Noriyuki Fujima, MD, PhD
Hokkaido University Hospital
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Sapporo Hokkaido, Japan

Advancing neuroradiology imaging in cancer and stroke patients

By Noriyuki Fujima, MD, PhD, Senior Lecturer, Department of Diagnostic and Interventional Radiology, Hokkaido University Hospital, Sapporo Hokkaido, Japan

In oncology, high-quality MR images are crucial for ensuring accurate tumor identification and delineation for treatment planning. Hokkaido University Hospital in Sapporo, Japan, performs 60 to 80 MR examinations per day, including 30 to 50 brain scans, five to 10 head and neck studies, and five to 10 spine cases. The institution recently upgraded a Discovery™ MR750w 3.0T with the latest MR 30 for SIGNA™ software, enabling both AIR™ Recon DL and PROPELLER DWI to deliver the high-resolution images necessary for more confident tumor diagnoses.

High-quality images across the board

AIR Recon DL removes noise and ringing from raw images, improving SNR to sharpen images up to 60% and enabling up to 50% faster scan times. It has been expanded to include motion-insensitive PROPELLER and 3D imaging capabilities. PROPELLER is designed to reduce the effect of patient voluntary and physiologic motion (breathing, flow, peristalsis), and reduce magnetic susceptibility artifacts.

AIR Recon DL has exceeded our expectations. It has noticeably improved image quality in all MR examinations and has dramatically enhanced the quality of routine images, making it very useful not only for patients requiring high-resolution imaging but also for those undergoing follow-up. The improvement in image quality with AIR Recon DL is seamless and effective.

This upgrade allows us to consistently obtain high-resolution images to clearly visualize pathologies and deliver accurate diagnoses. We now have images with less noise, which has made diagnoses easier. The improved image quality has made interpretation more straightforward and stress-free, leading to a significant improvement in the output of interpretations.

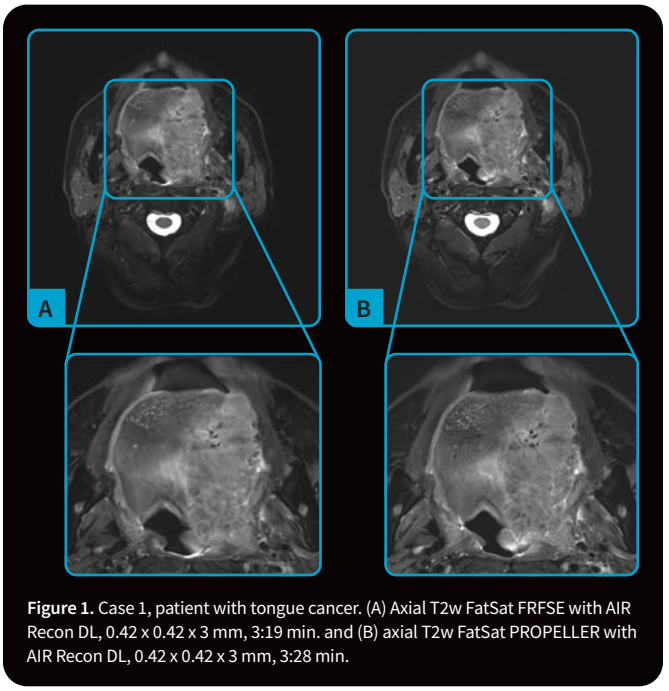

Figure 1. Case 1, patient with tongue cancer. (A) Axial T2w FatSat FRFSE with AIR Recon DL, 0.42 x 0.42 x 3 mm, 3:19 min. and (B) axial T2w FatSat PROPELLER with AIR Recon DL, 0.42 x 0.42 x 3 mm, 3:28 min.

Due to limitations in sequence design, EPI-based diffusion-weighted images (DWI) can't completely eliminate distortion, even with optimized parameters. On the other hand, high-speed

spin-echo-based PROPELLER DWI offers the significant advantage of distortion-free DWI. However, traditional PROPELLER DWI suffered from insufficient SNR, making it difficult to provide images suitable for adequate diagnosis due to noise. That's all changed with the recent upgrade.

With the introduction of deep learning, the image quality of PROPELLER DWI has significantly improved. Now, anatomical structures are presented in distortion-free images and lesions are depicted with high signal intensity, making the images much easier to interpret.

Our hospital also implemented 3D ASL with flexible label duration. It allows for the visualization of delayed blood flow that was not possible with the previous label duration. With the long label duration, the correlation with brain blood flow SPECT has also improved, thereby broadening the scope of diagnosis.

Additionally, neurosurgeons have responded positively to the Silenz MRA for evaluating post-aneurysm coiling. At our hospital, a significant number of patients with aneurysms are treated using flow diverter stents. The visualization of blood flow within the stent after insertion has significantly improved with Silenz MRA, which we believe is a major advantage of this technology.

The impact on cancer treatment planning

This clear visualization means clinicians at Hokkaido can more confidently delineate the shape and extent of lesions, determine the irradiation range for radiation therapy and, in surgical procedures, determine the extent of tumor resection.

In the past, tumor signals were detected from images "buried in noise." Distinguishing between tumor infiltration and inflammation was challenging, often requiring the inclusion of ambiguous areas in the treatment range. This sometimes led to disagreements among physicians regarding the resection range and surgical approach during multidisciplinary conferences related to surgery. However, the software upgrade solved these challenges.

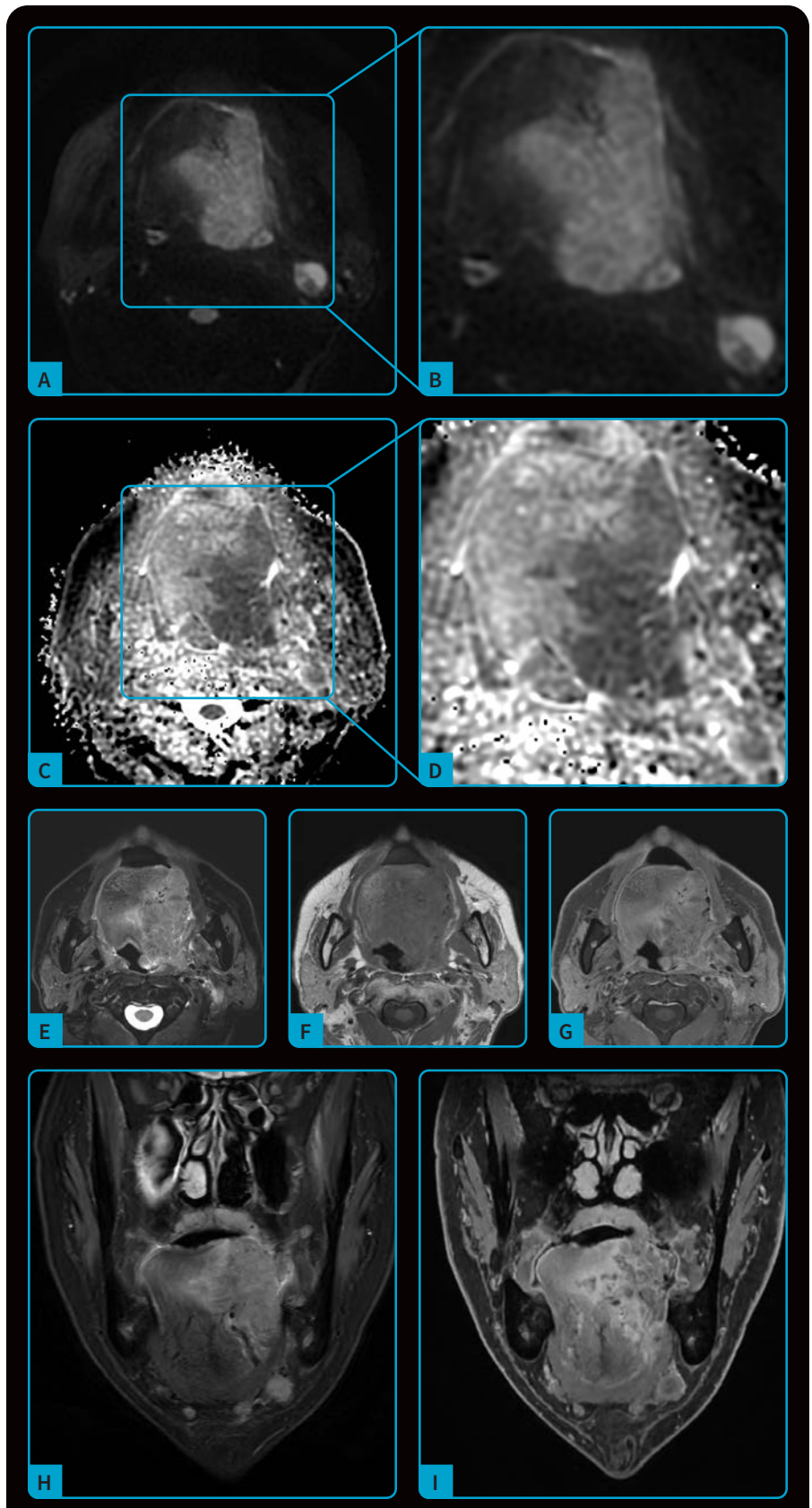

Figure 2. Case 1, tongue cancer. All images acquired with AIR Recon DL. (A, B) Axial DWI b1000 PROPELLER, 1.31 x 1.31 x 3 mm, 2:54 min.; (C, D) ADC map; (E) axial T2w FatSat PROPELLER, 0.42 x 0.42 x 3 mm, 3:19 min.; (F) axial T1w FSE, 0.68 x 0.76 x 3 mm, 2:16 min.; (G) contrast-enhanced (CE) axial T1w FSE Flex, water, 0.57 x 0.68 x 3 mm, 3:34 min.; (H) coronal T2w FSE Flex, water, 0.55 x 0.78 x 4 mm, 2:17 min.; and (I) contrast-enhanced (CE) T1w FatSat LAVA, 0.73 x 0.73 x 0.7 mm, 2:16 min.

By using AIR Recon DL, we can now better assess the extent of tumors and the progression of inflammation. As a result, we can confidently determine the resection range for radiation therapy and surgery, and approach treatments and surgeries with greater psychological reassurance.

The improvement in image quality has made a significant difference by providing images that are easier to understand not only for experienced radiologists, but also for trainees and clinicians who are less familiar with MR oncologic imaging.

Case 1: Tongue cancer

Patient history

A male patient in his 60s, presenting with a primary complaint of numbness of the left side of the tongue.

Results

The findings/diagnosis reported in the radiological diagnostic report indicated left tongue cancer T4aN2cM0. This patient was pathologically diagnosed with squamous cell carcinoma through biopsy.

In this patient, PROPELLER DWI and AIR Recon DL were used to visualize the tongue cancer. Images show a clear delineation of the lesion boundaries. The extent of tumor progression was clearly visible, which helps support accurate chemoradiotherapy. The patient subsequently became a candidate for radiation therapy.

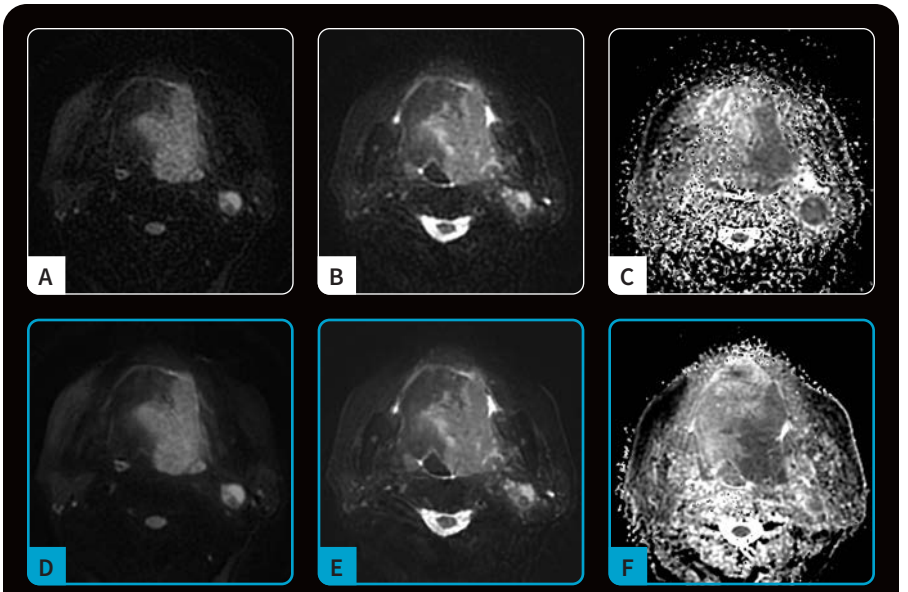

Figure 3. Case 1, tongue cancer. Comparison of PROPELLER DWI with and without AIR Recon DL. Conventional PROPELLER DWI, (A) B1000, (B) B0 and (C) ADC map. PROPELLER with AIR Recon DL, (D) b1000, (E) B0 and (F) ADC map. Both sequences acquired with 1.31 x 1.31 x 3 mm, 2:54 min.

Discussion

Depicting the extent of tumor progression is crucial in diagnosing tongue cancer and determining the resection range necessary for surgical planning. Additionally, when chemoradiotherapy is chosen, setting an accurate target volume is important. However, distinguishing between the tumor, inflammation and reactive changes is a key challenge in treatment planning.

Fat-saturated T2-weighted images and contrast-enhanced T1-weighted images make it difficult to accurately determine the extent of a tumor due to the effects of inflammation. DWI highlights only the tumor areas with high cellular density, making it easier to distinguish between the tumor and surrounding edema. Previously, noise affected the accuracy of delineating tumor boundaries, but with PROPELLER DWI, it is easier to determine the extent of the tumor.

The presence of air or dental implants can also cause distortions in the images, which can make it difficult to discern the shape and boundaries of the lesion. Moreover, the tongue is a highly mobile area, which can lead to motion artifacts in T2-weighted and T1-weighted images.

These issues with diagnosing tongue cancer have been addressed by PROPELLER and PROPELLER DWI. Because the sequences

Discovery MR750w 3.0T with MR 30.1 software							
Case 1: Tongue cancer	PROPELLER DWI	Axial T2w FatSat PROPELLER	Axial T2w FatSat FSE	Axial T1w FSE	Coronal T2w FSE-Flex water	Axial T1w FSE-Flex water, post-contrast	Axial T1w LAVA-Flex water, post-contrast
TR (ms):	82.6	88.3	81.7	8.4	74.3	11.2	2.1
TE (ms):	5600	8303	4740	708	4565	835	6.2
FOV (cm):	20	22	22	2	25	22	25
Slice thickness (mm):	3	3	3	3	4	3	0.7
Frequency:	152	512	512	320	452	384	352
Phase:	152	512	512	288	320	320	352
NEX:	2	1.56	1	1	1	1	0.7
Scan time (min.):	2:54	3:28	3:19	2:16	2:17	3:39	2:16
Options/other:	AIR Recon DL	AIR Recon DL, Acc, TRF	AIR Recon DL, Acc	AIR Recon DL, Acc, Z1024	AIR Recon DL, Acc, Z1024	AIR Recon DL, Acc, Z1024	AIR Recon DL, Acc, Z1024

are FSE-based, they also reduce the effects of magnetic susceptibility changes.

Previously, PROPELLER DWI image quality suffered from noise and blurring, making it challenging to use clinically. With the introduction of AIR Recon DL, these issues have been mitigated, leading to confident, accurate diagnoses and effective treatment with PROPELLER DWI and AIR Recon DL.

The improved ability to determine the extent of the lesion has led to greater consensus on treatment plans, enabling clinicians to confidently proceed with chemoradiotherapy or surgical procedures.

Case 2: Pituitary microadenomas

Patient history

A male patient in his 40s with a primary complaint of palpitations and dyspnea with no notable past medical history.

Results

The findings/diagnosis reported in the radiological diagnostic report indicated pituitary microadenoma. Low thyroid-stimulating hormone (TSH) levels were detected in a blood test.

Discussion

Pituitary microadenomas are challenging due to their small size and the low contrast between the lesion and normal tissue in non-contrast imaging. Therefore, dynamic contrast enhancement (DCE) becomes crucial for diagnosis. Pituitary DCE is performed using FSE to avoid susceptibility artifacts due to air in the sinuses. However, with FSE sequences, setting imaging parameters to maintain short temporal resolution while ensuring high spatial resolution and sufficient SNR has been very challenging.

AIR Recon DL is highly effective in addressing this issue. Achieving both short temporal resolution and high spatial resolution in pituitary DCE typically leads to insufficient SNR. With AIR Recon DL, it has become possible to achieve the desired scan parameters for DCE, which is highly beneficial for clinical practice.

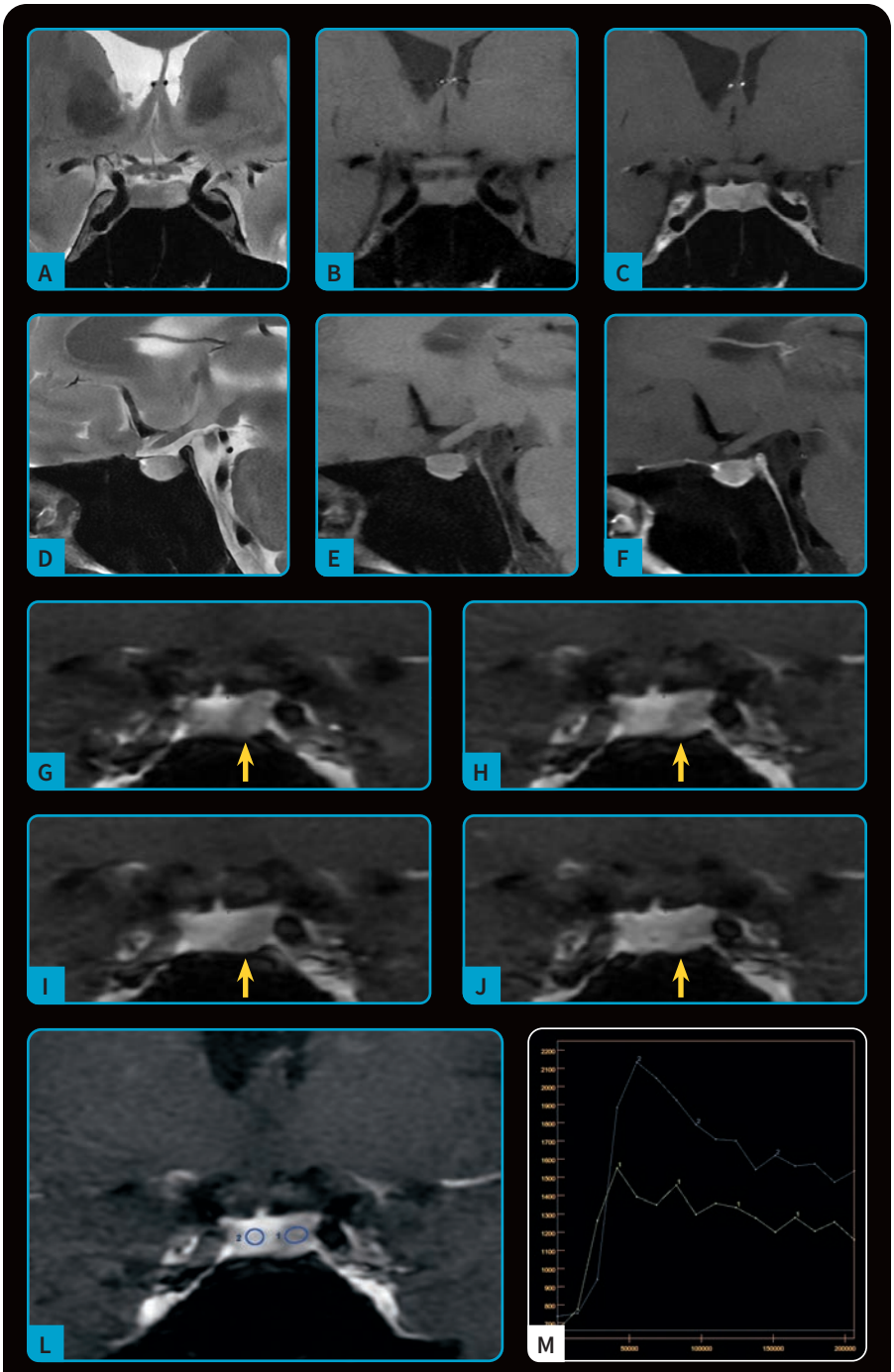

Figure 4. Case 2, patient with pituitary microadenoma. All sequences acquired with AIR Recon DL. (A) Coronal T2w, (B) coronal T1w, (C) contrast-enhanced coronal T1w, (D) sagittal T2w, (E) sagittal T1w, (F) contrast-enhanced sagittal T1w, (G-K) coronal DCE T1w and phases 4-7 and (L) T1 landmark image with (M) corresponding enhancement curve.

DCE provides clear contrast for lesions, making it easier to make confident diagnoses. In the past, achieving improved temporal resolution while maintaining a slice thickness of 3 mm was difficult. However, with AIR Recon DL, it is now possible to balance temporal resolution and image quality when diagnosing pituitary microadenomas.

However, simply increasing SNR with the same imaging parameters as before doesn't necessarily improve diagnostic efficiency. To detect pituitary microadenomas, it's important to achieve high spatial resolution with thin slices. With a slice thickness of 3 mm, only 1 to 2 slices of the pituitary are visible. If a microadenoma of approximately 3 mm

to 4 mm spans between slices, detecting the lesion becomes difficult. Additionally, partial volume effects may lead to decreased contrast in such cases.

For diagnosing microadenomas, imaging with thin slices at high spatial resolution and high temporal resolution during DCE is essential. AIR Recon DL allows clinicians to obtain images with 2 mm slice thickness, less than 1 mm in-plane resolution, and temporal resolution of less than 15 seconds.

With the traditional system, setting scan parameters for such a combination was extremely challenging, but AIR Recon DL maintains sufficient SNR in these studies.

When using other systems for this examination, it is necessary to reduce spatial and temporal resolution, which can result in difficult-to-diagnose images and may necessitate additional re-examinations. With the upgrade, clinicians can now confidently diagnose pituitary microadenomas by performing DCE with challenging scan parameters, ensuring high-quality results.

Achieving the balance of temporal resolution, in-plane resolution, slice thickness and SNR has proven to be crucial for diagnosing pituitary microadenomas. The ability to clearly identify such small lesions has had a significant impact for Hokkaido University Hospital. The quality of DCE imaging benefits from AIR Recon DL, as it helps in detecting subtle differences in signal intensity in T1-weighted and T2-weighted images that also contribute to accurate diagnoses.

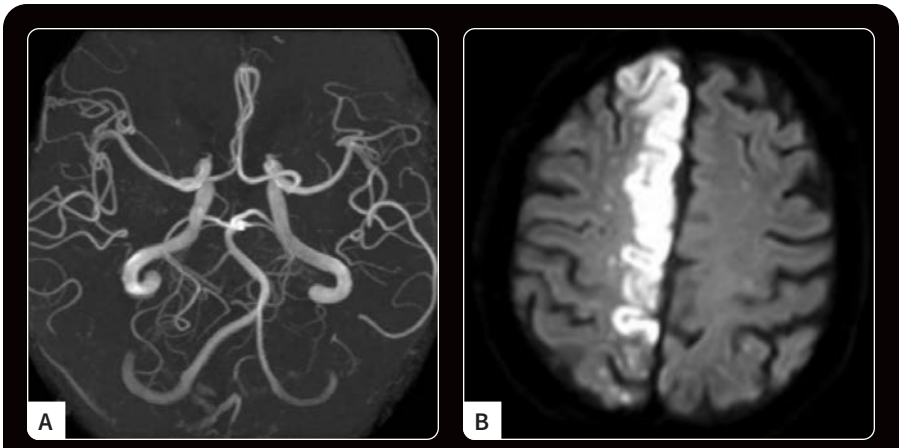

Figure 5. Case 3, patient with acute cerebral infarction. (A) TOF-MRA and DWI

Case 3: Acute cerebral infarction

Patient history

The patient is a male in his 70s, with a height of 162 cm and a weight of 46 kg. The patient's medical history includes pancreatic cancer.

The primary complaint is symptoms of paralysis.

Results

The findings/diagnosis recorded in the radiology report indicated an acute cerebral infarction in the right frontal to parietal lobe.

Using 3D ASL with flexible label duration, we extended the label duration to 4000 ms. This confirmed that collateral blood flow was maintained, which was useful in predicting the prognosis of this patient. The flexible label duration allows us to confidently diagnose the patient with acute cerebral infarction, or ischemic stroke.

Discussion

In cases of acute cerebral infarction, the patient's prognosis is heavily influenced by whether blood flow is completely blocked or if collateral pathways are present. However, the presence of vessels such as collateral circulation cannot be confirmed with non-contrast MRA. While brain perfusion SPECT is an effective method for assessing cerebral blood flow, its long exam time is not suitable for stroke patients requiring urgent treatment. Therefore, MR-based Arterial Spin Labeling

Discovery MR750w 3.0T with MR 30.1 software							
Case 2: Pituitary microadenoma	Coronal T2w	Coronal T1w	Sagittal T2w	Sagittal T1w	Coronal DCE T1w	Coronal T1w, post-contrast	Sagittal T1w, post-contrast
TR (ms):	99.4	12	99.1	11	9.4	12	11
TE (ms):	3518	460	3359	440	440	440	440
FOV (cm):	16	16	16	16	16	16	16
Slice thickness (mm):	2	2	2	2	2	2	2
Frequency:	400	440	400	384	260	440	384
Phase:	320	224	320	224	160	224	224
NEX:	1	1	1	1	1	1	1
Scan time (min.):	1:11	2:12	1:41	3:05	12 sec. x 16 phases	2:06	3:05
Options/other:	AIR Recon DL, TRF, Acc	TRF, Acc	AIR Recon DL, Acc, Z1024	AIR Recon DL, Acc, multi echo multiplanar	AIR Recon DL, Acc	AIR Recon DL, Acc	AIR Recon DL, Acc, multi echo multiplanar

(ASL) is an important imaging technique for evaluating cerebral blood flow. Yet, conventional label duration means the imaging might finish before collateral blood flow reaches the region, causing the penumbra to appear larger than it actually is.

In conventional systems, the label duration is fixed at 1450 ms, while a label duration of 1800 ms is recommended for these studies. In the diagnosis of acute cerebral infarction, it's important to observe the DWI/PWI mismatch. However, with a short label duration, imaging can be performed before perfusion occurs, raising concerns about overestimating the ischemic area due to insufficient signal. By extending the label duration to 4000 ms, as shown in this case, the mismatch can be visualized in the same regions seen with CT angiography.

This upgrade offered 3D ASL with flexible label duration, a significant advancement that overcomes this issue to improve accurate stroke diagnoses. Setting a long label duration allows for the confirmation of collateral blood flow, which significantly contributes to patient management after the examination. Acquiring images with a long label duration provides clearer images that are more easily interpreted and can be used reliably in routine clinical practice.

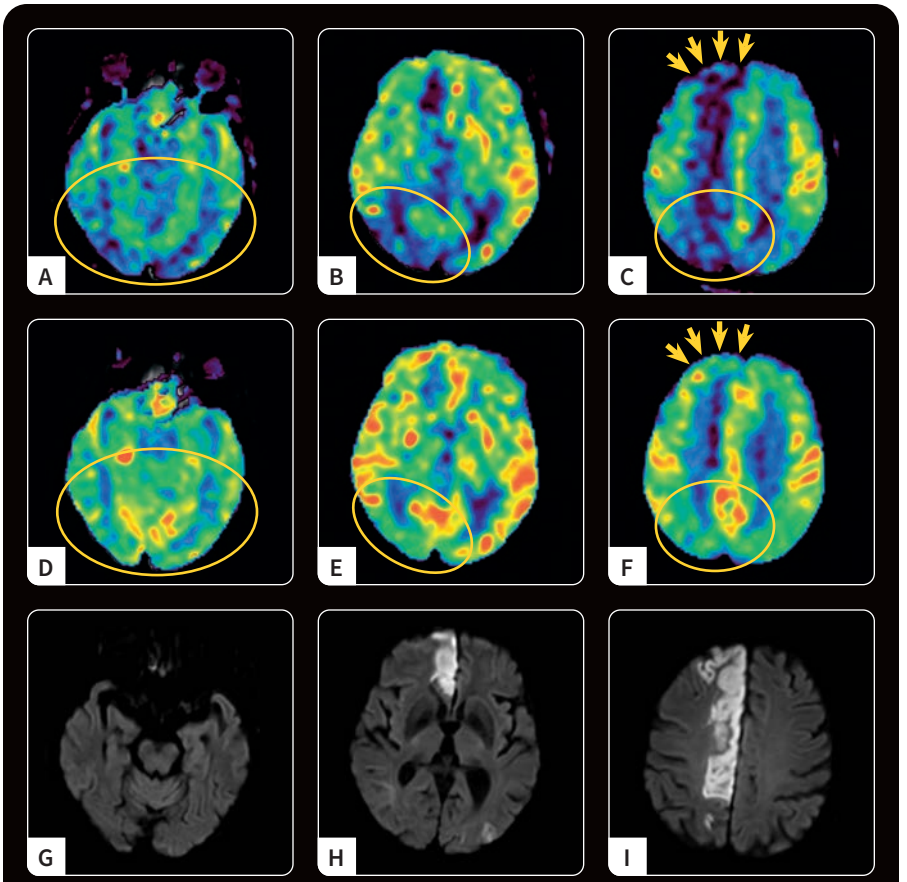

Figure 6. Case 3, patient with acute cerebral infarction. Images demonstrate value of 3D ASL long label duration. (A-C) Axial 3D ASL at 1800 ms, (D-F) axial 3D ASL at 4000 ms and (G-I) axial DWI b1000.

Discovery MR750w 3.0T with MR 30.1 software						
Case 3: Acute cerebral infarction	**3D ASL, 1800 ms**	**3D ASL 4000 ms**	**Axial DWI**	**TOF MRA**	**Axial T2 FLAIR**	**Axial T2*w**
TR (ms):	10.7	10.7	76.6	3.4	88.1	20
TE (ms):	4466	7016	5014	20	10000	700
FOV (cm):	21	21	21	21	21	21
Slice thickness (mm):	4	4	5	1	5	5
Frequency:	512 x 6	512 x 6	129	416	400	400
Phase:			192	224	300	256
NEX:	2	2	2	0.84	1	1
Scan time (min.):	2:10	3:29	50 sec.	4:28	2:50	1:26
Options/other:	Flexible label duration 1800, post label delay 1525	Flexible label duration 4000, post label delay 1525	AIR Recon DL, Acc	Acc	AIR Recon DL, Acc	AIR Recon DL, Acc