Transcript

Spinal Implants – with Ben Woodington

Steven Bruce
Welcome to the academy once again. Great to have you with us. As always. Tonight, we've got another of our virtual shows that is to say I don't have my guest in the studio. I've got him on a virtual link courtesy of Microsoft Teams. Not that that should have any impact whatsoever on the subject matter of our discussion. The subject matter of that discussion sprang out of me reading an article in The Guardian, in which Dr. Damiano barrier Baroni, who is a neurosurgeon was interviewed about inflatable spinal implants and it caught my attention and I thought this is something which is a fascinating and be relevant to what we all do as osteopaths, chiropractors, physios, and so on. So I thought, let's see if Damiano will come and join us on the show and he agreed to come on the show. However, as I said, Damiano is a neurosurgeon. And at the last minute, he's been otherwise called away. And he has nominated instead the first author on the paper on this subject, and which has been Willington now give you I'll give you a bit of background on Ben before I actually get him talking. Because it's him, we're here to listen to you obviously. He started life as a medical chemist moved into pharmaceutical technology after that, where he was doing drug delivery devices, in particular with respiratory conditions, such as cystic fibrosis, went back to Cambridge for a master's, and then a PhD in bio engineering, which is neuro technology. But I've cocked up that last bit. But I'm sure you can give us much more detail on exactly what you're doing at Cambridge and about the unit that you work with and and all these fabulous ideas that are coming out of that unit. Welcome to the show. Anyway.

Ben Woodington
Thank you. It's a pleasure to be here. I'm sorry for those of you on the call there was expecting another clinician, I am not a clinician. I'm kind of an engineer. I'm kind of a scientist. I'm kind of falling between the cracks of both at the moment but I am is I guess it's kind of interestingly positioned because I've been working with doctors, clinicians for the last eight years of my career now, from the engineering side. So I'm hoping that I can cover a lot of bases. And

Steven Bruce
I'm probably you're probably an honorary MD by now. And you would have thought, maybe if I'm feeling more sorry for you, because Damiano, having been called away has dropped you in this not quite at the last minute, but I mean, he couldn't have picked someone better place to discuss spinal implants, neuro technology could also not. So give us a bit of background on the unit that you work with at Cambridge?

Ben Woodington
Yeah. So our group is the electronics group here at Cambridge, we sit with an electrical engineering, but the group is CO run by you mentioned Damiana, Baroni, who works in clinical neurosciences. So the group really has a push pull on the technology. So we in engineering, we build lots of fun, interesting tools. And then the clinicians tell us often No,

that won't work, you need to design it like this, which is great. We leveraged kind of technologies that have been around in the semiconductor industry for the last 20 or 30 years, which means we can fabricate very, very small, flexible, and biocompatible electronics that we stick in and on the body to do interesting things. The group covers neuro engineering, as you mentioned, that is electronics that we stick on the spinal cord or the peripheral nervous system or on the brain. We have a drug delivery part of the group that looks at cancer therapies. And then we also have a cutaneous electronics group. So this is like EEG or EMG, muscle measuring muscle activity,

Steven Bruce
in terms of, you know, all these wonderful things that you're having fun with at the moment. Do you have a good track record of these things, actually making it into the medical market and becoming usable medical devices?

Ben Woodington
Yeah, this is a very good question. It's hard, right? We're developing these technologies that are ahead of what is currently used. And as I'm sure many of your listeners will know, medical device technology, pharmaceutical energy moves slow, you're looking at decades, not not years. We are working on translatable technologies. So we try not to use crazy materials that are never going to get into a person that are toxic. We try to develop things that have a track record of being in the medical market. So these materials like silicones, for example, apparently in which they used to coat pacemakers with and then we look at translating those. So in terms of getting to human Yes, we were up to the human experience. Now though, we're looking at like the next day is an RPI George Moneris. And also Damiana, the CO lead, Diana Maroney are both very, very enthusiastic. Now in the next few years, okay, we develop this kind of array of technologies, how do we now take them into humans, and you know, into medicine as well, not just first in human but actually on the market?

Steven Bruce
Yeah, and you and I had a bit of a chat about this before we went live. And you were saying that at the moment, most of the funding for the unit is through grants. But for it to become mainstream, it's going to take millions, which means there has to be a commercial investor in this series, it's got to be stuff, which offers real promise to that investor isn't

Ben Woodington
absolutely true. Like you can get so far with grant funding. And you can get up to that, you know, you can do that preclinical animal work that's necessary with grant funding, you can even do this first in human testing, with grant funding. But in terms of actually launching a product into market, you're looking at 10s of millions of parents or hundreds of millions of dollars. If you look in the US market, where you get the money from you get that money from from from private investors, or you get it from industrial partners, of which there are kind of only a few really medical devices.

Steven Bruce
Yeah, I will tell me then, I mean, this might well have come up in questions if I didn't ask it now. But we're very fond of criticising the pharmaceutical industry for skewing the research so that they can get stuff they've invested into on the market, sometimes with questionable medical success, it's probably a polite way of putting it. Is there any of that sort of pressure on you from investors? And I don't if you've got them yet for what we're going to talk about

this evening, but is there any that sort of pressure on you to make sure the research fits what they're investing in?

Ben Woodington
I think my experience is primarily from the UK and European side of things. And there I think is far less pressure in Europe and in the UK. I think there's less pressure and better places. However, the route to market for medical advice is tends to be easier there is it's still complicated, but it's it's easier to get in then usually then a pharmaceutical product, which you know, changes suggest strategy slightly.

Steven Bruce
So we're, let's go, let's go to these inflatable spinal implants, which was the Guardian headline, I think. Could you put a bit more body on that? No pun intended, exactly what it is you're working on?

Ben Woodington
Yeah, no, absolutely. I mean, this is probably if we can, can we can we see the slides at the same time here? Yes, of course. Okay, so maybe if we go to Slide eight to begin with. Slide eight. Yep. Just give some colour text I think probably based on that, are we are we on that one?

Steven Bruce
Yes, we got that one up. Perfect.

Ben Woodington
So this slide is just showing some of the flexible electronics that have been developed in the lab. So probably most of these kinds of technologies will be unfamiliar to people who are used to dealing with sort of bulky silicone devices that if anyone's placed a spinal cord stimulator, I'm sure there'll be lots of them, they'll be familiar with these kind of semi flexible devices with kind of thick layers of platinum on the inside. They're pretty robust. You do get cable breakers quite regularly, but they're relatively breasted surgeon can knock on round on the table, and it tends to be okay. Well, we develop a much much thinner like orders of magnitude thinner. So we use thin as a polymers that are made of, as I mentioned, parts of nickel, Parylene, C, and silicones. But they're in the order of microns, so maybe four to 100 microns. So this

Steven Bruce
this thing here is what human hair width,

Ben Woodington
even thinner. So human hair is what 30 to maybe 80 microns,

Steven Bruce
these my hairs a bit thinner than most

Ben Woodington
minds getting that way. Unfortunately, the two devices that can see on the left are four microns in thickness. So you know that they're tiny, a 10th of the spinal cord devices, the device that you can see on the right of the image, the sort of gold device that's wrapped

around a tube, which is kind of simulating the vague size of the spinal cord. That device is about 60 to 80 microns thick. We have to have it sorry,

Steven Bruce
no, I was misled there. I thought this was the device. This is this represents the spinal cord. Yeah, the device is just this little bit of film as long as

Ben Woodington
that one sat on top. Yeah, absolutely. Absolutely. So it's just demonstrating their the kind of flexibility of the device and the conformability conformability of the device, which kind of is an intrinsic benefit of using these thin these materials, right. So especially when you're looking at the brain, you want to be going over the curvature of the brain, not just a slab of polymer sat on top the brain so that those electrical contacts are actually in contact with with the with the tissue. So yes, those final devices, they're about 80 microns. And I can explain why that isn't.

Steven Bruce
This is probably getting ahead of ourselves here. But these are electrodes where's their electronic signal coming from?

Ben Woodington
Yep. So again, for anyone familiar with this kind of classic spinal cord stimulators, you've got these bulky silicone, paddles, and then cables coming off the back of those. And then you've got a implantable pulse generator battery that sits sort of further down in the lower back. So our devices exactly the same. We designed this device to interface with conventional implantable pulse generators. It's a part of the surgery, it's not our innovation, it's not part of the surgery, they want to change. People do it very well already. Those big medical device companies do a good job of miniaturising them improving battery technologies. What we wanted to do was design advice that could be plugged straight into that interface directly into that, but offer a better interface with extra spinal tissue and also reduce the clinical burden of implanting one of these, so I should wait back a little bit. The beauty of this device is that we can roll them up into tiny, tiny dimensions, so about one to 1.5 millimetres in diameter, which means we can package them into needles and implant them percutaneously as one word percutaneous spinal cord stimulator. At that point, then we inflate the thing and it unfolds unfurls onto the spinal cord stimulator onto the spinal cord. At that point, a clinician would then plug it into the IPG that they've sat wherever she uses device that IPG then then it becomes the active device.

Steven Bruce
So sorry, so where typically is that IPG, which is the power pack that stimulates the thing that sends a signal to the the accurate,

Ben Woodington
it sits down sort of in the lower back and under the skin as well. That's all as well, but away from the actual, you know, the sensitive neural tissue, the spinal cord,

Steven Bruce
okay, so it sounds all very well that you can implant this using a hypodermic needle. But somehow someone's got to connect the wires on the end of this to something which is inches below it in the back.

Ben Woodington
Yeah, yeah. Usually, maybe 30 centimetres or so. A stretch down, but it's, it's, uh, yeah, importantly, it's away from any of the delicate parts of the body. Yet only only the sort of soft interface goes within the spinal column and unflexible spinal cord, we do have that is obviously a line of wires and a fluidic tube as well, that comes off the back to that device.

Steven Bruce
Right. So those come out through the spinal column and are sitting under the skin rather than within the spinal along the spinal cord itself.

Ben Woodington
Absolutely. And if we go if we can, if we go to slide 13, there's a bit more of a clearer image of how that works as well.

Steven Bruce
Okay, great. So those

Ben Woodington
those devices on the left hand side are the kind of classical spinal cord stimulators that people will be familiar with plant implanting. I think these are from Boston Scientific these devices. So you've got those bulky, wide, semi flexible implants that are maybe 15 millimetres wide or so. And then you've got those percutaneously is that a 1.5 mil? So yeah, about 1.5 mil to mil wide, are devices you can see in the image on the on the right hand side actually goes through it's a to a needle that you can thread that device through as one word a percutaneous. Lead, and then the diagram is just showing the device on the spinal cord and then kind of popping open onto the onto the tissue.

Steven Bruce
Right. Okay. You've got a little bit later on two slides further on number 15. You've got a little bit of a video going on there. Michelle, that Justin? Yeah, that's the one.

Ben Woodington
Yeah, so yeah, please. So

Steven Bruce
I'm not sure what the video is actually rolling on this. But in this bit, the bit in the middle. That represents what?

Ben Woodington
Yeah, it's a video, doesn't it on click? Does the video play? Or does it not?

Steven Bruce
I don't know Justin, can you get that video to play? No, he won't play. No, my first my fault for messing around with your slides. I'm sorry, Ben. It's not a problem.

Ben Woodington
So what we're seeing there as the device rolled up, it's in a kind of simulated environment. So we set the pressure inside this sort of balloon inside the tube to simulate that the epidural space within the spinal cord, spinal column, the device has kind of just been threaded, and then what we're doing in that video is activating that device. And it's kind of unfurling across

in filling that space. And then the image to the right of that, what we can see is actually the device before it's been packaged inside any of the kind of percutaneous tubing, we set this thing inside like a silicone sheath tubing to protect the delicate electronics. And you can see the device there just like laying it on the table, the devices about 50 mil 55 mil in length, and then it kind of matches the dimensions of those. It's actually about too much. It's one of the Medtronic devices, or the 565 Medtronic device, which is very common spinal cord summit advice most people are familiar with. Again, we can make much more complicated devices than this. But we're kind of going baby steps like what are surgeons, what are clinicians familiar with, we can match that device architecture, but using a very, very minimally invasive surgical procedure.

Steven Bruce
So it's amazing stuff. And I just say a quick word for our viewers, I would normally share the slides with you after the show in the form of a handout. Ben's asked me not to do that, because some of this stuff hasn't been published yet. So we're at the cutting edge of the cutting edge here. Ben, I think if I send them to the unit's website at Cambridge, quite a lot of these images, and a lot of the background information is available there, isn't it? Yeah,

Ben Woodington
absolutely. And you know what I, you know, I didn't have time to do it. We're given the given Damianos short notice. But I can act on the information that we just don't want public. And I can send you a slide deck that I'd be happy for you to share.

Steven Bruce
Thank you. I mean, it's useful for people to have that as a as a record, because it's hard to keep up with what with all this stuff that you're putting over to us. And I have had a polite request to say that we are simple osteopaths and chiropractors, could you please speak a bit slower? bit slower? Because we don't follow it?

Ben Woodington
I absolutely will. I apologise I should. I should know that after working with clinicians for the last three years, four years in this field, I should I ask the same thing and a lot of language that I've had to absorb

Steven Bruce
another explanation for you. The the system whereby people ask me questions, auto generates the names for them in on one of the channels that we have. So I'm forced to address people by very strange titles for some time. And the first question has come in from someone who has known as helpful person who wants to know who typically is going to benefit from this? Yeah.

Ben Woodington
So the device has been designed with pain management in mind. So these conventional spinal cord stimulators, they're used for drug refractory pain. So patient often gets put on, you know, increasingly difficult drugs, usually on a bunch of opioids by the by the end, for any kind of any kind of pain, but usually pain of neuropathic origin. And but they have been used also for sort of angina and lower limb pain or this kind of stuff. Pain Management is they're used for the moment, that's what we're targeting. They're very effective at treating pain in patients for a period of time. But what we're kind of excited about in this group as well are the future applications, the blue sky applications of which there are many not to diminish pain. I have spoken to many people suffering from chronic pain, and it is a completely

debilitating, debilitating issue that, you know, completely halt life. But we're also looking at movement disorders in Parkinson's and also, interestingly, spinal cord injury. So there's a lot of excitement at the moment in the field of using these types of devices to treat people with spinal cord injury. During their rehabilitation phase for movement disorders, of course, but also for bladder function and for sexual function for blood pressure. And there are lots of applications here as well.

Steven Bruce
Let's go back to the pain relief aspect for a second. Does this mean that this is just an internal version of 10?

Ben Woodington
It functions in the same principles, it functions, same principles, they're far more effective. They're on that tissue, you can target the the neuromodulation, the where you're directing the power, far better than a 10s machine. You're the 10s is out on the outside the two contacts, I think, four contacts, not nowhere near as effective, but they

Steven Bruce
work on similar principles. So it's pain gating that's going on?

Ben Woodington
Precisely Yeah. Right. It's very, very contentious. Sorry, which is the literature on pain gating. Payment gating was very contentious. Well, I mean, you know, there were these theories of pain gating from I think, 1965, like kind of seminal publications, that people kind of still stand next to, and by low, I think many aspects of it, it's kind of been disproven. People can come along with high frequency stimulation. So people usually they stimulate at a tonically. Between, I think it's like 20 to 100 hertz, usually, then some a company called never came along and started stimulating in a high frequency regime, at 10 kilohertz, the mechanism seems to be completely different. The way the pain is treated seems completely different. And it seems that no one really knows why lots of people have theories, and then they they trade their theories, but there's no really prevailing mechanism, or, you know, underlying theory as to why these actually work the way

Steven Bruce
it's always it's always a bit chastening to realise that there is still so much uncertainty in the medical world isn't there? And I imagine that your sort of research in any other research is vastly complicated by the fact that the the placebo effect will play an important role in this as well as the actual technology.

Ben Woodington
I mean, yeah, you hit the nail on the head there, especially when, you know, doing it running a placebo is difficult when we're running a control group, I should say, is difficult when someone has to undergo a surgery, right? They're having a device implanted, and you can have sham device operating. That's not actually stimulating. But there have been studies haven't there where people have had, I mean, you and your audience will know this way better now. But people have had knee surgeries, and they've done nothing, they've not tried to fix anything, and they still report pain relief. We are a little bit in the in the Wild West, I think we're sort of where pharmaceuticals were some decades ago, where people are running experiments where they they do neuromodulation on the spine on the or on the vagus nerve or somewhere else, and they get an effect. And they don't really know why or

what the underlying mechanism is. But they are getting an effect. So they kind of shrug their shoulders and they say, Okay, let's move on to clinical development.

Steven Bruce
Yeah, and frankly, a lot of us would say, well, that's a good approach. There's also no adverse effects. I mean, let's just get benefit for the patients.

Ben Woodington
Yeah, of course. C is understanding the underlying mechanisms, then you can design better treatment modalities, which is kind of not where we are right now. We're sort of we, the 10 kilohertz treatment seemed to have come out of nowhere, but we tried it and it worked. And so there we are.

Steven Bruce
So in terms of spinal cord injury, which you mentioned a little while ago, as well. Are you suggesting that with these devices, we don't have anything to show this on the on the screen, but we can reconnect across across a rupture or

Ben Woodington
reconnecting is difficult. It's something that we sort of vaguely tried to do and I can touch on some of our kind of more even more cutting edge research in a second. It's but recording from above an injury and stimulating below is is difficult. Some people say it's, it's impossible for reasons that I'm happy to go into people are interested,

Steven Bruce
they will be definitely.

Ben Woodington
But what's more interesting is kind of the rehabilitation so if you don't have a complete spinal cord injury, and I have to confess this is not the expertise of my group, but the expertise of groups in in Switzerland, you can stimulate in a certain pattern at the injury or below the injury, and you can kind of reinforce that movement again, so paired with very, very intense rehabilitative therapy, and spinal cord stimulation. They have managed to get people to a point that they would never got just in terms of rehabilitation alone.

Steven Bruce
Right. Okay. Rupert says does playing around with the connections on the spinal cord, alter application of the device, calibrate which nerves are activated below the lesion? I'm not quite sure why didn't quite slow there but you get the idea.

Ben Woodington
Is the question sort of, Can you can you target. Can you read it again, I think

Steven Bruce
just playing around with the connections on the spinal cord off application of a device calibrate which nerves are activated below the lesion. So it was my poor reading of the question.

Ben Woodington

No play around with connections on the spinal cord? I don't quite follow. But I mean, we can definitely

Steven Bruce
guess he means, you know, where does this thing actually sit on the spinal cord? I mean, how would you position it precisely to target the the, the part of the spinal cord that you need.

Ben Woodington
It's something that we can do by numerous electrodes, which is kind of again, the benefit of this device over something where you just have a electrodes, once you've got the electrodes on the spinal cord, you can then tune and play with the parameters to direct that electric field, which is something we want to do, we have tracks on the spinal cord. Usually with these devices, we're only targeting the dorsal column on the spinal cord. But we can kind of aim that electric field towards one side towards the other towards a branch to the spinal cord. A benefit of working with micro electronics, which we can do by making these devices is we can put if we wanted to hundreds of electrodes on the spinal cord not be limited by eight or 16, which means we can target then tracks kind of anywhere we like on the spinal cord. And what we're trying to work on now is okay, we built this based on the Medtronic footprint of this sort of like 15 mil wide device, because that's what people do at the moment. But if we go wider if we wrap around the spinal cord, how much further can we go? And how much more control do we have over those tracks on the spinal cord?

Steven Bruce
And that control is practised exercised externally by some sort of remote control of the sensor, which is internal to the patient.

Ben Woodington
Yeah, exactly. So usually, a clinician would have that there'd be like a trial phase and a tuning phase where someone would sit with the patient undergoing the surgery, and they would they would tune and kind of calibrate that device. But once they've set those parameters, patient is stitched up patient goes on his way. He then the device has not been touched until they need to reprogram it if they do need to reprogram it at some point.

Steven Bruce
Okay. Moving a bit upward from the spinal cord itself. And Joseph asked whether this would help stroke patients, potentially.

Ben Woodington
Yeah, people have looked at stroke as well. For sure. The devices we usually use for stroke or sat on the brain or the spinal cord. But it's definitely not the application that we're exploring.

Steven Bruce
Right. And Alex has asked how it actually works. So I asked him for a bit more precision here on whether it stimulates the spinal cord or nerve axons or something else.

Ben Woodington
Yeah. Again, I think it's a good question. So the theory is that you're you're you're stimulating the these dorsal tracts is ascending sensory tracts for for pain. For the rehabilitation side of things, again, very contentious. There's an amazing work by Gregory Katene, from

Switzerland and Miko, CoverGirl. So these guys do phenomenal work in this exact area, trying to figure out when you're stimulating for rehabilitation for spinal cord injury, what are you actually doing? What the hell are you doing? Like, what are you activating? Are you activating just those dorsal pathways? Probably not, you're probably activating something deeper in the spinal cord, are you activating these kind of reference? They're going back into my record? And is that having some sort of like, effect on central pattern generators that are also kind of contentious in origin? But it's it's work that people are really trying to figure out like, what are you actually doing when you're doing these neuromodulation therapies? What are you stimulating? And what are you triggering? And what are you trying to add? Like, what are you lacking in the body's biology to get people out of pain or walking again?

Steven Bruce
And have you actually put any of these inflatable devices into a human yet?

Ben Woodington
Only human cadavers, so they weren't going?

Steven Bruce
Right. But if we assume that the effect is likely to be similar to those larger paddles and devices that you showed earlier on, have there been would you expect there to be many adverse side effects from these side effects?

Ben Woodington
Absolutely not. And it's something that we're working very, very closely on. Which actually be quite helpful. There's another slide actually, that would support this. Maybe it's the next slide, actually. Next slide. 16. Possibly,

Steven Bruce
okay. This is making devices with the clinician in mind. Yeah,

Ben Woodington
yeah. So this is unfortunate. It doesn't look like the video is gonna gonna run again. But that's okay. It's still it can be used. So will there be adverse effects, we don't want to just be engineers running in with our tools and saying, Hey, chuck this in a human body, it'll be fine. I'm sure. This is why we work with clinicians. This is why we work hand in hand with clinicians to be like, how do we design these devices have therapeutic benefit without causing any damage because otherwise these devices are dead in the water. So the original device that we built was kind of sharp on the front to sharp on the front, as opposed to the soft silicon devices that they're using the beginning. And as we went in percutaneously, very, very first cadaver session, the device went straight through the spinal cord, that backside hit the bone and then you're running on the backside. Okay, that's you've just you've just, you know, lost the use of someone's legs. So quite a reader We had to redesign it to make the device softer. And then another aspect we had to do was the way the device inflated at the beginning inflated, as you describe kind of like a balloon. If a device inflates like a balloon, and you get a kind of anterior posterior expansion, so you're putting pressure on the spinal cord, you're again, you're going to cause you're going to cause damage. So it's something we had to engineer out. It's why we do these cadaver experiments is why we don't even think about preclinical animal work before we actually get these kind of fundamental engineering problems first. So we did now design the device in a way that it means it can be introduced in a much more effective way without causing too much like reducing the risk of damage to the spinal cord. And then with the way the device unfolds, it's kind of cleverly

engineered to only unfurls laterally rather than in this dimension, so that it doesn't put pressure on the spinal cord.

Steven Bruce
Oh, I'm glad you practice on cadavers first, that's everyone's advantage. Pip was sent in an observation. She says that pain is there for a reason. In many cases, it stops people doing things they shouldn't be doing these devices, are they likely to stop pain completely? Or do they just reduce pain? Are they likely to encourage the patient to do things they shouldn't?

Ben Woodington
Know? I mean, again, they Yeah, it's the beauty of neuromodulation over kind of just being absolutely chock full of opiates is you don't want to block that acute pain. You're right. You don't want to put your hand on the hub and burn it and not be aware because you're getting you know, but that's of course stimulation. But these don't these these are intended to block chronic pain. They're intended to block pain again, as I say, like neuropathic origin and pain that are targeted specifically for for the particular ailment that person has, whether that's sciatica, angina, or, or failed back surgery syndrome. You tune for that you don't seem to make people numb in the legs so that they're going to injure themselves. And it's a very important part of the delicate procedure.

Steven Bruce
Right. Robin sent in a really useful interesting question from from our point of view, which is, he's asked about how robust these devices are. Because of course, if we as osteopath, chiropractors physio therapists start wrestling around with a patient's spine trying to mobilise things and rebuild their strength and their stability, are we going to damage these things?

Ben Woodington
Yeah, again, a very important point, and something that we had to work with our surgeons on as well. These four micron devices that I described, we handle them in the lab very delicately, delicately, we're fine with them. But soon as you give them to someone who's not familiar with how, you know, flimsy these things can be, they can start pulling them around and tagging them and they can tap. So this is why another reason this device is a little bit thicker, stuff enough that we can roll it up but thicker than some of our hyper conformable devices that we would stick on the brain so that they can be tugged around, they also need to be robust enough so that they can be x planted. So it's no good just sticking a device into someone, they may be have to have that device taken out at some point, they probably will have to have that device taken out at some point. And the device needs to be retrieved. You don't want to make these things flimsy enough that as the surgeon goes to pull it out, it snaps off and stays inside the patient that is a lawsuit waiting to happen for the developer or the surgeon, whoever else. So these

Steven Bruce
things are not actually stuck to the spinal cord, they just lying on the surface and staying there by what surface tension,

Ben Woodington
what Absolutely, so they sit in, in the epidural space. So they said Apogee early and they're kind of surrounded by fat and tissue in a kind of like virtual enclosed space. So they are, they're held by by surface tension by capillary forces on on a cord, but also that they're stuck within a space, they're not free floating, which again, is one of the benefits actually of these paddle type devices. The linear probes, they move, they migrate quite a lot. They're just

smaller in footprint, and so they slide around. But when you have something that sits actually open, opens up and sits on the surface of the spine kept in that space tends to stay relatively still, obviously, as I've just said, you can spend hours tuning the parameters of this device to treat a specific pain of wherever in origin, you don't want the device to then slip out of line and be targeting somewhere else and be effective anymore.

Steven Bruce
I think I might have dragged you away rather quickly from this slide here. And I just wonder if you could explain what's going on in it because we've got three images on here. And it's not clear to me exactly what they're showing.

Ben Woodington
Yeah, no, absolutely. So if we go to the next slide, actually slide that'd be slide

Steven Bruce
17.

Ben Woodington
Yeah, so what I just wanted to show first with images on the left is a don't lacerate the spinal cord with a device. The damage is below show after we've developed a soft soft tip device it means that we can make contact with the the tissue that are on spinal cord and then and then run up the spinal cord.

Steven Bruce
What is lying within those harsh white rectangles? So

Ben Woodington
that is where the spinal cord is sitting? Yeah. And then beyond that, it is the spine, that kind of darker areas. All

Steven Bruce
right, I see yes, of course, yes, yeah.

Ben Woodington
And then within the kind of yellow patch box is the spine and then the device is actually sat there on the surface of the spinal cord. And then we can guide the device then and sort of train the device up the spinal cord, then through a through a percutaneous needle that sits much further down. The image I want to show you on the right is actually another demonstration of designing with the clinician in mind. So we did develop this super, super fine device, very thin, using very thin layers of metal that were in the order of hundreds of nanometers. And we said, this is going to be great. This is going to work perfectly look how flexible it is, look how much it rolls up. And then we took it into the surgery working with the Simba divers, and the clinician says so how do I see it? It's what do you mean? How do we see it? Well, usually, we usually use fluoroscopy kind of type of X ray to image the device and to see where it's gone and how it's been placed. And 100 or 200 nanometers of gold, you cannot see with an X ray and layers of Perylene or layers of silicon, you absolutely cannot see what an x ray. So what you would see is a two needles set where it was supposed to be and then nothing. Which makes the minimally invasive procedure completely redundant and useless. Because I'd have to open up the you know, I've had to perform a laminectomy, I'd have to open up the spinal column to actually see what the devices we actually had to then do is develop X ray or peak markers, something that's still flexible, still

conformal conformable, but actually allow us to know where the boundaries of device are. And whether or not the device is actually unfold and deployed where we expect it to be. To be then actually a surprising amount of time on an engineering challenge here thinking, you know, being kind of proud, cocky engineers, we're like, Ah, it's easy, we just make it a bit thicker. Well, we have to see an X ray actually took quite a lot of work to get that figured out how to do that, and how to do it safely, and how to also package all of this still inside of that tiny needle.

Steven Bruce
Yeah, and you make it sound as though it's easy and good fun. But I think most of us can recognise if you're working in materials that are nanometers thick, that it's quite, it's quite sophisticated stuff that you're actually doing here. Won't be complaining too much. But one day is going to go into somebody real.

Ben Woodington
Exactly right. And it's important, it's important that we do this right now. And we don't want to go, we know we don't want to be as engineers, we don't want to go two years down the line without really, really engaging with conditions, freeze a device, and then it just be completely useless. Because it has to be completely redesigned with a second condition in mind with the surgical procedure, because that's what we're doing it for, we're not just doing it to, you know, make a pretty paper or be out on the benchtop in the lab and wave it around and show people we want it to be in clinicians, hands and inpatients bodies eventually.

Steven Bruce
Yeah. Now I compare this to 10s. Earlier on, Bob was actually sent in a very interesting observation. Could this be used for functional electrical stimulation? For example, to treat things like foot drop?

Ben Woodington
Yep. Yep, absolutely. And I mean, it's, it's something that people can do with this technology, both cutaneous Lee, on the muscle or wherever else, we can use these type of devices, but also invasively as a kind of cuff somewhere in the body. The beauty of these devices, again, is maybe I can touch on it in a second is we design them using something called a conductive polymer interface. So we use the material P dot, our lab absolutely loves P dot, it's marvellous material, it means that you can massively increase the current injection. So you can do things like functional electrical stimulation, or spinal cord stimulation, without upping that power to such a point that it's gonna start causing damage. That's fantastic.

Steven Bruce
So where would the stimulation if let's say we're treating foot drop? Where does the stimulation come from to overcome the foot drop? How to how does it know when to fire the muscle?

Ben Woodington
Up? That is not my expertise? I would not on a call with clinicians, I would not want to start explaining procedures of treating foot job.

Steven Bruce
Okay, well, we will move on from that, as Simon Says. So this is only about pain control. And he's moving on to some area where I think you were going to go, what about lack of nerve

innervation? Such as Ms. When those recovering from spinal cord injury? How does it work? They're all kind of out there.

Ben Woodington
Yeah, I mean, it's something that many groups including ours are looking at as well as not just functional stimulation, but then regeneration as well. So there are groups that have looked at, for example, like lysing, the nerves killing the nerves and allowing regrowth back into electrodes, or, you know, co treatment with stem cell therapy, for example, or someone in our group actually works on a bio hybrid technology where they implant sort of stem cells on devices, and then look at like functionally restoring the nerves as well as using electrical stimulation.

Steven Bruce
Thank you, Lauren. I think Robert for See, she has asked how these things are charged? Do they take double A batteries?

Ben Woodington
Yeah, it? I mean, it's an important question. It's, um, there is a, there was a large investment on wireless charging devices. So these batteries sit inside the body for a surprisingly long time for they can last for five years for 10 years, depending on the kind of power characteristics of the device, then there was a push to look at kind of inductively charged devices. So you don't want the device to be taken out every five years and replaced with a new battery. So instead, what we'll give you is an inductively charged device that sits is implanted, but then a belt that one would wear to charge that device seems like a great idea. Turns out patients don't really want that. I think a lot of patients would opt for their five year, you know, change of battery over having to wear this belt all the time and charge and it's a again, it's an interesting question around like human centred design, like, you think like, oh, let's remove the surgery, patients hate surgery. But actually, then patients then have to remember to charge their belt and stick it on every day. And if they don't, the device dies and the pain comes back.

Steven Bruce
Yeah, yeah, good thinking when I was thinking how easy it would be to just stick my iPod iPad charger onto my back of my iPhone charger onto my back and recharge this thing every night. But yeah, I take the point. We're not We're not dealing with people with mild aches and pains here. Oh, we were dealing with people who are in severe severe pain. Absolutely. Yeah. This kind of follows on from what I said earlier on. But somebody who has been named the divine specimen by the system says, Are there any problems that you can get with the devices, any risks in fitting them and clearly it is surgery, although is minimal, minimally invasive?

Ben Woodington
Yep. There always are right there. There are always risks with these kinds of devices with any kind of surgery, as you say. But as certainly when you're introducing a device, there are always risks, there are infection risks, there are risks that you do damage the spinal cord in some way, shape or form. You can cause a haemorrhage if you you know, you've lost something that you're not supposed to, there are always these risks, we try to reduce them as much as possible when we're designing these devices, we try to reduce them as possible in terms of the device engineering, there are both kind of hardware and software controls on the device so that you don't, you know, jack up the power so much that you're causing damage. So that the risks really with our device, when we're at that stage, I suppose to be in

line with the kind of existing surgical risks of doing an invasive surgery, which are always going to be there, right?

Steven Bruce
Yeah, one would like to think the risk could be a lot less. I mean, one of the guiding principles of medicine, surely, is that new technologies or new, new approaches shouldn't be simply as good as the old ones, they should be better?

Ben Woodington
Absolutely. I mean, this is why we're moving to this minimally invasive approach. So rather than going for full laminate laminectomy, where Why would presume, please, any of the clinicians on the core call me out, but I presume if you're going for a full laminectomy, they said the infection risk is higher than a percutaneous lead going straight in. But also, the risk of damaging the final column spinal cord is also higher, right, rather than just going between the vertebra and guiding a device up the spinal cord. So that's kind of the approach we've taken here, like how do we reduce the surgical burden, and then a lot of patients don't qualify for those kinds of invasive surgeries, right? And maybe you don't want a kind of invasive, you know, surgery where they're gonna take days to recover. And they do just want that outpatient procedure.

Steven Bruce
Somebody did ask, and I've lost the question for the moment. And it sort of follows on from what you were just saying there? What is the threshold for being referred for this sort of surgery? And maybe that's outside the scope of operations for an engineer? But where would you imagine that to be?

Ben Woodington
Ei? This is probably where you would want Damiana on the call, because he probably will be able to answer that question. These devices tend to be reserved for patients who are suffering the most pain patients, as I mentioned, patients who are having drug refractory pain, so they've been on all the treatment options, they're still struggling, or they're on such a cocktail of opiates that they can't really live their life, they can't work, they can dry, whatever else, those the patients you're looking for. What we again, what we're trying to do with this device is reduce those surgical barriers so that more people can qualify for this device again, or more people will opt into this device at a simple in our procedure rather than kind of hectic, invasive surgery that one would have to go through. Well, that doesn't mean it's it is a moving picture, whether they have this panel type device or the percutaneous device, their level of pain changes on kind of the threshold that a patient be accepted for this and then where you are geographically so these procedures are carried out far more regularly in the US and they are carried out in Europe. The UK does carry out some of them but but not not nearly as many

Steven Bruce
on that. On that note. are other people doing the same thing as you elsewhere probably in the US or is this okay? in which his own sort of development.

Ben Woodington
Yeah, as far as we know, this is completely novel and no one's working on it at the moment, we file a patent to try to protect that and trying to raise our money to work on this further. There is a Italian company who work on something vaguely similar, but we have benefits over them that they can only extend mechanically sprung device. So they can only go a little

bit wider than the percutaneously, we can get really, really wide coverage by kind of act. Active unfurling rather than just passive.

Steven Bruce
Okay. Helpful persons come back in and said, How long does it needs to be in there once it's implanted? And how is it monitored? And? And to follow on when? And what are you looking for as a success? And how do you work out a prognosis? There's a lot of questions that there isn't that I didn't realise when I started that one, there were several questions in there.

Ben Woodington
How long it's in there for unfortunately, this is not a cure, this is a treatment. So this is used to treat the symptoms of the pain. So this is advice to stay in as long as they work. And unfortunate problem with spinal cord stimulation for pain is they tend to stop working after a period of years. 510 1520 years at some point, it has to stop working. Again, there's no clear

Steven Bruce
story where you say that the device doesn't stop working, but it ceases effective.

Ben Woodington
Patients stops responding to the yeah, you can tune the parameters or you like the patient stops, stops responding. It there's no clear literature on to or consensus as to why that happens. And we hope with this kind of technology where we're sitting even more conformably onto the spinal cord that we would not have that effect. But we can't say that a speculative until we've done the trials. Understanding that would be would be huge. And again, maybe introducing more electrodes and being able to tweak exactly where your electrodes are like spinning your electrode, so you're treating the top half and then halfway through the treatment, you're going to the lower half of the device. Maybe that would have some better effect. But again, it's entirely speculative, and would require lots of research to understand that. There were more parts to that question. Would you want

Steven Bruce
to ask a bit more on that? How many years before it stops working? Generally?

Ben Woodington
Variable? I think 10 is the is around the mean, but I think it's quite variable. Okay, these patients are, is to be slightly dark, these patients are often older. So 20 years of treatment, maybe? Okay, maybe what you need?

Steven Bruce
Well, that was my next question. Is there an age threshold for doing this? And as you said, a lot of people in chronic severe pain are elderly. So this is the being minimally invasive. I presume it's more acceptable for the older patient?

Ben Woodington
is what we're looking for. Yeah, exactly. We don't want to go for these very invasive surgeries for elderly patients or, you know, and then loads of criteria that people get dropped for in these kind of surgeries for but but age is definitely one of them as well. Yeah.

Steven Bruce

Yeah. So back to helpful person. She is I'm going to assume that helpful person as she has said, How is it monitored?

Ben Woodington
monitored in terms of ones that, I assume they mean, once the device is implanted? How do we keep an eye on it? Yeah. The patient would go back to the doctor regularly, and they get checkups. But usually this paper, this is self reported,

Steven Bruce
there is some symptomatic rather than there being some sort of printout that you get every five minutes from, from the device.

Ben Woodington
Precisely. Some of these devices now are running kind of, I guess you'd call it telemetry, the devices are collecting certain levels of data on how how the treatment is kind of going and being reacted to that. But the patient is not intended to see any of that information. It wouldn't the patient in any way. So usually, if the device, you know, if pain comes back patient would go back to their clinician and say, Okay, it's come back, and then you could you could reprogram the device, or you could expand the device if that was, you know, the necessary route.

Steven Bruce
I might be getting a bit matrix on this at the moment. But I'm just thinking that, presumably, there's the scope that this thing will report its data to a smartphone, and the smartphone will report its data to a central hub. And you'll be able to monitor the activity levels of the patient and relate it to what the device is doing or somebody will not necessarily, which is all it's all a little bit big brother ish, but possibly very helpful in development of the devices.

Ben Woodington
Well, that's it I'm me and important in in treating people I mean, data is, is gold, I would say that as maybe as an engineer, as a scientist, but that data is so important. I mean, knowing where the electrodes are and how long that pain has been treated for and in what way in which which kind of condition you're treating is incredibly valuable or not data that is gathered at the moment, and maybe if it was or when it is, you'd have you'd be able to design better protocols. Okay, so a patient is presenting with failed back surgery syndrome, they need this device. We placed this slice in this place. We used these particular power parameters. And it worked in this way. I don't think that data is really collected that memory is very sporadic. And on very few case numbers like, you know, 10s of patients rather than hundreds of 1000s.

Steven Bruce
By man wants to know how long you've got with this device to treat a severed nerve before it's just not going to respond?

Ben Woodington
I would not know the answer to that, I'm afraid would not know the answer to that no, no. Okay, some plasticity, right. And they will stop at some point.

Steven Bruce
And I imagine there are all sorts of other functions or other factors in the survival of a nerve beyond just the the axons in the nerve itself. Lawrence says, as the opiate pathways focus

on the posterior of the spinal cord, those pain reduction through this device function in the same way.

Ben Woodington
No, it doesn't function in the same way they don't they don't function the same as as a good dress. They function they function a very different way they function by this gate gating pathway that OPI it's absolutely not the the gating pathway for people who maybe are not familiar with it on here. My my, my mentor, my boss Damiana has described in a very good way for me before I said that when you stub your toe was the first thing you do you rub it. If you burn your finger, you grab it, and you put some pressure on it, and you're trying to send different signals to the ones quicker signals, in fact, than the slow signals for the acute pain. So the original devices were made, basically to initiate some nickel paraesthesia, where you get a kind of tingling sensation in your back. And that kind of distracts distracts is a crude word that distracts from the slower signals of pain. opioid drugs, again, not my specialty specialty but do not function in that way. Definitely not.

Steven Bruce
In given what you've just said, is a is a patient who has one of these devices implanted would they feel anything from the device? And as you would from 10? Would they feel that tingling?

Ben Woodington
Absolutely. So photonic stimulation, the the stimulation I mentioned earlier in the range of kind of 2200 hertz, they feel a tingling sensation. That can be quite irritating, I think. But with high frequency stimulation, this kind of new way of treating Parthia free you don't feel anything at all, which is why many people are saying this is this is a different pathway. There's you're not doing the same thing. You're doing something entirely different, different mechanism. Yeah,

Steven Bruce
there's not quite sure what it is

Ben Woodington
just not quite sure what it is. Yeah.

Steven Bruce
Lawrence's Lawrence is getting very clever on me here. He says pain gating question mark, does that increase the post synaptic membrane potential, or changes the potential ation of the chronic pain pathways?

Ben Woodington
He sounds like he knows better than me.

Steven Bruce
Lawrence, perhaps you come on the show. And then sometime in the near future and explain all these things to us. A couple of people who asked if the dynamics of the spinal cord allows the device to stay in place the cord and cord recliner move a lot quite new quite a lot in flexion and extension within the spinal canal.

Ben Woodington

Yeah, that's absolutely right. And it's testing that we carried out as well. Flexing, twisting, bending. And then also, depending on whether the patient is stood up, right or laying down changes, the pressure on the device changes the expansion of the spinal cord, right. And all of this affects how the device moves without device because it's so thin and flexible. It does, it moves with the body, rather than reacting to the body

Steven Bruce
moves with the body, it stays in the same place on the spinal cord as the body moves

Ben Woodington
as the body moves. Yeah, so we've done studies where we where we have like a flexing, flexing, and we see the device kind of flexing with the spinal cord as well, which is incredibly important, because you want again, you want those electrodes to stay in place, but you also own the electrodes to stay in contact with the tissue. If the patient stands up, a spinal cord expands and device moves kind of further away, there's a increase in CSF thickness and device moves further away, you're going to change exactly how much power is going into the spinal cord and changes the treating promises. This is vaguely important for pain. So you can go you can get away with it. When you're looking at spinal cord injury and trying to fire up motor pathways is this becomes incredibly important. Like you don't want to be targeting the completely wrong area of the spinal cord for when you're when you're looking at rehabilitation.

Steven Bruce
Now I can send that Dave has asked in terms of nerve blocking, would this treatment be used on nerves tethered by scar tissue post post surgery? He says he's come across this more than once and patients end up on massive doses of medication.

Ben Woodington
Okay, where these repeats are at the beginning the

Steven Bruce
reserves are tethered by scar tissue after surgery.

Ben Woodington
Again, it sounds like a question that ought to be asked to a clinician rather than an engineer working with clinicians. But, I mean, it sounds like we would have similar kind of procedures that

Steven Bruce
technical question then Stewart says do the control boxes currently exist into which these probes plug and if yes, how do they work? If it's not a Pain gauge theory, how are they perceived to function? I think we've dealt with the last part. But in terms of control boxes, obviously, you've mentioned the power pack. Yeah. Presumably that is adjustable to send different signals to different parts of the device.

Ben Woodington
Yeah, absolutely. So you have an external programmer, which is a larger machine, you plug this into this implantable pulse generator that you then are programming. And the device has a what's called like a pigtail connector that goes into that. So at some point, the patient is very wired up, they have a device, Southern spinal cord, they have their usually have a trial

stimulator first placed in that's, that's run with the external programmer. If it works, they don't have the real device put in. But it's quite a quite a procedure.

Steven Bruce
Right. Okay. Which I suppose the is leads into this next question, again, from helpful person who says, how was it? How was the process being used today? And is it available on the NHS? And clearly the stuff that you've been developing is not yet available in humans? But in terms of the preceding devices? Is an NHS service?

Ben Woodington
Yeah, as far as I'm aware, it is nice recommended some the 10 gigahertz I think is well treatment, relatively recently, within the last few years. So yes, it's just I think expensive. The economics are interesting, actually. I mean, it's a whole different discussion. People think these devices are expensive, and they are expensive. They're they cost between 10 and 20,000 pounds, usually, to the NHS plus then the surgery, obviously, the surgical burden as well. But the cost of keeping a patient on opioid drugs for 10 years, 20 years, you know, far can far exceed that, especially in the US, perhaps not in the UK. I don't know the cost of opiate drugs in the UK, but a sustained treatment for many, many years is no less economically viable device that you place once and can be forgotten about. In many cases,

Steven Bruce
it was the intangible benefit as well, isn't there or having a patient who is not on opiate drugs, which have all sorts of potential side effects?

Ben Woodington
Well, absolutely. And they become, you know, they're treated with the spin up as soon as they can become often like a functional member of society, can they can go back to work they can they can live their lives rather than stuck doing nothing.

Steven Bruce
Yes, possibly criteria, which the NHS is less keen to look at. And they tend to look at the budget more than anything else. Someone wants to know, if you if there's a chance that this will be developed into a purely subcutaneous technology where you can just plug it in externally.

Ben Woodington
You would, so then the source of the APG would be sat externally, and the device would be in generally,

Steven Bruce
what he means yes,

Ben Woodington
I mean, you don't usually want to go one or the other. So usually, you don't want to leave ports in the skin, you know, leads to the infection, right. We do this for clinic, clinical research, any kind of preclinical animal work, but any human, you don't want to do this. You don't be leaving things externally, or going through the skin continuously. These devices can be placed subcutaneously, and they are placed subcutaneously. For other applications. Again, if you're looking at like muscle activation units up Kingsley, some recording devices that you go on the brain or on the spinal cord can also go subcutaneously, but usually want to be as close to target as possible being the brain, spinal cord, peripheral nerve,

Steven Bruce
right? Peripheral nerves. You did mention those earlier on somebody who hasn't given the name says that some patients who've had chemotherapy can then have peripheral neuropathy. And are these devices able to help out with that?

Ben Woodington
I guess if the neuropathy is leading to pain they can be there are also cuff devices that function in the peripheral. So maybe in the arms and the vagus nerve or in the leg or wherever else. People do that as well. They don't

Steven Bruce
use them for pain. Generally, when you say cuff devices, what do you mean? So these

Ben Woodington
are devices that wrap around the nerve? Right? Yes. So it's hard to do in the spinal cord, though. It's exactly what we're trying to do on the spinal cord, we're trying to completely circumferentially wrap the device around the spinal cord to do very interesting things to it. But on a peripheral nerve, it's it's just easier, it's far more accessible. So you can wrap devices are in the cut or they're in the nerve. There is quite a lot work both academically and also in industry looking at this so Galvani then the company that was set up jointly by alphabet, I guess echo now Google verily and GlaxoSmithKline are looking at peripheral nerve stimulation. So splenic nerve stimulation. There are several other companies that are looking at vagal nerve stimulation for migraines and for monitoring for heart control and lung control asthma, all kinds of things. It's not generally what we do. We do a little bit of vagal nerve work vagus nerve work, but it's possible as well to do that.

Steven Bruce
When you say those companies are doing it, presumably they're doing it through a research organisation such as yours, but it's just not your organisation that's

Ben Woodington
Yeah, absolutely. I mean, they work on collaborative, they work collaboratively with these universities, including us. But certainly Galvani and some of the others now are looking to commercialise it. I think they're probably leaning away now from the academic space. And looking more at what is the actual indication how we're getting into that right now.

Steven Bruce
And you you mentioned heart disease earlier on, how can these be used in connection with heart disease,

Ben Woodington
people are looking at replacing kind of beta blockers or the whatever is used instead of beta blockers now, but instead looking at vagus nerve stimulation, so from the vagus nerve, you can record the signals coming from the heart and from the lungs and from other parts of the body as well, you can kind of probe that information to figure out so you can look at, for example, you can look at the vagus nerve glucose levels, you can also look at breathing rate, or kind of whether the lungs are tensing or not, then you can go backwards and you can stimulate to try and override those things. So you can try to speed up the heart, you can try to slow down the heart, you can try to speed up breathing, you can try to relax the soft

tissue in the lungs. It very, very early research, again, not my research, but they're using these similar technologies. So

Steven Bruce
I might have missed something there. Because you're saying that devices like the one that you you've talked about, can not only stimulate they can also measure, record what's going on?

Ben Woodington
Yeah, absolutely. Yeah, absolutely. And I mean, it probably bigger chance if we go to sly Reed

Steven Bruce
1111.

Ben Woodington
Yeah. So it's kind of this is some older work from religious group to as a collaborator. But it's kind of where these technologies originally came from. So taking these very, very fine thin electronics. And what you can see the image on the left is actually like a like a lotus flower with the device lying on it, the device, the image on the right is a device lying on the brain, you can do is make hundreds if you want 1000s, if you really want to tiny, tiny electrodes, and you record the electrical signals from the brain, you're not recording the electrical signals from a lotus flower that's just aesthetically pleasing. But it means that you've got these very hyper conformable devices, they can sit on the on the brain and spine, brain, spinal cord peripheral wherever you would like to. And if you go to the to the next slide, actually, slide

Steven Bruce
12. Slide 12, Justin, thank you.

Ben Woodington
This is just a demonstration of the kind of data that you can get. So the black and blue lines at the bottom, there are signals that you'd be recording with conventional metal based electrodes. And then the signals that we're getting the upper is looking at polymer based transistor technologies that our lab develops. So these are the sensors that are very, very close to the tissue and kind of amplified at sites, which means you get much, much higher signal to noise ratio. And you can do much more clever things by probing the brain or the or whatever the vagus nerve, the spinal cord, and actually trying to extract that information from from the New York tissue.

Steven Bruce
caisson asked an interesting question about sort of this stimulation that we're talking about here, you know, it does this does the electrical conduction over the five to 10 years that this device might be working? Does that itself cause damage to the nerves, or does the heat from the battery cause any damage for battery generates heat?

Ben Woodington
Yeah, so he is not an issue. These badges are designed in such a way and the electrodes have been designed in such a way that you're not getting heating effects. Or if you are getting very, very mild heating effects are not going to cause damage to the to the tissue. The body is not happy with anything you put in it. That isn't itself. So though these devices

are more biocompatible, they're softer, they're more flexible, the body still recognises it as a foreign object and will attack it as such. So it's less that you're doing damage to the body over a long period of time, it's more that the body's natural defences are coming up and trying to attack the device, you're getting foreign body reaction and you know, tissues building up to try to x plan, X partner device from the inside out. We can do things to fix that we can do things to change that. But it's a problem in terms of stimulation, because you're getting these layers of tissue build up, which means you have to up the power of the device to kind of overcome that barrier that's built up around it. In stimulation, it's we can do that in stimulation, we can jack up the power and if we're using especially these conductive polymers, that's not a problem for recording device, it actually can become quite a severe problem because the signal integrity is going to degrade over time. So once upon a time you've had a beautiful array of sensors that are placed on the brain and Brent's happy after months or years, the body is building up barriers, layers of tissue, and that signal integrity is degrading. And maybe the application has gone where it once was.

Steven Bruce
Claire says, Does this device constantly stimulate? Or is the patient able to control it, modulate it in the way that you might say with a tennis device?

Ben Woodington
So the patient know the patient does not have control over that with with most of these technologies. The whether the patient whether their treatment is on all the time or not depends on the treatment depends what you're treating. So some of them work. Yeah, in a manner where they're on for a period of minutes or hours or however long and then they switch off. But many of them are on all the time that stimulating. Yeah.

Steven Bruce
And in terms of treating something like muscular sclera sclerosis. How is that? How is the device actually working there? If you've got damage all the way along various neural pathways? How does one of these devices affect the patient?

Ben Woodington
I'm not familiar with these devices being used to treat Ms. was on

Steven Bruce
one of the press releases. And that was one of the the hopes for that it will be able to treat Ms. Maybe that was the hope of the journalist not of the the researchers and the technicians.

Ben Woodington
Maybe I'm not familiar with that application. Okay.

Steven Bruce
Lisa says, Is this the wrapping of this, these devices around the nerves? Is it effectively similar to remodel a nation?

Ben Woodington
No, unfortunately, not. Not not not not not quite as functional as reimagination different applications for sure. But No, unfortunately not. You'd need to be looking I think for a for, you know, a biotech application.

Steven Bruce
This is this is taking us back to something we did touch on a few minutes ago, James was asked whether manual treatments such as mobilisation sort of thing that we do, is that going to be contra indicated in patients who have these implants?

Ben Woodington
As far as I'm aware, again, this is a question that a clinician should answer better than I can, but it's fine. Why these these treatments are used in parallel with kind of existing mobility as well, standard rehabilitation. The same goes for spinal cord injury as well, you don't want to remove the rehabilitative therapy, you want to use a device in tandem to kind of improve the outcome. Okay.

Steven Bruce
helpful person says me again. So she says how do patients get a referral? Then? Where do they go? And actually, I was thinking this earlier, and I was thinking, I'm sorry to admit that when I read that read press release. This is I think the first time I'd heard of this, so would you expect most spinal consultants to be fully ofay with this technology and to know how to get it for their patients?

Ben Woodington
That's Parkinson's I've spoken to a here in Cambridge are very, but as far as I'm aware, from from who it there are a few centres in the there are only a few centres in the UK who will regularly carry out these kind of surgeries. Probably if you're in one of those, I think Liverpool is one Addenbrooke's here is another one, then you'll probably will be very okay. In terms of how you get a referral, Stephen, that's probably more as I see, as an as an experienced surgeon, that's probably more your experience in mind.

Steven Bruce
I'd love to serve as an experienced surgeon, but I'm not. Yeah, I guess my suggestion would be, now that we know about these things we tell patients to ask. And if they ask if they're if they're referred to a spinal consultant, orthopaedic consultant, and they ask about this technology, maybe there's a chance that they will be pointed in the right direction? I don't know.

Ben Woodington
Yeah, I mean, I think you're right. And I think that's what we want as well, right? We want more patients to be going out there and more collisions to be saying, to be demanding these technologies. If they're, they, if they are as effective as we believe they are, then we want we want those, those, you know, those just been treated with them. And the only way to do that is through demand.

Steven Bruce
Yeah. And I think we would all love to say, oh, we'll fix everybody with our hands. But we're not stupid enough to think that we can do that. And what we would like to do is to stop people having to use drugs of any sort, but opiates in particular, and maybe something like this is a is a much more attractive option for them. Neva is asked how you actually remove the devices once you achieve what you regard a success with your rehabilitation. And I and you said earlier on, actually these things are there for good because they're not going to fix people. But actually sometimes pain relief gives the body a chance to develop the stability in the strength in the right areas in order to overcome the problem, doesn't it? So maybe there's a point where you say, well, I'll take this thing out, is it a simple process?

Ben Woodington
Absolutely. And it is a simple process simpler than putting it in. And it's something that many pain surgeons or neurosurgeons are familiar with, because sometimes these devices are not compatible with MRI. The patient has an MRI, that's one of the most common reasons to remove the device. So well characterised how you exactly I buy that for our device exactly the same, you take the implant the you take the APGA, and you put the device at the back. It's nothing more complicated than that.

Steven Bruce
When you put it in, it was all nicely rolled up, though now you're pulling it out, it's not rolled up any longer. So does that make it more difficult?

Ben Woodington
It doesn't. Because these devices are so thin, they collapse in on themselves. If you had something like a semi rigid device, maybe with like a mechanical actuator or a passive actuator, yes, you're not gonna be able to pull that back through the same tiny percutaneous hole that you inserted in. But for our device, we need we run these experiments as well, you absolutely can you can just pull the thing back through a through a fine hole through your wants to mil hole and the device just comes back in on itself.

Steven Bruce
And then from what you said, though, your device is perfectly compatible with MRIs.

Ben Woodington
It is yeah, yeah. So

Steven Bruce
there are a few reasons to have to remove it until it stops working while we were stopped being effective.

Ben Woodington
Yeah, absolutely. I mean, that's the goal. I mean, it's something that we're working on the moment especially using these markers, we're adding kind of metals then to the device, more metals device. And we have been looking at like, does that change the MRI compatibility as well? Do you get heating effects on the device? Or do you get artefacts in the MRI and something that again, like with the clinician in mind is you really have to think about you can't just throw these devices out there and hope for the best. Some of the implantable pulse generators are also not MRI compatible through heating effects. But it's something again, the industry has been working on to make sure that new devices are

Steven Bruce
right. Okay. Lawrence, again says this all sounds great paracetamol, was discovered in 1893. And is used widely. They have theories but still don't know how it works. All they know is that it works centrally, chronic pain can be distracting and disabling. But if the devices work, then go for it. So just supporting what you say that there's no reason not to use something just because we don't know why it works properly.

Ben Woodington

I've used the exact same anecdote about paracetamol. So that's why I say we're kind of in a similar neuromodulation therapy like we're in this place now where people, so many, so many indications, so many things, and no one quite knows how they're all working. But maybe that's okay.

Steven Bruce
Well, I don't I don't know how often in your particular position, you come across patients in chronic pain, because clearly yours is a Research and Development Organisation rather than a clinical environment. But I mean, Lawrence is putting it mildly to say that chronic pain can be distracting. You know, chronic pain stops people sleeping. And sleep deprivation is one of the first tactics when you're interrogating people because it's really, really unpleasant and makes life miserable. And of course, chronic pain just makes people's lives completely miserable, isn't it? Carrie says Would it be possible still to use an epidural with these in place?

Ben Woodington
Sex she's an epidural. I would believe so. I wouldn't want to be that cool. Again, probably a pain surgeon should should advise on that. But I can't see why not as long as you're going below the device. You should be fine, right? You don't want to be neat. You want to be having a needle placed on the device. You are going through similar but I think epidurals will be placed. Probably often an epidural will be placed lower than this device. But please consult a pain technician.

Steven Bruce
Well, we don't administer epidurals either. So I mean, there's somebody else can think about that when you come across these Djp says in my knowledge of spinal issues in neurology, my explanation to patients or animal owners is that typical structures involved other disc joint facet joint sacroiliac, joints, etc. While the spinal cord may not necessarily be compromised, all the devices you've been describing, able to be used within those structures to modulate the nociceptive and makhana receptive activity.

Ben Woodington
Yes, but I mean, again, it's a very important point, again, like what is the root cause of the pain? And you know, is this the right therapy to treat it? Because if the pain is not a neuropathic origin, then you're already at a place where you're sort of like, Is this necessary? Or should they should there be some corrective surgery first, and probably many would say, first, you try to cure it right? Not just treat the symptoms. And it's something we're actually exploring, again, with, with a mentioned with dogs as well with a veterinary surgeon to look at, you know, many of these dogs and suffer from back problems way more than people and they're usually through skeletal issues, bone issues. We're looking at these devices in those in companion animals as well in dogs and seeing like, Does this make sense in those places as well or not?

Steven Bruce
So you're looking at them in dogs and asking that question, what answers you're getting so far?

Ben Woodington
We have not answered that question yet. Alright. Okay.

Steven Bruce

So James, going back to the the removal of these things and says, doesn't the buildup of scar tissue make it difficult, more difficult to remove them?

Ben Woodington
Yes, it can. But it has to be okay. Obviously, we've not tested these these particular devices yet on living patients. So we'll have to assess that. The percutaneous the and the panel devices tend to be fine they can be taken out with relative ease we expect ours will be the same You wouldn't expect scar tissue to be kind of completely encapsulating the device. There's no perforations in device, there be no tissue growing through the device. But it's something of course, we'd have to try. And we'll be trying in the coming years.

Steven Bruce
Okay, well, we've got a few minutes left. So You teased me earlier on, before we came on, that there was lots of other stuff going on around you. So what's coming up next? What am I next gonna read in The Guardian? That's gonna pique my interest?

Ben Woodington
Yeah, I mean, so we're, we're about to submit a paper actually, which I will speak only slightly about, where we're looking at the devices that once we've covered the dorsal part of the spinal cord, how much further can we go around, and what utility is there in going all the way around, and we've got some really, really cool data where we've wrapped this device all the way around the spinal cord covering, you know, fully ventral side of the spinal cord. And we started recording studies. So this is kind of never been done before, like placing a device circumferentially around the device is only possible by using these these particular soft materials.

Steven Bruce
Living in a living creature.

Ben Woodington
Yes, yes. Well, yes.

Steven Bruce
Are they still alive?

Ben Woodington
They are not alive at the moment. No, but that was because they got to the end of this study. But we're looking at actually probing that information. So can you understand like which pain pathways are activated, and also which motor activities motor pathways are activated? When the persons living their life or an animal was living its life. So moving around, and you know, stubbing a toe or like pinching a finger, like what is lighting up in the spinal cord, and which reflex pathways are lighting up in the spinal cord, and it's not something that's ever been able to do ever been able to have been done before without penetrating probes, but actually sticking wires into the spinal tissue, which causes damage and ends up being completely useless. Okay, if I understanding fundamental neuroscience questions, but it's completely useless for any kind of like, how does this being behave in the real world, what's going on in the real world? So what we've done is a very interesting work where we've wrapped these devices ran, we've looked at motor effects, sensory effects, we've looked at spinal cord injury and which pathways are still alive when there's an injury in place that we've looked at stimulating above and below that injury, and kind of really, really trying to probe the spinal cord, like what is going on, and when and where we're gonna be setting up lots of

elaborations at the moment with that device that we've developed now. We're going to go first and human interpretively, and look at like how exactly, yeah, these these tracks, these pathways in the spinal cord are working.

Steven Bruce
And I'm just being dragged back to the earlier bit of the discussion by for some of these questions. Jen says that she's confused and thought this was only being used on cadavers. And then we're talking about patient referrals. I'm am I right in saying that it's not the device that the inflatable devices being used currently in patients? It's the older pedal devices. So your pearls for those?

Ben Woodington
Precisely? Yeah, yeah. So spinal cord stimulation exists? It's been out in the market for, you know, 5060 years now, I think. People can get these devices currently, our device if we, if we check all the right boxes, and we get the right funding, you know, we're still looking at some years before what we on the market.

Steven Bruce
How many years would you speculate, Assuming all goes well and getting funding,

Ben Woodington
medical devices take a long time to develop, we've got a pretty low, we've got a pretty healthy grant that we've just been awarded, which will take us up to preclinical work in the next, maybe first inhuman the next sort of couple of years. It'll then take another three to four years probably to actually get to market, you're looking to five years minimum really to get a medical device. If you do very well. We're talking about highly invasive class three medical devices, really jumped through a lot of hoops to get them out onto the market, anywhere in the world. But especially in the UK and the US.

Steven Bruce
You need some sort of massive virus to affect the spinal cord, which will prompt people to get these things through more quickly, perhaps,

Ben Woodington
maybe that's what we need heart accelerate, etc.

Steven Bruce
George has asked if this is what Elon Musk's neural link is based on.

Ben Woodington
Yeah, we get asked that question a lot in our lab. Musk's technology is built on P dot PSs, which is the conducting polymer that that we use in our lab as well and have have used for the last decade or so. They're looking very similar underlying technologies with different application. They've got some profound innovations on the way they place the electrodes using these kind of surgical robots. But ultimately, yes, we're looking at similar similar technologies.

Steven Bruce
His thing then I'm not familiar with the new rolling because it aimed to achieve the same patient symptomatic relief.

Ben Woodington
So they're looking at brain treatment. Brain probes for People suffering from property to Tetra Puget to begin with. They have grand plans than that. Elon Musk always does have grander plans in that. First, for their first effect they're looking at, they're looking at people with who have lost the use of some part of their body. It's interesting application, of course.

Steven Bruce
Feminist has been this is a really good I mean, we had lots and lots of fantastic comments about the the discussion this evening and I'm sure we will get more coming in any second now, but just so you're aware, one viewer has called you the Ben Fogle of the PhD world. I'm not personally familiar with Ben Fogle, but again, that's a really, really nice compliment to you. Simon Simon has said that you really should be an osteopath is probably Kira practising you should have been a chiropractor as well, because in Simon's case, you remind him of his father in law, who was an engineer before he was an osteopath, and who will soon celebrate his 100th birthday. So my own view is that if you were osteopath we'd need somebody still doing your sort of work we otherwise patients we've given up

Ben Woodington
100 years that's amazing, isn't it?

Steven Bruce
There's still time for you to have yet another career isn't there? You know medical chemistry and pharmaceutical devices and you can move on to osteopathic Craig says if we treat the if we can treat people with devices in place, they can help with osteopathic research to see exactly which pathways are being affected with treatment. Yeah, I guess that's one of the osteopathic and chiropractic worlds that perhaps we could if we can monitor what's going on using devices like this. And Joe has asked about the cassava work, Should we be worried about the Frankenstein effect? I think there's a certain amount of tongue in cheek in that question.

Ben Woodington
On your osteopath question, please, anyone reach out if they if they do think of these applications? Our group very keen to collaborate with these kind of applications. So please do reach out to us as well.

Steven Bruce
Well, I mean, it won't come across your radar, I'm sure. But physical therapy suffers from a lack of evidence because of nobody's putting money into physical therapy for evidence. You know, if you're trying to develop a drug or something which will sell for millions, then that you can easily do the research. And I suspect that would still be the case with these. But I will feed that question back to you about how we might incorporate it into into osteopathic or chiropractic research. We've had lots and lots of lovely comments I've told and I speculated before we started that we get somewhere between four and 600 people and I would pretty much write we got 550, according to my, my team here. So yeah, that's a pretty damn good audience for Tuesday evening, and enjoying the pub or whatever else it is people do on Tuesday evenings. Before we close anything else you'd like to tell us about what's coming out of your department.

Ben Woodington

So much coming up out of this department. I'm not sure what my my PA would like me to talk about. And we're not to talk about, but I just want. My principal investigator is a Professor George Moneris. He runs the last year, he is a phenomenal mentor and a brilliant scientist. He is not in this room. He's not telling me to say that is the lab in his office at the moment. We're working on so many exciting technologies, we really do many of us in this group, the clinicians we work with and also George, we really, really do believe this is the future of medicine. We believe it's the future of measuring what the hell is going on in the body? And then how to treat it done downstream as well. I think there are a lot of people getting involved in the space now academically, it's been going for 10 2040 years, probably. There are a lot of companies now jumping on this. And I think finally we're starting to get translation because we're getting militarization of these technologies, because the kind of safety questions are being answered with going to start doing that translation in the medical world. And I think we'll start to these technologies, actually, people will be more familiar with them, doctors will be more familiar with them.

Steven Bruce
And it's, it's fantastic. It really is. We like to think that we try to treat the causes rather than the symptoms. But there comes a point when you've got to treat the symptoms. Maybe because there is no other resolution for a problem. But also maybe because treating the symptoms gives you that opportunity to help the body recover, you know, all these things. So I think we're extraordinarily grateful for all the work that you're doing. And I'm looking forward to seeing these things on the market and seeing some benefit for our patients. When it's been great. Thank you very much for giving up your time. Again, I'm sorry that you were bounced into this by Dr. Baroni. And you can tell him that he missed out on the clinical questions which you were unable to answer, but that's not your fault at all. I think we've had so many wonderful comments about all this information that you shared this evening that yeah, he should be jolly pleased that he put you in the spot. Anyway, that's it for you tonight. So just a few words for the audience for me. We've got a couple of case based discussions coming up one on Thursday, lunchtime. This week, one on Tuesday, the 22nd of February. We have a free lunchtime broadcast on Monday, the 28th of the month. That's where Steven Barabbas of K laser, a lot of people very interested in the implications of laser in clinical therapy. We are getting it in my own clinic and I know lots of people have it on a really, really shoot seeing the benefits of using laser in clinic. We're not trying to sell K laser to anybody. We simply have a relationship with Steven and we'll be talking about the types of lasers laser which can be used clinically. And also we are talking to rob shanks and Darren's Darren Chandler about setting up a an MRI analysis training day. It'll probably be Sunday the sixth of March he will be in studio in the studio here an APM. The aim will be to help osteopaths chiropractors, analyse MRI images better and see beyond just the radiologist report and if you've seen our previous shows, you'll know that very often there is stuff that goes beyond the radiologist report that you might want to use in your own handling of the patient. But also so that you know when you might want to refer patients on for other treatment, whether that's to send them to an orthopaedic consultant or to an IDD specialist or anywhere else. So places on that are opening up. I have no idea at the moment what we'll have to charge for that. Obviously, that depends on what we're being charged for their services by Rob and Darren, who, you know, are real experts in this field. So I'm looking forward to getting them in the studio. But I hope you've enjoyed this evening. I hope you benefit from that. I hope that it'll all be good grist to your clinical mill and useful information for your patients. That's it for tonight. Hopefully we will see you later in the week. But for now, good night.