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Evaluation of intracranial aneurysm: Comparison between ZTE-MRA and 3D-TOF-MRA

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► ***Case report***

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ABSTRACT

The high incidence of intracranial aneurysms and the high mortality rate after rupture highlight the requirement and importance for early and accurate visualization of the aneurysm profile for subsequent patient treatment. Here we report a patient with an intracranial aneurysm who underwent digital subtraction angiography (DSA), zero echo time MRA (ZTE-MRA), and three-dimensional time-of-flight MRA (3D-TOF-MRA) on admission and after operation. The imaging quality and accuracies of ZTE-MRA and 3D-TOF-MRA were compared with DSA, the gold standard, in pre-operative and post-operative evaluation of intracranial aneurysms. Comparison of the two MRAs, ZTE-MRA has greater advantages in imaging.

INTRODUCTION

Intracranial aneurysm is a common cerebrovascular disease that often leads to a high incidence and mortality rates from subarachnoid hemorrhage [(1)]. Therefore, selecting the most appropriate imaging method for diagnosis for treating the patient early and promptly is critical to saving a patient's life. Digital subtraction angiography (DSA) has become the gold standard for the diagnosis of intracranial aneurysms. [(2)]. However, this method has several important disadvantages, such as invasiveness, the use of radiation, relative cost, and complications of arterial entrapment formation. Therefore, DSA is not appropriate for all patients or suitable for use in multiple examinations. Magnetic resonance angiography (MRA) is an important adjunct to preoperative imaging assessment by DSA, and the use of MRA improves the detection rate of intracranial aneurysms. In addition to conventional angiographic techniques, such as contrast-enhanced MRA and three-dimensional time-of-flight MRA (3D-TOF-MRA), MRA uses the principles of zero echo time MRA (ZTE-MRA) strategies.

This report describes a patient with an ophthalmic aneurysm that was located in the right internal carotid artery. The patient was examined by DSA, ZTE-MRA, and3D-TOF-MRA preoperatively and postoperatively, and the imaging quality of the two MRA techniques was evaluated and compared. The advantages and disadvantages of both examinations were also comprehensively compared. As far as we know, this is the first case report comparing the efficiency of 3D-TOF-MRA and ZTE-MRA for aneurysm imaging.

Case report

A 58-year-old female patient was admitted to the hospital with a sudden headache without an obvious cause. The patient is Han Chinese, married with one child, currently freelance, and income unknown. She had a persistent headache and pain that was tolerable but that was not significantly relieved by rest and accompanied by dizziness. She reported no significant change in symptoms as a result of the change in body position. There was no nausea, no vomiting, no twitching of the limbs, and no impairment of limb movement. The patient had an 8-year history of hypertension and had a cerebral hemorrhage 8 years earlier. The patient had no history of hereditary or psychiatric disorders in close family members in three generations. On physical examination, no obvious abnormal manifestations were found, except for blurred vision and weak muscles around the lip. Contrast-enhanced magnetic resonance imaging (CE-MRI) of the brain performed at an external hospital showed an occupational lesion in the right temporal lobe. The patient was admitted to the hospital to improve the relevant laboratory indicators, and no significant abnormalities were observed.

DSA examination at our hospital revealed an aneurysm in the ophthalmic segment of the right internal carotid artery with a size of approximately 3mm×7mm. No abnormality was found in the rest of the blood vessels. The family members of the patient requested surgical treatment. Stent-assisted interventional embolization of the ophthalmic aneurysm of the right internal carotid artery was performed after the preoperative examination. Both ZTE-MRA and 3D-TOF-MRA were performed before and after the operation. The operation went smoothly, and postoperative symptomatic support treatments, such as nerve nutrition and fluid replacement, were administered. The patient recovered well and was discharged from the hospital.

The imaging results by the two MRAs scanned by a Discovery MR750w 3.0T system (General Electric Healthcare, GE, Milwaukee, WI, USA). Standard 8-channel orthogonal head and neck coils were used, and the parameters and methods were the same for both of the scans. The DSA imaging machine is from Philips (Netherlands). The post-processing workstation use GE AW4.6 software, which uses the maximum density projection (MIP) to reconstruct the original images from the ZTE-MRA and 3D-TOF-MRA scans to obtain MRA images.

DISCUSSION

Intracranial aneurysm refers to the abnormal eminence caused by the injury of the local vascular wall of the internal cerebral artery. The incidence of intracranial aneurysm is high, at approximately 3%–4%, and rupture often leads to mortality [3]. Therefore, regular monitoring for and accurate diagnosis of intracranial aneurysms are critical. DSA has been regarded as the gold standard for the diagnosis of cerebrovascular diseases [4]. However, wide clinical application of DSA is limited because of several issues, such as the invasive techniques, risk of renal insufficiency, and hyperthyroidism caused by contrast media [5]. 3D-TOF-MRA uses blood flow enhancement to form the MR signal. However, slow blood flow is usually unable to image clearly because of radio frequency saturation [6]. ZTE-MRA imaging combines the zero echo time technique with the pseudo-continuous arterial spin labeling technique to avoid interference of blood flow velocity, blood flow direction, and magnetic susceptibility artifacts[7]. ZTE-MRA accurately shows lesions with a small diameter and the relationship with the parent artery. Figure 1 shows the preoperative MRA image of a patient with an ophthalmic segment aneurysm of the right internal carotid artery. There are high signal thrombus components in the tumor lumen, and the 3D-TOF-MRA (figure 1A) reconstruction map shows the real tumor cavity (figure 1B), which is consistent with the results of DSA (figure 1C). The 3D-TOF-MRA reconstruction map still shows the real tumor cavity using the silhouette technique used by ZTE-MRA, minus the thrombus components in the background. In addition, 3D-TOF-MRA has been used to evaluate embolized intracranial aneurysms. However, the uneven magnetic field caused by stents and coils affects the image quality of stent lumen, and the short T1weighted imaging signal of intra-sac thrombosis is similar to that of aneurysm sac residues [8]. This leads to an inaccurate assessment of aneurysm sac residues [9]. ZTE-MRA minimizes the effects of uneven magnetic fields and eddy current electric fields and reduces the effects of stents and coils. Labeled blood was also used as an endogenous contrast agent [10]. This avoids the turbulence, slow flow, and false-negative blood signal caused by vascular tortuous blood vessels and lesions [11], so that the stenosis in the stent and the residual tumor cavity can be more accurately evaluated. The accuracy and stability of imaging quality are improved. Images of stent-assisted embolization in the treatment of ophthalmic aneurysms of the right internal carotid artery are shown in figure 2. 3D-TOF-MRA showed that the enhancement of intracapsular thrombus can lead to false-positive residue. The embolized lumen of the tumor was not shown because of the signal loss caused by the stent, and the ophthalmic segment of the right internal carotid artery was also not clearly shown (figure 2A). Both ZTE-MRA and DSA showed the tumor lumen after embolization (figures. 2B and 2C). Together these findings indicate that compared with the intensity on 3D-TOF MRA, the signal intensity of the residual lumen displayed by ZTE-MRA was higher and more uniform, and the boundary was clearer and sharper. In addition, the display of the lumen in the parent artery stent was significantly better with ZTE-MRA than that of the 3D-TOF-MRA. Therefore, these results indicate that ZTE-MRA can better evaluate the embolization effect of intracranial aneurysms compared with 3D-TOF-MRA, demonstrating its clinical practicability and reliability. We speculate that this MRA method can be widely used in the future after further development.

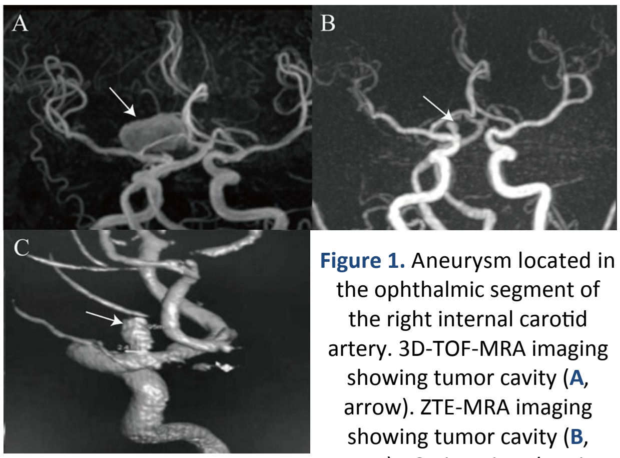

Figure 1. Aneurysm located in the ophthalmic segment of the right internal carotid artery. 3D-TOF-MRA imaging showing tumor cavity (**A**, arrow). ZTE-MRA imaging showing tumor cavity (**B**, arrow) DSA imaging showing tumor cavity (**C**, arrow).

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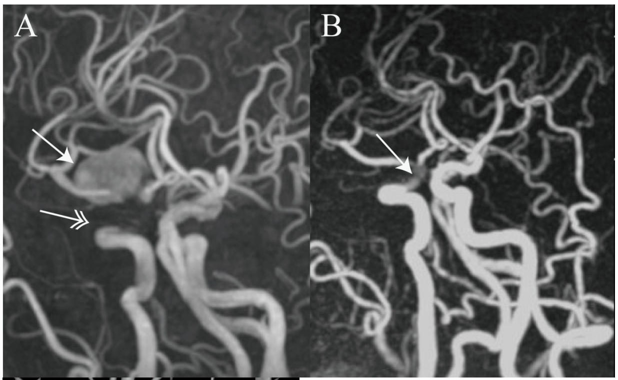

Figure 2. Stent-assisted interventional embolization of aneurysm located in the ophthalmic segment of the right internal carotid artery. 3D-TOF-MRA imaging showing tumor cavity (**A**, arrow). The ophthalmic segment of the right internal carotid artery is unclear (**A**, double arrow). ZTE-MRA imaging showing tumor cavity (**B**, arrow). DSA imaging shows the tumor cavity (**C**, arrow).

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Author contribution**:** Conceptualization: L.Sh. Data curation: J.B.L, X.Q, Zh.Ch.; Formal analysis: J.Bo.L, X.Q, Zh.Ch.; Investigation: L.Sh.; Methodology: L.Sh.; Project administration: J.Bo.L, L.Sh.; Resources: J.B.L, L.Sh.; Software: J.B.L, X.Q, Zh.Ch.; Supervision: L.Sh.; Validation: L.Sh.; Visualization: L.S.; Writing-original draft: J.B.L, L.Sh.; Writing-review & editing: J.B.L, L.S.

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