Usefulness of DWI MR-neurography in the diagnosis of piriformis muscle syndrome

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Purpose

Assess the advantages provided by the inclusion of Diffusion Weighted imaging (DWI) MR-neurography in the MRI protocol of the piriformis syndrome (PS) study.

Describe the different sequences and technical approaches of DWI MR-neurography that we can use in the assessment and evaluation of the lumbosacral plexus and sciatic nerves.

Methods and Materials

We reviewed 12 cases of clinical suspicion of PS, 8 women and 4 men with ages ranges between 23 - 56 years old. They were evaluated with 1.5 T (Intera; Phillips Healthcare) and 3 T (Archieva; Phillips Healthcare) MRI scans performing a conventional protocol for evaluating pelvic anatomy and adding axially oriented DWI MR neurography and Diffusion Tensor (DTI) neurography (Fig. 1 on page 2). Field gradients and and slew rates were 33 mT/m² and 80 T/m/s for 1.5 T MRI and 80 mT/m² and 200T/m/s for 3 T MRI, respectively. In both equipments an eight - channel phased array body coil was used.

All patients with chronic pain in the gluteal region were included in the study. Any subjects with lower back pain with spinal disc herniation, pelvic or spinal tumor coexistence and / or previous pelvic surgery was excluded from the study cohort.

Apparent diffusion coefficient (ADC; mm/S²) and fractional anisotropy (FA) were registered in DWI and DTI neurographies of the sciatic nerves respectively at the major sciatic foramen level in both affected and unaffected side. Mean and standard deviation of both ADC and FA were registered in all subjects.

Images for this section:
**Technical parameters DWI and DTI sciatic nerve neurography**

<table>
<thead>
<tr>
<th></th>
<th>1.5 Tesla (Intera®)</th>
<th>3 Tesla (Archieva®)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TR (ms)</strong></td>
<td>167226</td>
<td>6995</td>
</tr>
<tr>
<td><strong>TE (ms)</strong></td>
<td>70</td>
<td>72</td>
</tr>
<tr>
<td><strong>TI (ms)</strong></td>
<td>160</td>
<td>50</td>
</tr>
<tr>
<td><strong>FoV (mm)</strong></td>
<td>385 x 301 x 240</td>
<td>385 x 308 x 270</td>
</tr>
<tr>
<td><strong>Matrix</strong></td>
<td>128 x 99</td>
<td>148 x 120</td>
</tr>
<tr>
<td><strong>Calculated voxel (mm³)</strong></td>
<td>3 x 3 x 3</td>
<td>2.60 x 2.60 x 2.60</td>
</tr>
<tr>
<td><strong>EPI factor</strong></td>
<td>99</td>
<td>63</td>
</tr>
<tr>
<td><strong>SENSE factor</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Acquisition time</strong></td>
<td>2 min; 40 secs</td>
<td>6 min; 17 secs</td>
</tr>
</tbody>
</table>

TR: Repetition time; TE: Echo time; TI: Inversion time; FoV: Field of view; EPI: Echo planar imaging; SENSE: Sensitivity encoding.

**Fig. 1**
**Results**

Of the 12 cases evaluated, there were 2 cases with MRI features of PS: the first patient was a forty years old women with chronic left gluteal pain, in which ADC and FA values for the left sciatic nerve were 1.643±0.196 mm$^2$/sc (ADC) and 0.459±0.073 (FA), being these values for the right sciatic nerve significantly lower 1.421±0.122 (ADC) and 0.372±0.107 (FA) (Fig. 2 on page 6). The second case was a fifty-five years old women with chronic right gluteal pain, in which ADC and FA values for the right sciatic nerve were 1.382±0.112 mm$^2$ (ADC) and 0.418±0.054 (FA), being these values for the left sciatic nerve 1.279±0.175 mm$^2$ (ADC) and 0.317±0.096.

In the cases where no MRI features of PS were found, the following pathological findings were depicted: a neurogenic tumor was found on a patient with right gluteal pain and, also (Fig. 3 on page 7 Fig. 4 on page 8 Fig. 5 on page 9), an anomalous pathway of the sciatic through the left piriformis muscle was seen in other subject under study (Fig. 6 on page 10).

Attending to the remaining 8 cases with clinical suspicion of PS no one showed significal differences between ADC and FA values among left and right sides.

**DISCUSSION**

The piriformis syndrome is a neuritis secondary to compression or irritation of the sciatic nerve arising from the pyramidal muscle. This entity appears in patients with an age range between 18 and 55 years. It is much more common in women than in men (6:1).

It is a controversial entity, and most commonly, it is an exclusion diagnosis, if there is not any other underlying cause for the sciatic neuritis. From a clinical point of view, its main differential diagnosis is compression of lumbosacral neural roots by herniated lumbar discs. Other causes of sciatic nerve irritation are: trauma, overuse (runners), antialgic postures involving the external rotation of the hip, spinal stenosis or sacroiliitis.

Clinically piriformis syndrome is characterized by chronic pain in the buttocks that radiates to the lower member and is exacerbated by adduction and internal rotation of the hip, which are very inespecific symptoms, making its diagnosis difficult.
Electrophysiological studies are limited in the diagnosis of PS due to factors such as: depth of the sciatic nerve path at this point, poor reproducibility of the test and scarce value to determine the underlying cause.

Morphological MRI has been proven useful in the assessment of peripheral nerves and especially in the case of PS. Conventional MRI sequence, such as TSE T1-weighted, fat-suppressed TSE T2-weighted or STIR sequences can show significant asymmetries in the nerve thickness, differences on T2 signal intensity between the pathological and healthy sciatic nerve, or directly visualize intrinsic or extrinsic causes of sciatic nerve irritation, such as neurogenic tumors ( Fig. 3 on page 7 Fig. 4 on page 8 Fig. 5 on page 9 ), hematoma or piriformis muscle hypertrophy or anomalous bundles ( Fig. 6 on page 10 ). However, in some cases where the clinical suspicion of PS is high, morphological MRI may not show any pathological features.

Diffusion neurography is usually performed using a DWIBS sequence, which benefit of a SS EPI DWI sequence using STIR to obtain a complete background signal suppression. It is necessary to obtain a higher b value between 600 to 1000 m/s². For ADC measurements, which are useful to quantify differences between normal and pathological nerve, it is necessary to obtain also a b value of 0 m/s². This sequence is suitable to perform a neurographic sequence as an optimal contrast between the lumbosacral plexus and the background pelvic tissues is obtained. Coronal and axial MIP allows to assess at a glance the whole path of the lumbosacral neural roots an sciatic nerves. The use of fusion of the higher b value acquisition with STIR or T1-weighted sequences provide anatomic landmark to better assess the sciatic nerve path.

Visual assessment of DWI-neurography permits to evaluate the presence of asymmetries in thickness or signal of the neural structures ( Fig. 7 on page 11 Fig. 8 on page 12 ). However, it should be noted that a slight asymmetry in sciatic nerve thickness may be physiological. Therefore, it is necessary to obtain an objective measure of this difference. At this point, it is where DWIBS-neurography provides a major advantage, as it allows a quantification of the differences in ADC values of the sciatic nerves ( Fig. 2 on page 6 ).

Most commonly, the compressed nerve shows increased ADC values compared to the healthy one, below the point of compression. The measurement of ADC values using a ROI should be performed in the passage of the sciatic nerve through the greater sciatic foramen or below the compression level. Furthermore, DWIBS-neurography limits the differential diagnosis of PS, as it allows to excluding other causes of extrinsic or intrinsic compression, such as neurogenic tumors.
DWI neurography does not usually employ motion probing gradients in more than three orthogonal directions, which prevents tracking the anisotropy of the nerve. Another approach of DWI-neurography for the study of the lumbosacral plexus and sciatic nerve is based on DTI sequences. DTI is performed acquiring multiple directional vectors (at least 6) to determine for each voxel included in the study the main direction of water molecule motion, providing information on the maximum direction of the nerve fibers. In peripheral nerves, diffusion is slightly higher along axons in the peripheral nerves. Besides, measurements derived from the diffusion tensor allow to calculate Fractional anisotropy maps and quantifications.

Preliminary reports in animal models suggest that a decrease in FA value after an acute peripheral nerve injury indicates the presence of Wallerian degeneration, and that FA measurements may be good biomarker of nerve regeneration. Therefore, DTI can be used to determine the functional integrity of the nerve fibers by comparison with the contralateral nerve. In this sense, DTI sequences allow to assessing axonal integrity before structural abnormalities are present (Fig. 9 on page 13).

It has also been reported that FA values decline in chronic nerve injury and that their quantification is useful to assess nerve regeneration. This has been especially studied for carpal tunnel syndrome, although there is still lack of consensus about normal FA values of the median and other peripheral nerves. Besides, FA values of the tibial nerves were significantly lower in patients with chronic inflammatory desmyelinating polyradiculoneuropathy than in healthy volunteers. Assessment of the involvement or no involvement of peripheral nerves or neural plexus in a tumor, such as perineuromas or neurogenic ones, may be of interest in the planning of surgery or therapeutic management. Preliminary data has shown the potential of DTI in this task.

Images for this section:
Fig. 2: ROI analysis of the ADC and FA values of both sciatic nerves at the major sciatic foramen level, showing a significant difference in both parameters between left (pathologic) versus right (healthy) sciatic bundles.
**Fig. 3:** Coronally oriented fat-suppressed T2-weighted sequence showing a nodular lesion in the pathway of the right sciatic nerve. This lesion probably depends on right sciatic nerve but its difficult assure it
Fig. 4: Fusion imaging between coronally oriented TSE-T1 weighed and reconstructed colour scale based DWI-neurography showing how the nodular lesion depends on right sciatic nerve.
Fig. 5: Maximum intensity projection (MIP) coronally oriented DWI-neurography that reveals a neurogenic tumor on the right sciatic nerve.
Fig. 6: DTI-tractography revealing an anomalous pathway of the left sciatic nerve through the piriformis muscle. This finding constitutes a normal variant.
Fig. 7: Fusion imaging coronally oriented TSE T1-weighted and reconstructed colour scale based DWI-neurography, showing asymmetries of thickness and intensity between sciatic nerves. Although this subjective measure is useful to ascertain a substantive pathologic condition, the calculation of an objective value is mandatory for the diagnosis of PS.
Fig. 8: Fusion imaging coronally oriented TSE T1-weighted and reconstructed colour scale based DWI-neurography, showing asymmetries of thickness and intensity between sciatic nerves.
Fig. 9: DTI-tractography showing the pathway of sciatic nerves.
Conclusion

DWIBS and DTI neurography allows studying the lumbosacral plexus and sciatic nerve in cases of PS.

The association between using diffusion neurography sequences with conventional morphological sequences allow a more accurate diagnosis of piriformis syndrome.

References


