From physeal bar to physical deformity - preventing the progression.

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Learning objectives

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1. Review the pathology behind the formation of physeal bars
2. Illustrated review of the various imaging appearances of physeal bars, associated complications and post-treatment appearances on plain radiographs, CT and MRI
3. Literature review of the optimal imaging modality for investigating physeal bars
Background

Physeal bars (also known as physeal bridges or bone bars) are interruptions of the normal growth plate cartilage, due to the formation of bony or fibrous bridges between the epiphysis and metaphysis. Most cases occur as a sequelae of previous physeal injury, typically trauma; however other causes may include infection, vascular insults, thermal injury, radiotherapy and corticosteroid use. One mechanism of physeal bar formation is thought to occur due to local compromise of physeal blood supply following physeal injury, resulting in bone deposition. Alternatively, physeal bars may also form following fractures if there is displacement of bone, causing contact and union between epiphyseal and metaphyseal bone [1].

Physeal bars can be evaluated across a variety of imaging modalities. Plain radiographs are unreliable for assessing non-ossified physeal bars. However, established osseous bars may be appreciated as areas of focal bone density that bridge across the normally lucent physis. Furthermore, sequelae of physeal bars such as epiphyseal displacement and bone angulation may also be seen.

CT is helpful for the three-dimensional characterisation of physeal bars, and as with plain radiographs, established osseous bars appear as focal high attenuation bone bridges that cross the low attenuation physis. Fibrous physeal bars may be perceived as subtle regions of soft tissue attenuation relative to the lower density cartilage, but are easily missed and poorly visualised. Hence the primary use of CT is for pre-operative planning of established ossified bars [1].

MRI is useful for detecting both early fibrous bars as well as established osseous bars, appearing as low intensity T1w fat-sat, T2w and T2*w signal areas within the background high intensity physis. On T1w sequences, established osseous bars may appear as high signal bridges if they contain bone marrow [2-4].

Unrecognised physeal bars may go on to cause significant morbidity due to abnormal bone angulation or limb length discrepancies with continued bone growth. Smaller bars (<30% of the physis) are typically managed conservatively whereas larger physeal bars may require surgical excision.
Findings and procedure details

In this exhibit we present three cases from our institution, which illustrate the key features of physeal bars both pre- and post-treatment, across a variety of modalities.

Case 1: A 12 year old boy who presented following a basketball injury with a tender and swollen left wrist.

The initial plain radiograph demonstrates a buckle fracture of the left distal radius (Figure 1). The child then re-presented two months later with left distal radial growth arrest, and a CT study was performed for further characterisation. This demonstrates a densely ossified physeal bar affecting the middle and volar aspect of the left distal radial physis, with volar tilt of the radial articular surface (Figure 2). The child subsequently underwent surgical resection of the bar, and follow-up plain radiographs demonstrate the typical post-resection appearances; there is lucency centred on the physis at the site of resection, with metalwork seen surrounding it (Figure 3).

Case 2: A 7 year old girl presenting with left hip pain for 6 months.

On the initial plain radiograph there is an ill-defined lucency centred on the left proximal metaphysis, but there is no cortical destruction or periosteal reaction (Figure 4). The subsequent MRI demonstrates multiple cystic areas corresponding to the lucency seen on the radiograph. Furthermore, there is linear area of low T1w and T1w fat-sat abnormality which is seen to cross the antero-medial aspect of the physis, in keeping with an osseous physeal bar (Figure 5-6). The following CT study clearly delineates the osseous physeal bar, with additional patchy sclerosis seen within the metaphysis (Figure 7). Multiple lucencies are again seen within both sides of the physis, raising the possibility of infection, and this was considered to be the likely aetiology for the physeal bar.

Case 3: A 13 year old boy presenting with query acute exacerbation of chronic osteomyelitis of the distal tibia.

The initial MRI performed at an external hospital demonstrates an area of low T1w and T2w signal crossing the distal tibial physis medially, and this is in keeping with a physeal bar (Figure 8). A complementary CT study confirms these findings, and a physeal bar can be seen medially, composed of both an osseous and fibrotic component (Figure 9).
These features can be appreciated on plain film, with an area of lucency, corresponding to the fibrotic component of the bar, seen at the medial aspect of the physis (Figure 10).
Fig. 1: Pre-operative plain radiograph of the left wrist - AP (left) and lateral (right) views. There is a focal area of density crossing the distal radial physis, in keeping with a bone bridge (arrow).

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**Fig. 2:** Pre-operative CT study of the left wrist - coronal (top row) and sagittal (bottom row) slices. There is focal density bridging the normally lucent physis (arrows), in keeping with an osseous physeal bar.
**Fig. 3**: Post-operative plain radiograph of the left wrist - AP (left) and lateral (right) views. There has been interval resection of the physeal bar, with an area of lucency demonstrated in its place (arrow). Surgical metalwork is seen surrounding this.
Fig. 4: Plain radiograph of both hips - AP (left) and frog-leg (right) views. There is some lucency seen within the left proximal femoral metaphysis (arrows), without any associated periosteal reaction or cortical destruction.

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**Fig. 5:** MRI study - coronal view of both hips, T1w sequence. There is a focal area of low signal crossing the medial aspect of the left femoral physis (arrow), suggestive of a physeal bar.

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**Fig. 6:** MRI study - coronal (left) and sagittal (right) views of the left hip, PD fat-sat sequences. There is focal low signal seen bridging the high signal physis (arrows). High signal areas are seen within the epiphysis and metaphysis, in keeping with cystic structures (*).

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Fig. 7: CT study - coronal (left) and sagittal (right) views of the left hip. The osseous physeal bar is clearly demonstrated, crossing the medial aspect of the physis (arrow). Lucent areas are again seen within the epiphysis and metaphysis (*), corresponding to the high signal, likely cystic, structures seen on the previous MRI.

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Fig. 8: MRI study - sagittal views of the ankle, T1w (left) and STIR (right) sequences. There is focal low signal seen crossing the anterior aspect of the tibial physis on both sequences (arrows), in keeping with a physeal bar.

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Fig. 9: CT study - sagittal (left) and coronal (right) views of the ankle. The physeal bar is seen to be predominantly lucent (arrows), with a small inferior osseous component. Findings are suggestive of a predominantly fibrous bar which contains a small osseous component.

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Fig. 10: Plain radiograph of the ankle - AP (left) and lateral (right) views. At the medial aspect of the physis there is a subtle area of lucency (arrow), corresponding to the fibrous component of the physeal bar.

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Conclusion

Physeal bars are important imaging findings; although they may not be initially clinically apparent, without appropriate recognition and management they may cause significant morbidity due to bone deformity. Advanced physeal bars may be readily seen on plain radiographs, however earlier appearances may be detected on appropriate MRI sequences. Characterisation with CT is important, in order to aid surgical planning for resection. Early radiological identification and accurate characterisation of physeal bars is therefore key in facilitating prompt management, and preventing subsequent morbidity.
References