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Limb Restoration: Osseointegration gives amputees a new option

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Ken: Whether the trauma is from war injuries, birth defects, diabetes, car accidents, amputations, or cancer, Dr. Jason Stoneback at the CU Anschutz Medical Campus has enabled hundreds of patients with limb maladies to lead a relatively normal life. Dr. Stoneback is chief of orthopedic trauma and fracture surgery, director of the limb restoration program, and vice chair of clinical affairs. Today on CU on the Air we talk to him about the treatment of these and many other complex conditions. Thank you for joining us doctor and welcome.

Dr. Jason S.: Thanks for having me. It's my pleasure.

Ken: So you're a pioneer in the area of osseointegration, which I would imagine not many listeners have heard of. You've called it a game changer. You've just described it as mind boggling before we started. What is it?

Dr. Jason S.: Osseointegration is the method that we help treat existing amputees who are having difficulty with traditional socket fit and wear. Osseointegration is the procedure where we actually anchor a bone-anchored prosthesis. So a piece of metal, an implant into the patient's existing skeleton that then protrudes through the skin, that they can then clip on and clip off their prosthetic limb and walk more normally, with a more normal gait pattern. It allows them to have a more fulfilled, meaningful life. It's a huge game changer amongst many other benefits.

Ken: Who are the people who benefit from it most?

Dr. Jason S.: Most patients that benefit from this are existing amputees who have had an either an above knee amputation or below knee amputation. We do take care on patients also that have had an amputation through their arm, most commonly through the humerus or the upper arm. But if you're the person that benefits from it, most is likely the above knee amputee, although every amputee can benefit from this.

As an above knee amputee with a traditional socket fit, you actually have to put on a system of liners or complex garments that help keep this socket on. When the socket or the prosthesis fits onto a person's lower limb, it fits over their limb. There can be a combination of suction devices or different suspension mechanisms, but there's a lot of wear and tear on one's body. It digs into your groin area and other areas, can be very uncomfortable, and if you can imagine wearing a large cylinder that's not contoured to your body all day long and just having dinner with your family or friends, how challenging that would be. If they lean to the side to accommodate this, it can be very taxing.

Also, it takes a lot of energy to move a prosthetic limb as an above knee amputee. So imagine your limb, especially if it's a very short femur or the thighbone, it fits into this socket and you have to manipulate it in space to try to move your limb around. There's a lot of motion inside that socket, excess motion. Moving your hip in a normal manner doesn't really necessarily translate to a normal motion of your prosthetic limb, so it can be very challenging for them.

Ken: You mentioned it can help with people's gaits, so it sounds like it really provides a lot more freedom of moment?

Dr. Jason S.: Absolutely. So one of the things that a patient once told me as they were coming to be evaluated for osseointegration as an above knee amputee, I always ask these patients, I say, "What is your daily life like? What can you do? What can you not do, and what do you hope to get from osseointegration?" One gentleman, young gentleman who lost his leg to cancer when he was a teenager

told me, "I want to improve my relationships." I thought, "Wow, what exactly does that mean?" He told me, "When my friends call and they say, 'I want to go out to the movies or to hang out somewhere, I have to think, 'Should I tell them that I'm afraid my leg's going to fall off and it will be embarrassing?' Or should I just say, 'You know what? I'm sorry. Thanks for calling, but I'm busy. I have other things I have to do.'" and he's in his young 20s now. Pretty powerful to me, and kind of strikes at the essence of what this does for existing amputees. That's one of the things that commonly happens to an above knee amputee is, their limb will fall off. It comes on, gets put on crooked, they get wounds, sores. It's uncomfortable. It's hard to move around.

One of the most common things that amputees will ask us when they show up to our clinic, one of my team members meets them at the door and asks them, "Would you like to walk up the clinic," on their prosthetic limb, "or would you like to take the wheelchair?" The first thing they ask, almost universally, is, "How many steps is it?" Because their days are centered around "How much effort, how much energy, how much am I going to get beat up by this prosthesis?" Those that aren't doing well, "How much am I going to be sore at the end of the day?"

Another story that people will frequently tell is, "I'm an amputee." We'll say, "Well, what do you do for a job?" They say, "Well, I do office work as an above knee amputee," and you think, "Well, that's a sedentary job. We sit down, it's good, right?" So people will describe, "I will print out five jobs to the printer before I get up and go get them, because I'm going to pay for it later," or, "I'll print out five jobs and make a trip by the snack machine all in one to decrease the amount of time that I'm up and walking." So taking that away and doing the bone-anchored prosthesis where they can just clip on and clip off, they can sit normally, it's a huge game changer for them. Not to mention, there's this phenomenon called osseoperception, which is fascinating.

So as a traditional socket wearing APTT, when you put on the socket, you can't feel where your prosthetic limb is in space. You're not really sure how much pressure you're putting on. People will talk about stepping on their loved one's foot, not knowing they're doing it, that sort of thing. When we attach this bone anchor prosthesis, you can feel vibration and you can feel pressure, and where that limb is in space, it's quite phenomenal and it often makes our patients come to tears when they feel it for the first time. They're like, "I can feel my prosthetic foot on the ground. I can feel that I'm more on the ball of it. I can feel that I'm more on the heel of it," that sort of thing. It's huge.

Ken: Substantial ripple effects beyond just the osseointegration.

Dr. Jason S.: Absolutely.

Ken: That's great. What is a typical day like in your clinic?

Dr. Jason S.: In terms of the osseointegration clinic, that's a multidisciplinary clinic where we have patients flying in from all over and they're evaluated first by a surgical team, myself and a nurse practitioner. Sometimes we have a plastic surgeon, microvascular surgeon, depending on their condition that also joins us. Then they would meet the rehab team, which consists of our athletic trainer, our physical therapists, and our physical medicine rehabilitation physician, as well as our prosthetist, who has been specifically trained all over the world to help amputees adjust to this bone-anchored prosthesis. Also, we have a psychologist that helps evaluate and helps them prepare for this life changing surgery and see if there's anything we can do to help with that, that transition. There's also financial counselors who deal with the insurance hurdles that can be there.

Then finally, probably the most special part of the visit is we always have some osseointegrated peer amputees. So these are patients who have been through what our patients are here being evaluated for. They have lived it, and they've gone through osseointegration, and they can answer those questions that they have that none of us who have been through this could possibly answer.

Ken: You've talked about people flying in from all across the United States, and one of the things you're working on is to make this a little more widespread. How widespread is it and what does it take to make it more so?

Dr. Jason S.: There are only a few major centers in the world that are doing this at a programmatic level, and they are primarily in Europe, Australia, and we are partnered with several of these groups, I've trained over in Europe. I've done surgery over there in preparation to bring this technique to the Anschutz Medical Campus. So we're working very hard with these groups around the world to bring this to the United States in a very meaningful way and impact a wide range of amputees who could benefit from this.

Ken: Given the benefits you described, why isn't it more widespread?

Dr. Jason S.: I would say that there's still a lot that we need to learn. There are two major variations in technique and implant design, and we're still sorting out which one of those is the best. We offer both types of techniques here at the University of Colorado, but there's a lot that goes into it. There are, while we have a track record of success in Europe dating back 25 years, there still is a lot to learn.

So currently, it's indicated primarily for those patients who've had amputations from trauma or from some sort of tumor. There are a lot of other amputees that can benefit from this type of surgery, and we do offer that to other amputees. But trying to figure out who is the best candidate that would benefit from this, for instance, "Are there certain patients who, when they unfortunately have to go through an amputation, should we be intervening in offering integration sooner?"

Currently, we wait until they've tried many sockets and they're unable to function well, and then they are potentially a candidate for this procedure if they fall into that bucket. But perhaps, this may be a game changer for more amputees on a much larger scale.

Also, the largest number of amputees in the United States, in the world are from vascular problems and from diabetes. These currently are not our first line amputees that we're offering technology to because of the risk of infection and other things. So our team's currently actively engaged in research to try to figure out which of those patients we could potentially help with this technology.

Ken: I think when people think about prosthetics, they typically think of something you kind of described earlier, these clunky, difficult to manage things. Talk a little bit about the evolution of where this has come from and where you see it going.

Dr. Jason S.: Traditional sockets haven't changed drastically in a long time. So it is a process of trying to mold the socket to the patient's limb. There has been some improvements in technology where we can adjust, make these socket somewhat adjustable. One of the largest improvements, the microprocessor knee, which can actually get feedback from your gait and adjust itself, we can tailor that device more to your gait, and walking speed, and utilization desires.

So those are some improvements for sure, but no matter what you do, people don't often realize that patients can fluctuate. We all gain weight or lose weight, right? Periodically, as they-

Ken: Not so much on the lose.

Dr. Jason S.: Right. We all have that trouble. So as an amputee gains weight or loses weight, their socket then becomes obsolete. So they can unfortunately go through many sockets, even through daily fluctuations or changing in an altitude, et cetera, diet changes. That can be a real difficult thing to deal with.

So this bone-anchored prosthesis and the osseous perception that it brings to the table, it's huge. I mean, it is huge. That coupled with the microprocessor knee, and probably the most exciting things that we're working on is, "How do we incorporate a patient's neural network into driving a myoelectric prosthesis? So how do we use our residual limb's native nerves and connect them to some sort of electrodes or wires to function a robotic hand or ankle and foot?"

Traditionally, those devices are available. However, they are quite cumbersome, and they're heavy, and patients often like them initially, but then don't wear them because they're too heavy, they slide off, they're just too cumbersome. But now, we can anchor that to the skeleton, and reel, and hook in the electrodes to our neural network, and when we think about opening our hand or we think about closing our hand, it'll do it. So it's pretty exciting stuff.

Ken: Remarkable.

Dr. Jason S.: Yeah.

Ken: Seems like that would actually complicate things.

Dr. Jason S.: Well, I would say that the technology is making improvements, leaps, and bounds, and that's what we're all about here on this campus, is pushing the envelope and looking for the next horizon. What can we do to improve patient lives?

Ken: A recent article described how you were able to save a man's leg that would've had to been amputated, and certainly preventing amputation is probably your top priority. What are some of the methods that you can use for healing critically fractured bones?

Dr. Jason S.: Well, it all starts with a team. It's definitely not just me. It's my privilege to run the limb restoration program here at the University of Colorado hospital on the Anschutz Medical Campus, and that's a team of over 20 specialists, as well as nurses, and athletic trainers, and nurse practitioners, and physician assistants, and you name it. We meet once a week and go over incredibly difficult, complex cases who often have not had success elsewhere. They've really hit a roadblock for whatever reason, so they're referred to our program to see if we can come up with a solution. That can range from congenital birth defects to limbs that are unequal from trauma, meaning a short leg or a severe missing soft tissue and bone, you name it.

So when these patients with these difficult problems come to our program, we meet with them and we offer a wide range of approaches depending on the problem. I've liked to make sure that we understand that we often, we always offer amputation as an option. Now, it's not often our first choice, but we don't see that as a failure. We see that as the right procedure for the right patient to restore their form and function at the right time.

Now, limb sparing surgery. If we're missing a large segment of bone, we can take healthy bone, say in someone's shinbone, their tibia, and make a specialized cut, and shuffle that bone from one area of the leg to another, and grow a new bone behind it by a process called distraction osseogenesis. So your body is skeletal system, and musculoskeletal system has amazing regenerative capabilities.

We've fractured the bone surgically and leave it there for a short period of time, about a week, and the bone thinks, "I'm broken, I need to heal." So it begins to heal, but right as it starts to heal, at about 7 to 10 days, we then start moving it about a millimeter a day, wherever we want to go, and it keeps trying to heal behind it. I've done bone transport, is what it's called, beyond 10 centimeters,

so up to 12 centimeters, and then grown a new tibia behind it. That's just one of the techniques we use.

Another, we had a young girl that's undergoing that exact technique, but she had a lot of soft tissue loss. Her muscles no longer function because they're missing, and Dr. Matt Iorio, one of our plastic and reconstructive surgeons who is just a phenomenal micro surgeon, actually took multiple muscles, one from her leg, and one from her thigh, and one from her back. The one from the thigh and back, the blood vessels to those muscles were actually disconnected and then reconnected to blood vessels in her leg.

So taking muscle from one part of the back and then transplanting it with its blood supply to the leg to not only cover this horrendous wound, but also, he was able to take that muscle function and hook the nerve that normally makes her footwork to the back muscle and tie the back muscle to the tendons in her leg, her foot. Now when she thinks in her mind, "I want to pick my foot up," her back muscle fires, and then picks her foot up.

Ken: Amazing.

Dr. Jason S.: It's truly amazing, and I think that shows you how it's truly a team sport. Not to mention our nurse navigator, Lauren, who's constantly talking to these patients who are all over the United States and overseas? It's a quite a coordination effort, and it can't be done in a vacuum.

Ken: Do you see a lot of demand as CU Anschutz's getting to be known as the place to come for this kind of work?

Dr. Jason S.: Absolutely. We have been very fortunate to have a lot of support from the Medical Campus as well as UC Health, and have developed a phenomenal team, and we are getting a lot of patients from all over the place. We're doing phenomenal work, and patients are really doing well and preach the benefits of coming to this campus for, if you have a severe problem like that.

Ken: Some of your areas of specialty, one I can imagine, limb length discrepancy, but a couple of others. I am not familiar with nonunions and malunions. Can you describe those and how you treat them?

Dr. Jason S.: Sure. Well, the limb length discrepancy is really one of my favorite things to treat. So you can develop a limb length discrepancy either being born that way, or from a severe trauma, or having some other surgical procedure that creates this one leg being shorter than the other. You can also have an upper extremity limb length discrepancy for the same reasons.

There are a multitude of ways to address that, but one of the most elegant ways that we'd address that is with an internal lengthening nail. It's a rod that goes inside the patient's long bone. We make that specialized cut that I described

where we can shuffle good bone from one place to another. We can then put that rod in the patient's leg. After we make that specialized cut, it has a magnet and gears in it. The patient then holds a larger magnet over their limb and runs it, on average, three times a day for a couple minutes, and that large magnet drives the smaller magnet inside their leg. So, the nail will then lengthen the patient's leg a third of a millimeter three times a day until we get to the desired length. Once it gets there, it holds it there until the bone is mature enough that they can walk on it. So, it's a really cool procedure that patients do very well with, and it's one of the more gratifying things that we get to do.

Ken: Sounds incredibly simple, yet incredibly complex.

Dr. Jason S.: It's really cool.

Ken: And cool.

Dr. Jason S.: And cool. So the nonunions, or the malunions, those are bones that are having problems healing. So either a nonunion meaning bone didn't heal, or a malunion meaning it healed, but it healed crooked. There's different ways to approach that depending on where it is and how long it's been, "Do they have an infection? Do they have a problem with the amount of soft tissue covering that problem area?" So we use a whole host of things, from plates and screws, and rods, and everything in between to correct that patient's alignment and get those bones to heal.

Again, can't be done without a really sophisticated, well-trained and dedicated team. Often, we have medical doctors who specialize in bone metabolism in the metabolic bone clinic at the University of Colorado Hospital. They help us make sure that the patient's ability to heal their bone that didn't heal before is optimized and can go on to heal.

Ken: Sounds like you're part physician, part handyman.

Dr. Jason S.: Yeah, that's it. Orthopedic surgeons, or orthopods as they call us, we're like human carpenters, sort of like that. Yeah.

Ken: I probably don't want to think too much about that. How did you get interested in this? What drew you to it?

Dr. Jason S.: When I was younger, I was a big athlete, really interested in athletics. I used to rodeo when I was younger. So with that sort of, I also played rugby, and without-

Ken: Two of those are two sports where there's not many injuries, right?

Dr. Jason S.: Right, right, so I was really fortunate, but in those sports there's a lot of injuries. So I was always interested in, "How do you get better faster? How do you heal

quicker? How do you perform better?" As my path led me to being a physician, I knew that I wanted to intervene in a meaningful way.

As I was going through medical school, I had the opportunity to experience a patient who had been in a severe car accident, and the orthopedic surgeons at that time fix their bones, set them, place rods down them, and then they were able to walk immediately. I thought, "Wow, that is, talk about intervening at someone's," what they consider the darkest hour. No one plans to get in a bad car accident or have some horrendous injury, but these people were able to intervene in that person's life, and then immediately I could see an x-ray and their bone was straight, and now they were walking. So I thought, "This is really neat. This is sort of a marriage of improving form and function and making a person able to function," and that's what led me to orthopedics.

Ken: Seems like it'd be extremely rewarding as a physician. Is there any patient or type of case in particular that sticks out in your mind that's particularly rewarding?

Dr. Jason S.: I would say I've been very fortunate in our teams and very fortunate to touch many lives, and there are so many. It's hard to talk about one, but one of our recent osseointegration cases, when they attached their prosthetic limb to their skeleton for the first time, to see their face and to, the astonishment of being able to feel the ground and put force through their limb for the first time, I think that was one of the most impactful moments of my career.

Ken: You talked about it earlier, the field is certainly, come a tremendous distance, but what do you see happening in limb restoration and osseointegration in the short term and in the distant future,

Dr. Jason S.: In the field of limb restoration, and getting back, and restoring their form and function, we deal with a wide range of injuries. I would say in that arena, figuring out how to get bones to heal better before they don't heal is one of the areas that we're actively looking into. "How do we make sure that they don't become a limb restoration patient? How do we get bones to heal faster, better, with more assurance every time?"

For those patients that do go on to not heal, the improvements in technology, some of the ways we shuffle, for lack of better term, shuffle bone, healthy bone from one segment of a limb to another to replace bad bone or missing bone is traditionally done with, lots of different ways, but most commonly with a circular ring fixator where we put this large cumbersome device on a patient's limb, but they're able to walk on it and things like that. I've been fortunate to be one of the few surgeons to pilot new technology where we use that same type of magnetic nail to achieve the same thing, and it's done a very good job, and that's really promising cause that's all inside a person's limb.

The field of ortho biologics, where we use substances to help augment healing by injecting fractures, or if you're missing cartilage, we can recreate your cartilage that's missing. Those are really exciting in the intermediate term and, "How do we use STEM cells or regenerative medicine in a responsible way to achieve good results?" That's not done just anywhere. You'll hear a lot of this STEM cell therapy, but having a true program that's backed by science, like our department, that section is headed up by Dr. Jason Dragoo here at the University of Colorado School of Medicine, that's super exciting, super exciting.

In terms of osseointegration, that in of itself, just with the bone-anchored prosthesis and the ability to connect the residual limb, have osseoperception and function so much better immediately is super exciting. Developing that technique, the techniques and technology to make the results continually improve and be better and better so that we can offer it to more patients around the world is really exciting. Then as we discussed, the ability to attach one's own neural network in your brain to an electronic prosthesis, a myoelectric prosthesis, is really, really exciting.

Ken: It's remarkable, and it's remarkably interesting. Dr. Jason Stoneback, thank you for the life changing work that you and your colleagues are doing here at the CU Anschutz Medical Campus, and thank you for joining us today, and see you on the air.

Dr. Jason S.: Thanks for having me, really appreciate it.