Lumbosacral nerve root avulsion is a rare disease entity that is usually associated with a fracture of the pelvic bone. We report on two cases to share our multimodal images and to introduce new magnetic resonance (MR) imaging findings. In one case (a pediatric patient), neither a history of pelvic ring fracture, nor a history of hip dislocation with characteristic MR myelography findings was evident. In the other case, secondary MR findings associated with lumbosacral nerve root avulsion were found that had not been introduced previously. Thus, we report on two cases to share our multimodal images and to introduce the new MR imaging findings.

**Case Reports**

**Case 1**

A 7-year-old boy presented with weakness at his right knee and ankle, as well as numbness and a tingling sensation in his right thigh. According to the medical records of the hospital where he was initially treated, he sustained multiple injuries 2 years prior, including a displaced fracture of his right proximal femur and fracture of his proximal tibia after he was struck by a car. However, no fracture of the lumbar spine and bony pelvis was detected in a CT scan performed at the time of accident. Also, no significant head, chest, and abdominal trauma were evident. The patient underwent closed reduction, internal fixation using the Ilizarov technique, and hybrid external fixation of his fractures. Little progress was noted in his weakness of the right lower extremity even after long-term conservative treatment. The patient was referred to our facility for a consultation.
regarding the plan of treatment.

During a physical examination performed at our institution, he was found to lack strength in his right knee extensors, ankle dorsiflexors, and plantar flexors corresponding to L3, L4, and L5 levels, respectively. He was unable to rise up on his toes on the right side (L5), and he showed loss of sensation below the L2 dermatomes. Subsequently, he underwent electromyography (EMG) to determine if the boy had sustained nerve injury, which revealed a severe proximal lesion of the right femoral (L2-4) and sciatic (L4-S1) nerves.

A pelvic radiography revealed a healing fracture at the right proximal femur, without an acetabular or other axial skeleton fractures. Conventional MR imaging and MR myelography of the lumbar spine were performed; T2-weighted sagittal MR images demonstrated pseudomeningoceles on the right sides of L1-5 and S1, which typically appeared as elongated lobulated lesions in the neural foramina with cerebrospinal fluid (CSF) signal intensity (Fig. 1A). These lesions were observed to have a mushroom appearance with MR myelography (Fig. 1B).

Although the patient was treated conservatively for 6 months, his neurologic symptoms did not improve.

Case 2

A 60-year-old woman experienced chronic lower back pain following a traffic accident that occurred 2 years prior. At that time, an EMG had revealed right femoral nerve palsy and a pelvic radiograph had demonstrated fractures of the right acetabulum and femur. A physical examination performed after the current admission revealed a non-tender palpable mass in the right lateral region of her flank. Laboratory findings were normal.

T2-weighted axial MR imaging of the lumbar spine revealed lobulated lesions extending through the neural foramina (Figs. 2A, B). Additionally, discontinuity of nerve roots was observed on the right side of L1 and 2 (Fig. 2C).

T1-weighted coronal MR imaging showed abdominal wall bulging containing large bowel loops with thinning of the right abdominal external and internal oblique

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Fig. 1. Case study of a 7-year-old boy. Right parasagittal (A) T2-weighted images (TR/TE, 4000/125) show extending lobulating lesions (arrows) on the right L1-S1 neural foramina with bright signal intensity. 3D Thin Slab MR myelogram (TR/TE, 6000/198) with coronal view (B) show mushroom shaped pseudomeningoceles in the neural foramina of L1-S1, right.
muscles. Additionally, atrophy of the psoas major muscle was observed in the right side of the L1-S1 vertebral body, but the remaining lumbar nerve root and spinal cord were normal (Fig. 2D).

Despite three months of conservative treatment, no significant improvement of the lower back pain was observed. A 6 month follow-up physical examination showed no interval change in the size of the abdominal mass in right lower abdomen.

**Discussion**

Lumbar nerve root avulsions result from high energy trauma [1]. If the traction force is sufficiently strong, dural tearing may occur and root sleeves may be retracted out of the intervertebral foramen. Subsequently, CSF leaks into adjacent tissue planes to form a pseudomeningocele [1]. A pseudomeningocele is usually

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Fig. 2. Case study of a 60-year-old woman.
A-C Axial T2-weighted image (TR/TE, 4000/120) shows nerve root disruption (arrows) and the presence of pseudomeningoceles (arrowheads) at levels L1 and L2.
D. MR coronal T1-weighted image (TR/TE, 803/12) shows atrophy of the psoas major muscle that was observed in the right side of the L1-S1 vertebral body (arrow) and abdominal wall bulging containing large bowel loops with thinning of right abdominal external and internal oblique muscles (arrowhead).
associated with a nerve root avulsion, but the latter may occur without the pseudomeningocele because the degree of nerve injury can vary from mild stretching to a complete injury [1]. Thus, other imaging findings, such as perineural fat edema and peripheral nerve enhancement in the acute phase, are valuable to help lead to a correct diagnosis [1]. In the chronic phase, atrophy of the psoas and iliacus muscles can be demonstrated [4].

However, in a brachial plexus injury, in contrast to a lumbar injury, visualization of the intradural nerve roots by conventional MR imaging may be limited. The most common reasons for a failure in detection were partial root avulsion and intradural fibrosis of a traumatic pseudomeningocele [3]. MR myelography can be an effective complementary tool for evaluating nerve root avulsion because it has complete coverage of the nerve root in a single image [3]. A previous report regarding MR myelography has described characteristic imaging findings of a brachial plexus injury as having a “mushrooming” appearance [5]. Additionally, the authors insisted that a MR myelogram is superior to a CT myelogram in the diagnosis of root avulsion because filling of subarachnoid spaces with contrast medium was not required in a MR myelogram and it can show meningoceles even with the presence of obstacles such as small necks or surrounding epidural scar, which block the penetration of contrast medium. Thus, MR myelography can provide valuable information about the size, shape, and extension of a pseudomeningocele better than conventional CT myelography [5].

In brachial plexus injuries, evaluation of MR myelography can be limited by artifacts caused by fast CSF flow [1]. In contrast, MR myelography provides more benefit in lumbar plexus injuries, in which CSF flows relatively slowly [6].

As observed in the second case, the extent of atrophy of the psoas muscle by MR imaging was well correlated with the EMG findings [fibrillations and positive sharp waves in corresponding innervated muscles]. Because psoas muscles are innervated by the lumbar plexus [L2-4][7], lumbar plexus injuries can cause atrophy of the psoas muscles, which has been reported as a secondary finding in lumbar root avulsion injury [4].

Another characteristic MR finding associated with lumbar root avulsion is the bulging of the abdominal wall which is innervated by T7-12, L1-2 [external oblique muscle] and T6-12, L1 [internal oblique muscle] nerve roots [8]. Muscle atrophy of the abdominal wall is rarely caused by a denervation injury because the abdominal wall has rich innervations [9]. However, a previous report has demonstrated abdominal wall bulging caused by segmental denervation due to diabetic neuropathy [9]. Billet et al. [10] described lower abdominal wall bulging in a patient with a prolapsed L1-L2 intervertebral disc. The L1 root was decompressed by open surgery and the bulging wall was almost normalized 10 months later. We believe that injury of the lumbar root avulsion can be a cause of the abdominal bulging, which was observed in our second patient (Fig. 2). To the authors’ knowledge, this is the first report of abdominal bulging caused by lumbar root avulsion.

As observed in our patients, a MR scan is rarely performed at the time of injury, resulting in a delay in the timely diagnosis of lumbar root avulsion. Two main reasons for this delayed diagnosis exist: First, performing a thorough neurologic assessment is difficult in patients with multiple injuries, including head injuries. Second, the incidence of lumbar root avulsions is very rare, especially in cases without pelvic fracture [1].

Although a management strategy has to be clearly established for the treatment of traumatic lumbosacral pseudomeningoceles, primary surgical repair of traumatic pseudomeningoceles could be considered for a symptomatic and clinically significant mass lesion only when conservative measures have not been successful and the patient remains substantially symptomatic [2].

In conclusion, we believe that MR imaging provides a useful tool for the evaluation of lumbar root avulsion injury. In the first case, a pseudomeningocele could be detected using MR myelography in the patient without pelvic or acetabular fractures. In the other case, MR findings, including atrophy of the psoas major muscle and abdominal wall bulging, suggested secondary changes to denervation injury of the lumbar plexus. We expect these findings will contribute to the diagnosis of this rare but important clinical entity.

References