

## **Your Complex Brain - Season 3 Episode 9 - How AI is Helping Scientists Understand Chronic Pain**

Adriana Salazar 00:00

[gentle electronic music] The pain that I felt, it was like electricity was pulsating inside of my face, like a very electric shock. It's a pain that is so hard that it brought me to my knees a few times, and you feel so helpless. You just cry because there is nothing else you can do.

Heather 00:25

[Your Complex Brain theme music] This is Your Complex Brain, a podcast all about the brain, the diseases that impact it, and the path to finding cures. I'm your host, Heather Sherman, and I have the great pleasure of working alongside the team at the Krembil Brain Institute in Toronto, Canada, a leader in brain research and patient care. In each episode, we'll take you behind the scenes into our clinics and research labs to meet the game-changers of the future. We'll empower you with the latest research to help you take charge of your own health. You'll also hear from people who are living with brain disease, as well as their loved ones and the care teams who support them. Join us on a journey to unravel the mystery of your complex brain. [theme music continues then fades out]

[dramatic electronic music] In my time at the Krembil Brain Institute, I've met several people living with an extreme facial pain disorder called trigeminal neuralgia, and each time, their stories bring me to tears. Patients often describe the pain as a lightning bolt to the face or an electric shock. Some talk about the impact on their family and relationships, not being able to hug their loved ones, or kiss their child good night. One man told me the story of a single snowflake landing on his cheek, triggering a wave of pain so severe it rendered him helpless on a sidewalk.

[music continues] For many patients, surgery and medications can bring welcome relief. In today's episode, we're going to talk about how artificial intelligence is helping researchers better understand where pain emanates from and travels to within the brain, looking for patterns and clues for which patients may benefit from different types of treatments. First though, here is Adriana's story.

Adriana Salazar 02:22

[gentle electronic music] My name is Adriana. I just turned 40 years old, married, one kid, only child. She is going to be five next month. I was on my honeymoon—I was in Portugal—and I felt a pain on the left-hand side of my face, mostly on my nose, and I was like, "Oh, well, this is weird," but I had just gone to Portugal and I was like, "Maybe something on the flight. Who knows?" I chalked it up to I was travelling. And then, the pain went away, so I was like, "Okay, well, it was nothing."

And then I became pregnant in 2019, and I felt the pain again, and I was like, "Okay, well, this is weird." So, I went to the doctor and they said, "Well, because you're pregnant, we cannot do any exams." And then, they said, "Pregnancy changes the body, so this is all pregnancy related. You will see. It will go away," and I was like, "Okay."

Meanwhile, I couldn't eat some days or I couldn't smile some days, and I'm like, "Man, this baby is kicking my bum," but I chalk it up to pregnancy, right? It was pregnancy related, and that was the end of it. Meanwhile, I also saw a dentist who referred me to a specialist of pain and he said, "I can do none of the exams because you're pregnant. Once you're not pregnant, come back and we will do more exams." I was like, "Okay."

I had my baby. The pain went away, and I was like, "Oh, look at that. Definitely was the pregnancy. Nothing to worry about." About six months after I delivered my baby, the pain came again, and now it was stronger – stronger than the first time, stronger than the second time. And now, it is just a shock of pain on my face, especially on the top side of my left, going to the eye. And, ever since then, I just had the pain. It will come, give me the shock-like pain, and then go away. And, it just progressed. The intensity progressed and the duration of it progressed, and everything just started to escalate.

So, I was, at that point, in contact with a neurologist. She then asked me to do an MRI and that was when it was determined that I had trigeminal neuralgia and that it was very clear that I had a vessel affected, that it was a possible compression of the nerve on my left-hand side, but that it was in both sides. So, I have it in both sides, but it was more prominent on the left side, and this is the side that was hurting.

The pain that I felt, I felt like electricity was pulsating inside of my face, like a very electric shock, [electricity buzzes] and it would go from the top of my mouth all the way to the bottom of my eye, to the point that my eye would shake, and you could see it moving. I delivered my baby naturally, and I tell my husband, "I'd rather do that with triplets and I'll be fine if I didn't have to experience this pain again." [pulsating electronic music] It's a pain that is so hard that it brought me to my knees a few times and you just cry because there is nothing else you can do. You hold your face and your face is pulsating, and you just feel this electricity and it's just lightning bolts inside of your face and you can't control them. It's agonizing, it's debilitating, and you feel so helpless and so useless that it just brings you so down. You turn into a bowl of mush at that point. I have never experienced greater pain in my life than what this condition has given me. [music continues then fades out]

It was the first time my daughter was going to be spending Halloween with the grandparents and we had this trip planned and it was going to be a fantastic couple of weeks. I was very excited to go home, and we got to Colombia and everything is going okay, and then my daughter got extremely sick.

Heather 06:54

[bubbly electronic music] Once her daughter was stabilized, Adriana and her family headed back to Canada, where her baby girl was treated for a high fever and severe pain in her leg. That's when doctors told them she had a hip infection and they needed to operate right away.

Adriana Salazar 07:10

[music continues] It was just a lot of hours of crying at the hospital in the praying room and worrying and pacing back and forth. Throughout this time, I'm okay. Like, I'm not feeling other than the regular pain that is being managed with my medication, so I'm not really paying attention to anything. I'm just worried about her. She comes out of surgery. Surgery is a success. She can walk again. Her fever comes down, so we're like, "Oh, my God." Like, "Thank you, God. Thank you, God." [music fades out]

We bring her home few days later, and the moment I got home, I got hit. It was like a slap on my face, and it was just a wave of pain, so unbearable, on my knees on the floor, crying, holding my head, and walking back and forth because I couldn't deal with that anymore. [music fades out] [gentle electronic music] My husband, oh my God, he was such a trooper throughout all of this. He's bringing me ice; he's bringing anything that he can think of.

Right after that, he ended up emailing Dr Hodaie's office and he said, "Honey, I emailed him. I cannot bear to look at you anymore." Luckily, they answered, and by December 7th, I was meeting with Dr Hodaie. I am told that I have to get an MRI and then I have to come back to do all the other exams. We booked the MRI for, like, six months in the future, so I'm freaking out because I couldn't deal with the pain. Honestly, it was one of the lowest points of my life and I'm not very happy or it doesn't please me to say that, but I did ask my husband at that time to let me go. [emotionally] I said, "If my life is like this for the rest of it, please let me go," because I couldn't deal with it.

Luckily, somebody cancelled and I got to Toronto in a week or so after, got the MRI done. By January 8th, that was my surgery, so it was a very short turn around from when I met her to getting my exams done to getting the MRI done. I had the MVD which is the microvascular decompression. So, basically, they open my skull, go in. I do not know a whole lot about the surgery other than it is just a surgical procedure to relieve the symptoms of pain due to a nerve being pinched by an artery or a vein. So, that's what I had done. [music fades out]

[upbeat electronic music] I am doing so much better. Honestly, I have my life back. I can eat. I can smile, I can laugh, I can kiss my daughter. I'm so grateful. I still experience some pain every now and then, but it's not that pain. It's more of a bruised type of pain. So, the recovery, I think it is still ongoing. My headaches have improved. I was getting a lot of migraines, so that has definitely improved, as well.

I have just been medicine-free only for a couple of months now. It was last month that I went fully off. I am so happy not to have the electric-shock-like pain from trigeminal neuralgia. When they asked me if I wanted to be part of the study, I'm like, "Sign me up. Anything to help anybody," you know, just because it's so hard and it gets misdiagnosed so often because it's like, "Oh, it's your teeth that hurt. Go to the dentist." [chuckles] I'm so happy somebody's researching this. [music fades out]

[bubbly electronic music] To the team at Western Hospital, honestly, I am so grateful for everyone. My nurses were fantastic. They took so good care of me, and Dr Hodaie, I honestly owe her so much of my life now.

One of the hardest things I think, for me, was going day by day, not being able to kiss my daughter goodnight or good morning, or just even play with her, because if she would grab my face, the pain was so hard, and to be able now to let her touch me or be able to kiss her goodnight, it has been the world. So, I am so thankful for everybody. Everybody took fantastic care of me and to Dr Hodaie, honestly, she was sent by God to me, so thank you. [music fades out]

Heather 11:49

[gentle electronic music] Dr Mojgan Hodaie is a neurosurgeon and senior scientist with UHN's Krembil Brain Institute, and an international expert in the diagnosis and treatment of trigeminal neuralgia. She's performed more than 1,000 surgical procedures to treat the severe pain disorder. Dr Hodaie is also the Greg Wilkins-Barrick Chair in International Surgery at UHN and the Postgraduate Medical Education Director for the Department of Surgery at the University of Toronto.

Her surgical practice and research laboratory use advanced imaging technology and machine learning techniques including artificial intelligence to unravel the cause of trigeminal neuralgia and other neuropathic pain conditions.

Thank you so much for joining me today. It's always a pleasure to talk to you.

Dr Mojgan Hodaie 12:42

Thank you so much for asking me. It's wonderful to be here.

Heather 12:46

Doctor Hodaie, you're one of the few neurosurgeons in Canada—and globally—to treat patients who are living with this rare pain disorder called trigeminal neuralgia. So, can you just tell us a little bit about the condition and why you've decided to dedicate your career to help people who are living with it?

Dr Mojgan Hodaie 13:02

Thank you. This is a very unique condition. It's been known of for hundreds of years. There's reports in the Middle Ages of patients suffering with this condition, but the name of it came quite a bit later. There are peculiar aspects to this condition, and that is it affects the face. It's what we call a neuropathic pain condition, which means like a nerve pain, obviously, and that gives it unique characteristics. But, perhaps it's best known because of its extreme severity. So, patients use very unique descriptors to say what this pain feels like, and I have become accustomed to asking them, when I see them in clinic, as to, "What does this pain feel like?" if they had to describe it to a friend or family member, and their descriptions are quite remarkable. A most-recent patient described this pain as a sensation of a knife that is connected to an outlet in the wall and is being jabbed into the face and turned.

Heather 14:02

Wow.

Dr Mojgan Hodaie 14:02

So, this type of descriptor, we don't hear it from people that have broken bones or people that have, you know, other pain conditions. I would also say that I have a few patients that have—or have had—cancer and we are all very aware of the severity of cancer pain, and when I asked them to put the two side by side and which one they would like looked after, they say, "Oh, trigeminal neuralgia pain is what's killing me. It's not my cancer pain."

So, this unique condition is actually something that we can help with surgery, and it's a condition that, when we operate on patients, oftentimes, they do very well. We are able to get them to a pain-free state, which is not very common with pain, and it's the management of this condition with surgical options that has been a subject of intense curiosity on my end, and has really led to a career in management of patients with facial pain.

Heather 15:03

It's really incredible how patients describe living with this type of pain. Trigeminal neuralgia is one form of an extreme pain disorder—chronic pain disorder—but how prevalent is chronic pain in the general population, and why is it so difficult for clinicians to both diagnose and treat?

Dr Mojgan Hodaie 15:20

That's a very important question. When we look at disease entities within society and how we classify them, for instance, cardiovascular disease, stroke, cancer, etc., the burden of chronic pain actually surpasses all of the other ones added up together. In terms of numbers, roughly one out of five patients in Canada have a condition of chronic pain. But, as far as we currently define pain, it is effectively a subjective condition. We do not have any specific tests that allow us to definitively

diagnose pain, and this means that we diagnose pain by inference. If someone comes to clinic or to the emergency room and say, "I have terrible leg pain," and we do an X-ray and we see a broken bone, then we put the two of them together. The pain is in the correct place. The bone is broken there. Therefore, the fracture must be the cause of pain.

But, we're not able to do that for quite a lot of pain conditions, and therefore, patients get stuck in this silent entity that cannot be properly diagnosed, that is subjective, and oftentimes goes unrecognized. For instance, we are aware of this disorder of multiple sclerosis, which affects patients and patients are quite debilitated by it, and we typically associate motor phenomenon with multiple sclerosis. For instance, patients cannot walk well, or they might have impairment of swallowing and, you know, a variety of conditions that are objective. Well, about 50% of patients with multiple sclerosis have chronic pain, but that is essentially a silent aspect and silent entity that lives with these patients, results in impairment, goes underdiagnosed, and oftentimes, not treated.

Heather 17:07

It's true; we don't often hear about chronic pain being associated with MS.

Dr Mojgan Hodaie 17:10

That's right. And, what happens is, in disorders that are subjective in this nature, such as chronic pain—chronic neuropathic pain is one of—then there is a general regard for aspects that are more objective to be treated, and therefore, there's quite a lot of work being done, for instance, if we talk about MS, quite a lot of work being done in management of the motor symptoms, but, you know, pain and subjective symptoms fall by the wayside.

Heather 17:37

[down-tempo, gentle music] So, we have this issue with chronic pain being something that's just so prevalent in our society. It's almost impossible to diagnose, which brings us to your latest research. So, you want to try to understand the pathways in the brain better to be able to try to solve this mystery, right? So, tell me about your most recent study. I believe it was out in the Journal of Pain, which used artificial intelligence to search for patterns among patients living with all types of chronic pain. Tell me more about that.

Dr Mojgan Hodaie 18:04

Let's put ourselves in our patients' shoes. If I were to be a patient with this condition of trigeminal neuralgia, which is what I look after a lot, surgically, and I come to see my doctor, I would like to be in a position to have some understanding of how likely it is that I get treated with surgery and get better and, at the moment, we are not able to share individualized outcomes with patients. We just don't have the tools or the techniques to do that.

Heather 18:37

So, they have to take a chance, really.

Dr Mojgan Hodaie 18:39

They have to take a chance. That's right. Yeah. So, if I were to have a brain tumour, I've come to see my doctor, I have come to see my surgeon, and I can see on the MRI where the tumour might be, so it's likely that I will be able to have surgery and have complete removal of the tumour, or maybe just a partial removal. [music fades out] It's objective. We see the entity. We're able to give information.

But, if we're talking about pain, we can't really provide that information. We can just give general odds, so I can say, for instance, if I were to treat 100 patients, 90 out of those 100 would be better after surgery and so on, but not individualized odds. So, one of the key areas where they wanted to expand their research is I would be able to draw any objective markers such that, when I speak with patients, I'm able to give them better information, allow them to make better choices, and even be able to present, for instance, options and say, "You know what? It's much more likely that this option will work for you versus this other option," and therefore, people can make choices in a much more informed manner.

So, this led me to the development of a field of research that is based on imaging. So, we started by studying the nerve—the trigeminal nerve—and then also, the brain to understand what features are there within the nerve, within the microstructure of the nerve, and also within the brain that allow us to understand the signatures of pain, what leads to a patient having a really good outcome, and what, for instance, might not lead to the best outcome with surgery.

As we expanded in this area, we observed that the typical methods that we have for the study of brain images is a little bit limiting, and by that, I mean the common methods that we use for statistical analysis and so on require the data sets to be rather uniform, and then even if we have a very, very large pool of subjects of a good study, then the subjects become narrower and narrower and narrower, and therefore, there's a lot of data that we are actually not able to make use of.

So, that's really what prompted us to move to methods that allow us to have better and broader assessment of data and that took us to the world of artificial intelligence which, I have to say, was partly serendipity but incredibly impactful because we are, in fact, able to study a subjective condition using the latest development in computer technology and artificial intelligence.

Heather 21:12

It's amazing. So, tell us more. How many people were included in this study and how did you go about using artificial intelligence to crunch the data?

Dr Mojgan Hodaie 00:00

We included three populations of patients: patients with trigeminal neuralgia; patients with osteoarthritis; and patients with back pain. The neuroimaging community and particularly, the pain neuroimaging community, now has large data sets available, publicly accessible to the medical community, where we are able to, in fact, out of collaboration with the different teams, use data of patients that have other pain conditions and put them side by side and compare. And, this is actually very valuable.

There's some earlier data that was the impetus of our study, and this earlier data suggests that the structure of our brain is dynamic in how it ages. I'll make a little pause here to explain this concept because it's rather novel. So, it turns out that, obviously, we talk about how old we are and we talk about how old we feel and, you know, it's a subject of general conversation. You know, if I'm particularly tired in a day, I might feel a little bit older than, you know, a day that I'm on vacation. It happens to all of us.

Heather 22:19

I hear you.

Dr Mojgan Hodaie 22:19

But, it happens that we are able to actually capture this and, you know, I'm making light of it with vacation and so on, but there are, in fact, conditions that speed up our aging.

Heather 22:31  
Our brain aging.

Dr Mojgan Hodaie 22:31  
Our aging altogether, but let's focus on brain aging, for now. If we grab the MR images of 100 completely healthy people and we image the brain, we're able to use machine-learning algorithms that allow us to correlate our chronological brain age—how old we are, based on numbers and when we were born—with how old our brain looks. And, therefore, for instance, the brain of a 25 year old will match to the age of a 25 year old, the brain of a 50 year old will match to the age of a 50 year old, and so on.

So, we can create, effectively, an identity line, plus or minus a little bit, where we match our chronological age to our brain age. Now, if we take a variety of conditions that interfere with our health, our brain age can actually be a little bit older.

Heather 23:22  
[bubbly electronic music] What does that look like on a brain scan – brain aging?

Dr Mojgan Hodaie 23:27  
Yeah, so that's actually very important because the aging of the brain does not necessarily mean that the whole brain shrinks. There are potentially specific parts of the brain that change in shape, change in morphology and structure, and that is captured as equivalent to an older brain. So, what we wanted to know is what happens in the condition of pain and whether every pain is the same thing.

Conceptually, we think that every pain is not the same thing, because if I have a headache, it could be because, I don't know, I have been potentially up all night, or maybe I'm really, really hungry, or maybe I have a brain tumor. You know, they're not necessarily the same things.

Heather 24:04  
Mm-hmm.

Dr Mojgan Hodaie 24:04  
So, we wanted to check the same, as well, to see whether this can be captured in the imaging and how it looks. And, we observed, in fact, that all pains are not the same, that our brain does age with pain, and, for instance, for the subjects that we analyzed with the trigeminal neuralgia, the brains were about 10 years or more older than they should have been, based on their chronological age.

So, this really was a wow moment for us to see how chronic pain, chronic neuropathic pain, impacts the brain, and we saw some of these changes reflected, or some of these abnormalities in terms of brain aging, reflected in patients that have osteoarthritis, but not in patients that have back pain. So, again, each pain is not necessarily the same, and therefore, as the neuroimaging community relies on sometimes studying pools of patients with pain, we can't necessarily characterize them all as the same because they are entirely different conditions. [music fades out]

Within our findings, we also found other peculiarities that were very, very important, and that is this effect was primarily driven by females in our cohort, and particularly younger females. And,

this is, in fact, very important because, within the population of subjects that have pain, typically, females are slightly predominant and, most often, have delays in diagnosis, delays in care, and many of them, out of the difficulties that we have in diagnosis and providing treatment, many of them, unfortunately, are ignored. And, we see that, you know, the impact that the pain has on the brain is actually quite significant, so it's a bit of a wake-up call for us as to how we need to work with our colleagues and with our patients to bring better care to everyone.

Heather 26:00

Okay, this is so fascinating. You analyzed the brains of more than 900 scans and you found, overall, that neuropathic pain and osteoarthritis patients were likely to have a 10-year advance in brain aging with those conditions, but not back pain. But, the most fascinating part is this link to female brains. Is that something that we knew before in the research world, or was this really an a-ha moment in terms of how many more women are impacted by chronic pain in terms of the brain aging?

Dr Mojgan Hodaie 26:31

The finding that females exhibit accelerated brain aging in the group of subjects that we have with trigeminal neuralgia and osteoarthritis is very novel, and I will match this again with a different study – the model of biopsychosocial model of pain. When we study pain, we look at its biology, at its psychology, and also as a social context. We had a small—but I would say very powerful—study where we looked and mapped out the journey to care by subjects that have trigeminal neuralgia. We use a random number generator and we take 50 males and 50 females and went all the way back in their charts and looked to see what was their journey to care. Is it that, you know, they got to see myself, as a surgeon, very quickly? Were there any delays along the way? And so on, and in this group, the female patients had a significantly higher description of severity of their pain.

Heather 27:35

Hmm.

Dr Mojgan Hodaie 27:35

Obviously, it was a retrospective study, but when we reviewed the chart, the number that they gave their pain out of 10 was higher, compared with their male counterparts. And then, when we looked at how long it took them to come and be seen by surgical service, there was a significant difference. Regardless of whether they were in pain or they were not in pain, the males were referred very quickly. The females were not. The females that were, if I can say in quotation marks, considered to be "tolerant", either handling the medications well, it took them up to 14 months delay to be referred for surgical service, and this is for a pain condition that, of all the different pain conditions, we know that surgery can help these patients. So, let's put these two studies side by side.

Heather 28:20

Mm-hmm.

Dr Mojgan Hodaie 28:22

Females have accelerated brain aging that is quite remarkable—younger females, in fact, more than older females—and they're having delays when they're getting referred to a surgical service. So, the impact that this has on the life of a person is significant and I will insert here another study where we have mapped the structural abnormalities of the memory networks in patients that have trigeminal neuralgia, and this is important because patients with pain often go to their doctor and say, "You know what? I have trouble thinking. I can't function with this pain. People have to tell me



things again and again." I've had lawyers that have had to leave their jobs because they're just not as sharp.

But, we were actually able to map out that key subfield areas of the memory networks are affected in subjects that have trigeminal neuralgia and, importantly, when these subjects undergo surgery and we study their MRIs again, these areas normalize, which means that our brain is a dynamic structure. It responds to pain, and then once the pain is relieved, it says, "You know what? I'm done with this. I'm going back to where I was meant to be."

So, this really is slowly, slowly able to provide us with an objective analysis of what is happening in our brain, what are the neuroimaging signatures and the microstructural changes in our brain when we have pain and how we're able to use this to leverage better treatment and better care for our patients. [music fades out]

Heather 30:03

Okay, so this is all so fascinating, but I just want to clarify and make sure that I understand – when it comes to women and brain aging, in particular and in women who live and suffer with chronic pain, why this delay in terms of seeking treatment and diagnosis?

Dr Mojgan Hodaie 30:18

Yeah, this is a fascinating question. I think, again, it refers to the social context that we live in and how that impacts our patients when they seek care. It is a social reality that, when females go to their physicians and they seek care, sometimes they're ignored and they don't get the care that they need in an expedited manner.

But, there's also intersections of bias that we have to be aware of, and that is a well-educated, eloquent female might get heard sooner than someone who might be in a sector of society where there are an ethnic minority or where maybe English is not their first language, and then you intersect all of these together and then we see that it's the unfortunate reality that we have to deal with, that some segments of our society do not get care in an expedited manner as others. And, hopefully, this study, in fact, serves to highlight how important this problem is.

I'll take you back to the very beginning when I said that chronic pain impacts one out of five patients. That's quite a lot of people that we need to look after, and maybe we need to reevaluate how we assess things and how we can expedite care as best we can to everyone.

Heather 31:42

Would you say that you're getting closer to understanding chronic pain in a way that might be able to revolutionize treatment, in a way? I mean, how exciting is this for you, all of these advances that you've told us about today?

Dr Mojgan Hodaie 31:59

[pensive electronic music] You know, it's so rewarding for us to be able to do this. I have really focused on one specific condition because it's a surgical condition. I see these patients, I offer them surgery, they ask me questions. We need to intervene and perform a procedure to help them. We're just knocking on the door of pain, I would say. There's many, many other conditions that we do not have the good fortune of being able to provide our patients with a procedure that is able to help. But, I would like to suggest that these type of studies and research protocols are slowly opening the door of the understanding of pain in a more objective fashion.

You know, I remember many years ago, I was sort of a young faculty at the time, and I gave a talk to a group of colleagues about pain and so on, and I don't know, maybe I went on a little bit too much about my thoughts about how we can be a little bit more objective in the analysis and the understanding of pain, and a very well-respected and very well-known senior colleague in the crowd got up and said, "But pain is a subjective entity." You know, it made me think that we have stamped the definition of subjectivity and pain and we are now essentially slaves to that definition and we can't move beyond that, and that's really stopping us from growing. [music fades out] And, this is sometimes the impact of our own self-defined bias in research that it holds us back from looking at new avenues and new ways of studying entities that we do not quite understand.

So hopefully, we're turning the corner and, you know, trigeminal neuralgia is not the most common neuropathic pain condition in our bodies but, as I said, it's an extremely severe condition and, to some level, a misdiagnosed, late-diagnosed condition. When I first started, you know, building a practice in management of patients with trigeminal neuralgia, I would have a patient who would be in crisis and needed urgent treatment maybe once every other year. Now, it's probably every other month, and it's not that these patients, all of a sudden, have pain that they never had it before. It's that now they know that there is a centre at Krembil Brain Institute where these patients can get expedited care, and rather than suffering, they know which door to knock on so that they're heard, and this is why I think it's really powerful to have this type of combined clinical and research practices such that the clinical work drives the research, and research drives better clinical care.

Heather 34:33

Thank goodness for you and your team, for all the great work that you do. Just before we go, I just wanted to ask you about next steps with this research because it's so exciting and you're on the cusp of so many new learnings when it comes to chronic pain and the pathways in the brain, specifically when it comes to artificial intelligence. I mean, how are we going to be able to use these new technologies more successfully to help streamline research in this area and come to these results and findings quicker to be able to help the patients?

Dr Mojgan Hodaie 34:58

We want to have better methods for diagnosis and better methods for providing prognosis to patients. So, we've done some work in this area. We've been able to use a large model of subjects with chronic pain that we studied with artificial intelligence, and we can very accurately predict which brain is in pain and which is not.

Heather 35:26

Hmm.

Dr Mojgan Hodaie 35:26

So, this is very helpful for us and I hope that this will eventually guide us in a better understanding of subjects that have pain, and how we can provide better diagnosis to them. The second one is our ability to provide better prognosis to patients that are potential surgical candidates so that, when we discuss the options of surgery with them, we're able to provide better personalized care. These are two very important areas. A third one is brain aging then sort of our biological clock. We are trying to understand whether there is, in fact, impact on biology. So, rather than focusing on the brain alone, we are actually studying what aging represents in the rest of the body when patients have accelerated brain aging. And, with that, we can draw upon biospecimens, so a sample of saliva, the morning of surgery, is able to give us our DNA age and tell us whether there is, in fact, biological aging that accompanies brain aging.

Now, this is not simply a curiosity. Aging impacts our health, it impacts our body, it impacts how we function, and again, these are additional measures of objectivity as we assess patients and we decide on the treatment that would be best for them. [gentle electronic music] The work that we've done has just opened new doors for us and also new questions with it. One of them relates to this construction of the brain age map, where we map chronological age with brain age, and we've decided to see whether we can actually make that map even more accurate, and one of my PhD students has focused on constructing a brain aging map that focuses purely on the memory pathways, and it seems to be a much more accurate map and one that will, in fact, help us link the aspects of cognition that are so important in pain, with the memory pathways, as well as accelerated brain aging so that we have a clearer understanding of the relative contribution of each of these platforms, and are able to link accelerated brain aging with cognition and with pain and see how all of these contribute to each other and, importantly, how we can normalize hopefully everything once patients are pain-free.

Heather 37:51

Amazing. Thank you so much for being with us today and thank you so much for all that you do.

Dr Mojgan Hodaie 37:57

Thank you very much for allowing me to speak on this very exciting field of research. [music continues then fades out]

Heather 38:01

[Your Complex Brain theme music] Thanks so much to Dr Mojgan Hodaie for joining me on the podcast today, and special thanks to Adriana Salazar for sharing her incredible story. If you'd like to hear more from Adriana, head to our website for an extended version of her interview. That's [uhn.ca/krembil](http://uhn.ca/krembil). You might also be interested in our episode about trigeminal neuralgia from season one, so check that out while you're there.

[music continues] This episode of Your Complex Brain was produced by Jessica Schmidt. Dr. Amy Ma is our executive producer. Thanks also to Kim Perry, Ali Wilson, Meagan Anderi, Sara Yuan, Liz Chapman, Emma Krebs, and Lorna Gilfedder for their production assistance.

[music continues] If you enjoyed this episode of Your Complex Brain, please tell your family and friends, and don't forget to leave a rating and review on your favourite podcast listening app. We'll be back in two weeks with another exciting episode. Have a great day. [music continues then ends]