



Direct **visualization of nerves** can influence surgery decisions

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Northern Fukushima MRI team adds 3D NerveVIEW sequence to visualize spinal nerve abnormalities

At Northern Fukushima Medical Center in Japan, excellent MRI visualization of nerves helps support confident diagnoses and informs surgical treatment decisions for patients with lower limb symptoms. MRI technologist Tanji and orthopedic surgeon Dr. Yabuki share how direct nerve visualization with the 3D NerveVIEW method adds information when diagnosing atypical herniations. The additional insights changed their way of working and benefit their patient care, as illustrated by some clinical examples.

“NerveVIEW helps us to determine the disease matching the symptoms by directly visualizing nerves”



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NerveVIEW may help when other sequences are inconclusive

Northern Fukushima Medical Center (NFMC) Imaging Center uses the 3D NerveVIEW sequence for performing MR neurography, particularly in patients with pain and weakness in the lower limb. “It is included in about 20% of the approximately 150 lumbar spine MRI exams each month at NFMC, and can help us to determine if structures are impinging on the nerves,” says Hajime Tanji, RT, MRI technologist at NFMC.

“In patients with lower extremity neurological symptoms, NerveVIEW helps us to determine the disease matching the patient’s symptoms by directly visualizing the nerves. We use the sequence mainly, when there is suspicion of intraforaminal stenosis, extraforaminal stenosis or lateral disc herniation, which is often based on routine T2- and T1-weighted images. Additionally, the excellent depiction of the course of nerves makes NerveVIEW a good navigator when applying treatment such as block therapy or surgery.”

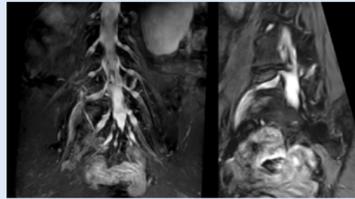
A useful addition from surgeon’s perspective

“Before NerveVIEW, diagnosis by MRI alone was sometimes difficult, unless there was a strong suspicion based on clinical symptoms,” says Shoji Yabuki, MD, DMSc, Orthopedic surgeon at Fukushima Medical University School of Medicine. “This is why we routinely perform selective lumbosacral radiculography (nerve root block) and x-ray in such cases. However, radiculography can only depict nerves as far as the contrast agent reaches. When a nerve is distorted by compression, the contrast agent will not pass through this compressed area, preventing us from evaluating the full nerve compression.”

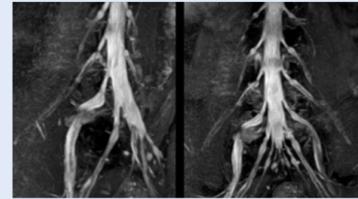
“In such case, we would then browse through axial T2-weighted MR images slice by slice and mentally reconstruct the actual situation based on both radiculography and MRI. Fortunately, NerveVIEW can now very well show nerve courses and presence of nerve compression or edema in one single image series.”

“We have often seen NerveVIEW directly depict details of the nerve compression that were not observed by radiculography. Therefore, we think that with NerveVIEW we can reduce the number of invasive examinations, especially for some patients with lumbar plexus symptoms.”

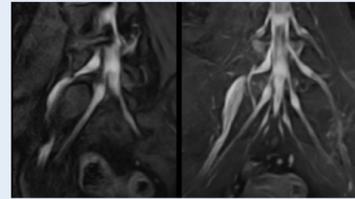
Clinical cases



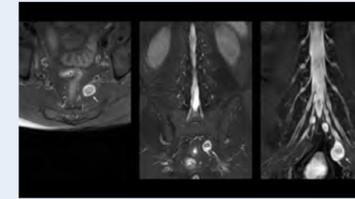
NerveVIEW shows right L5 radiculopathy and informs surgery



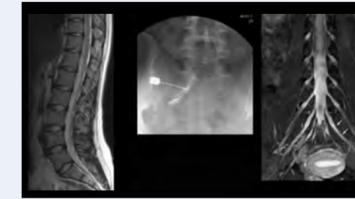
MRI of right L5 radiculopathy



NerveVIEW imaging of right L5 radiculopathy



Peripheral nerve sheath tumor (schwannoma)



Left sacroiliac arthritis

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“NerveVIEW can clearly show nerve courses and presence of nerve compression”

Direct imaging of nerves aid diagnosis

The key concept in MR neurography, Dr. Yabuki stresses, is the ability to directly visualize spinal nerves, versus inferring the presence of pathology indirectly. “Before NerveVIEW, we estimated compression of the nerve by looking for the presence or absence of fat signal on other MR images,” he says.

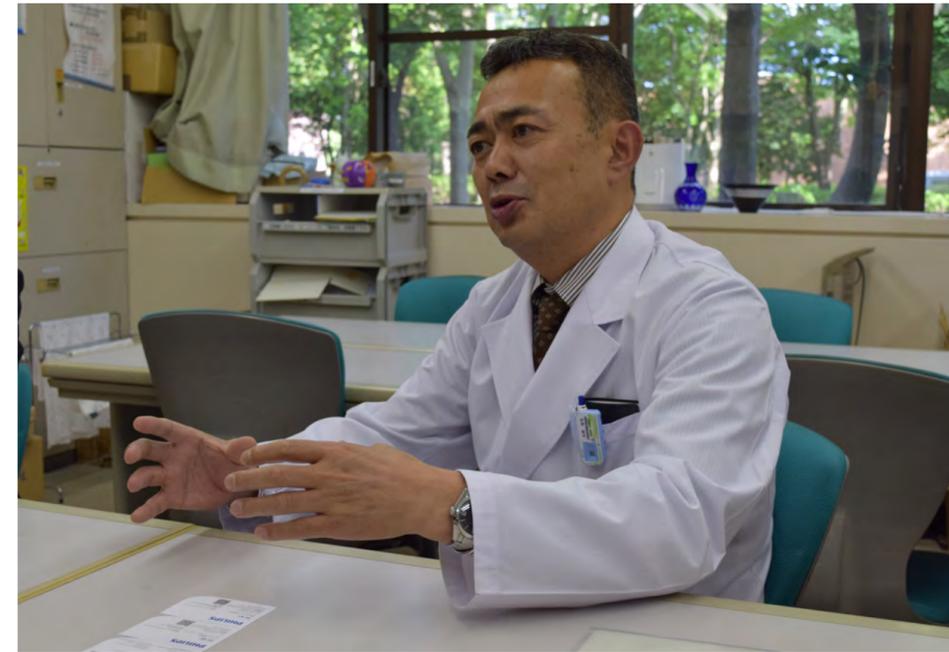
“For example, in sagittal images, when the presence of fat is observed in the intervertebral foramen, it suggests that there is a margin around the nerve. Similarly, the absence of fat indicates that the nerve is being compressed. So, we used to deduce nerve compression indirectly. With NerveVIEW, however, we can observe the condition of the nerves directly, regardless of the presence or absence of fat. We always prefer such direct observation of anatomy over having to make an inference about it.”

Distinguishing typical from atypical herniation informs the surgeon

“NerveVIEW is really useful for those cases where a nerve disorder is strongly suspected based on the clinical examination but our regular MRI images do not show any findings. These atypical herniations and spinal canal stenosis, occurring in 5% to 15% of the total lumbar herniation/stenosis cases are our main target when using NerveVIEW,” says Dr. Yabuki.

“Although symptoms of typical disc herniation and atypical hernia are very similar, the actual site of herniation is different. It is therefore important to characterize the nerve’s condition both inside and outside of the intervertebral foramina.

“Conversely, if we see no abnormality in NerveVIEW, we can assume at least that there is no severe condition that requires surgery. Like this, it can help us avoid unnecessary surgery. NerveVIEW can have a tremendous impact in this way.”



“Because NerveVIEW helps us identify the actual hernia site, it can inform selection of the surgical approach”

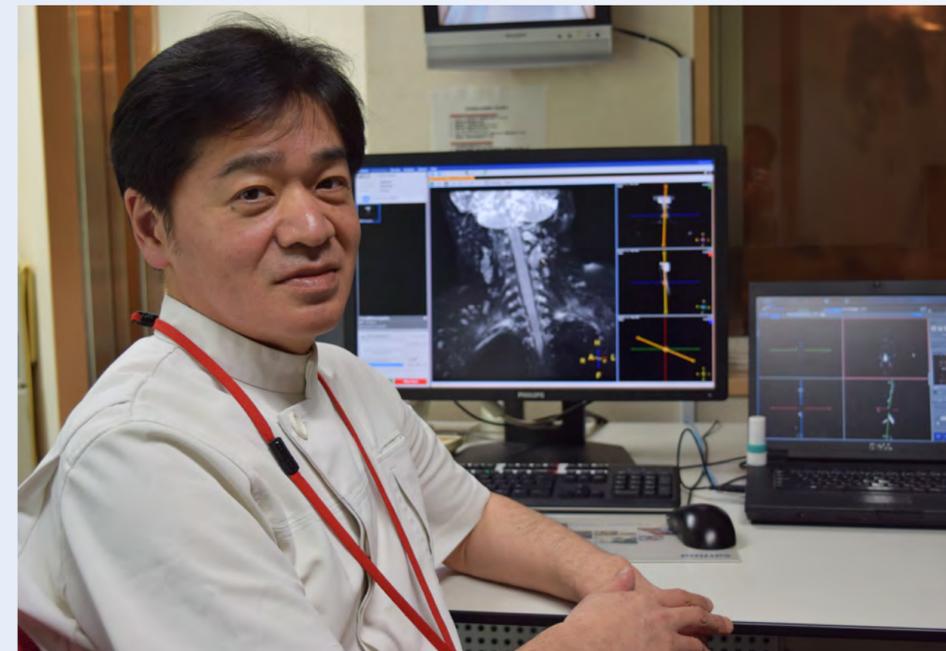
Why 3D NerveVIEW is highly appreciated at NFMC

According to Tanji, methods such as ProSet FFE, STIR or 3D VISTA are anatomically nonselective because background signals, for instance from blood vessels, often interfere with nerves, which hampers evaluation of details, especially at the peripheral side of the nerves.

“The intra-luminal signal of veins, especially around the intervertebral space, can be suppressed well with NerveVIEW. As a result, we can easily observe the detailed nerve structure around the posterior ganglion,” he says. “This is why we use 3D NerveVIEW for intraforaminal stenosis and extraforaminal stenosis/herniation (lateral disc herniation). On the other hand, if herniation is suspected to exist inside the dorsal root ganglion (DRG), balanced TFE or ProSet-FFE is applied. NerveVIEW is not suitable for evaluating the median type of herniation.”

The SE-EPI DWI-based method for MR neurography works well for large FOV exams like whole-body MRI, but focal examination of nerves is often limited by the attainable spatial resolution (both in-plane and slice direction) and geometric distortion. “3D NerveVIEW achieves higher in-plane resolution – close to our other routine spine sequences – and the source images can be used instead of adding a fat-suppressed T2-weighted sequence,” Tanji says.

“3D NerveVIEW achieves high resolution and we use its source images instead of adding fat-suppressed T2W”



Good spatial resolution is required

“For both brachial and lumbar plexus, we are currently using a 230 mm FOV and voxels of about 1 x 1 x 2 mm acquired (1 x 1 x 1 mm reconstructed). This provides us a good representation of the nerves, even though this FOV is relatively small. Regarding the in-plane resolution, we hope to be able to bring that down to 0.7 mm, similar to our typical 2D multislice T2W images,” says Tanji.

“Recently, the two surgical methods extreme and oblique lateral interbody fusion (XLIF and OLIF) have become mainstream for minimally invasive treatment of lumbar spinal canal stenosis and intervertebral foramen stenosis. With these surgical techniques, the spine is approached from the flank, and prior knowledge of the exact anatomy of the lumbosacral plexus would be extremely helpful. To that end, high slice resolution (less than 1 mm acquisition) that enables sharper sagittal MPR images will be needed.”

NFMC MRI protocol for 3D NerveVIEW in lumbar spine

FOV 230 mm
Voxels 0.99 x 1.07 x 2.5 (1.25) mm
50 (100) slices
dS SENSE factor 2.0
Scan time 5:17 min.

Postprocessing:

Because the obtained NerveVIEW images often exhibit a high signal in the intervertebral discs, we use partial MIP images to eliminate such intervertebral disc high signals. MIP image generation is based on the center of the coronal stack, and RAO (right anterior oblique) and LAO (left anterior oblique) images rotated in the range of 45 degrees are used for diagnosis.

Implementing NerveVIEW without lengthening exam time

“The source images of NerveVIEW exhibit a contrast similar to STIR or fat-suppressed T2-weighted images. So, in our neurography exams we are replacing the 2D T2-weighted coronal sequence with 3D NerveVIEW. With this, we add a lot of useful information without adding scan time. This is important for patients with severe lower extremity symptoms, as they often find it difficult to maintain still during the whole MRI examination, so the exam should be as short as possible.”

“We have currently implemented 3D NerveVIEW on our Achieva 3.0T dStream MRI system only. Because the 3D NerveVIEW method is based on a background signal suppression technique, we decided to use the high SNR of our 3.0T MRI system for obtaining the best possible visualization of peripheral nerves,” says Tanji.

“Where NerveVIEW of the lumbar plexus is currently used as a subroutine scan for patients with strong lower limb symptoms, its use for visualization of the brachial plexus, is currently limited to special cases such as schwannomas and neuritis, usually only 1 or 2 cases per month.”

Lumbar spine MRI examination with 3D NerveVIEW

T2W sagittal and axial
T1W sagittal and axial
3D NerveVIEW

Routine lumbar spine MRI examination (without neurography)

T2W sagittal and axial
T1W sagittal and axial
Fat suppressed T2W coronal

“This is important for patients with severe lower extremity symptoms”

“The sequence facilitates diagnosis of lower extremity pain and informs our decision-making regarding therapy and surgery”

Building confidence with NerveVIEW

“NerveVIEW can clearly show nerve courses and presence of nerve compression. However, when multiple abnormalities are seen, it can still be hard to determine which nerve is causing the symptoms,” says Dr. Yabuki. “In our experience so far, we see abnormal findings on NerveVIEW in about 70% of elderly patients. As the pain is usually caused by only one nerve, we thus need to find the exact corresponding nerve.”

“With a nerve root block, the patient’s pain is improved by infiltration of local anesthesia directly around the nerve root considered to be responsible. Knowing such nerve root block findings prior to image interpretation, helps to easily recognize abnormal findings on NerveVIEW as well. In other words, without a priori knowledge, based on symptoms and/or nerve root block findings, we must be aware of the possibility of overdiagnosis.”



MR neurography attracts referrals at NFMC

The addition of the nerve-selective NerveVIEW sequence to its spine MRI protocol has given NFMC competitive advantages, according to Tanji. “Since we started including NerveVIEW routinely, the demand for lumbar spine MRI examinations has increased, especially for pre-surgical planning purposes and for patients with chronic lower extremity symptoms,” he says.

“Moreover, because no other hospitals in our region are doing nerve plexus imaging yet, we often receive referrals for MR neurography studies from other hospitals even if they have an MRI scanner. Some requests come from as far as 100 km away. NerveVIEW definitely provides us a competitive advantage.”

“Based on our experience, we can certainly recommend NerveVIEW to other centers,” Dr. Yabuki adds. “The sequence opens up many possibilities to facilitate the diagnosis of lower extremity pain and to inform our decision-making regarding therapy and surgery.”



Clinical cases

NerveVIEW shows right L5 radiculopathy and informs surgery

Low-grade glioma in a 5-year-old patient with neurofibromatosis 1. This low-grade lesion does not enhance on the post-contrast images, but does show an intermediate APT signal. The lesion stability over time confirms that it is a low-grade pathology.

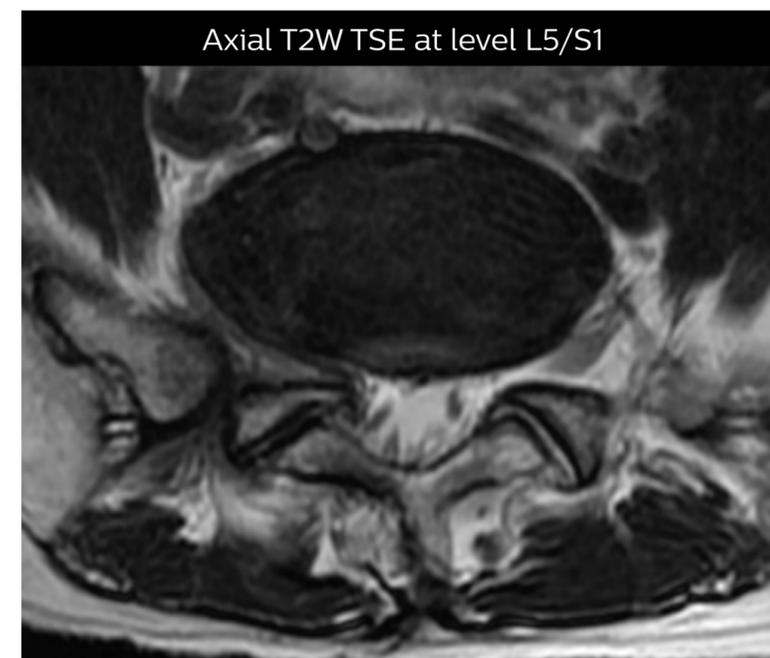
No abnormal findings were seen on routine MRI. Then x-ray radiculography was performed, but the contrast agent became trapped in transit and the nerve could not be fully observed. The peripheral nerve root is not contrasted in the nerve root block (x-ray radiculography) at the suspected location.

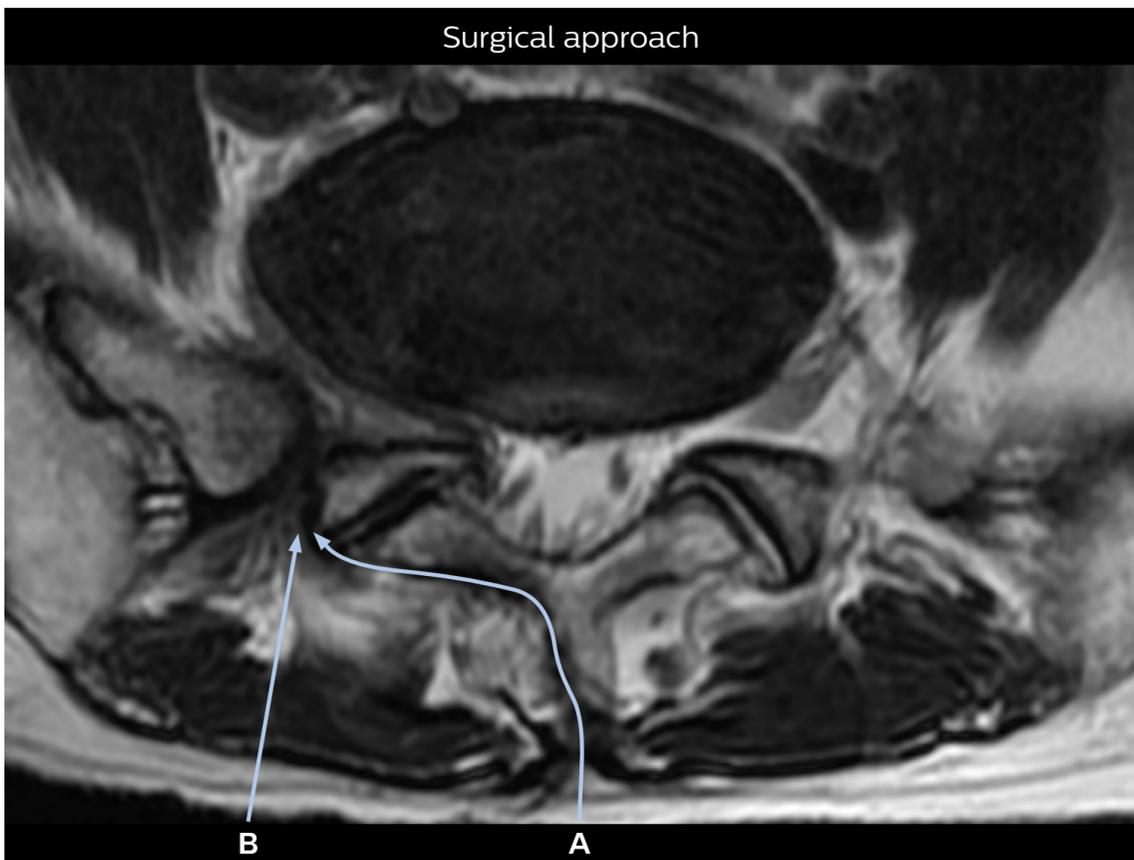
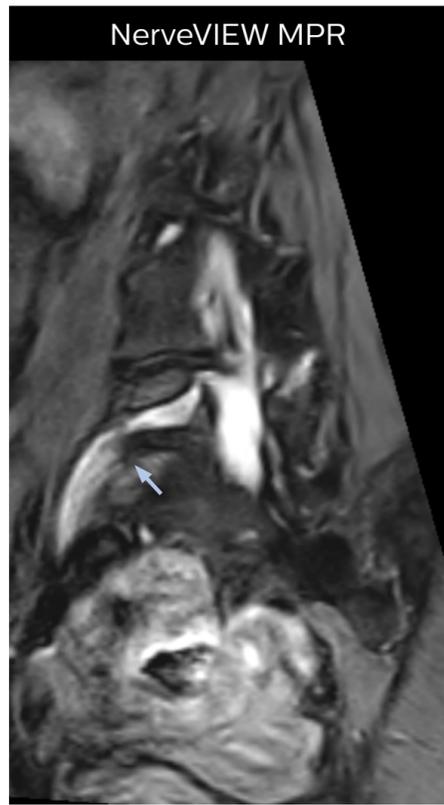
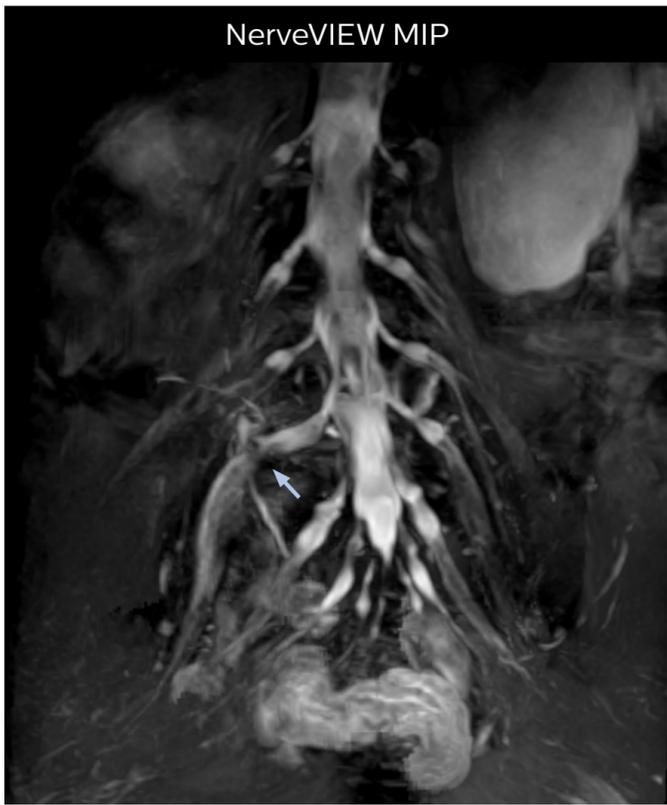
NerveVIEW images show that the spinal nerve is discontinued at the periphery of the dorsal root ganglion of the right L5 nerve root, suggesting nerve compression there. No other findings could explain the symptoms. With a diagnosis of extraforaminal herniation, surgery was performed.

Based on the findings using NerveVIEW, the surgeon decided to perform a hernia resection with a different, less invasive surgical approach from the outside of the multifidus muscle (B) instead of the usual approach (A). During surgery, disc herniation outside the intervertebral foramina was confirmed. Hernia resection released pressure on the nerve root and the right lower limb pain disappeared.

Impact of 3D NerveVIEW in this case

MRI on Achieva 3.0T dStream with NerveVIEW shows compression of nerve root outside the right L5/S1. Because NerveVIEW helped to accurately identify the location of the causative disease, a surgical approach could be chosen that prevented the need to peel off the muscle unnecessarily.



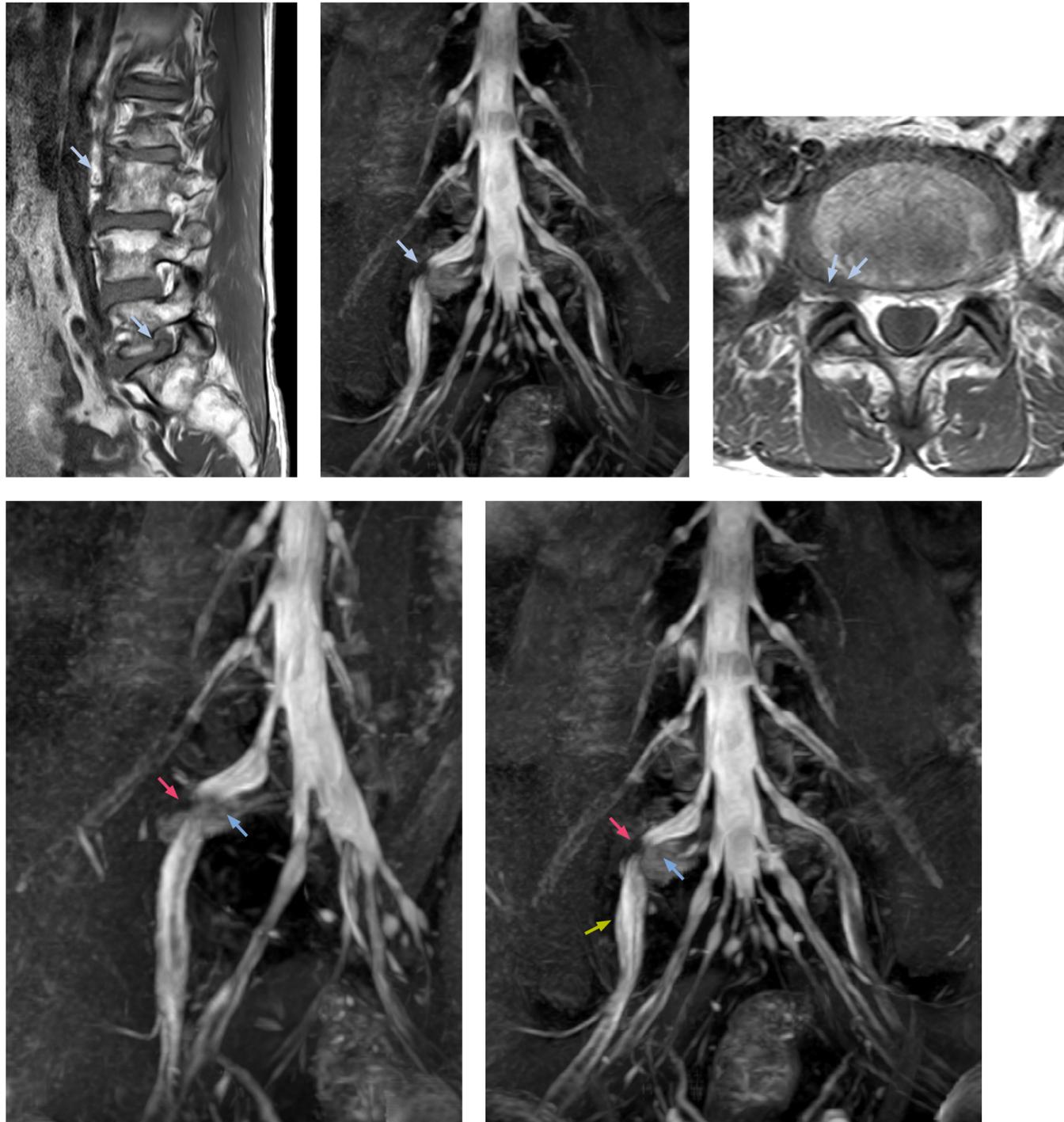


MRI of right L5 radiculopathy

In this patient with right hip to lower extremity pain, routine spine MRI at another hospital revealed L5/S1 disc herniation at the opposite side to the symptoms, but no abnormalities that could explain the patient's chief complaint. At NFMCC the patient underwent spine MRI with 3D NerveVIEW, because of a strong suspicion of L5 nerve root dysfunction based on the location of the painful area and symptoms related to sensory disorder. Achieva 3.0T dStream was used.

The L5/S1 (extraforaminal) far lateral lumbar disc herniation (blue) is seen in the images, as well as identification of the narrowing point in the right nerve root (pink) and edematous change on the proximal and distal part (green).

After surgery for right L5 radiculopathy, the symptoms of the patient were significantly improved.

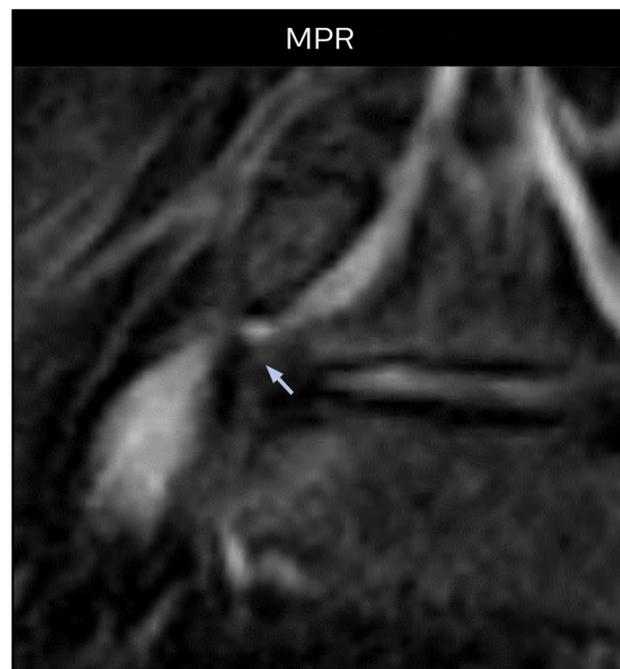
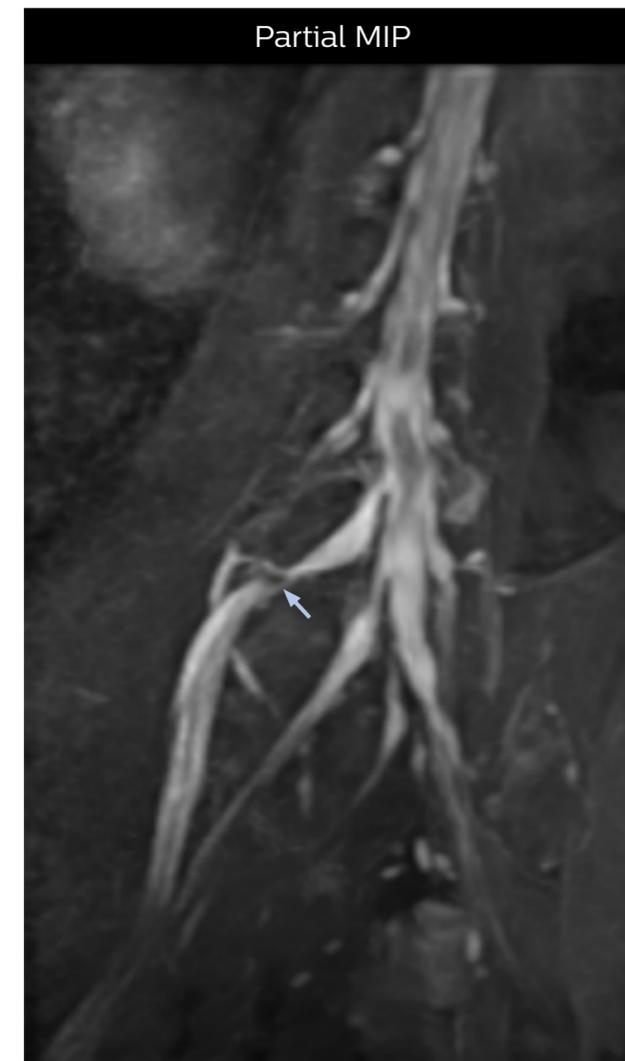
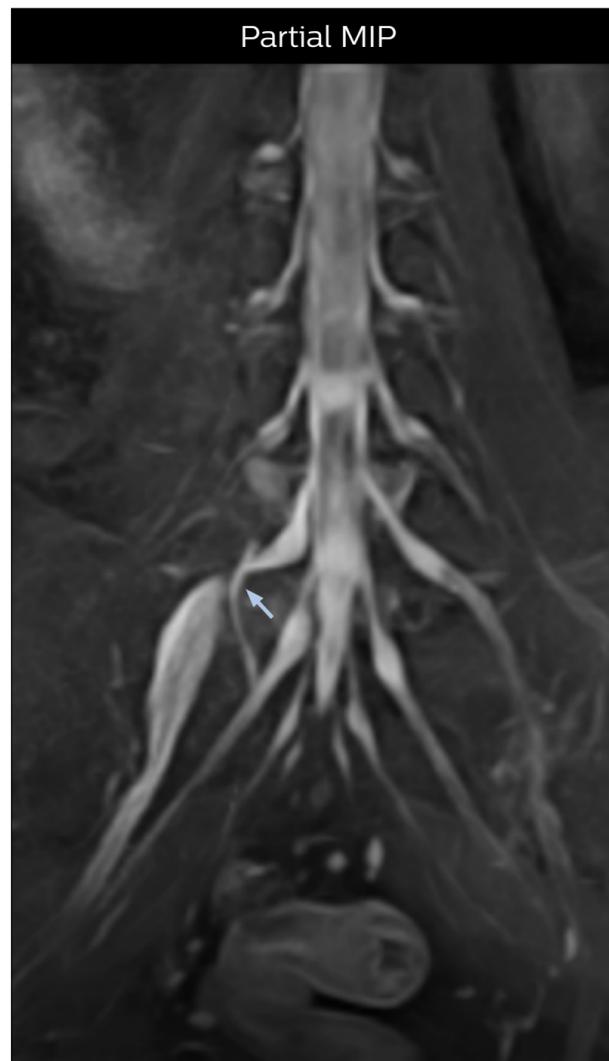
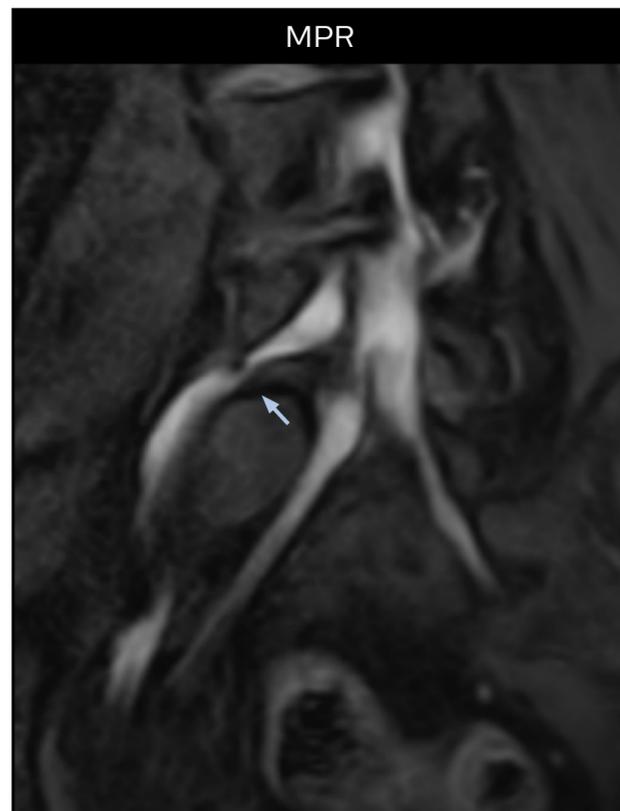


Voxels 0.99 x 1.07 x 1.25 mm rec, 5:47 min.

NerveVIEW imaging of right L5 radiculopathy

After a previous successful surgical operation to treat a lumbar disk hernia, this patient still had strong numbness from right hip to the lower extremity. The patient then underwent MRI with 3D NerveVIEW on Achieva 3.0T dStream. NerveVIEW voxels 0.99 x 1.07 x 1.25 mm rec, 5:47 min.

These NerveVIEW images helped to identify the cause of pain, being L5/S1 (extraforaminal) far lateral lumbar disc herniation. Based on these findings, the patient underwent a second surgery, after which symptoms significantly improved.

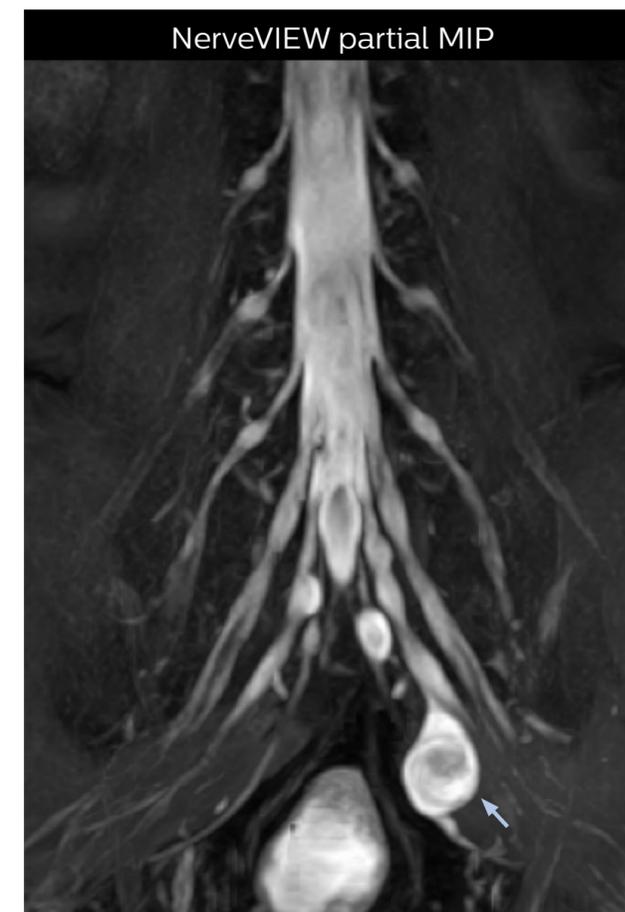
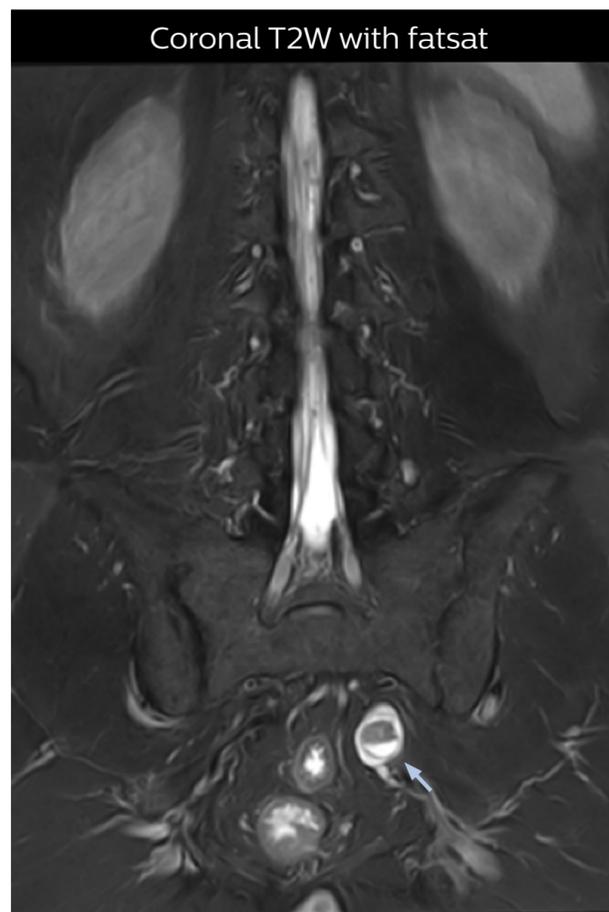
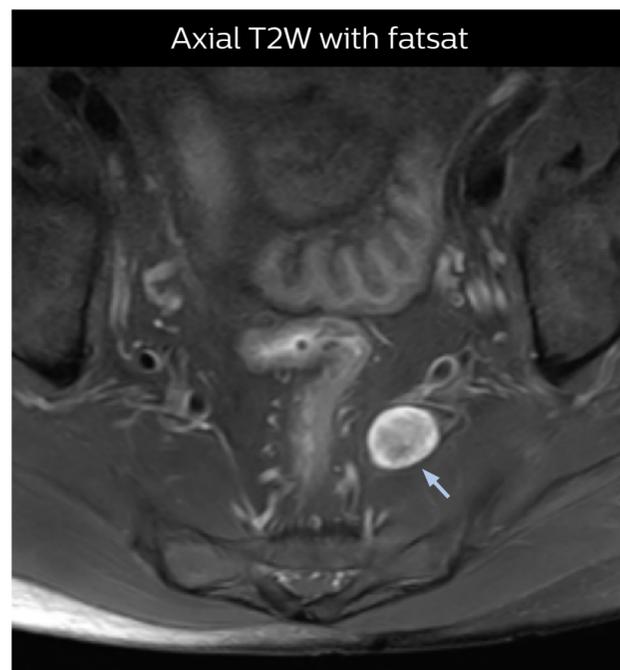


Peripheral nerve sheath tumor (schwannoma)

This patient presented with right lower back pain. Both fat suppressed T2-weighted axial and coronal images show the tumor, but the relationship between nerves is unknown. NerveVIEW imaging shows the relationship between tumor spread and nerve.

Previously, a positional relationship with a tumor was assessed from axial images, but now the course can be assessed more continuously on a coronal NerveVIEW MIP. Achieva 3.0T dStream was used.

A nerve sheath tumor is usually removed by cutting only the tumor's capsule without cutting the nerve itself. However, a tumor emerging from the nerve fiber itself cannot be removed unless the corresponding nerve is also excised. If a tumor-nerve connection can be successfully visualized, making a diagnosis and choosing the optimal surgical approach may be possible without performing a biopsy.



Voxels 1 x 1 x 2 mm, 5:47 min.

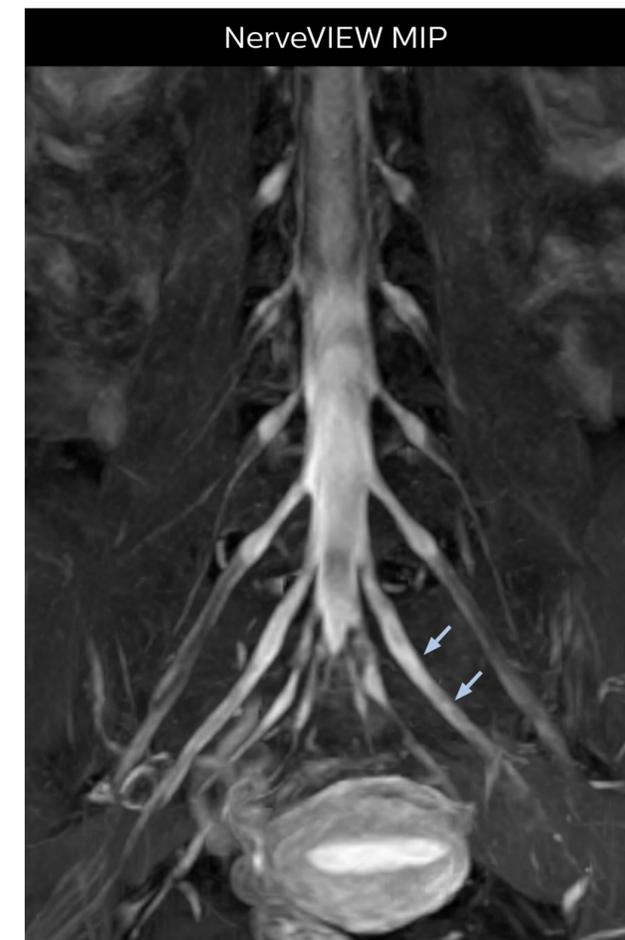
Left sacroiliac arthritis

In this patient with left hip pain as main complaint, a combination of left sacroiliac arthritis and left S1 radiculopathy was considered. Pain temporarily improved by the left S1 nerve root block, so nerve root disease was suspected to be the cause.

There were no obvious findings in routine MRI on Achieva 3.0T dStream. With 3D NerveVIEW imaging, the left S1 nerve root is well visualized from proximal to distal. However, no abnormality seen in the nerve root (arrows), so pain is not due to radiculopathy. Diagnosis is sacroiliac arthritis.

Impact of 3D NerveVIEW

Pain due to nerve injury and arthritis can show similar symptoms. Since part of this patient's pain is in the sacroiliac joint, the pain ceased when a root block was done, but often recurred, so the patient underwent many block treatments. Finally, the entire nerve was well depicted with NerveVIEW, and no significant abnormalities were observed. In conclusion, the nerve root block relieved pain only by blocking the place to convey the pain, and the actual cause was not there. This case illustrates that NerveVIEW can be useful not only in identifying lesions but also for ruling out lesions.



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