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Advance imaging with magnetic resonance neurography for the diagnosis of unusual extensive pelvic perineural spread in colorectal cancer: a case report

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Abstract

Background Perineural spread in rectal cancer is a rare occurrence, particularly when it extensively disseminates along the lumbosacral plexus, as well as the sciatic and pudendal nerves. Its diagnosis is challenging and represents a critical prognostic factor owing to its association with higher recurrence and metastasis rates.

Case presentation A 55-year-old Spanish female with a history of rectal adenocarcinoma underwent standard treatment, including neoadjuvant chemoradiotherapy, ultra-low anterior resection, and adjuvant chemotherapy. Five years later, a fluorine-18 fluorodeoxyglucose positron emission tomography-computed tomography scan detected a hypermetabolic lesion near the right piriformis muscle and internal iliac vessels, leading to surgical excision and radiotherapy, which confirmed metastasis. Three years after that, the patient presented with right-sided sciatica. Magnetic resonance neurography revealed characteristic features of perineural spread, including thickening, hyperintensity, enhancement, and diffusion restriction of the right sciatic and pudendal nerves, as well as the sacral roots (S1–S4). These findings differed from other neuropathic conditions, such as tumoral compression, traumatic neuropathy, and post-radiotherapy changes. Positron emission tomography-computed tomography and biopsy confirmed adenocarcinoma. Despite additional chemotherapy, the disease progressed, resulting in cerebral, lung, and bone metastases. The patient passed away 1 year later.

Conclusion This case highlights the potential role of the magnetic resonance neurography in the accurate diagnosis of perineural spread in rectal cancer, emphasizing the value of functional magnetic resonance neurography sequences in differentiating it from other causes of neuropathic pain. This is essential for clinicians, as perineural spread is associated with a poor prognosis and necessitates appropriate management.

Keywords MR neurography, Perineural spread, Colorectal cancer, Metastasis

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Background

Perineural spread (PNS) refers to the macroscopic involvement of tumor cells along nerve pathways extending away from the primary tumor and is essentially an extension of the invasion process initiated by perineural invasion (PNI). In contrast, PNI is a histological finding characterized by the microscopic infiltration of tumor cells into small nerves adjacent

to the primary tumor, which cannot be detected with standard imaging techniques.

PNI is an important histopathological characteristic associated with poorer outcomes and reduced survival in various types of cancer [1, 2]. Recently, it has been recognized as a key pathological characteristic in colorectal cancer (CRC). The 8th edition of the American Joint Committee on Cancer—Union for International Cancer Control (AJCC-UICC TNM) staging system includes pathological PNI as an additional tumor-related prognostic factor. PNI is linked to tumor spread, recurrence, and lower overall survival, making its identification and reporting essential for cancer staging and treatment planning [1].

Although most cases of PNI in CRC are identified through pathology, imaging can also be a valuable tool for detecting PNS. Advanced imaging techniques play a crucial role in differentiating malignant nerve involvement from nonmalignant conditions, such as radiation-induced neuritis or inflammatory neuropathies [3]. Among these, magnetic resonance (MR) neurography has emerged as an essential modality owing to its ability to provide high-resolution images of peripheral nerves, allowing for a detailed evaluation that is not achievable with conventional imaging techniques. This case report describes a patient with metastatic CRC exhibiting an unusual pattern of PNS, characterized by extensive tumor infiltration along the lumbosacral plexus and pelvic nerves, as seen on MR imaging. The patient's history of radiotherapy complicated the diagnosis, highlighting the importance of MR neurography in confirming the presence of PNS and aiding in the diagnostic process when other imaging modalities proved insufficient.

Case presentation

A 55-year-old Spanish female with a medical history of Widal's triad (asthma, nasal polyposis, and non-steroidal anti-inflammatory drug [NSAID] intolerance) and renal lithiasis was diagnosed with rectal adenocarcinoma. Her body mass index (BMI) was 22.5 kg/m^2, within the normal range. The initial clinical TNM (cTNM) staging at diagnosis was cT4bN2M0, based on MR imaging and clinical findings. She underwent neoadjuvant chemoradiotherapy followed by ultra-low anterior resection and adjuvant chemotherapy. Histopathological examination confirmed adenocarcinoma (pT3N0M0), with no evidence of perineural or lymphovascular invasion. The resection was classified as R0, with clear margins. The patient subsequently underwent follow-up computed tomography (CT) scans. Five years after treatment, a follow-up CT revealed a solid lesion adjacent to the right piriformis muscle and internal iliac vessels. A fluorine-18 fluorodeoxyglucose positron emission tomography-computed tomography (^{18}F-FDG PET-CT) was then performed (Fig. 1), demonstrating increased metabolic activity in the lesion, with no evidence of other metastatic sites. The patient underwent surgical excision followed by radiotherapy, and the pathology report confirmed colorectal metastasis. She remained disease-free after treatment and continued imaging surveillance. However, 3 years later, the patient developed sacral pain and newly onset sciatica. Pelvic MR neurography revealed thickening, hyperintensity, and enhancement along the right sciatic and pudendal nerves, as well as the right sacral roots (S1–S4). In addition, diffusion restriction was observed, characterized by high signal intensity on diffusion-weighted images (DWI) and low signal intensity on apparent diffusion coefficient (ADC) maps. These findings were consistent with perineural

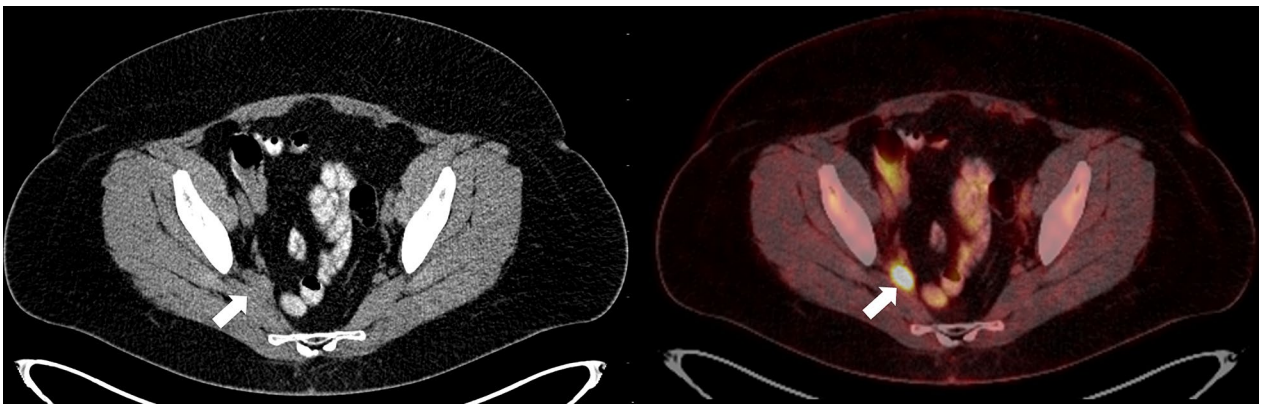

Fig. 1 Positron emission tomography-computed tomography findings of recurrent disease. Fluorine-18 fluorodeoxyglucose positron emission tomography-computed tomography demonstrates a focal area of intense fluorodeoxyglucose uptake (SUV_{max} 13.99) (arrow) near the right internal iliac vessels, in close proximity to the piriformis muscle, consistent with a tumor implant. Surgical resection confirmed adenocarcinoma

tumor spread (Fig. 2). A percutaneous biopsy confirmed adenocarcinoma, and an ^{18}F-FDG PET-CT showed intense uptake in the right greater sciatic notch. The patient was then treated with chemotherapy, but despite treatment, she experienced progression to cerebral, lung, and bone metastases and passed away 1 year later.

Discussion and conclusion

We present a case of PNS in rectal cancer, highlighting the rare occurrence of extensive tumor infiltration originating in the intrapelvic sciatic nerve, extending along its subgluteal pathway, involving the pudendal nerve, and proximally reaching the lumbosacral plexus. The proposed route of tumor spread in this patient was along the pelvic splanchnic nerves from the rectum through PNI, eventually reaching the sciatic nerve from the initial implant adjacent to the right piriformis muscle [4]. PNS often manifests as localized or radiculopathic pain, which can serve as an early warning sign of malignancy, but typically lacks other neurological symptoms, making it difficult to diagnose without advanced imaging [4]. Given the patient's history of prior surgery and radiation therapy, her sciatica could have been attributed to several causes, including PNS, post-radiotherapy neuropathy, traumatic sciatic neuropathy, or extrinsic tumoral sciatica. In cases such as this, distinguishing between these conditions is crucial, as recurrence limited to a mass may be surgically resectable, whereas perineural tumor spread or post-radiotherapy changes might require additional treatments. This distinction is essential for determining the optimal treatment strategy to improve the patient's prognosis.

MR, specifically MR neurography, was performed to assess nerve involvement and proved to be the imaging modality of choice, offering a distinct advantage in differentiating neural tumor spread from other causes of sciatica. Key MR features indicative of PNS include nerve bundle enlargement, hyperintensity on T2-weighted imaging, loss of the normal fascicular pattern, and thick, irregular enhancement after gadolinium administration [3, 5]. In addition, loss of perineural fat (the "fat-pad sign") and muscle denervation (characterized by muscle edema progressing to fat infiltration) are also key components in diagnosing perineural tumor spread [5]. Conversely, tumoral sciatica typically presents as a well-defined mass that compresses or directly invades the nerve, without other associated nerve abnormalities. Furthermore, differentiating between PNS and radiation neuritis can be challenging, as both may exhibit nerve bundle thickening, T2 hyperintensity, and variable enhancement [3]. However, PNS tends to show a thicker, sometimes nodular enhancement, and restriction on DWI, as observed in this case. DWI plays a significant role in diagnosis, as post-radiotherapy neuritis typically shows no diffusion restriction, with hyperintensity on both DWI and ADC images [6]. Traumatic sciatica, on the other hand, may present with nerve discontinuity, edema, or hemorrhage, exhibiting hyperintensity on DWI and ADC during the acute phase. In contrast, chronic cases may show signs of scar tissue formation or neuroma, both characterized by low signal intensity and variable enhancement [4, 6].

The integration of morphological and functional MR neurography sequences enhances diagnostic accuracy

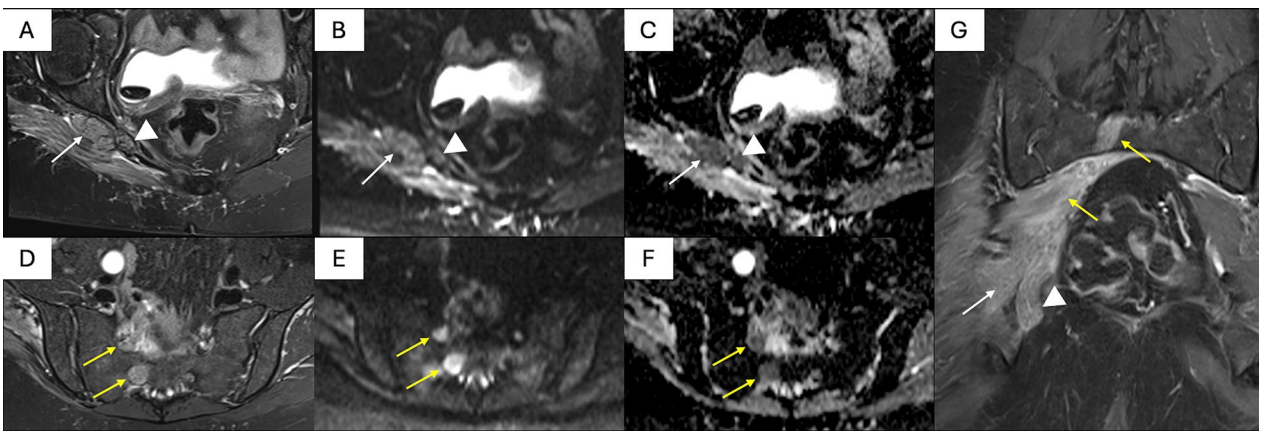

Fig. 2 Pelvic magnetic resonance neurography. **A**, **D** Axial T2-weighted spectral attenuated inversion recovery images, **B**, **E** axial b800-diffusion-weighted images, and **C**, **F** axial apparent diffusion coefficient images, at the level of the sciatic notch (**A**–**C**) and the sacral plexus (**D**–**F**). **G** Coronal T1-weighted fat-saturated post-gadolinium image. These pelvic magnetic resonance images demonstrate thickening, hyperintensity, enhancement, and diffusion restriction (high signal on b800-diffusion-weighted images and low signal on apparent diffusion coefficient images) of the right sciatic nerve (white arrows), pudendal nerve (arrowheads), and right sacral roots (S1–S4) (yellow arrows), consistent with perineural spread

and establishes MR neurography as the imaging modality of choice for assessing neural involvement. These include high-resolution T1- and T2-weighted sequences with spectral attenuated inversion recovery (SPAIR) or Dixon for homogeneous fat suppression and an improved signal-to-noise ratio, as well as DWI, as demonstrated in our case. Additional sequences, such as three-dimensional (3D) black-blood short tau inversion recovery (STIR), 3D DWI partially saturated inversion recovery with frequency-selective inversion (DWI-PSIF), and diffusion tensor imaging (DTI) [7], may also be utilized.

The primary strength of this case lies in the novel application of MR neurography, which provided superior visualization and diagnostic confirmation of perineural invasion compared with conventional imaging techniques. However, the limitations include the technical need for adequate image resolution and the requirement for specialized expertise in interpretation.

In conclusion, PNS in rectal carcinoma is an underrecognized cause of recurrence and morbidity. Its diagnosis is often challenging, particularly in the setting of prior radiation or surgical treatment. MR, especially neurography sequences, plays a pivotal role in differentiating PNS from other causes of neuropathic pain, thereby improving diagnostic accuracy and guiding treatment decisions.

Abbreviations

PNS	Perineural spread
PNI	Perineural invasion
CRC	Colorectal cancer
AJCC	American Joint Committee on Cancer
UICC	Union for International Cancer Control
MR	Magnetic resonance
NSAID	Non-steroidal anti-inflammatory drug
BMI	Body mass index
TNM	Tumor, node, metastasis
CT	Computer tomography
^{18}F-FDG PET-CT	Fluorine-18 fluorodeoxyglucose positron emission tomography-computed tomography
DWI	Diffusion-weighted imaging
ADC	Apparent diffusion coefficient
SPAIR	Spectral attenuated inversion recovery
STIR	Short tau inversion recovery
PSIF	Partially saturated inversion recovery with frequency selective inversion
DTI	Diffusion tensor imaging

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VR and ACF were major contributors in writing the manuscript. AIGD interpreted the patient's images regarding perineural invasion and supervised the manuscript. All authors read and approved the final manuscript.

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Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Competing interests
The authors declare that they have no competing interests.

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