization for acute MCA occlusion for five patients who were admitted in our hospital from October 2012 to October 2014. Patients consisted of 1 man and 4 women with a mean age of 76.2 years (range: 59–86 years). Fusion images were created from three-dimensional time of flight (3D-TOF) MRA and 3D-FIESTA with phase cycling (3D-FIESTA-C). Then thrombectomy was performed in all the 5 patients. Merci retriever to 1 patient, Penumbra system to 1, urokinase infusion to 2, and Solitaire to 1 using such techniques. In all cases, a 3D-FIESTA-MRA fusion imaging could depict approximately clear vascular information to at least the M3 segment beyond the occlusion. And each acute revascularization was able to perform smoothly using these imaging techniques. In all cases, there was no symptomatic hemorrhagic complication. It showed that 3D-FIESTA MRA fusion imaging technique could obtain vascular information beyond the MCA occlusion. In this study, no symptomatic hemorrhagic complications were detected. It could imply that such techniques were useful not only to improve treatment efficiency but also to reduce the risk of development of hemorrhagic complications caused by vessel perforations in acute revascularization.

Key words: three-dimensional fast imaging employing steady-state acquisition, endovascular thrombectomy, middle cerebral artery occlusion

Introduction

Magnetic resonance angiography (MRA) is useful for observation of a vascular lumen. Basi-parallel anatomical scanning (BPAS) with three-dimensional fast imaging employing steady-state acquisition (3D-FIESTA) is a useful option to depict the outside of a vessel even if there is no blood flow. This technique is reported to be useful in the imaging of vertebrobasilar system and of the nerve system, which are surrounded by rich amounts of cerebrospinal fluid (CSF).¹⁾ There seems to be no doubt that while using recombinant tissue plasminogen activator (rt-PA) or endovascular interventional treatment for acute occlusion of a major cerebral artery, a more favorable outcome is

obtained and the risk of development of hemorrhagic complications is reduced consequently if a vascular information beyond the occlusion is available in advance. We performed a 3D-FIESTA-MRA fusion imaging in 5 patients with middle cerebral artery (MCA) occlusion to preprocedurally visualize the neurovascular relationship, and evaluated the usefulness of such diagnosis technique at application acute revascularization.

Patients/Materials and Methods

Five patients were admitted to our hospital and performed an endovascular revascularization for acute MCA occlusion from February 2012 to April 2014. Patients consisted of 1 man and 4 women with a mean age of 76.2 years (range: 59–86 years).

Three-dimensional time of flight (3D-TOF) MRA and 3D-FIESTA with phase cycling (3D-FIESTA-C) were obtained by using the Signa Excite HDxt 3.0T (GE Healthcare Japan Corp., Tokyo). The parameters of the 3D-TOF MRA sequence were as follows: repetition time (TR)/echo time (TE): 19/3.4 ms, flip angle (FA): 18, thickness: 1.2 mm, matrix: 416 × 192, field of view (FOV): 20 × 20 cm, area imaged: 112 mm (3 slabs), zero-fill interpolation (ZIP): 2, acquisition time: 4 min 11 s. The parameters of the 3D-FIESTA-C sequence were as follows: TR/TE: 4.6/2.2 ms, FA: 40, thickness: 1.2 mm, matrix: 288 × 224, FOV: 18 × 18 cm, ZIP: 2, area imaged: 50–60 mm, acquisition time: 2 min 17 s. We used the Advantage Workstation Ver. 4.6 (GE Healthcare Japan Corp.). We traced the MCA of the 3D-FIESTA-C in the work station and removed information having no relation with the vessels. At that time such image was superimposed to the MRA for preparing the fusion images. In terms of revascularization

methods, Merci retriever® (Concentric Medical, Mountain View, California, USA) was used in 1 patient, Penumbra System® (Penumbra Alameda, California, USA) was used in 1, urokinase infusion was used in 2, and Solitaire® (eV3 Neuro-vascular, Irvine, California, USA) was used in 1 patient, respectively.

Results

In all cases, a 3D-FIESTA MRA fusion imaging made it possible to depict appropriately clear vascular information to at least the M3 segment beyond the occlusion. And these vascular information contributed to perform an acute revascularization smoothly (Fig. 1). Recanalization more than II b on thrombolysis in cerebral infarction (TICI) scale was achieved for 3 patients.²⁾ In all cases, there were no worsening of symptoms associated with the procedure (Table 1).

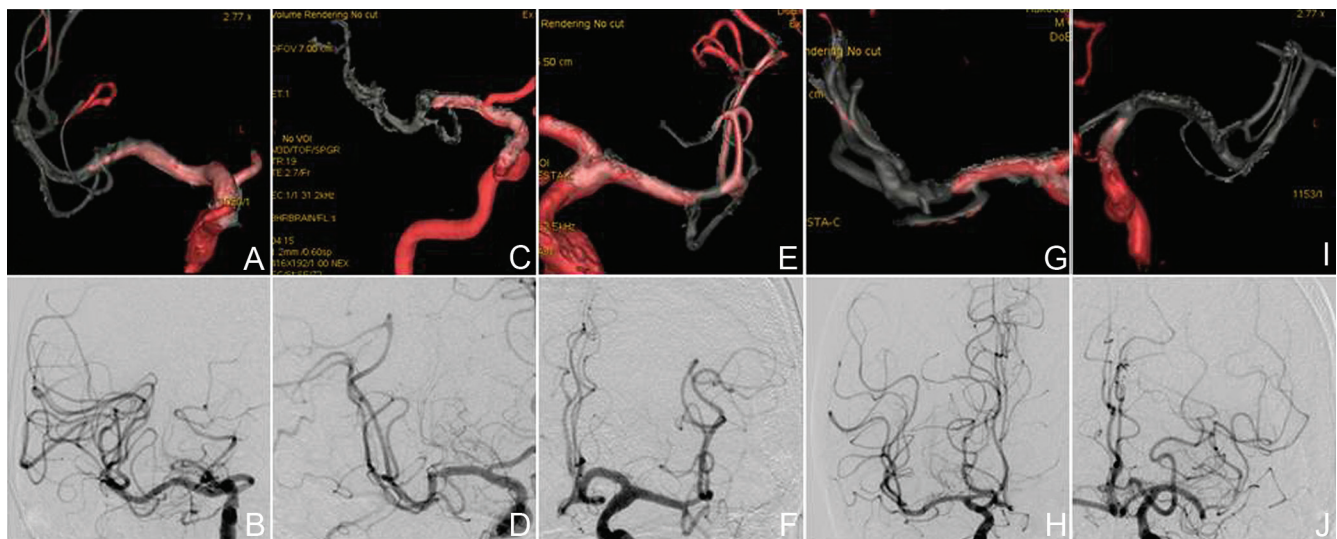


Fig. 1 A–J: Three-dimensional fast imaging employing steady-state acquisition magnetic resonance angiography fusion images made it possible to depict vascular information beyond the occlusion to, at least, the M3 segment. They were compared with cerebral angiography after procedure.

Table 1 List of five cases

Case	Age, sex	Location	Device	TICI scale	Complication
1	85, F	R M1	Merci retriever	III	no
2	59, F	R M1	Penumbra	0	no
3	86, F	L M1	Urokinase	II a	no
4	66, M	R M1	Urokinase	II b	no
5	85, F	L M1	Solitaire	II b	no

F: female, L: left, M: male, M1: first segment of middle cerebral artery, R: right, TICI scale: thrombolysis in cerebral infarction scale.

Discussion

An endovascular thrombectomy using clot retriever or aspiration catheter is a useful treatment option in patients with acute ischemic stroke. However, these methods may result in hemorrhagic complication and it would lead to poor prognosis of patients. It is suggested that one of the causes is its failure to obtain adequate information about targeted vessels performing such procedure. In this study, a 3D-FIESTA MRA fusion imaging made it possible to depict appropriately clear vascular information to at least the M3 segment beyond the distal segment of occluded MCA in all cases. Furthermore, by such technique, we could obtain and evaluate considerably accurate vascular information of anatomical structure before the procedure.

Shi et al. reported 128 cases who were treated by thrombectomy with Merci retriever devices.³⁾ Subarachnoid hemorrhage as a hemorrhagic complication reached 12.6% and procedure-related vessel perforations were found as an independent risk factor of hemorrhagic complication.

In case of thrombectomy, a guidewire must be introduced distally beyond thrombus to be inserted into a microcatheter. It is very important to obtain information of anatomical structure such as anomalies like fenestration, route of MCA, and existence of cerebral aneurysm to prevent hemorrhagic complications. According to previous investigations, the incidence of fenestration of MCA is reported to be 0.02–1.0%,^{4–6)} duplicated MCA 0.3–4.0%, and accessory MCA 0.2–2.9%,^{7–9)} respectively. The presence of an MCA anomaly seems to increase the probability of vessel perforations. To set a suitable C-arm angle of an angiography machine using 3D-FIESTA MRA fusion image seems to reduce the risk of vessel perforations associated with the procedure.

In this study, thanks to the information obtained by such method, we were informed of where we should guide microguidewires and microcatheters to and were able to let these devices reach at the distal segment of the occluded MCA in all cases more smoothly rather than the procedure without referring to 3D-FIESTA MRA fusion image. Then, in all subjects, we observed no worsening symptom associated with such treatment. Therefore, we speculated that such endovascular revascularization method based on the information obtained from 3D-FIESTA MRA fusion image might enable to reduce excessive pressure and damage to vessel wall by intravascular devices such as microguide-wire and microcatheter, as a result, it would lead to reduce the risk of vessel perforations within the preprocedural period.

Although 3D computed tomography angiography (CTA) would enable to depict vascular information on the distal segment of occluded MCA when the penetration of contrast medium occurs by retrograde blood flow due to leptomeningeal anastomosis, such vascular information is not depicted by an angiography since there is no blood flow at the lesion. On the other hand, 3D-FIESTA MRA fusion imaging makes it possible to depict clear vascular information beyond the distal segment of the occluded MCA in the lesion without blood flow. Therefore, from the result of our investigation, we have considered that 3D-FIESTA MRA fusion imaging is more superior rather than 3D-CTA in terms of description of the distal segment of occluded MCA.

With regard to an extension of time for application of such procedure, acquisition time of 3D-FIESTA-C is 2 min 17 s and it takes less than 10 min to obtain the superimposed fusion images, but such idle time can be utilized to prepare the procedure effectively. In addition, since an adequate numerical staff including radiological technicians are always available in our institution, it would be thought that we have a reliable organized system for the acute endovascular treatment.

There are two limitations in our method. First is about subjectivity. There is no denying the fact that an evaluation result depends on the subjectivity of the evaluator. Namely, it might be fraught with potential risks that a device is guided to an inappropriate direction, since we have to compare fluoroscopy image and fusion image by the naked eye when we apply 3D-FIESTA MRA fusion image to acute revascularization. The other is about the location of thrombus. Our method could not evaluate distal end of the thrombus.

Conclusion

3D-FIESTA MRA fusion imaging can obtain vascular information beyond the distal segment of occluded MCA and we could perform the procedure smoothly using this. There is no symptomatic hemorrhagic complication in this study. It has the possibility of the reduction of hemorrhagic complications mainly by procedure-related vascular perforation. We consider that it is a useful treatment option for acute endovascular revascularization.

Conflicts of Interest Disclosure

All authors who are members of The Japan Neurosurgical Society (JNS) have registered self-reported COI statements through the website for JNS members.

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