INTRO TO PEDIATRIC MSK RADIOGRAPHS: APPROACH TO SHOULDER RADIOGRAPHS

Developed by Dr. Kai Homer for PedsCases.com.
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Introduction:

Hi, my name is Dr. Kai Homer, and I'm a resident in Radiology at the University of Alberta. This video is the second in a series discussing musculoskeletal radiology in children. We're going to focus on musculoskeletal injuries, and going through some cases to help you understand how radiology fits into the whole clinical picture. This fourth video will discuss ossification centres in the elbow.

This module was reviewed by Dr. Adrienne Thompson, a pediatric radiologist at the University of Alberta. I'd like to thank the University of Alberta Department of Radiology for allowing access to images from real cases. All images have been de-identified and are used here for educational purposes only. These slides are available at www.pedscases.com and on the Canadian Association of Radiologists website.

After watching this video, the learner should be able to:

1. Correctly identify anatomic structures seen on pediatric elbow radiographs
2. Recognize radiographic evidence of an elbow joint effusion
3. When an elbow joint effusion is present, know to look for an associated radial head or neck fracture

Let's dive into elbow radiographs. On the following slide, I'm going to show you a normal elbow radiograph from a 32-year-old male. Before we discuss any kind of pathology, it is important to get our bearings anatomically. I have outlined the ulna in blue, the radius in pink and the humerus in yellow. It is important to notice some normal anatomic relationships between the bones of the elbow. On any view of the elbow, a line cutting through the middle of the long axis of the radius, should always go straight through the center of the capitellum. The capitellum is the surface of the humerus that the radius articulates with. Here, I've drawn out this imaginary line in purple. This line is called the radiocapitellar line. The cool thing about this rule of radiocapitellar alignment is that it works on any view of the elbow on radiographs. If the radius doesn't align with the capitellum, it could be a sign of radial head dislocation.

Now, we're going to talk about the anterior humeral line, which is an imaginary line drawn along the anterior cortex of the humerus all the way through the condyles. This line should intersect the middle third of the capitellum. Drawing the anterior humeral line is useful for

picking up supracondylar fractures of the distal humerus. Because the fracture fragment in supracondylar fractures typically moves posteriorly, the anterior humeral line would then either intersect the anterior 3rd of the capitellum or not go through it at all.

This is a radiograph of the same patient from the same day, however, this is an AP view rather than a lateral view. Let's make sure we can identify the anatomic structures here. Here, I've outlined the humerus using the mint green color. The radius in blue and the ulna in yellow. The location of the trochlea is outlined with the letter T. Remember how the radiocapitellar line view works on any view of the elbow? As expected, here, the radiocapitellar line goes straight through the capitellum even on this frontal AP view of the elbow. We have already seen how well the radiocapitellar line performs on the lateral radiograph of the elbow and now with this frontal AP view of the elbow, we can confirm that the radiocapitellar line works on any view of the elbow. Here, it goes straight through the capitellum as expected.

Let's go to a new case. The following 29-year-old female fell on her elbow and now presents with localized pain and decreased ROM. Here, we're looking at a lateral radiograph of the left elbow. It is always very important to be sure of basic anatomy on radiographs. Here, I've again outlined the humerus in mint green, the radius in blue and the ulna in yellow. Here, you'll notice that I've denoted the location of two regions, one anterior to the distal humerus and the other posterior to the distal humerus with the yellow dotted line and the blue dotted line, respectively. The presence of a prominent, bowed anterior fat pad, shown in yellow, and a bulging posterior fat pad shown in blue, indicates that there is an elbow joint effusion. The fluid causing the effusion in this case is blood. Usually, when displacement of the fat pads is seen, the fluid forming the elbow joint effusion is blood. A bloody effusion in a joint is called hemarthrosis. In any adult with hemarthrosis of the elbow joint, it is important to start looking for subtle fractures, especially radial head and neck fractures. Here, I've taken off all the drawings and I'll just give you a second to look at the radiograph without any markup, to see if you can find anything. Does anything look abnormal to you? Indeed there is an abnormality. The abnormality of interest here, shown on this lateral view of the elbow is an impacted fracture of the radial neck. What exactly does the radial "neck" refer to? Here, I've traced out the radial head in mint green and the radial shaft in blue. I've cleverly used the explosion emoji to mark the site of the fracture. The radial neck is right where the head and the shaft meet. So, radial neck just describes the part of the radius at the junction of the radial head and radial shaft. The red arrows here indicate the direction of the impaction injury. The red arrows on either side of the radial neck show the directions of the impaction force in this injury. In addition, there is a subtle but clearly visible thin line of sclerosis along the radial neck. This indicates an impaction fracture. If you take a moment and pay close attention to the yellow dotted line. I'd like you to try to remember where that yellow line is situated on this radiograph with respect to the anatomy. So, in this image, the location of the radial neck is shown by the yellow dotted line. I want you to take a good look at it and get a good mental image of where the radial neck is located on this radiograph. I am about to remove the drawings.

So, if you take a look at where the yellow dotted line was on the last image, you are looking at the radial neck and you can actually see that thin, white line of sclerosis. In order to help

recognize abnormalities on any radiograph, it is always helpful to compare the abnormal radiograph to a normal radiograph from the same anatomic location. Here, I've taken a normal elbow radiograph from the beginning of the presentation and placed it in the inset on this slide. Here, I've marked the location of the radial neck in both radiographs using the blue dotted line forming a rectangular box. Take a look at the radial neck in both the abnormal radiograph and the normal radiograph. In both x-rays, the radial neck is located within the blue box. It becomes easier to appreciate the thin, white line of sclerosis on the radiograph with the impaction fracture of the radial neck. If you look at the normal radiograph and use your mind's eye to outline where the radial neck would be, you can see that there is no discernible white line whatsoever. Another sign of impaction fracture is angulation of the radial head off of its normal 90º alignment with the axis of the radius. According to the report for this radiograph, a very subtle amount of angulation is present in this radiograph but it is definitely not obvious.

Here, we have a slightly different lateral view of the left elbow. Again, the humerus is shown in mint green, radius in blue and ulna in yellow. But, you'll also notice that I've outlined a triangular region of tissue just anterior to the distal humerus using fuchsia. Notice how the soft tissue within the pink triangle is a different shade of gray from the soft tissue outside of it. That is, it is a darker gray. So, the density that we're looking at within the pink triangle is actually fat density, whereas the density outside of it would be soft tissue or fluid density. So, why is there this big random chunk of fat right in front of the humerus? Well, if you recall from a few minutes ago, there are actually fat pads both anterior and posterior to the distal humerus. On the prior radiograph, the anterior fat pad was shown in yellow and the posterior fat pad was shown in blue. You can again appreciate the difference in radiographic density of the soft tissue or fluid density outside of these areas and the areas of darker fat density outlined by the yellow and blue dotted lines. Here's the same radiograph without the colored tracings, take a mental snapshot of the triangular areas of fat density on either side of the distal humerus. This is an abnormal appearance. Usually, those fat pads are not visible on radiographs. So in a normal radiograph you should not see that darker shade of gray on either side of the distal humerus. In particular, you should not see that sail or triangular anterior fat pad shape.

Coming back to this radiograph, the pink dotted line here encloses the anterior fat pad. This case is an example of a classic radiographic sign called the sail sign. If you compare the shape of the front sail on the sailboat emoji that I've placed on top of the radiograph, you may agree with me that the shape of the fat pad outlined in pink is reminiscent of the shape of the front sail on the sailboat. Hence, the sail sign. For classic sail sign to be seen on a radiograph, there needs to be a very sizeable joint effusion in the elbow, that completely displaces the anterior fat pad outside of the humerus. I haven't actually outlined it using a coloured tracing, but on this image, there is actually a visible posterior fat pad, as you can see, there is a thin vertical stripe of radiographic fat density just posterior to the distal humerus. Interestingly, it takes more fluid to fully displace the posterior fat pad than it does the anterior fat pad. Thus, if the radiograph shows an anterior fat pad without a posterior fat pad, this is strongly suggestive of a joint effusion. Presence of both the anterior and posterior fat pads on a radiograph definitively indicates a joint effusion.

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Just to be extra sure we know our anatomy, again, humerus here is in mint green, the ulna is in yellow and the radius in blue. Now, we're going to zoom in on the radial head. Just to clarify the anatomy here, at the *distal tip of the radius in the image, where it flares out into that wider kind of cap-like appearance, that region is known as the radial head. The radial shaft is not included in this image it is cropped out, but if we were able to extend the lower border of this image and see more of the lower aspect of the radius, that is where the shaft would be. In between the shaft and the head is the neck. Before I proceed with a drawing to indicate where it is, can you find it? On this image, are you able to see that fracture? It for sure is present at the location shown here. There is a nicely appreciable actual fracture line at the junction between the radial head and neck. I've used the solid white line to show the normal contour of the cortex indicates the break in the cortex where the fracture line is present.

Now that you've seen where the fracture is located with the drawings, you can take a look at the fracture here without any of the markup covering it. So we are looking at another radiograph from the same patient, this time, it is an oblique view of the left elbow. On this view, you can again appreciate the impaction of the radial head into the radial neck. There is a degree of overlap between the radial head and the rest of the radius shown on the image. 50% of radial head and neck fractures are non-displaced, like this one. Them being non-displaced means that they can be very difficult to see, so these are cases which speak to the importance of really scrutinizing the cortex along all the bones in the elbow radiograph. Again, looking at the left elbow of the same patient, but this time it is a different oblique view, focusing again on the radial head, let's zoom in, this particular oblique view nicely shows the broken cortex at the radial head and neck junction, as well as a band of bony sclerosis along the junction between the radial head and neck. Within those yellow boxes, I've tried to show the cortical deformities with those white dotted lines. I didn't actually colour in the location of the bony sclerosis here, but you should be able to appreciate it as a horizontal line of abnormally white bone which extends horizontally all the way across the radius right where radial head meets radial neck. Taking a second here and just going back to the unedited image, where you can clearly see the cortical deformities associated with this fracture. This image really nicely shows the degree of impaction of the fracture, you can see how it almost looks like the radial head has been skewered onto the radial neck. Right at that spot where there is kind of an abrupt transition from the more narrow neck to the wider radial head, you can clearly see on this image that horizontal white line of sclerosis that's formed by the crushing of bone in between those two pieces. This is a great case because it's actually uncommon to see the fracture line in radial neck fractures, but you can clearly see it here extending horizontally.

OK, let's move onto another case. The following 53-year-old female presents to emergency with a large left elbow effusion. Here, we're looking at an AP view of the left elbow, at this point, I think our bony anatomy is pretty solid, so let's get to work. First question, normal or abnormal? Hint: the answer is abnormal. OK, so where is the abnormality? Take a few moments and see if you can find it. We can't really see fat pads or signs of joint effusion on this view of the elbow, but take a careful look at the cortex of each bone. OK, time's up, I'm going to give away the answer now. If you weren't able to see it before, you should be able to clearly see the cortical deformity on this zoomed in image of the radial head, where there

is a roughly 1.5 mm step at the articular surface. This is the appearance of your typical radial head fracture, a vertical fracture line in the articular cortex. This part is likely only of interest to those wanting to go into radiology or already in radiology, so for those people, first of all, congratulations on choosing radiology, what an excellent profession! Second, there is a classification system used by radiologists to describe radial head fractures. These fractures are graded using the Hotchkiss modification of the Mason classification. The gradations are type 1, type 2 and type 3. Type 1 refers to fractures in which there is under 2 mm of displacement. Type 2 refers to fractures in which there is displacement of > 2 mm. Type 3 refers to radial head fractures in which there is severe comminution, as well, type 3 fractures may also show dislocation. Because the step at the articular surface in the case shown here is 1.5 mm, this would be a type 1 radial head fracture. In terms of clinical information, both radial head and neck fractures are usually caused by FOOSH mechanisms, where the force an outstretched hand breaks the fall ramming the radial head into the radial neck. So, the first thing that jumps out at me when I look at this image doesn't actually have so much to do with the bones themselves. Does anybody know what I might be referring to? We did talk about it earlier. We are looking at the anterior and posterior fat pads here. Posterior fat pad being outlined in blue and the anterior fat pad being outlined in white. So, this is a true lateral view of the elbow on which we can make out a radiolucent triangle in the olecranon fossa behind the humerus just above the elbow joint. This radiographic finding is creatively termed the posterior fat pad sign. The posterior fat pad sign is highly sensitive and highly specific for an elbow joint effusion. As we were discussing earlier, while a bit of the anterior fat pad may be visible on normal elbow x-rays, the posterior fat pad is not usually visible. Recall it takes a significant amount of fluid in the joint to force the fat pad out from where it normally sits. In summary, if you see a posterior fat pad, you know pretty much there is an effusion, and with a history of trauma to the joint in an adult, it behooves you to start looking for subtle radial head and/or neck fractures.

Before I let you off the hook, there is one more thing. This patient was unlucky enough to have not just a radial head fracture, but another one on top of that. Bonus points to anybody that can see it on this image. This patient also sustained a minimally displaced and comminuted ulna fracture at the ulnotrochlear joint. OK, that's it for the elbow, that's pretty much all I've got.

This concludes part 5 of this video series. In the next video in this series we will look at injuries in the pediatric wrist. Before we leave, we wanted to leave you with a few key take home points

1) The key anatomic structures in pediatric elbow radiographs are the distal humerus, the radius and the ulna
2) An elbow joint effusion can be identified by the anterior and posterior fat pad signs
3) Remember to look for subtle radial head or neck fractures whenever you notice an elbow joint effusion on a pediatric elbow radiograph

Thanks for watching part 5 of the pediatric MSK radiograph series on PedsCases, and please stay tuned for the rest of this series.

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References:

1. DeFroda SF, Hansen H, Gil JA, Hawari AH, Cruz Jr AI. Radiographic evaluation of common pediatric elbow injuries. Orthopedic reviews. 2017 Feb 20;9(1).

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