Understanding DWI and ADC

When water movement decreases, that area generally remains brighter on high-b-value DWI. However, to determine whether this brightness truly results from restriction, we look at ADC.

What are we looking at with diffusion MRI

Water molecules within tissues constantly make small, random movements. Diffusion MRI allows us to assess **how freely water can move within its surroundings.**

To understand this, imagine two environments: In one, water has plenty of room to move; in the other, cells and cell membranes limit its displacement. Water does not stop completely in the second environment, but it can travel a shorter distance over the same period. **This is what we mean by reduced or restricted diffusion.** [1]

What does the image look like when water moves freely

On high-b-value DWI, the signal from freely moving water decreases more. These areas therefore tend to appear darker.

When water moves less, less signal is lost, and the area may **remain brighter** than its surroundings. The basic reason for brightness on diffusion-weighted images is therefore that water with reduced movement retains more signal. [2]

Cerebrospinal fluid is a good example: Because water moves relatively freely within it, it usually appears dark on high-b-value DWI.

What does the b value do

The b value is an acquisition setting that determines how sensitive the image is to water movement. It does not change the movement of water; it changes how that movement affects the image.

On the b=0 image, there is very little suppression related to water movement.
On the b=1000 image, the signal from freely moving water is suppressed more. Areas with reduced movement can therefore become more conspicuous.

These two images are often used together in routine brain MRI. Increasing the b value further does not always produce a better image; image signal may also decrease. [2]

Why do we need ADC

Because **not every bright area on DWI means that water movement has decreased.** Some tissues may also appear bright on DWI because of their T2 properties. This is called **T2 shine-through.** [3]

The ADC map is calculated from images acquired at different b values and helps us assess whether water movement has truly decreased. On a standard grayscale ADC map:

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Water movement	High-b-value DWI	ADC
Reduced movement	Generally bright	Dark relative to the appropriate reference tissue
Water moves freely	Generally darker	Brighter
Brightness due to T2 effects	May be bright	Not low; may be normal or high

This is why we follow this sequence when readingthe images: **First, we find the bright area on DWI, then we look at the same location on ADC.** If the brightness is accompanied by reduced ADC, true diffusion restriction is supported. If ADC is not low, we do not call it “restriction” based on DWI brightness alone. [2,3]

Why normal brain tissue and CSF look different

CSF stands for cerebrospinal fluid. Water moves more freely within this fluid than within brain tissue. In brain tissue, cells and cell membranes limit water movement. Normal brain tissue therefore has a lower ADC than CSF. [1]

What does apparent mean in ADC

ADC stands for **apparent diffusion coefficient.** We can think of it as a measurement that helps express water movement within the tissue being examined as a number. It is called “apparent” because the value obtained is influenced both by tissue structure and by how the measurement is performed. [1,2]

At this stage, the key point is this: **A low ADC tells us that water movement has decreased relative to the tissue used for comparison; it does not tell us the cause on its own.** To understand the cause, we need to look at the lesion’s location, shape, and appearance on other images.

Now let us look at the illustration using the same reasoning

There is a bright focus on the left-hand image in each row. If we looked only at these images, we might think that both foci show restriction. Now let us move to the ADC images in the middle.

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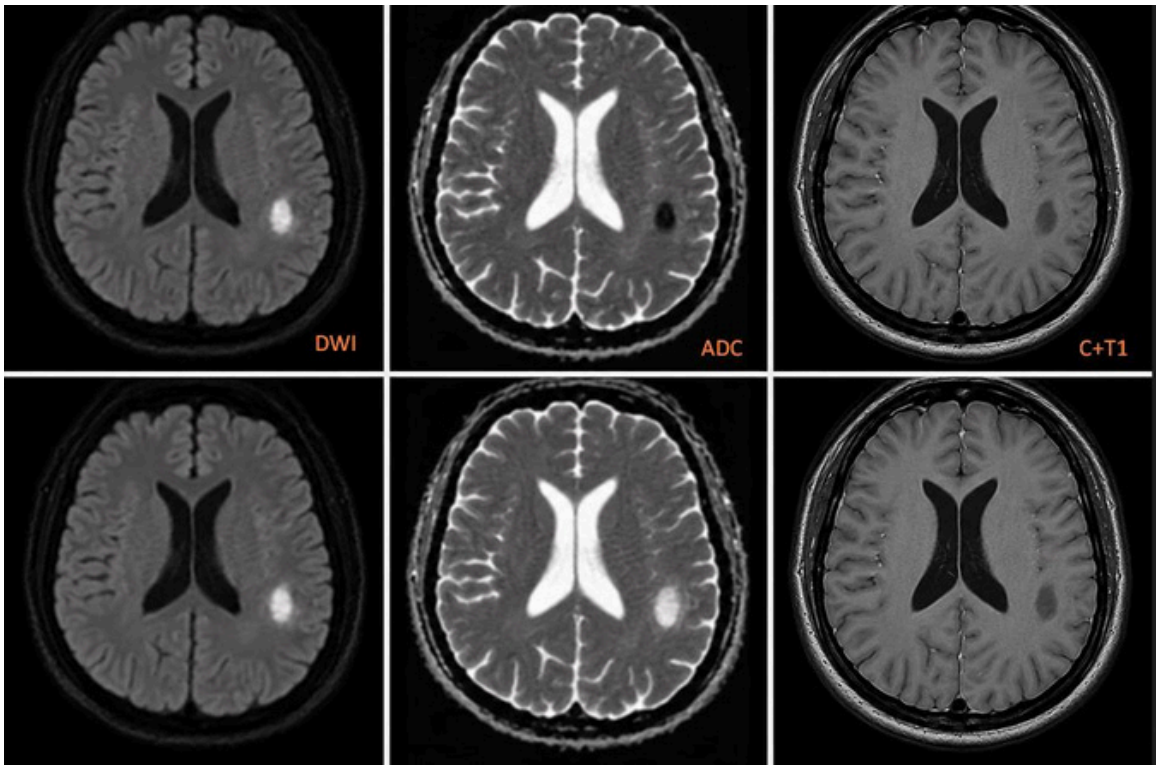


Figure 1. This illustration compares true diffusion restriction with the T2 shine-through effect. The bright focus in the upper row has low ADC, whereas the focus in the lower row has high ADC.

In the upper row, the bright focus appears dark on ADC. Because the DWI brightness is accompanied by reduced ADC, true restriction is supported.

In the lower row, the focus is also bright on DWI, but it does not become dark on ADC; it remains high in signal. Here, reduced water movement does not explain the brightness. The T2 shine-through effect becomes the leading explanation. [2,3]

The columns in the illustration are DWI, ADC, and postcontrast T1 from left to right. Neither focus is shown with appreciableenhancement in this example; the distinction is provided by its ADC behavior.

Image note: This is an AI-generated educational illustration, not an actual patient image. Signal shades cannot be used as quantitative ADC measurements.

What else does the postcontrast image tell us

We assess water movement with DWI and ADC. The postcontrast image shows which part of the lesion enhances. These answer different questions; **an area does not have to enhance to show restriction.**

For example, in a typical abscess, the pus-containing center may show restriction, whereas the enhancing component is the capsule surrounding that center. In lymphoma, the solid, meaning non-fluid, tumor tissue that shows restriction may also enhance markedly. We therefore ask not only “Does it restrict?” but also **“Which part of the lesion shows restriction?”** We will explore these comparisons in greater detail in later parts. [4,5]

How should we approach the initial reading

We can open the images together and proceed in the following order:

Find the bright area. Where is the focus that stands out on high-b-value DWI?

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Look at the same location on ADC. Is it darker than the appropriate normal reference tissue?
Confirm its location. Are we truly looking at the same tissue on the other MR images? Is motion or image distortion affecting the assessment?
Then investigate the cause. Which possibility is supported by the area's location, shape, enhancement, and the patient's clinical information?

Can we immediately call it an infarct if restriction is present

No. Reduced water movement is not unique to infarction. Abscess contents, some highly cellular tumors, and seizure-related changes may also show restriction. A low ADC does not indicate the same diagnosis in all these processes. [4–6]

Nor can we conclude that "this tissue will definitely not recover" from a low ADC alone. Some changes related to seizures and hypoglycemia, meaning low blood glucose, may regress. We interpret the outcome by assessing the imaging findings together with the clinical course. [6,7]

What should we remember from this part

On high-b-value DWI, signal decreases more when water moves freely; when movement is reduced, the area may remain brighter.
We always check DWI brightness against ADC at the same location.
We compare ADC with normal tissue appropriate to the area being assessed.
Once true restriction has been confirmed, we investigate its cause; restriction alone is not a diagnosis.

Next part

In Part 2, we will examine the causes of DWI brightness and conditions that can mimic true restriction in greater detail.

Abbreviations

DWI: diffusion-weighted imaging. ADC: apparent diffusion coefficient. CSF: cerebrospinal fluid. Unit of the b value: s/mm².

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