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Compressive myelopathy in fluorosis: MRI

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Abstract We examined four patients with fluorosis, presenting with compressive myelopathy, by MRI, using spin-echo and fast low-angle shot sequences. Cord compression due to ossification of the posterior longitudinal ligament (PLL) and ligamentum flavum (LF) was demonstrated in one and ossification of only the LF in one. Marrow signal was observed in the PLL and LF in all the patients on all pulse sequences. In patients with compressive myelopathy secondary to ossification of PLL and/or LF, fluorosis should be considered as a possible cause, especially in endemic regions.

Key words Magnetic resonance imaging · Fluoride poisoning · Ligaments · Spinal cord compression

Introduction

Skeletal fluorosis is endemic in several parts of India [1]. Its hallmarks are osteosclerosis and ligamentous and interosseous membrane calcification [1]. However, ossification of the posterior longitudinal ligament (PLL) and ligamentum flavum (LF) has uncommonly been reported in fluorosis [2–4]. In most instances, ossification of the PLL and/or LF is thought to be idiopathic [2]. The MRI appearances of ossified PLL and LF causing spinal cord compression are well described [5–7]. However, demonstration of ossified PLL and LF secondary to fluorosis on MRI has not been reported. We present four cases of fluorosis where MRI demonstrated spinal cord compression caused by ossified PLL and LF.

Materials and methods

We studied two men and two women, aged 38–48 years, presenting with compressive myelopathy. Their symptoms and signs included paraparesis, tingling and numbness and/or severe back and neck pain. All hailed from an endemic belt of fluorosis in the state of Uttar Pradesh and had high urinary fluoride levels. A skeletal survey revealed predominant osteosclerosis in three patients and a coarse trabecular pattern with mixed changes in bone density in the other. A calcified interosseous membrane was seen in the forearm in all patients. In two, an ossified PLL was visible on plain skiagrams. Surgery was performed in two patients and ossification of the ligaments was confirmed on histology. The remaining two patients did not undergo surgery and continue to be followed.

Spinal MRI was performed on a 2.0 T superconducting system operating at 1.5 T, using an oval surface coil. T1 (TR/TE 500/15), proton density (PD) (2500/20) and T2 (2500/80) weighted images were obtained using a spin-echo (SE) sequence. FLASH (fast low-angle shot) (TR/TE/FA 185/10/12°,45°) images were also obtained in the sagittal plane. The slice thickness was 3 mm, interslice gap 0.3 mm and matrix 195 × 256.

MR images of 50 normal spines were reviewed and the signal intensity and thickness of PLL and LF were determined on SE and FLASH images.

Results

Normal spines

The PLL was identified as a thin, low-intensity, linear structure on SE and FLASH images, continuous in the midsagittal plane. Parasagittally, the low-signal line was interrupted and present only at the intervertebral disc level, conforming to the normal segmental denticulate configuration of the PLL. The LF was visualised as a 2–5 mm (mean 4 mm) thick structure which gave low signal on all SE images and high signal on FLASH.

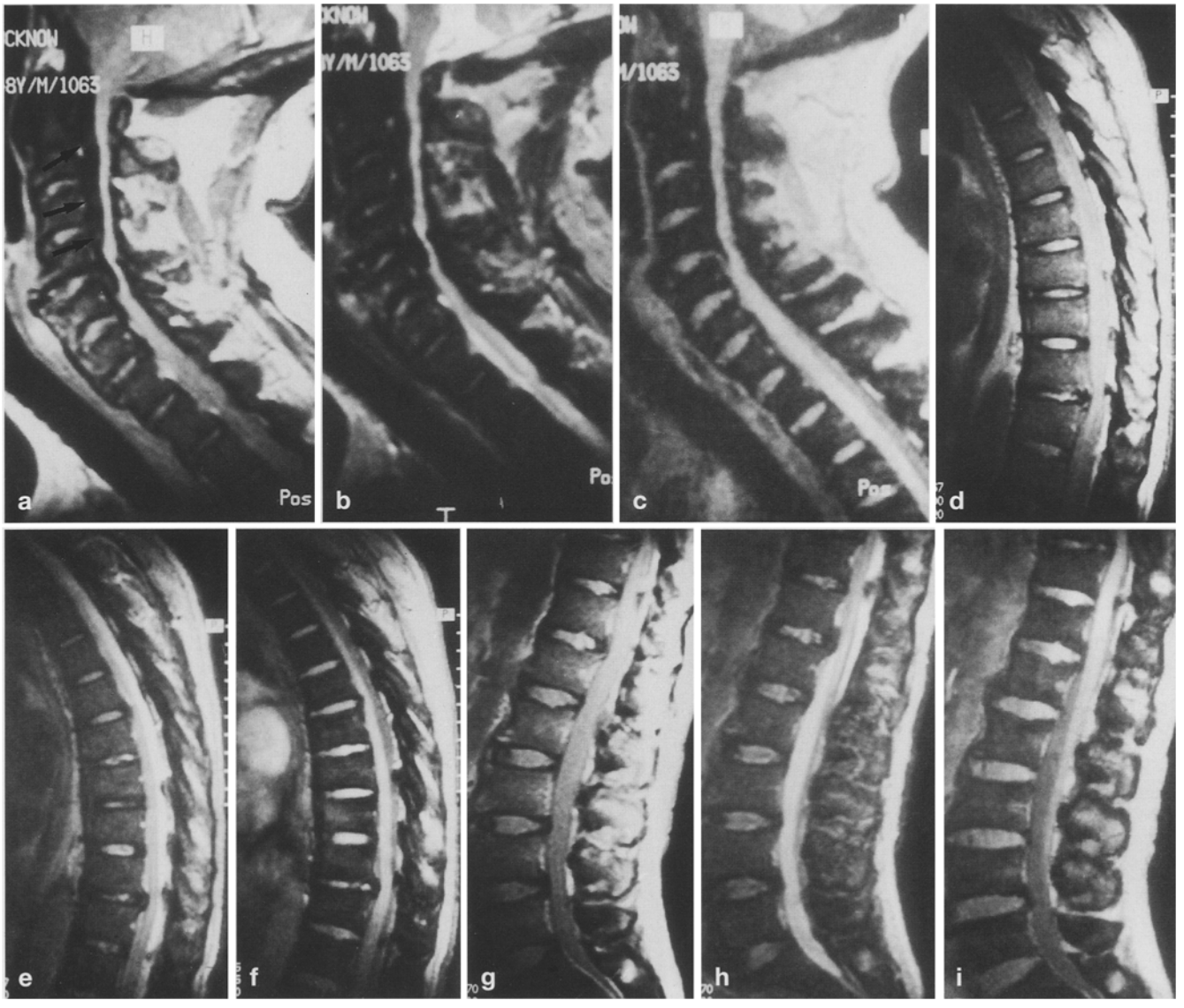

Fig. 1a–i Case 1. **a** Proton density, **b** T2-weighted, **c** 45° FLASH sagittal images of the cervical spine show a predominantly low-signal posterior longitudinal ligament (PLL) extending from C2 to C5, causing cord compression. There are foci of intermediate intensity within the PLL, best seen in **a** *(arrows)*. Posteriorly, the ligamentum flavum (LF) also shows ossification and is further compressing the cord. A prolapsed intervertebral disc is seen C4/5 level. In **b** the spinal cord shows high signal in the region of compression. **d–i** Similar images of thoracic and lumbar regions. These show thickened and ossified LF at multiple levels and ossified PLL at T6–7. Better demonstration of these ligaments in **f** and **i**. A disc prolapse is seen at T10/11 level

Patients

The results are summarised in Table 1. Thickened (range 6–7 mm, mean 6.3 mm) and ossified PLL was observed in three of the four patients. The cervical, thoracic and thoracocervical regions (Fig. 1) were involved in one patient each respectively. The PLL gave lower signal than in the normal subjects. Thickening (range 6–20 mm, mean 12 mm) and ossification of the LF was seen in all four patients. The characteristic triangular contour of a thickened LF causing spinal cord compression was demonstrated in the thoracic spine in two (Fig. 2), the thoracocervical spine in another and throughout the cervical, thoracic and lumbar regions (Fig. 1) in the fourth. The ossified LF gave low signal on SE and on FLASH images. All ossified ligaments appeared more prominent on FLASH images; within them, foci with signal intensity similar to yellow bone marrow were observed with all pulse sequences.

High signal was seen in two patients in the spinal cord on T2- and PD-weighted images. A prolapsed in-

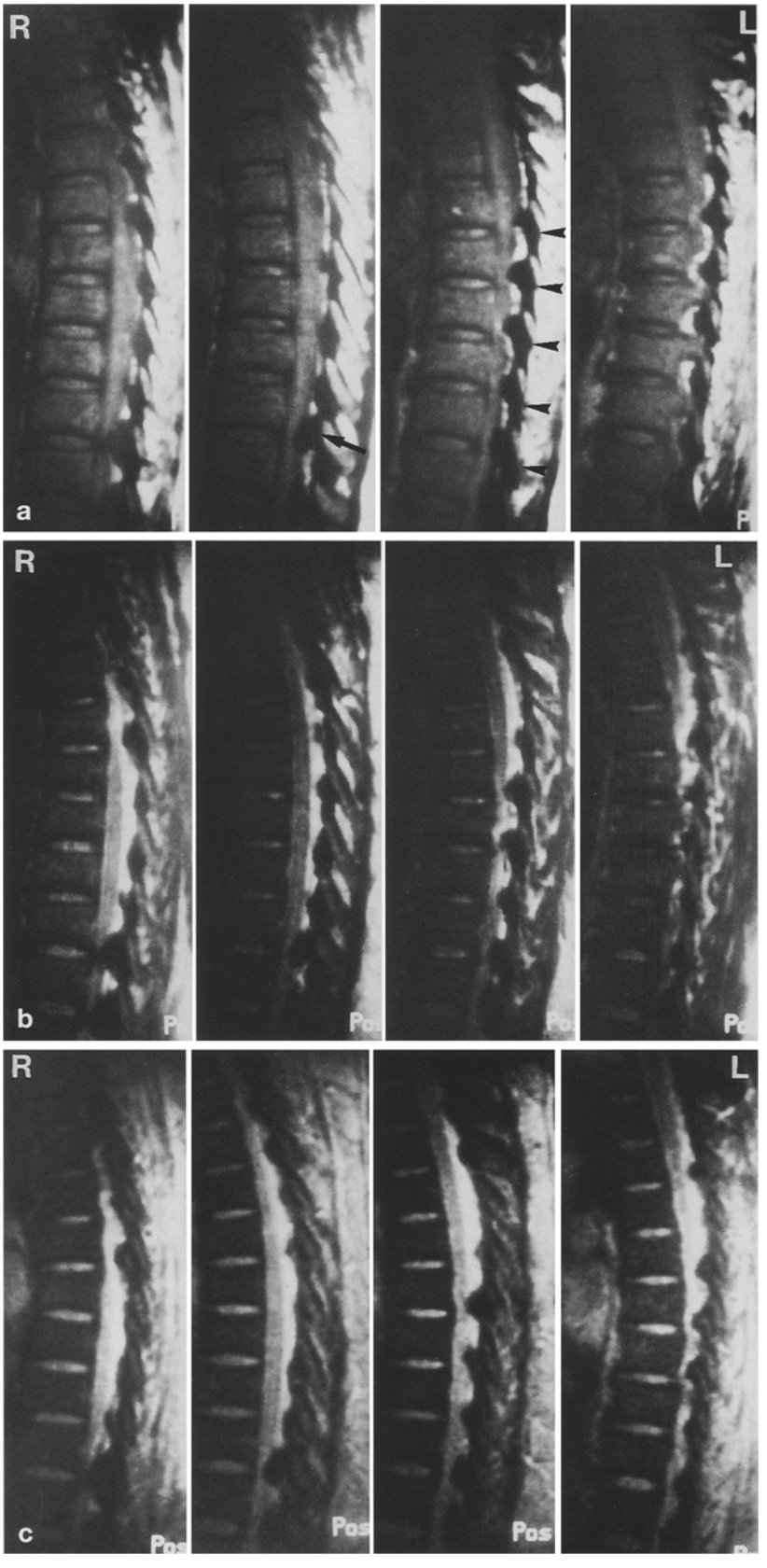

Fig. 2a–c Case 3. Images as in Fig. 1 (FLASH 12°) of the thoracic spine from right *(R)* to left *(L)* show ossified LF *(arrowheads)* at multiple levels with spinal cord compression, maximal at T11–12 *(arrow)*. The ligaments show foci of signal isointense with the marrow on all pulse sequences

Table 1 Clinical features and MRI findings

Case No	Age (years) sex (male/ female)	Symptoms and signs	Duration (years)	Posterior longitudinal ligament			MRI features ligament flava			Abnormal cord signal
				Region	Thickness	Marrow signal	Region	Thickness	Marrow signal	
1	48M	Back and neck pain, motor and sensory deficits	10	Cervical, thoracic	7 mm	+	Cervical, thoracic, lumbar	Cervical 6 mm Thoracic 12 mm Lumbar 15 mm	+	+[a]
2	45M	Motor and sensory deficits in all limbs	1	Cervical	6 mm	+	Cervical, thoracic	7 mm	+	+
3	38F	Motor and sensory deficits in legs	2	–	–	–	Thoracic	20 mm	+	–
4	40F	Motor and sensory deficits in legs	1	Thoracic	6 mm	+	Thoracic	12 mm	+	–

[a] Prolapsed intervertebral discs at C4/5 and D10/11

tervertebral disc causing thecal compression was observed in the cervical and thoracic spine in one patient.

Discussion

The PLL is attached to the body of the axis and continues down to the sacrum [8]. Its fibres are attached to the intervertebral discs and the margins of the vertebral bodies but separated from the vertebrae between these attachments by the basivertebral veins [8]. Behind the vertebral body, the fibres converge to form a narrow central band, giving a denticulate configuration [9]. On MRI, the PLL is seen as a linear structure with very low signal intensity on SE and gradient echo (GE) images [10]. In the median plane it appears as an uninterrupted band whereas parasagittally, it is not visible at the vertebral level; only the part adherent to the annulus fibrosus is identified [3]. However, distinction between the dura mater and PLL can be difficult in vivo [9]. We believe that the low-signal line represents solely the PLL; the dura mater should not appear discontinuous in parasagittal sections. In an anatomical study, a specimen of lumbar spine imaged after separating the dura mater from the PLL, identified the thecal sac as a thin line of intermediate signal intensity distinct from the PLL [9].

The LF is a yellow elastic ligament which connects the laminae of adjacent vertebrae and extends from the second cervical to the first sacral vertebra [11]. Its thickness increases progressively in the cephalocaudad direction, the ligament being 1.5 mm in thickness at C2–3, 2.0 mm at T11–12 and 4–6 mm in the lower lumbar region [12]. The normal LF gives low signal on SE images and higher signal on low flip-angle GE images [10, 13].

Ossification of PLL and LF are important causes of spinal cord compression [5]. Although reports of ossified PLL and LF date from 1838 and 1920 respectively [14, 15], the aetiology is not known in most cases. Ossification of the PLL may occur secondary to trauma, in diabetes mellitus or in association with diffuse idiopathic skeletal hyperostosis (DISH) and ankylosing spondylitis [2]. Calcification or ossification of the LF is seen in calcium pyrophosphate dihydrate crystal deposition disease, diabetes mellitus, haemachromatosis and hyperparathyroidism [6, 16]; it may be associated with ossified PLL and DISH [12].

MRI appearances of ossified PLL and LF have been described [5–7]. Ossified PLL and LF give low signal on SE and GE images [5–7]. The latter demonstrate calcification better than SE images, by accentuating the diamagnetic susceptibility properties of calcium salts [17]. The low signal seen on GE images is more prominent and consistent than that on SE images and closely matches the calcified zone on CT [17]. In this study, the ossified PLL and LF gave low signal on both SE and FLASH images and appeared more prominent on the latter.

MRI is the modality of choice for demonstration of the longitudinal extent of calcified ligaments and spinal cord compression; CT is better for demonstrating calcified or ossified spinal ligaments [5–7, 12]. Fat-containing marrow in the ossified PLL and LF; giving intermediate or high signal on T1-weighted images, has been reported [5, 7]. In our series, foci isointense to yellow bone marrow were observed in the ossified ligaments on all pulse sequences. This marrow signal may help in differentiating calcification from ossification. Even when MRI reveals a null signal (on SE and GE sequences), a combination of the characteristic contour and the site of ossification points towards the diagnosis of ossified LF [18]. Good correlation has been found between the degree of extradural cord compression by ossified ligaments seen on MRI and the severity of myelopathy [12]. In severe compression, increased signal may be seen in the spinal cord [19].

Skeletal fluorosis is endemic in many parts of India and is sporadic almost worldwide [1, 20]. Neurological complications, mainly reported from India, arise late in the course of the disease [21, 22]; involvement of the nervous system is seen in about 10 % of cases of skeletal fluorosis [22]. The usual manifestation is radiculomyel-

opathy, thought to result from osteophytosis and osteosclerosis [21, 22]. Radiologically, the hallmarks are generalised increase in bone density and calcification or ossification of interosseous fascia and ligaments [21, 22]. There are few reports of ossified PLL in fluorosis with compressive myelopathy [4]. Ossification of PLL and/or LF may be extensive, involving the cervical, thoracic and lumbar spine [22]. It is difficult to determine the site of maximum spinal canal compromise on plain skiagrams.

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