

MRI Shockers - Ref 65DCRS

with Darren Chandler and Rob Shanks

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TRANSCRIPT

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Steven Bruce

Today, we've got two-star guests back in the Zoom studio, we've had them in before, we've got Darren Chandler and Rob Shanks, who have come to join us to talk about more MRI shockers, things that got missed on MRI reports, which were critically important, perhaps in our own diagnosis of what's going on with patients. Darren, Rob, welcome.

Rob Shanks

Hello, Steven.

Darren Chandler

Hi, Steven.

Steven Bruce

Great to have you back. I haven't introduced go2imaging.com again, of course, which you set up some time ago, but I'm hoping that everybody has already seen your previous broadcast and if they haven't, they should go and look at it. So, do you want to start us off today, what are we going to talk about?

Rob Shanks

Yeah, absolutely. So, we're going to do another, like you said, another kind of follow on from what we did last time and really, it's just to give people another chance of seeing some case histories and reinforcing the point, really. I mean, if you wanna bring up that first slide there just to see where we fit in to this MRI referral picture and we had this on last time, but just a bit of a recap. And it's just to clarify the point that when either we receive an MRI report, let's say, from a patient that comes into clinic, or even when we're referring for that MRI scan ourselves, it's really important to remember the process that they're going through. They start off with, they get invited to go along to the MRI center or the hospital and first of all, the first person, the main person they're gonna be greeted by is the radiographer. This is the person who puts them on the machine. And also, who's responsible for setting up if you like, the sequence, has the final say in terms of exactly which parts of the body get imaged, if it's a spine exactly which vertebral levels get imaged. Then those images will be then passed on to the radiologist, who's the medical doctor who does the reporting and will obviously generate a report. And that report then comes back to the referrer, whoever that may be. So the referrer could be the GP, it could be the surgeon, or it could be us as therapists referring for the MRI. Now the information we get back, if we're the referrer we should be looking for that MRI report. Sometimes what happens is we'll get the information or a letter let's say, from the surgeon, who's disseminated the information from the report and from the scan. So sometimes it's a little bit third party. But even if it is a case that we're getting that report back, it's important to remember it is just a report, it is just that person's opinion on those images at that time. And I think, the danger is that we can sometimes get lulled into this false sense of security thinking, right, this is the absolute gospel truth and there's nothing that has been missed and there's nothing extra to say. And unfortunately, time and time again, we find that's not the case, for whatever reason. And it could be through human error. It could be through just the communication process of this cycle that things can get missed, it's dependent on how good our referral report is. If we don't put on the relevant part that we think, okay, you need to image T7/T8, it might not get done. Equally, if the reporting is not right on the report to say what you think and what questions you want answered, you might not come away with the optimum, let's say, in terms of the images that are done, the report that gets generated.

Steven Bruce

Rob, when you say that, when you say "if you don't say image T7/T8 it won't get done" but isn't it also important to say that you think there might be something going on there, because even if they image it, they might not look at it?

Rob Shanks

That's right. I think, yeah, absolutely. And the feedback we get often from the radiographers, from the radiologists is, don't be scared to say what you suspect it is and what questions you want answered. Because if you just literally go along and say, right, I want the lumbar spine image. Well, what is it you're getting at? What differential diagnostic stuff are you looking for? Are you suspecting a pars fracture? Are you suspecting it's a disc prolapse? Are you suspecting some other, are you worried about some sort of sinus pathology? And that is very helpful to a) the radiographer and also b) the radiologist because they then really know your thought process and they know what you're getting at and exactly what to pay particular attention to. And I think in the NHS you've got to remember that particularly, I know we're not always, we don't refer for NHS scans, but the NHS illustrates the point, they are under immense pressure. They have huge volumes to deal with and unfortunately things can get missed simply because people are in a bit of a rush. So, if the referral report's a little bit rushed, it makes their job so much harder. So, I think we have the onus on us to make their job easier by putting in the relevant information on that MRI request, but also our point would be even so still don't rely on report, always have your questioning hat on and think, has it all be done correctly. If the report comes back saying it's unremarkable, everything's ruled out but your case history and your examination, your gut instinct says, I really do think they've missed something or there's something not quite right here, that's when I would say, you've got to go, and Darren and I would both say, you've got to go probing and really questioning then and looking for these things. And we would encourage everybody to try and get used to looking at the images themselves, because we've got the time to really scrutinize it. We've got the patient in front of us, we can ask them, we can clarify with the patient, we can ask them again, we can ask another question if we need to. Unfortunately, the radiologist, you've got to remember doesn't even meet the patient. So the radiographer does.

Steven Bruce

You said we don't refer for NHS imaging, but of course, if we want images, we are going to tell the GP what it is we want to refer for. So, he will take that information and pass that on, I'd have thought.

Rob Shanks

Absolutely. So indirectly, we can obviously start that process, but again, it's another loop in the system and it's another, then we write letters to the GP, the GP then has to write the accurate information in the report. And it's just another cycle where things can go amiss and loopholes can appear. So, I think what I was going to do was start off with, this is quite nice kind of simple one or relatively simple one, to get us started. And this is one of my patients from a couple of years ago. And this was a lady who I'd actually seen on and for quite a number of years, she's one of the regulars who would come in every so often. I might have a year or two go by, but then she'd turn up again with another little niggle. And she'd had some back pain in the past, way in the past, 10 years ago or something and nothing really that much to report on by way of back pain until this particular episode. And when I questioned her and I was listening to her, she started off with some NHS physio, I believe, and she hadn't really gotten too far, too well. And I did suspect that her pain was

discogenic, let's say, coming from a disc. Just from the way she was describing it, the aggravating and relieving symptoms. So, I recommended that she, actually I didn't send her for the scan myself, I recommended to the GP that she could potentially have an MRI scan, might be worthwhile. And this was one of the images that came back. Now what she told me was, again, classic one, it was one of these ones where the report came back and said nothing found, nothing remarkable. Alignment's all good, minor disc degeneration, but nothing to speak of. And again, I decided I had to question that and I asked her, could you please go to the trouble of getting the MRI scan on CD so I could please have a look. And we loaded up the images on the PC and this is what we had. So, I don't know if everybody can just see there at L4/5, we've got this disc, it's a bit dehydrated.

Steven Bruce

This here?

Rob Shanks

Yep, that's it. It's a little bit dark in nature compared to say some of the higher discs, so we know it's losing some water content, but that's quite common. Nothing too remarkable with that. But at the back of the disc, we can see that, almost looks like a wiggly worm, like a white line, almost like an upside-down comma, right at the posterior aspect of the disc.

Steven Bruce

This thing here?

Rob Shanks

Yeah, that's it. And so that is what we call a HIZ zone or a high intensity zone. And what that indicates usually is an annular tear, so it's a tear in the disc. And we can see that on the axial image, so one next to it, right at the back of the disc again, we can just see that faint little white line right at the posterior aspect of the disc. That's it. Yeah. That's the one. So, very clear, it's absolutely obvious, there is that annular tear. And for me, that confirmed what I had suspected. It confirmed that, yep, this is likely to be a source of pain. The fact that it's so far towards the periphery of the disc as well, it's likely to be coming into contact with some of the nerve endings in the disc. And there is this whole controversy, do discs, are they pain sensitive? Are they not? Do they have nerve fibers? Do they not? I think the consensus now is, it used to be that no, they didn't, but now people are starting to realise, yes, they can do. And in certain populations or certain people even, that innervation can vary over time and one person can have more sensitive discs than another. But the point is I would say now it's pretty much as read that yes, you can have discogenic pain from these sorts of things. And that isn't an insignificant tear. That's actually a relatively large one. And really the management for that, for me, was to be making sure the lady wasn't doing stuff that was aggravating that tear, that's the first and foremost. So, I was trying to educate her on how to sit properly, potential exercises to do, but the thing I wanted her to avoid too much of was too much kind of loaded flexion really, where she might be opening up that tear even more.

Steven Bruce

What were her symptoms, Rob?

Rob Shanks

Her symptoms were morning pain, very stiff in the morning, aggravated by sitting. She didn't have much in the way of referral too much down her leg, but she did have a vague kind of sense of

something happening in her leg. She didn't have any signs of nerve root tethering. But again, there was a vague idea that maybe something was getting neurally irritated.

Steven Bruce

That's the bit that surprised me. Because that's the bit that would've made me think there's discogenic pain, or nerve impingement pain. But of course, I wouldn't have thought that tear would have caused referred pain, radiated pain.

Rob Shanks

No, that's right. You wouldn't expect on value, at least on those two images, for that to be causing an impingement on the nerve. But there's speculation that you can get like a chemical radiculopathy sometimes, so the fact that the area's inflamed can chemically irritate the nerves in the area. With that said, there's not much of a bulge or protrusion to that disc. So, yeah, you're right, I wouldn't be expecting in her case a positive straight leg raise test. And that wasn't the case from what I remember. But as I said, she just had this kind of central low back irritation that was particularly worse with sitting. And we tried a couple of treatments and it kinda was a little bit here and there. And I said, look, this is what I think, I think you've probably got something going on in the disc and that's probably what's driving it all. So, we saw that scan and I said to her, right, this is what I think is. And in fact, I even printed that picture off for her because she was about to go off to have her NHS physio follow up. And although the report had said nothing found. I said it's very important that your NHS physio is aware of this because that's going to have some bearing if you like, on the exercise and the advice they give you. So, I remember printing it off on a big sheet of A4, had it all blown up and said, right, I've had it circled, there you go, there's the tear. And anyway, she took it off to see the NHS physio and the NHS physio basically completely ignored what I'd said, they said, don't listen to him, he doesn't like what he's talking about, the report says you're fine so you're fine. I'm going on the report. I don't want to know what that person said. And unfortunately, she ended up getting a lot worse and she contacted me again a few months later, basically because she'd then gone, she was a diabetic and she'd gone to her diabetic consultant for a follow up explaining to the consultant that the back pain was so much worse and then all this stuff and he then sent her for a second scan. On the second scan this time came back and-

Steven Bruce

Rob? We're going to look at that scan I suspect in a moment; can I just go back to this picture that's in front of me? Cause people have been asking again to show the bit that you were talking about. My picture is reasonably clear. Justin, if you spotlight me. Just at the back of the L4/5 disc there's this sort of inverted comma here, which you're saying is the tear in the disc. And the slides will be available afterwards, I'll send those out to people so they can look at that for themselves and I'll highlight it on those. But also, over here, you can see there's a sort of a slightly grayer line, which is the same thing, but from the axial view. So hopefully that's clarified for those people who've been asking me just to make it more clear for them.

Rob Shanks

So when she had the follow up scan and she had the second report this time and then that came back, again different radiologists, and it actually said in black and white everything I'd told her, that she had this very large or relatively large annular tear at L4/5. And she kind of phoned me up again and said, look, I'm really sorry I didn't listen to you the first time and obviously that is what I have. So anyway, we then gave her a whole lot of different advice. We gave her some different treatment

in the end. And actually, she ended up getting a lot better. So, for me it highlighted the importance of really knowing what was going on with her and the fact that it turned out to probably be right, that it was the L4/5 annular tear that had been causing her pain. When we got her doing her sort of appropriate exercises and avoiding certain things, she then started to turn the corner within, I think it was less than a month she was feeling a lot better. So, it confirmed the diagnosis in our minds, confirmed the diagnosis in her mind as well. And it highlighted what she needed to get done.

Steven Bruce

Super. Well done, you.

Rob Shanks

I think we've got some other cases coming up now. So,, we can see that's the highlight there. We've just circled it there so you can see close up. Now, as I said, this sort of thing is quite common one to be on the lookout for, because you often will see these little HIZ zones, the high intensity zones. And like I said, sometimes they'll get reported and sometimes they won't and that's either because maybe they've not seen it or it might be because of the controversy surrounding or historical controversy surrounding is this a normal finding or not? And some let's say old school people would say, well, the annular tears are quite common, they're not symptomatic. I personally would take strong objections to that. But I think that's why it's important to be aware that these particular things can often go on reported. And this is, as I say, quite a common one, it's a relatively frequent finding that you'll see on the scans and it may or may not be reported. Now it goes a little more complicated than that and I think we've got Darren coming up now to talk about a few more, even more in depth, quite complicated case histories or more complicated.

Steven Bruce

Darren, these are yours.

Darren Chandler

Hi Steven. We've got three cases here and I think they're brilliant. Everyone watching today, I think they're going to be a big eyeopener for everyone. The first one that we're going to look at, which is on the screen at the moment, this is actually a lock down patient. So, where I live in Essex I'm in a kind of area where there's about, I dunno, a few hundred people on a WhatsApp group, there's a Neighborhood Watch WhatsApp group. And one Saturday morning, one of the ladies on this group, sort of texted in saying she was in considerable pain and was there any doctors on the WhatsApp that could possibly help her? So, a few doctors who do live in the area got in touch with her, but one of them, who's a gynecologist, actually rang me after speaking to her and they said, look, this lady has been diagnosed as having a large fibroid in her pelvis, but she's got terrible lower back pain with radiculopathy. So, she had an L5 sort of dermatomal numbness on the left-hand side. And she sort of felt that it was maybe best the lady spoke to me instead of the gyne, because the gyne felt the fibroids there, but it isn't necessarily the cause of her symptoms. So, I spoke to this lady and although she kind of was pleased to be talking to me, she sort of really knew that her condition was fibroid lead and the back pain was due to her fibroid and the leg pain was due to the fibroid and kind of when I questioned her on this and I said, how do you know all of this? She said, well, I've had an MRI scan and it's come back, fibroid is the source of the pain. So, you kind of automatically think, okay, well, if it is, it's gotta be humongous and it's gotta be affecting the sciatic nerve as it goes through the notch, which I kind of put a bit of a question mark on when I was speaking to her. So, she said, look, I've got the MRI scan and I can drop it off into your letter box. I said, I'd love to

have a look. So, on the screen right now, you can clearly see that we have three sagittal images. And on the left we have a sagittal T2, sorry, sagittal STIR on the left and in the middle, we have a sagittal T2 and we also have a sagittal T2 on the far right.

Steven Bruce

Are those all exactly the same plane?

Darren Chandler

No, so if you look at the middle plane, the middle picture of all three, what you'll see is a midsagittal cut. And the reason we know this is because we can see the spinous processes present. Okay? So, we're looking at the central aspect of the spinal canals, cord, et cetera. But on the left-hand side, you're looking at a parasagittal view because now the spinous processes have gone. So, we know it's the left-hand side, or we're looking at the aorta, which is slightly higher up in front of sort of T12, L1/2. So, when I put the CD in, there was no axial images whatsoever. Okay? So, the radiographer had not done any axial imaging, which is quite unbelievable, but they weren't there. So that's one thing. If you look at the midsagittal cut, in the middle, you'll see that the L4/5, S1 discs are slightly degenerative. So, they're slightly desiccated is the better word. They're slightly darker. But if you look at the posterior aspects of the disc at four and five, they look okay, the canal looks good, there doesn't seem to be very big sort of protrusion or extrusion there. But if you go back to the left-hand picture, which is the STIR, when you come to the parasagittal view, you can clearly see at the back of L4, there is a very small projection of disc material. That's perfect where you've got the cursor. And it's kind of going inferior, towards L5. Okay? Now, unfortunately we don't have the axioms to be able to look inside and see what part that's affecting, but if you understand the scan and you know that we're on the left-hand side and it's the parasagittal view, you know that that disc must be affecting the lateral recess. And if an L4 disc comes out in the way that it's doing there, likelihood is it would affect the descending L5 nerve root. So, this lady spoke of dorsum of the foot, big toe was numb, calf was numb. So, she had a typical L5 dermatome. So as soon as I looked at this, you instantly knew she had an acute or a fresh disc herniation. And the way that we know that it's acute is that if you look at the coloration of the disk, the nucleus pulposus, it's the same as the material that we see extending down towards L5, it's sort of a light gray. So, it has higher signal within it. And you can clearly see where your cursor is right now, the posterior longitudinal ligament has been peeled away from the posterior wall with L5. So, we know that there's been some kind of pressure onto that ligament to peel away.

Steven Bruce

How would that change if it were chronic then, Darren?

Darren Chandler

Well, if it was chronic, it's unlikely that you would see the signal within the disc because it would be darker. It would be more annulus, more fibrocartilaginous. So, it had been there a long time. You'll find with these acute lesions; the high signal gives it away. And secondly, if you rescan this lady in about six months, that should be completely gone. It's likely it would get absorbed by the CSF and the phagocytosis et cetera. So, I knew instantly that I was kind of right in my thinking, this isn't a fibroid issue, it's to do with that. So, I had to write to the GP, talk about getting involved, but you know, you write back to the GP and say, look, I think there's been a report that's been written wrongly. Please, can you have it redone? Plus, can you ask the patient to come back to have the axial images done again? Because they weren't done. So, if you go to the next slide, you'll clearly see that

the top part of this piece of paper is the original report. And you can see it was dated on the 3rd of May this year. And it says that there are minor degenerative changes, but there's no loss of disc or vertebral misalignment. And there's no neural impingement identified. It goes on to say that there is a 10-centimeter uterine mass. There's a bit of noise there, can you hear that?

Steven Bruce

No idea where it's coming from. I think Justin's popping his Coca-Cola can or something.

Darren Chandler

So you can see towards the end of this report, it's very much to do with the uterine mass being 10 centimeters, and further clarification of this needs to be obtained. But when they redid the scan, you can clearly see at the bottom here, he writes that there is an L4/5 left paracentral bulge and it is impinging on the left lateral nerve root, ie L5. And you can clearly see at the bottom here he's apologized for the observation that it wasn't put there when he first looked at it. But he's under no understanding as to why he missed it. But unfortunately, like Rob says, it's so, so common, we see this day in, day out.

Steven Bruce

Do you think, Darren, is this the fault of the radiologist being under pressure or being just lackadaisical or is it that he wasn't asked to look for the right things? Was he asked to look for uterine lesions?

Darren Chandler

Well, this is the thing, you just don't know. I mean, when you do a lumbar spine scan, which is what this is, that should have been just purely an incidental finding, but he's kind of concentrated on that and not concentrated on the spine. And what's even worse is that he hasn't even reported that there was no axial images present. So,

Rob Shanks

I'll just add my two pence there, Steven. I think even if he'd been asked to look for fibroid lesions, I'll be honest with you those sagittal images, that's so obvious that there's something in the parasagittal slice, there's so obviously something quite significant hanging out the back of that disc, he shouldn't really have missed it, I would have said, because if the lady is complaining of any sort of leg pain, even though you might be focusing on the fibroid, when you're doing a lumbar spine MRI, which is what that was, we teach this ABC approach, A for anatomy, alignment, B for bone, C for the contour of the bone and they shouldn't have missed it, really. I think there must've been at least some amount of, he was just whizzing through the scan there and missed it.

Steven Bruce

Is it common that they don't do axial scans? I thought you always got them. I thought it came out anyway with the standard imagery.

Rob Shanks

Yeah. So, there's a two-part fault here. There's potentially a fault from the radiographer not having done the axials. But equally the radiologist has reported on something that hasn't got axials but it has clearly got some sagittals there which show a high suspicion of the nerve root impingement from an L5. He should have really flagged the up and said, look, we haven't got the axials, but there is a

strong likelihood there could be some nerve root impingement here. And then have requested the axial images themselves. So, I think this illustrates how things can go wrong on the two parts, the radiographer and the radiologist.

Steven Bruce

Back to your imaging, Darren, I've had a question from Caroline who says what are the horizontal white lines in the vertebral bodies higher up? She didn't have a chance to count. I'm not entirely sure I can see which one she's talking about.

Darren Chandler

Normally, when you look at horizontal white lines within the body, it's literally the blood supply. I don't know if my computer is going absolutely crazy. It sounds like it's taking off. I don't know what's wrong with it.

Steven Bruce

You got one of those cheap computers knocked off from somewhere in Essex?

Darren Chandler

Well, I'm on a nice Apple Mac and it's as if the CD-Rom's spinning round and there's nothing in it.

Steven Bruce

So horizontal white lines?

Rob Shanks

If it's in the vertebral body, it's usually a blood vessel.

Darren Chandler

Very odd indeed. Is it really loud? Can you all hear it?

Steven Bruce

It's fine. Let's move on because otherwise we won't get through all your images.

Darren Chandler

Sorry guys. I have no idea what's going on. Okay, so the next case history: for me, this is the ultimate case history. So here we have a 17-year-old national level tennis player who's presenting with central lower back pain. And he had this pain for about a year on and off. And every time he played, he would pull up in agonizing pain and he just couldn't go on. And he was getting so disheartened and distraught with it. He'd been to see various people and they sort of suspected that he had more of growing pains and because he was 17 this was the problem. And ultimately, we sent him for a scan. Now I was sure that when I sent him for the scan, it was going to be likely that he had potentially fractures or a single fracture in his pars, because it's very common that age, lot of stress on that part of the body. So, looking at the scan right there, it has come across completely normal. Unremarkable. There was nothing wrong, really, with the scan whatsoever. It was perfect.

Steven Bruce

I'm going to betray my ignorance here, Darren, because up here, right at the top, that doesn't look like the normal shape of a disc to me, that's all-serrated edges and very low signal in the anterior part

Darren Chandler

Are you talking about sort of T12/L1, that one there? So, there is some wear and tear in that disc. Absolutely. But potentially this patient could be getting discogenic pain from that disc, but there's no, if you like, abnormality on the axial images, there was no bulge, there was no tear, but you can see the end plate definitely has a bit of a zigzag to it. So yes, I would agree that there is definitely some wear going through it. If you suspected that to be a pain source it's likely you would see some inflammation in the bone, but there wasn't any present. So ultimately, we would kind of review that as of a normal appearance kind of thing, albeit there are changes in there.

Steven Bruce

Down here at, is this L3/L4? There's a white line here. Is that one of the blood vessels you were talking about earlier on?

Darren Chandler

Yes. That's right. That's what's going through. Exactly.

Steven Bruce

Because again, high signal, some of us might think, oh gosh, that must mean it's fractured.

Darren Chandler

No, not at all. If it's always in the middle when it's going through it indicates that it's more vascular. So here we have a 17-year-old boy, he's got central lower back pain. It's worse on standing, it's worse on extending, and especially when he jumps up and down. So, he walks into any one of our clinics and he's completely distraught, his mom and dad are sitting there and they're like, please he's really in a lot of pain, what should we do? So, if we go to the next slide, you'll clearly see- I can't apologise enough for this noise. I have no idea what's going on in this computer.

Steven Bruce

I think it's worse with you than it is with us, Darren.

Darren Chandler

So here we have now a parasagittal view. And what we're looking at is that we're looking at the pedicles and we're looking at the pars. And if we look at the left screen here, you're seeing that there are two white little areas within the pedicle of the body of L3. Now on the left-hand side, this is STIR sequence on the left. And on the right-hand side, we have a T1 sequence. Now for those of you that know about lesions in the spine that show up as being hyper intense, as these are on STIR, these would be deemed an atypical hemangioma. Okay. So, when you see high signal within bone on a STIR, it generally means it's an atypical hemangioma. Now on the right-hand side, on the T1, if it was a hemangioma, it's always bright. Because hemangiomas are predominantly fatty tumors. So, the fact that it was dark on the T1 image and bright on the STIR image means that it had no fat content at all, which then means it's an atypical hemangioma, meaning that it has a high volume of blood vessels within it. Okay? Now my question, when I saw this was how do we know that that hemangioma, as it was labeled, is not a fracture of the pedicle. Okay? Now I spoke to the consultant radiologist and he said that because he'd seen these little two blobs on pedicles before that are bright on STIR, he was confident that it was an atypical hemangioma. Okay? So, I asked him, would he put his life on it that it was a hundred percent a hemangioma? And of course, he said, no, it could be a fracture. So, I spoke to the parents. So, I said, look, I've got to go with my gut feeling. I personally

think you have a fracture present and I'd like you to go for a CT scan. Cause it's the only way you can find out whether or not obviously it's fractured if it's not showing on MR. So, the parents didn't really want to do it because he's 17, there's quite a lot of radiation involved in that. So, after a week or two of him being continually in pain, they sent him for a CT. Before we bring those up, just go to the next slide, please, Steven. What you'll see here is the MRI report from the consultant. And you can clearly see here that there are no fractures of pars interarticularis of the lumbar spine, but it showed that the right pedicle has at L3 two small areas of bright STIR signal, which are likely to be hemangiomas and obviously not disc disease, et cetera. So now let's go to the next slide. So, this is now the CT and unbelievably we are here looking at the L4 pedicle and pars. Can you see that on the axial images I put two red arrows? You can clearly see he has two fractures present on both sides. So, he has bilateral pars interarticularis fractures. And you can see on the left side here, you can see the pars has fractures, you've got the fracture line going through. Now go to the next slide for me. So, what you should be looking at here is that not only is there a pars fracture at the L4, but there's a bilateral pars fracture at L3 as well. So, this child or 17-year-old teenager. He has bilateral fractures of L3/4 pars interarticularis and he has bilateral fractures of L4/5 pars interarticularis. So, it's quite an incredible case because the MRI completely missed *audio problems* and the hemangiomas the consultant radiologist spoke about *audio problems* indicating that he had a stress fracture there. *audio problems*.

Steven Bruce

Darren, I don't know if you can hear me clearly, but we're losing your audio.

Rob Shanks

Darren, your Wi-Fi is cutting out, I think.

Steven Bruce

Rob, I don't suppose you're in a position to talk about these are you?

Rob Shanks:

Yeah, absolutely. So, yeah. So, the point that Darren was trying to make was that whilst the MRI highlighted there was something not quite right at the L4/5, the first suspicion was hemangioma. The very alarming almost, interesting point is that it didn't even show anything at the L3/4. And it was only when the CT scan was done, that that had any, the L3/4 was a complete surprise to us all, that there was anything wrong with those pars. So, what it actually shows is that in fact, the radiologist in this case said, they're going to have to try and rewrite the rule book a little bit in terms of what protocols they send for these sorts of patients for in terms of imaging. And this was this was a Stanmore radiologist who said that. So, as a result now, anybody in that category, who you suspect has got a pars defect, even if there's nothing showing on the MRI, if there's a high suspicion that they could have a pars defect, they're often now going to be sending them for CT scans based on this one case history.

Steven Bruce

And lots of clues in the case history there, weren't there, in terms of his age and his activity level.

Rob Shanks

Absolutely. High end athlete, repetitive kind of extension movements, loading the posterior arch.

And then as you say the age as well. You are highly suspicious that there could be some sort of pars issue.

Steven Bruce

How are we doing, Darren? Are you back with us?

Darren Chandler

Yeah. How's that? The computer is fine now.

Steven Bruce

That's much better.

Darren Chandler

God knows what happens to that Apple. Okay. Yeah. So, it's quite a case in that we see so many people with the pain on standing, extending, and teenagers, and you suspect that the sort of pars, potentially facets, and yet the MRI, which should have shown it, completely was negative, which proves that it was a chronic condition. He had these chronic pars fractures. So, it just goes to show that even with the best MRI and the best consultants reporting it, it can get missed. So hence why it's important to send for further imaging such as CT. So brilliant case. So here we have the last case, again I think it's brilliant to sort of see how looking at different imaging can kind of help with diagnosing. So, we're looking at this patient's scan here. This is I believe, a 51-year-old lady who presented to us. She had unrelenting lower back pain. And when you look at this as a kind of complete novice say, you would look at the L5/S1 disc and you would instantly say, yeah, that's it, the disc is completely fouled. It's completely collapsed. There is a disc herniation present at 5, may or may not be hitting the nerve. She has no symptoms. And you can clearly see that there's high signal in the bone indicating that there's modic type 1 change. So, when you normally see this image, you would instantly think that potentially the pain source for this lady is the disc or it would be the end plate changes within the bone. And I'm sure that for every physio, chiro, osteopath listening, whenever we used to do our sort of differential diagnosis, no one, or I've never heard of anyone writing down that the lamina could be the source of the patient's pain. We've never really spoke about lamina pain as osteos, physios, chiros. So, this lady in particular, again, we talked about doing a surgical fusion and referring her for this. And in order to do the fusion, surgeons always like to make sure that the bone is what's hot and that potentially is where the pain's coming from and hence why they do the SPECT CT. So, if you go to the next slide for me, please, you'll clearly see here that- for those people watching, and they don't know what this is, this is a nuclear medicine scan whereby a radioactive isotope tracer is injected into the patient, and it has an affinity to osteoblastic pain generators. So, where there's a lot of osteoblastic activity, which normally means there's a lot of stress within bone. And if the area in purple presents in purple, it means it's cold. It means there's not a lot of activity within the bone. If the coloration is orange, it means that the bone is under some form of stress or orange can actually be a normal finding like a false positive, where there's just rejuvenation of bone. But whenever you see white, it means that the patient is generally hot and that's more than likely to be where the pain stems from. So, you can clearly see on the SPECT CT of this patient, that the lesion at L5/S1, although it was positive, it's nowhere near as hot as the laminae at 3/4, 4 and 5, and the associated facet joints. So, this patient's pain was actually more to do with the posterior arch than it was to do with the actual segment of L5/S1. So, the surgeon who fused this lady, he actually did a three-level fusion. So, he actually took out the good discs at 3/4, 4 and 5, because the angle that this had created over the years due to the collapse had put so much pressure

on the arch by fusing just 5 and S1, the 4/5 pain would have remained at the posterior aspect. So, they had to fuse and put certain wedges in, in order to take the pressure off the posterior arch. She had it done. She's been postsurgical now about five years. And I still hear from her, she's a neighbor, she's completely pain free, brilliant outcome. But again, it shows how with MRI, we kind of all go down one particular route. And yet the SPECT CT kind of gives us a different perspective on potentially where the patient's pain comes from. So just really interesting cases as to how we kind of go about finding the actual potential pain source anyway. Okay, so there's those three case histories. I think Rob's going to talk a little bit about, what's this one here, is it the before and after?

Steven Bruce

Are you guys happy to carry on for a bit, because we're already up to the end of our scheduled time?

Rob Shanks

We're happy to carry on if you are.

Steven Bruce

I'm very happy, and I hope our viewers can stick with us for another 15 minutes or so. That'd be good.

Rob Shanks

I'll just quickly mention then for the ones that have got to go off at two o'clock, and we'll perhaps come back to this at the end, next Thursday at 6:30, I believe it's scheduled, we're doing a live webinar where we're teaching people literally what buttons you have to press to view the MRI images. Because I think sometimes what people are overwhelmed by is, it's all very well saying this is an axial image and this is a sagittal, but when I've got that patient, who's got their CD in front of me, what do I do? Where do I go? How do I actually get the images up? So, we're going to talk people through that next week. Now we are charging for it, but we're going to offer all APM members free access to that webinar. So, if they use that code there, the APM15off.

Steven Bruce

Justin, if you just put this slide up, that's be useful for a second.

Rob Shanks

Yes, it's on the training page of our website and it's on next Thursday, I think it's the 25th of June. But yeah, if you use that code APM15off all your members will get access to that training tutorial completely for free.

Steven Bruce

I'll be sending all these things out afterwards anyway. So, everyone who's been watching, they'll get that slide as well.

Rob Shanks

Great. And then the plan is to get as many people involved and we can then get everybody hopefully being confident to start looking at images. We appreciate this is a lot to learn and especially if you've never been used to looking at these images, they all look a bit just like shades of gray. But it's like everything, start to get going with it and you'll start to gradually learn the process yourself. So, yeah. And the point is that it's different now for different, because of the GDPR different images need

different software. So, you've got the OsiriX that it's a very good thing for Macs, but often you can't use the Osirix for password encoded images, so then you have to use other software, either cloud-based software or PC based software, but we're going to cover all that in detail next week. But yeah, if we want to maybe talk about this. So, these are before and after, so the reason why we've put this one up, we touched on it earlier, we mentioned, I think right at the beginning, the high signal in the disc and this idea of, well, will it reabsorb, is it annular, is it nucleus pulposus? And the thing you'll see in the reports is they'll often mention, there's a posterior disc bulge or there's even an extrusion of the disc and it can sound very alarming. And sometimes it is very alarming and sometimes it does need either a referral to a surgeon or certainly vigilance for cauda equina and all those sorts of things. But the story is a little bit more complicated than that. And some people know this and some people won't, but the image on the left there, what you're looking at, you can clearly see it's a big disc protrusion. We'd class that as an extrusion, it's there's a risk of even being sequestered. But the interesting point is and the point to note is, that the signal and you've got to look at the coloration of the extruded material, and it is quite light. It's quite grainy. There's lots of flecks of high signal in there. So, we know that that is mostly going to be nuclear material, nucleus pulposus, and it's actually quite watery in nature. Now, what that means is it almost envelops the nerve roots rather than completely squashes them as a fibrocartilaginous bulge could do. So, a fibrocartilaginous bulge, an annular pole, that was very dark, even if it was half that size would probably be more devastating for the patient, because it would be a case of actually causing huge amounts of pressure and entrapment on the nerve root. So, what we do know is that the natural history of these sorts of lesions is often, you can hazard a guess that this is probably relatively fresh, relatively acute, it will be a matter of weeks or months old, probably even one or two months at most. And then you know that with the right management, the chances are that will gradually get reabsorbed, like Darren was saying earlier, by the CSF, by the phagocytosis. So, the prognosis for that patient, it's probably quite good. Obviously, they do require lots of vigilance, you have to go through the whole cauda equina vigilance thing, and they must be on the lookout for that because there is still potential of something, the consequence being very nasty from that. But in the absence of those symptoms, often if they sit tight, they hold tight, and you can see then on the after image, although the one on the left is a parasagittal, the one on the right is a pure midsagittal, but the point is we can see there that most of disc material has reabsorbed now. The point is also to make on this image, is that because, what sometimes gets thrown up, if we have the full sequences, we'd be able to make that assumption, but the point is on this here, what we're looking at, because it is a midsagittal, we haven't got the full sequences, you can't actually make that assumption. So, this was actually the truth is this was actually a before and after image put up by another clinic that we know of and it's actually giving you a slight false sense of security because they are different sagittal images. So actually, if we had the exact same midsagittal image that we're seeing on the left, it could still be there. So, the point I'm trying to make is be on the lookout for this, sometimes you'll see these put up before and afters that look very impressive. But actually, the story of this one in particular is actually not quite so straightforward. And if you look, what gives it away, if you can see, the spinous processes on the right-hand side, you can see how the spinous processes are present. So, we know that's a midsagittal cut. On the left we can't see the spinous processes. So, this is a parasagittal. This is slightly out to one side or the other. And it's going to likely be through the lateral recess, which is where most of the disc bulges will be going. The majority of them go in a posterolateral direction. So, you've got the posterior longitudinal ligament down the back of the discs, that acts as a bit of a barrier, so then often it will come out to the side. So that's what we're looking at there. So, whilst it is possible yes, because it is relatively light in nature that this disc may well have reabsorbed, we can't say that for certain based on those two images. You'd have to really see the exact same sagittal slices to be sure of that.

Darren Chandler

And there is - sorry, Steven, - but there is quite a few clinics that are doing this now, where they put up these before and after images, and it kind of gives a false, like you say, sell to the patient. Because they believe that, wow, look what my disc can achieve if I do this, but they're not really *audio problems*.

Steven Bruce

Yeah. We might have to revert just to you, Rob, because the audio from Darren is pretty dodgy.

Rob Shanks

Yeah. That was it, just once you get familiar with these MRI scans and once you really know exactly what slice you're on, you can start to really be a bit more critical in thinking really. And it is always much better to go on a full set of images than it is just on a one or two slices. Should we go to the next to the next slide? I think we might have some other ones coming up similar to this. Yeah. Okay. So again, I think we're talking a bit more now about what I was saying at the beginning, the wet and dry disc stuff. So, we've got the contrasting options here, on the left, we would classify that as a very wet disc, it's quite again, the extruded material's relatively high signal in nature. If you look at the shading of that disc that's going kind of superiorly, the disc protrusion, and you look at the disc above, on the L3/4, you can see it's not far off the nucleus shading in color. It's not like a really, really black dark shading as we have on the middle image. So, in the middle image on the L5/S1, this illustrates what we're saying here with a dry disc, a very annular bulge, it's almost a bit more jaggedy and almost you can see you've got a kind of beak on it at the end, and this would be very fibrocartilaginous in nature. And the other thing is they often act quite differently. So yeah, we often say, when you sit down often the disc will bulge a bit more, the jam donut effect. Well, that really applies for the hydrostatic content. So, the discs that are very relatively wet in nature that have got quite high-water content, that's certainly what's happened. And on dynamic MRI scans, you can see that happening. But on the dry disc stuff, the stuff that's really lost the water content, it's an annular bulge, often what you'll see on the dynamic MRI scans is the opposite, that actually those discs bulge even more, almost as though when they extend backwards, the posterior wall buckles even more. So, this leads a little bit into your management with patients. So, when it is and when it isn't a good idea to do things like McKenzie extension exercises, so the ones lying on the front propped up on the elbows. Sometimes that will help and sometimes it won't. When you start to really scrutinize the scans and the images you can get a bit of a half idea of is it in this case a good exercise to give that patient or is it not, as the case may be. And you don't really get that information so much from just the report itself. You'll hear there's a posterior disc bulge there. You may be lucky and it might say it's high signal in nature. They probably won't use terms like wet or dry, but they'll probably say it's a predominantly annular bulge or it's high nuclear content. But you can't beat actually looking at the images themselves and really making that judgment. And again, lastly on the right-hand side, this is just an axial image. I believe it's probably the same level. And it's just showing you how, again, it's almost like a space occupying lesion. So, in this case, on the patient's right-hand side in that lateral recess that will be hitting their L5/S1 and that's going to be a very hard material that's squashing that. And really the prognosis for that is not great. That's probably going to need surgery to take that pressure off the S1 nerve root impingement in that lateral recess. Okay. Have we got any more discs coming up, Darren, do we know? Sorry, slides. Here we go. Okay. Another one. So, yeah, so categorised them before, wet and dry, but the truth is in reality you can sometimes get a combination of the two. And again, it's quite a frequent thing that you'll see that often patients who have episodic periods of disc pain or sciatica, quite often what will happen is there'll be a certain amount of

longstanding kind of annular components where they've got this kind of hard disc protrusion, and then they'll have an acute flare up where there's then an extra fresh slightly wetter, if you like, bulge adding to that. And that's what we're seeing here. So, we're seeing, it's not the clearest to see, but this is a combination of wet and dry. So, the blue arrow is trying to show you where the edge of the annular bulge is. And then the red arrow is showing this extra, more nuclear, lighter color in nature that's bulging out in addition. So, what we could say about this one is right, that would probably eventually reabsorb and reduce, but it's not going to reduce the whole way. There's going to be a certain amount of posterior bulging left most likely with that patient. Hopefully though it will reduce enough to get them symptom free.

Steven Bruce

Rob, can I interrupt your flow and ask you a few questions? Because I'm conscious that this is learning with others, people want to get their two pence in on this as well. Sally says, I thought you could scan the non-symptomatic population and find disc abnormalities in those. So how does this all relate to that?

Rob Shanks

Yeah, no, absolutely and Sally is right. You do scan, I think the statistics are you'd expect to see probably if you took a hundred people, you would expect to see at least 60% to 70% of them with disc pathology, who are asymptomatic. And there's two points to make here, really, and one is that as we saw from the previous case history with the 17-year-old who had the pars fractures that weren't shown on an MRI, MRI is just one tool, it's just one piece of the puzzle. You shouldn't be pinning your hat just on an MRI scan or an MRI report. Obviously, you have to take the two, you treat the man, not the scan as the phrase goes.

Steven Bruce

I'm glad you mentioned the 17-year-old because, and I know this is not a broadcast about treatment plans, but somebody asked what was the treatment plan for that tennis player?

Darren Chandler

That's actually Darren's patient. So, I don't know Darren's still there. What did you do with him, Darren? Are you still there? I think he might have left.

Steven Bruce

He's still there and he's still moving, but he's not listening or can't hear us. Okay, well let's move one.

Rob Shanks

I think, from what I remember-

Darren Chandler

The patient was put in a brace and rested for four months.

Rob Shanks

So the answer to the question then, Steven, is Darren put him on severe rest, if you like, stopped him from doing his activities was able to explain to him that, look, you have got fracture, you can't keep playing tennis, you need to rest for four months. And I believe he made some improvement from that.

Steven Bruce

Nick has asked about the last patient we were looking at. I'm not sure if he means this one. I think actually he's talking about this one. What type of MR is this?

Rob Shanks

So, this is what we were saying. This is the 17-year-old chap, the tennis player. This isn't an MRI, Nick, this is a CT scan.

Steven Bruce

So, the MR scans, which ones were those? That one I think you said was STIR on the left.

Rob Shanks

Yeah. And then that's a T1 on the right-hand side.

Steven Bruce

Okay. Nick, I hope that was what you were referring to in your questions. Cause obviously we've moved on a little bit from them. We're trying to get through as much information as we can.

Rob Shanks

He might have been talking about the imagery with the brights and the purples, that was a SPECT CT. This one here, this is a SPECT CT. So again, this is a combination of nuclear medicine and CT scan.

Steven Bruce

No, I think he was talking about the MRIs because he specifically said the MRIs. Robin has said, if we found ourselves in a situation like this, where we have to question the report, and he's going back to the first case that we talked about, how do we go about getting a second opinion? I can see these things when they're pointed out but I suspect I'd miss loads of things if I was trying to read an MRI myself. And obviously we'll talk about you helping people learn that later.

Rob Shanks

I think if there's a very high suspicion, obviously the ideal thing is to be able to back yourself up and say, well, look on this image I can see this. And we quite often do that. I think though the truth is don't be afraid to ask for a second opinion, if you suspect or you strongly suspect something's been missed. And the clues to look out for are the ones that when the reports come back that are very sparse in nature. When they just come back and they're one or two lines and they say, well, alignment's normal, everything's fine. But they haven't systematically gone through and said, there's no this, there's no that. If they haven't gone through and they've ruled out this, they've ruled out that, they've ruled out the posterior arch, they've ruled out the facet, they've actually said there's nothing present on those individually. Well, then you've got quite a bit more confidence they've actually really been looking at these things. But the truth is the more you become confident in looking at these images yourself, the more you'll be able to back yourself up when you write back to the GP or whoever it would be. So just dive in, is what I want to say, start looking at images and the more you do it, the better you'll get, it's like driving.

Steven Bruce

Bob's asked how easy it is to get copies of MRI scans. He says he's struggled to get copies of the radiologist's report, let alone the scans.

Rob Shanks

Yeah. So, well, if you're the referrer, if you refer for the scan yourself, by rights you are the one who should receive the report, and I appreciate you're probably not talking about that situation. So really what I tend to do in my practice is I will ask the patient to request, stage one: they request the MR report themselves, and they pretty much always get that copy, the black and white copy of the report. Now getting the actual images themselves can be a bit more difficult, but if you're persistent, it can always be done. And what we won't be able to do is if we're not the referrer, they won't be able to send us the images themselves, but they'll be able to send the images to the patient. The patient can request a copy of their MRI scan on CD and then that's what they should then bring along to you.

Steven Bruce

Yeah. Okay. And I've just lost a very interesting question. A very interesting one here from Andrew. Andrew says, is it true that Vista Diagnostics and other companies do thicker slice images than the NHS? And if so, does that mean their images are compromised?

Rob Shanks

What a question. Okay. There is some truth to that in the sense that some of the budget scans that you get will, so let's say for example we're doing, you know axial slices through the L4/5, L5/S1. You're right to an extent, they may not do quite such fine slices as let's say somewhere like Stanmore. Stanmore, the Royal National Orthopaedics Hospital, they'll tend to do a full spinal, they'll really go into depth. Now, this sort of thing if you're paying for that privately, you'd probably be paying 800 pounds for. So as a rough rule of thumb, it's true. But having said that, we use Vista Diagnostics quite a lot. And I think if you're aware of what goes on and your confident, you tell them exactly which slices you need and what you're most interested in, 9 times out of 10 they'll be fine.

Steven Bruce

Okay. And I don't know who asked this question, but they say I've heard that there's an extension test compared to extension with hip flexion to help diagnose pars, in clinic, obviously. If that's used in conjunction with a history, is there any value with this? Does that make sense to you?

Rob Shanks

Makes vague sense. I believe they're talking about spinal extension versus hip extension, is that what they're saying?

Steven Bruce

It's not clear from the notes I've been sent.

Rob Shanks

All I would say is yes, if you're suspecting a pars defect, you would be expecting that to be symptomatic on spinal extension. Yeah. That could be a provocative test potentially that might, or the case history saying don't do those sorts of movements, they hurt you.

Steven Bruce

And Rose asks whether you review every single MRI that you send people for.

Rob Shanks

Pretty much we do. Yeah, to be honest. I always ask the patient to bring the CD in and let me have a look at the scan.

Steven Bruce

And I guess not least because that's one of the best ways of becoming familiar with MRI scans and learning how to interpret them.

Rob Shanks

Totally. And I think the opportunity here is that nobody's expecting us to be brilliant looking at MRI scans. So, the pressure's off really. The fact that you're going to be looking at those images doesn't mean you're expected to come up with a diagnosis or a report to rival the radiologist, you're just kind of checking a few things. And the other thing to look for is other little things like the muscle density, the alignment, stuff that might give you little clues as to, well, what do I need to do. Just from a very rough, never mind the disc bulge and the individual pathology, just looking at the very gross anatomy can be helpful?

Steven Bruce

Do you want to move on to looking at how we view MRI scans?

Rob Shanks

Yeah. Okay. So, we touched on this a little bit earlier. I mean, I don't know how we're doing for time?

Steven Bruce

Oh, we're way over time.

Rob Shanks

If you want me to share the screen, I'm quite happy to show you through as OsiriX viewing portal. But yeah, this is what we were saying slightly earlier on. Because of the GDPR stuff that's kicked in, once upon a time, it used to be great. You used to be able to get your copy of OsiriX, if you're a Mac user like I am, and you put any CD in the CD drive and it would load up and it's a fabulous piece of software, it categorizes all the images as a database according to the patient's name. And it's just so versatile, so easy to look at, so easy to navigate. Then what started to happen is the GDPR kicked in and all the CDs started to get, well lots of the CDs let's say, started getting password protected. And there's still a few out there that you can still load up and that still will load on OsiriX, but a lot of them now, especially the NHS ones, you just cannot use them on the Mac. Now I obviously appreciate not everyone uses Macs anyway. So, the thing to remember and the reassuring thing is that once you do get these MRIs on the CD, they will always have their own software on there. They will always have their own self-loading software. I'll be honest for my liking it's not quite as versatile, not quite as good as the likes of OsiriX, but at least it will still get you started and you will be able to load up, as we said before, the sagittal image next to the axial image. And there's things to know about how to navigate those and so this is what we're doing next Thursday. We're going to go through that as a live demo. So that you can know the things exactly like which axial

slice am I on and knowing how to bring up the axial images, as I say. Now, the other thing that there is also is that when your, we mentioned Vista Diagnostics earlier and InHealth, which now Vista is part of, they will, if you're a regular referrer certainly, they will often set you up with what's called a 3d net portal. So, it's essentially an online cloud viewing portal where all your images will be loaded on the cloud and you can then just log in and you can actually go through them that way. And that's pretty good because whether you're on the Mac or whether you're on the PC, you can still use that. And again, it's another thing we'll be covering next week. So yeah, my message really is to get into it, start dealing with this and the more you do it, honestly, the doors will open, you'll start to sort of get familiar and start to see all of it. And it'll take a bit of time, but it really will be worth people's while, I think, going on that journey as we have.

Steven Bruce

So Osirix, we won't talk about that-

Rob Shanks

I few things I want to mention about if you do go down the route of Osirix, so if you're looking at trying to go download the software, you won't find it on the app store. So, if you start looking for OsiriX, there's another one called Horos. Again, you won't find those just by looking on the app store. You have to go to- yeah, so this is what you get, if you go to the app store this is what you find. Don't get these, these aren't very good. Although it mentions OsiriX, this is the quick view OsiriX. It won't be anywhere near as good as the version I'm talking about. So, what you need to do is go to the website. I think we've got it on the next slide. Yeah. So, it's osirix-viewer.com and you need to download it from there. It's free. There is a paid for version, but the free version is fantastic. So yeah, just go for the free version, download that, and then you'll be up and running. And similarly, Horos is a rival. It's a very, very similar company. So horosproject is the one you have to go to horosproject.org. And again, it's a very, very similar software to the Osirix. To be honest out of the two I'd probably go for this one. It's got the slight edge, but there's not much between the two of them. That's just a few screenshots of you need to have that screenshot to go down to. So, this is the webinar we've got coming up next week, as I say, if you go to the go2imaging.com/training page it's on there and it's a live demo we're going to be going through, as I said, how to load the software. There's four different types of software for the PC, it's off the CD. We're going to do the OsiriX, we may well do the Horos as well, although they're probably very similar and we'll also do some cloud-based stuff, the 3d net and just show people exactly where they click, how they get images up. We won't go into too much case history detail as we've done today, it's more about getting people familiar with starting to have the confidence to look at these things themselves. And just to reiterate again, all the members, get it for free if they use that code, the APM15off.

Steven Bruce

Okay. Are you happy for me to send that out generally or just to the people who've watched this afternoon?

Rob Shanks

I'm happy for you to send it out generally that's fine.

Steven Bruce

Okay. Super, thank you. Darren, I'm very sorry that we lost your audio and your computer in the

middle of this. But Rob, you coped manfully with taking over from Darren when the need arose. I'm sure you're gonna get a load of people watching that because all of us, I think are very, very worried about our inability-

Darren Chandler

Thanks, Steven, sorry.

Steven Bruce

Darren's coming in 15 seconds after he speaks, I think. But as I say, a lot of us are worried about our inability to interpret MRIs accurately, unless somebody points to the things for us. So, I'm sure you'll get lots of people on that. And I hope we'll get you back on the show again as well, because there's clearly lots of this stuff that we can learn from and I've certainly enjoyed it and I hope our viewers have today. Thank you, guys, for what was meant to be a 45-minute show and turned into an hour and a quarter.

Rob Shanks

My pleasure.