Postinfective physeal bars – MRI features and choice of management

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Abstract

We present a series of 6 patients with physeal bars as a result of infection (predominantly meningococcal) demonstrating the typical MRI features of this entity and an explanation of how these features affect the choice of management.

Aim

Our aim is to demonstrate any distinctive magnetic resonance imaging (MRI) features of postinfective physeal bars caused by meningococcal and other infections and show how these features help the surgeon in selecting the best management option.

Introduction

There are various causes of growth-plate injuries and while trauma is the most common, infection (e.g. meningococcaemia) has also been known to cause significant injuries. Growth-plate injury is common and can result in lifelong disability with a subset of physeal injuries resulting in premature growth arrest due to bony bridge formation across the physis.[1] Also known as physeal bars, these are focal defects in the physis with resulting bony continuity between the epiphysis and metaphysis.[2] These bridges usually form 1 - 2 months post injury but only 2% of patients with growth-plate injuries develop physeal damage that is clinically significant.[3,4] Physeal bars result in either angular deformities or leg-length discrepancies.[2,4] MRI has been shown to be useful in the evaluation of physeal bars.[2]

Meningococcaemia may have a profound effect on the skeletal system of a growing child and survivors are at high risk of developing permanent effects.[5] Nine patients with physeal bars as a result of meningococcaemia have been reported but no MRI features have been described

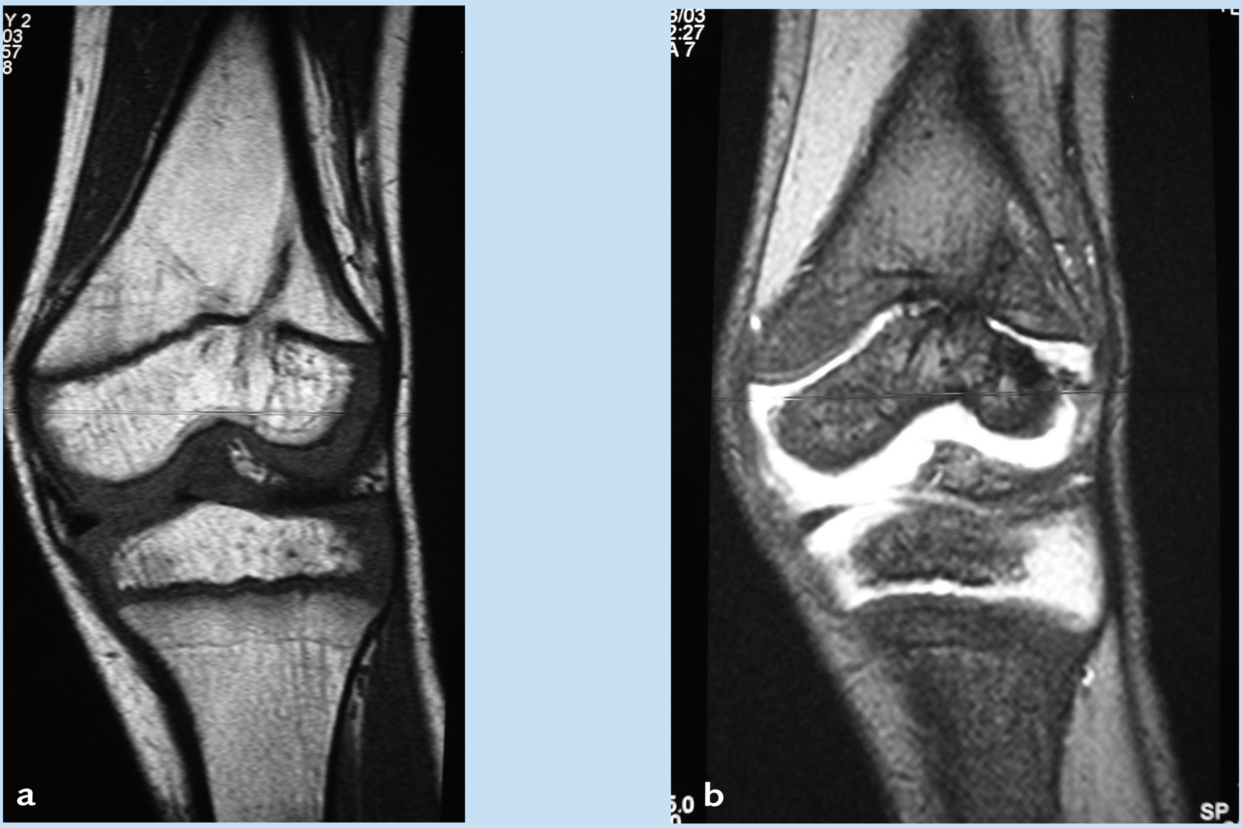

Fig. 1. Post-traumatic physeal bar due to a Salter Harris IV fracture – T1 weighted (a) and gradient echo (b) sequences demonstrate a continuous bar as well as the fracture line in both the metaphysis and epiphysis. The distal femur is a common site for post-traumatic physeal bars. The physis is regular, however, and the epiphysis is not significantly distorted.

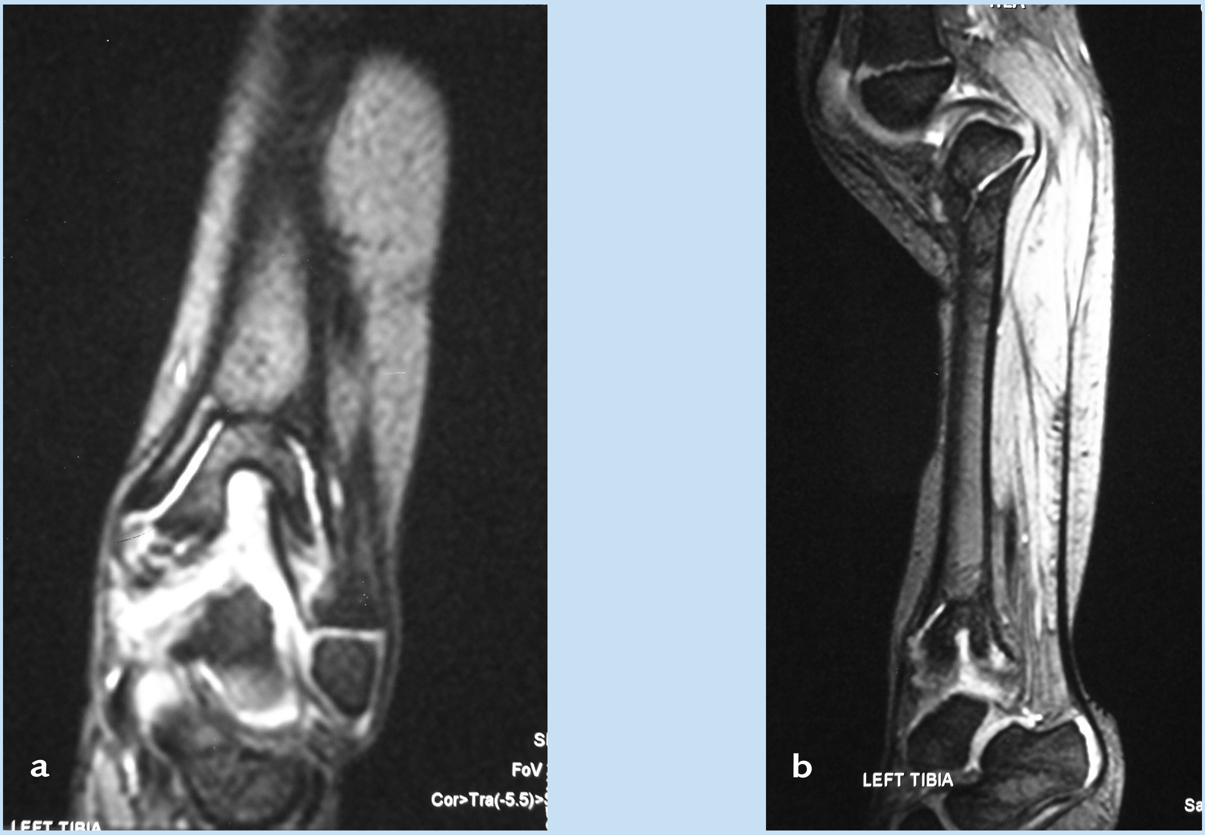

Fig. 2. Postmeningococcal physeal bar. (a) This gradient echo sequence demonstrates a distal tibial physeal bar that is central and results in a 'tenting' deformity of the epiphysis. (b) A sagittal image in the same patient shows the distal and proximal tibial physes revealing a second bar at the anterior portion of the proximal tibial physis.

for these.[5] We aim in this paper to describe the MRI features of physeal bars which are the result of meningococcaemia and other infections, and to show how these features help with management decisions.

Method

A retrospective analysis of a series of patients referred for evaluation of physes with postinfective leg-length discrepancies (meningococcaemia in 5 of the 6 patients, the sixth having had neonatal sepsis with no causative organism documented). The following features were evaluated based on features already described in the literature:

- Number of sites involved
- Percentage of physis involved
- Presence of flame-shaped protrusions of cartilage (the physeal line is displaced into metaphysis or epiphysis in a flame shape)
- Irregularity of physis (irregularity beyond the normal corrugated margin – more like an ECG trace)
- Distortion of epiphysis (the shape and/or size of physis is altered).

The percentage of physis involved was calculated by dividing the physis into sagittal and coronal segments which were then transposed as a grid onto an axial 'map' of the physis. The number of involved segments was then calculated and when compared with the total number of segments a percentage of involvement was calculated.

Figs 1 - 6 demonstrate various features encountered.

Results

Of the 6 patients evaluated, 2 had multiple sites involved with a total of 13 physeal bars. Overall 4 of the 13 bars showed involvement of 50% or more of the physis. The vast majority of postinfectious physeal bars evaluated showed flame-shaped protrusions as well as physeal irregularity and epiphyseal distortion (Tables I and II). In comparison the trauma group had no bars involving 50% or more of the physis, only two-thirds showed physeal irregularity and less than half showed physeal distortion.

Table I. Distribution of physis involvement and aetiologies

Percentage of physis involved	Trauma	Infection
<33%	5	7
>33% but <50%	4	1
+/- 50%	0	3
>50% but <66%	0	0
>66% but <100%	0	1
100%	0	0

Discussion

The different aetiologies of physeal bars presumably affect the physis in different ways, which in turn affects management. Any insult to the physis can result in a physeal bar.[2] The most common cause of physeal bar is

Table II. Distribution of features

Features of physeal bars	Trauma	Infection
Continuity through physis	7	10
Flame-shaped protrusions	7	9
Irregularity of physis	6	10
Distorted epiphysis	4	10

fracture/trauma. Other insults to the physis with formation of a physeal bar include infection, radiation, tumours, thermal injury, vascular injury and corticosteroid therapy, and some are considered idiopathic.[1-3, 6]

Meningococcaemia (due to infection with *Neisseria meningitidis*) results in diffuse vasculitis, thrombosis, haemorrhage and necrosis which also involves the growth plates, resulting in variable permanent ischaemic damage.[5] As a result, bony bridges develop.[5] The central part of the physis has been shown to be vulnerable and is often involved in meningococcal insults.[7]

Once a physeal bar has developed, imaging needs to evaluate size and location of the physeal bar as well as the severity of growth disturbance before decisions on management can be taken.[6] Historically diagnosis has been made using plain radiography, conventional tomography, computed tomography (CT) and scintigraphy.[1,4]

MRI has been shown to be more accurate than conventional techniques[2] as it has multiplanar capabilities allowing for cross-referencing of images in two planes[2,8,6] and facilitating mapping.[8,6] MRI has excellent contrast and spatial resolution.[2] MRI also has the advantage of detecting fibrous and cartilagenous bars, shows up the cartilaginous epiphysis, the actual growth plate and also detects injury to the ligaments, menisci and vessels.[4,6,8,9] Because of these advantages, subclinical bars can easily be detected by MRI, and in addition MRI can change the Salter Harris classification in approximately half of patients with physeal traumatic injury.[4,8] This is useful for differentiating between Salter Harris II and IV fractures when the distal humerus is un-ossified and also detects metaphyseal extension in Salter Harris type III fractures reclassifying these as type IV fractures.[8] Radiologist agreement has been better using MRI than using other techniques.[4] Sagittal and coronal-plane imaging diminishes the partial-volume averaging that is inherent in images of axially orientated structures.[2] Spin echo T1- and T2-weighted sequences are useful and T1-weighted sequences are especially useful for assessing the tilted growth arrest and recovery lines and for detecting fatty marrow in the physeal bar.[4,8] Gradient recalled echo (GRE) sequences are recommended by numerous authors and show normal physeal plate cartilage has a high signal.[1-4]

Certain anatomical sites are prone to growth arrest.[1] The distal

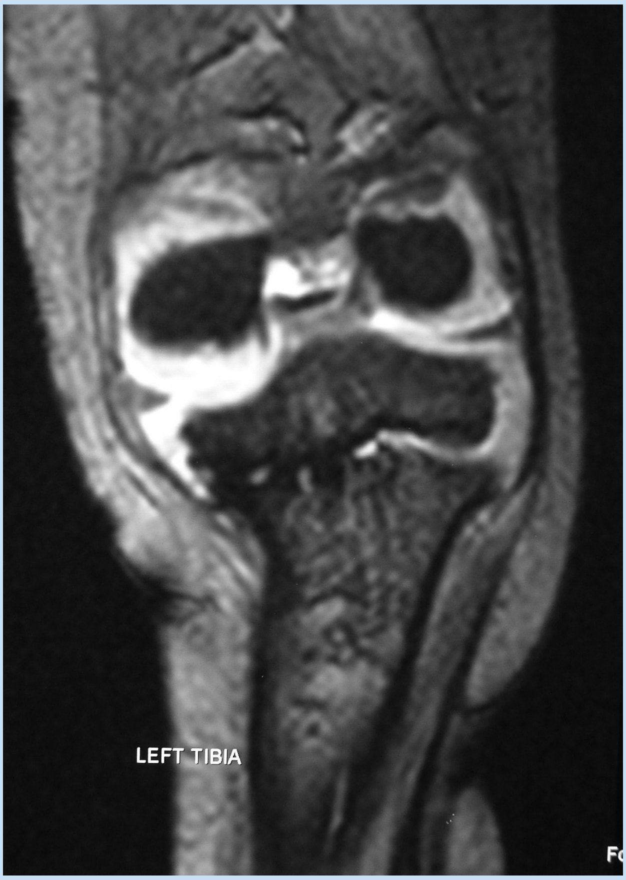

Fig. 3. Postmeningococcal physeal bar – a coronal gradient echo image demonstrates that the irregularity of the medial aspect of the proximal tibial physis is a result of multiple small bars.

Fig. 4. Postneonatal sepsis – a coronal image demonstrates a continuous physeal bar at the distal femur with marked irregularity at the lateral half of the physis. This is in contrast to the normal regular proximal tibial physis.

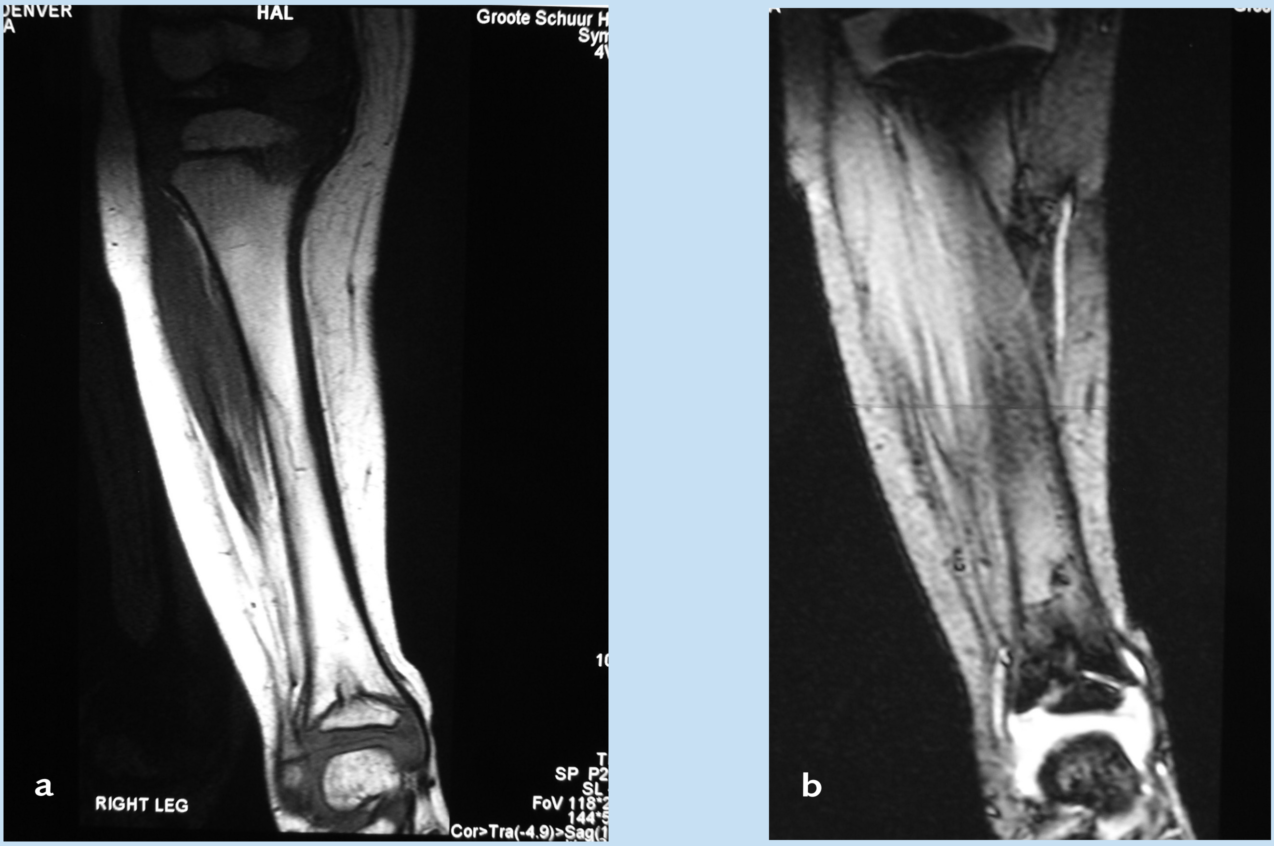

Fig. 5. Postmeningococcal physeal bar. (a) T1-weighted coronal sequence demonstrates both proximal and distal tibial physeal bars. At the proximal physis there is irregularity and discontinuity medially. At the distal physis a continuous physeal bar containing fatty marrow signal is present. (b) The gradient echo sequence confirms the central continuous bar at the distal tibia by showing discontinuity of the normal physeal high signal.

femur has a disproportionately high incidence of growth arrest, and this is related to the central physeal undulation.[1] There is also significant association between the cause of growth arrest and the anatomical site involved.[1] Physeal bars are more common in the lower than upper extremities irrespective of the cause.[1] Different sections of the physis are also more likely to be involved depending on which physis is involved. At the distal tibia the anterior medial section of the physis, also known as Kump's bump, is most susceptible to growth arrest.[1] The proximal femur and the proximal tibia are more susceptible to physeal bars in their periphery.[1]

Our results show that unlike bars caused by trauma, those caused by infection have the following characteristics:

- Involve more physeal locations (up to 6 in 1 patient) and can be bilateral
- May involve tibial and femoral locations (proximally and distally at the tibia)
- In addition to continuity of the epiphysis and metaphysis and flame-shaped protrusions of cartilage into the epiphysis or metaphysis they may cause irregularity of the physis beyond the normal corrugation and distortion of the size or shape of the epiphysis
- Commonly involve a larger surface area of the physis (50% or greater).

Current treatment for physeal bars aims to prevent deformity and correct leg-length discrepancy.[1,8] Treatment options include:

- Osteotomies to correct angulation[1,2]
- Contralateral physeal arrest to prevent leg-length discrepancy[1,2]
- Shortening/lengthening procedures[2]
- Physeal bar excision to relieve growth impedance.[1,2]

The radiologist can assist the orthopaedic surgeon with management choice and help with pre-operative planning. Pre-operative assessment requires determination of the size, location and contour of the bar.[1-4] This helps to determine optimal surgical exposure and helps minimise damage to the epiphysis.[1,2] Bridges between 30% and 50% of the size of the physis require excision and interposition of fat.[2,4] Bars less than 30% of the size of the physis can be managed without surgery.[4] Bars over 50% of the size of the physis require more extensive surgery.[4]

Our results show that postinfective physeal bars often inolve 50% or more of the physis, which may require extensive surgery, whereas post-traumatic bars often require no surgical intervention and when they do, it is unlikely to be extensive.

Conclusion

Physeal bars caused by infection, and in particular meningococcaemia, differ from those caused by trauma. The multiple locations involved and the extent of involvement of the surface area have direct bearing on prognosis and choice of management (including surgery) with extent of the physis involved being the most important determining factor.

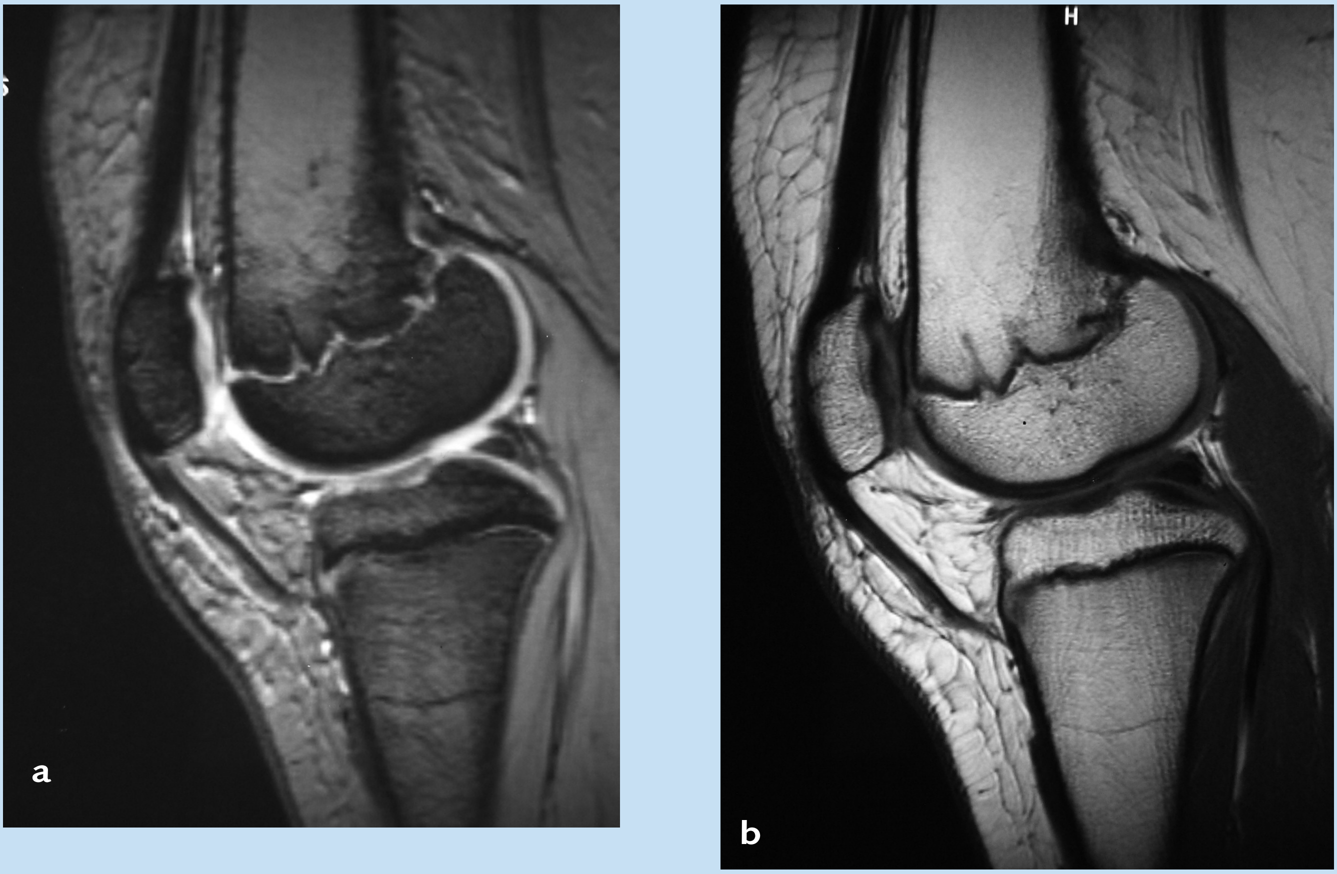

Fig. 6. Flame-shaped projections of the physeal cartilage into the adjacent metaphysis are demonstrated in both postinfective and post-traumatic physeal injury and are considered as features in keeping with a physeal bar seen in this patient on gradient echo (a) and T1-weighted imaging (b).

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