

The extreme athlete who built a new knee

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When Brian Bartlett was 24 he was hit by a car from behind so hard it ripped his right leg off instantly. It all happened so fast. He doesn't like to talk about it. "You really can't understand," he told me. "There's just no way to...until you have an injury where you're ripped or cut apart instantly."

He turned 25 in the hospital. When he left, fitted above the knee with a [prosthetic leg](#), he wanted to return to his life. Before the accident, Brian had been a competitive skier; he had a sponsorship, and he was on track for the US Olympic team. So after the accident, he was eager to get back to the slopes. It was 1998, long before Oscar Pistorius would take the track at the Olympics or Amy Purdy would take the stage on Dancing with the Stars. When he asked his prosthetist about getting back into skis, he wasn't ready for what he heard. He was told he wouldn't ski again, not the way he had before.

The best way to get Brian to do something is to tell him that he can't. Within a year of the accident, Brian was back on the slopes, skiing with disabled ski teams. In his first year he made it to the International Paralympic Committee's Alpine Skiing World Cup, and came in seventh in the world. But it wasn't enough. It wasn't the same. "It just didn't fill the need," he says. "It's not that I didn't like the disabled sports, it just wasn't like it used to be." Brian was back on the mountain using what's called three-track skis – skiing on one leg, using poles that have tiny skis at the end and are used as outriggers.

He has trouble remembering the exact sequence of events that followed.

At some point over the 17 years since his amputation – between truck driving, part-time jobs and a lot of extreme sports – he invented a new kind of knee. The Bartlett Tendon Universal Knee, or BTK, has been featured in museums and called a "pioneering development" in prosthetic technology. But for Brian, all that mattered was whether he could get back on the slopes.

Around 2001–02, Brian joined an able-bodied extreme skiing tour, filled with skiers with two sound legs. It was a disappointment. While the prosthesis he had then – a standard hydraulic mechanical knee – allowed him to walk and hike, it simply didn't work for the speeds and routes they were skiing. So he didn't use it. "I would hike to the back country, put the prosthesis in the backpack and ski down with one leg," he says casually.

He sends me a spread from a magazine called Powder ("The Skier's Magazine Since 1972") to show me the kinds of jumps and routes they were doing. The photos show a skier in Vail, Colorado, dropping down into something called Mushroom Bowl. The skier disappears into a cloud of snow and reappears at the other end, at the bottom of a 30-foot drop. In a discussion about Vail ski runs and Mushroom Bowl on one internet forum, a skier advised: "Expert plus. Averaging a death a year. Don't do it."

For the other members of the team, these routes could sometimes be dangerous. For Brian, they always were. "My ribs were getting broken. I didn't have two legs to absorb the hits, and so my ribs would break and once they broke they'd be susceptible to collapsing. I kept getting injured." Halfway through the season, Brian left the tour. "I was like, 'Man, I have to have two legs to do this'." So began his quest for a second leg.

Everyone told Brian that what he wanted didn't exist. That it couldn't

exist. That he was so unusual that there was simply no market for what he wanted. "You're one half of one per cent," they told him.

This moment – when an amputee realises that the arms or legs or hands that they're being offered simply aren't acceptable – repeats throughout history. It's also where many of the biggest advances in prosthetic technology have come from.

On 1 June 1861, James E Hanger enrolled in the Confederate Army. He was 18 and had just dropped out of engineering school at Washington College to join the fight. The very next day, in a skirmish against Union troops in Philippi – a town that was then a part of Virginia and is now located in West Virginia – a cannonball tore through his left leg. Philippi was the first battle of the Civil War, and Hanger quite possibly the first wounded veteran. Many years later, according to historian Jennifer Davis McDaid, Hanger's niece would remember him displaying a six-pound cannonball on his mantel, claiming it was the very ball that was removed from his leg.

By the end of the Civil War, surgeons on both sides had performed about 60,000 amputations. Never before had the country seen so many amputees. The demand for replacement parts was so high, states couldn't keep up. Those who applied for benefits would wait years before their cheques came in the mail, and the options for artificial arms and legs were limited. Many used peg legs and simple hook hands.

Hanger returned home with a peg leg and asked his mother for a secluded room where no one would bother him. He hated the 'Yankee leg' he was fitted, and for three months he spent his time working on his own artificial leg made out of barrel staves. He received two patents from the Confederate government in 1861 to develop limbs for soldiers, but he didn't find immediate success for his leg. Soldiers complained about its look and feel, and its flimsiness. He spent time working as a

teacher and a jeweller, all the while trying to improve and promote his Hanger Leg.

It wasn't until 1871, when he was granted an official US government patent for a new version of the Hanger Leg, that it started to really catch on. Looking less like a peg leg and more like a medieval knight's armour, Hanger's leg had joints at both the knee and the ankle, and included rubber pads to buffer the noise of the contraption. The idea was that the hinges would allow people a more natural gait than a single, solid stick of wood could. Today, Hanger Prosthetics and Orthotics is one of the largest prosthetics manufacturers in the USA. In 2013 they reported over a billion dollars in sales.

Hanger might be the most famous example, but he's not the only one. In 1912, an amputee named David Dorrance invented what's called the split-hook hand attachment for artificial arms – the first that allowed users to grasp objects comfortably. Even today, some amputees prefer the Dorrance hook over all the fancy electronic devices out there.

In 1976, Van Phillips lost his left leg above the ankle in a water-skiing accident. He was 21 at the time, studying communications in college, but after becoming frustrated with the designs available to him he switched his major and studied prosthetics instead. In 1984 Phillips founded the Flex-Foot company. You'd recognise his designs – he's the one who invented the C-shaped 'Cheetah' feet that have carried sprinters like Pistorius.

Today, able-bodied prosthetists recognise the unique insight their patients have. Jeff Erenstone, a prosthetist based in upstate New York who works with a lot of adaptive athletes, says that he spends a lot of his time listening to them. "I sit at their throat and just listen. These people, even if they're not mechanical, they spend so much time thinking about this stuff that you've got to listen to them. They may not be able to

articulate what they want, but they're probably right."

There's now a much larger market for specialist sports prostheses, one that didn't exist when Brian first started looking. Bob Radocy makes prostheses for active amputees – things like skiing hands, rock climbing feet, windsurfing hooks and weight-lifting hands. He says that the best ideas come not from him but from the amputees themselves. "The vast majority of design concepts...have come from consumers, and I think that's valuable," Radocy told me. "You have to know what you want."

One recent example is a basketball hand that a kid and his family thought of. The patient had lost his hand in a firecracker accident and was eager to get back to playing basketball. But nothing out there was really made for that, so he and his mother made a crude prototype out of splints. It worked well enough, but it broke every two weeks or so. Radocy now produces and sells a more robust version.

Like Brian, Radocy was a skier. But the prosthetic hands out there couldn't hold onto the ski poles well enough. "I didn't have technology to meet my needs to do what I wanted to do; I felt like I was being limited by the technology," he says. So he built his own. Radocy spent months researching patents for hands all the way back to the 1800s. By 1979 he had a hand that he liked, that could grasp his poles. Today, he still skis using his own designs.

But what Brian needed was a knee.

The first time I met Brian in person was in Breckenridge, Colorado. He had invited me to come see him at The Hartford Ski Spectacular, an event for disabled skiers and snowboarders. We had no plans for when, or where, to meet. "Just call when you're on the mountain," Brian said.

I worried that I'd fly to Colorado and never actually get to meet him, but

in the hallway among a sea of disabled skiers and teachers, we finally connected. "I'm about to go fit a guy with the knee, but I'm not sure I want you to watch," he told me.

Chris Canfield is a difficult customer, Brian said. Canfield is himself an athlete; he bikes up and down mountains all around Colorado. He had biked to the event that day. He'd known Brian for years, but uses a classic knee (Brian called it an "old-school hinge"). Canfield was sceptical of anything fancy. How much better could it really be?

Within minutes, Canfield was fitted with a tendon knee. Brian even popped the tendons off his own knee to give to Canfield, so he could try it with some rubber that was already broken in. Soon, Canfield was riding his mountain bike up and down the hotel hallway, past the Christmas tree decorated with lights and fake presents.

"Try standing," Brian said. Canfield stood on his pedals and grinned. One thing the Bartlett knee can do is allow bikers to push up on the pedals and stand while pedalling, something many other knees can't do. Canfield had never stood on his bike before. While Brian tried to make fine adjustments to the knee, rotating the cams on the outside that control how tightly the tendons pull, Canfield wasn't listening. He wanted to get outside and really ride. "Just make sure you bring it back," Brian said, laughing. Canfield was already out the door.

After quitting skiing, Brian decided he had to get away from the competitions. He wanted to find himself, he says, to figure out what his life was going to be like. So he got a trucking license, for the same reason he does most things: "because people told me I couldn't do it with the prosthetic". Brian had his prosthetist work with him to design a special knee brace for his prosthetic knee, to keep it in place and help him shift gears. And then he was off, with a mountain bike and a prototype biking leg he had been fiddling with.

Brian drove all kinds of trucks, and he drove them hard and fast. He drove a gleaming periwinkle blue rig for 24 hours without stopping to get ahead of schedule, all so he could pull the rig up into the mountains and bike for a day on his test leg. That was the routine: drive, bike, drive. "I was burning the candle at both ends, so I could test out the prototype and stay on schedule and make money."

During his trucking days, Brian's knee was cobbled together from parts that the University of Washington had given him. He'd spent time volunteering with students there as they practiced evaluating and fitting amputees in exchange for parts. Across the front he strapped a piece of rubber, to simulate a knee's natural bounce. At the time, he was experimenting with different thicknesses for that rubber, gluing strips of laminate together to see which version worked best.

After a year of trucking he returned home to Washington. He'd realised he needed to know more about prostheses before he could really make his own, so he convinced FabTech – the company his prosthetist worked with – to hire him part time, building devices.

Brian is the first to admit that this relationship was rocky: "They wanted to fire me. They didn't even like me," he says. He would do the work they asked, and then stay late, using their tools and materials to test out his own ideas. "I wasn't the best employee because I was trying to use their parts to make my stuff."

Greg Mattson, the CEO of FabTech, was Brian's boss at the time. They're now business partners. "Here's what I know about Brian," says Mattson. "He'll show up, he'll grab a pen and he'll sketch it out on a piece of paper, and he'll take that and say 'Here's what I want to do'. He's that mad scientist."

Brian paints it another way. "He thought I was crazy, which is probably

easy to do."

When I ask Brian what year it was, exactly, when he first came up with his special skiing knee, he laughs. "I'm not good with dates. I just kind of go day by day. My life is just day by day."

At some point Brian quit FabTech. And at some point – neither he nor Mattson remembers precisely when – came the change that was key to BTK's evolution: tendons.

Prosthetic or not, knees are essentially hinges. In a biological knee, the hinge is flanked by tendons that help it bend and move and snap back into place. These provide tension; when you push against them, they stretch, and when you stop pushing they pull the knee back into place. Prosthetic knees, especially active ones, are often supplemented with springs or shock absorbers to cushion impact. But they don't provide natural tension. "If you were standing right now and you bent your knee, most prosthetic knees would struggle to help you come back up and you'd have to use your able-bodied leg to go straight again," explains Erenstone. Of Bartlett's knee, he says the tendons are "more effective at giving you the power to straighten out your leg again".

Brian's rubber tendons flank the hinge and provide natural-feeling resistance and tension for the user. When Brian first started trying the tendons, he had welded metal tabs to his socket – the part that hugs the stump of his leg – and ran the rubber tendons through those tabs to keep them in place. Today, two rotating cams on either side of the knee help the user dial into exactly how much resistance they want for the task they're doing. The tendons can be replaced easily, as can the shock absorber – this is designed for a man going off 40-foot jumps, after all.

There are trade-offs, though. Erenstone told me that although he hasn't fitted an amputee with a Bartlett knee, he has serviced them before,

which has allowed him insight into what they can and can't do. "His tendons are ginormous," Erenstone says, which means the knee isn't good for every extreme sport. "It's heavy, it's bulky," he says. Erenstone wouldn't recommend it for rock climbing, and "for biking cross-country – in other words, going up hills – you have to overpower the tendons to do that, so it's inefficient." But for alpine skiing or downhill mountain biking, in his opinion, it's an "excellent design". "If you're going to have a specific prosthetic designed for wakeboarding and that's something you care a lot about, yeah, I'd fit one in a heartbeat."

Nicole Roundy, a Paralympic snowboarder, says what many say about the BTK: it just feels more natural. "You can really ride those tendons...rather than getting a kickback," she told me. She's the first above-the-knee amputee to compete in adaptive snowboarding, and in the 2014 Winter Paralympics she came in eighth in the snowboard cross, riding on Brian's knee.

Back in Breckenridge, Brian and I made plans to do a snowboard run down the mountain together. I wanted to see the knee moving in person. It would be my second time on a snowboard ever, and I was nervous – I knew the kind of skiing Brian liked to do. Even if he didn't race any more, he still talked about "ripping" – hurtling – down the mountain. I would not be ripping. Brian laughed in his sincere, hearty way and graciously agreed to take a trip down the bunny hill with me.

That never happened. Later that day I found Brian in the bar on the second floor of the lodge, his leg in pieces on the table. The part that connected the knee to the shaft below had snapped that morning; as he went down the mountain, his knee had started to rotate wildly. He made it to the bottom unscathed, but annoyed.

Long before Nicole Roundy was racing on Brian's knee, it was Brian once again speeding down hills on it. At some point, between working at

FabTech and heading into the hills with his truck, Brian got really good at mountain biking. This new kind of racing filled the need that skiing once did – the adrenaline, the competition, the thrill of hurtling down a mountain. Before the accident, Brian's skiing had been sponsored by Red Bull, so he got in touch. Soon they were sponsoring him as a biker.

Since there's no mountain biking circuit for disabled people, Brian was competing once again with able-bodied athletes – only this time with two legs, one a prototype tendon knee. And he was winning. People started noticing.

Many of the people fitted with the BTK heard about it by word of mouth. When Brian started competing, word spread. Here was an amputee, holding his own against the best downhill mountain bikers in the world, wearing this weird-looking prosthetic leg he'd built himself. People would ask where they could get one, if he could make them one. He always said no. The knee had never been designed for other people to use.

Brian still constructs all his knees by hand – "my hands are like the quality control" – but he doesn't always have control over how well certain pieces are manufactured. He tests every prototype himself, so nobody else gets hurt if something breaks. As he put the pieces of his leg back together in the Breckenridge bar, he told me that this was exactly why he had been nervous to start producing the leg in the first place. "I didn't want anybody to try it," he said. "It was too dangerous." In the early days he had another fear, too: "I was worried that maybe it was a placebo. That it was all in my head."

He finally caved for a friend, who wanted to get back on a mountain bike again. "He ripped, he still rips today," says Brian. The feeling of seeing someone using his knee was one he hadn't anticipated: it was a new high.

Then in 2007, Brian got a call from the Walter Reed National Military Medical Center – he remembers the year because in order to get a federal contract, he had to found his company, Left Side, Inc. The military wanted to test his knee on some active-duty soldiers. Brian was hesitant. This still wasn't something for mass production. But saying 'no' to the military is hard to do.

In 2009, amputee soldiers got their first BTK production unit. Since then, Brian has worked regularly with active soldiers and veterans. "Now we just work where the need is, whether it be active duty still, veteran or civilian," he says. He told me he couldn't talk about the details of his work, but that when fitting soldiers one thing is made very clear to him: it had better work.

For a while, the military made up the entirety of Left Side Inc's business. But eventually they started selling on the open market. Today, Brian Bartlett has a company and a product. He says it still feels very sudden – indeed, it took several years for him to stop racing and focus entirely on the business.

He finally gave up racing in 2011. Greg Mattson remembers that time well: "A couple of years ago he was jumping some huge gap and didn't make it. He shattered his whole helmet and had to have his whole face stitched up. And I was like, 'Dude, you're getting too old for this. We have an investment'."

"I'm not a business guy," Brian said every time we talked. He has no idea how many legs he's built – "I build them all by hand, about 20 at a time." For him, it's not about making money; it's about helping fellow amputees. If he had it his way, they'd be giving the knee away for free. "When someone orders something from us, they're missing something in their life. They want it back. I don't think of this as a product. Other guys, they're not amputees, they don't get it."

Mattson is one of those other guys, and they clash sometimes. He says that sometimes Brian will reject ideas for changes that might make the knee cheaper. But if it makes the knee look bad, Brian won't do it. "He's idealistic – he wants this knee to be perfect, even in the machining he wants it to look beautiful and have curves here and there. We butt heads. You might get two guys at a meeting who say we can cut half that cam off, and he says it makes it look funny."

What was once a wide-open market is now a crowded one. In the commercial market, two other prosthetic knees (the XT9 made by K12 Prosthetics and the Moto Knee made by Biodapt) compete for the tiny sliver of amputees who are healthy and active enough to want something for sports – and are able to afford it. Brian's knee costs about US\$6,000. Insurers are rarely willing to cover an extra sports knee, and broken or worn-down knees often have to be replaced whole.

Extreme prostheses are now more widely visible than ever before. Brian's competitors promote their products through advertisements, commercials and social media. In January 2013 Mike Schultz, the amputee who designed the Moto Knee, was on the cover of Wired magazine. Just this year he shattered his ankle competing at the 2015 X-Games in Aspen, Colorado, which made him unavailable for interview (the XT9 team didn't respond to multiple interview requests). "They all have a ski knee, a bike knee...I take them with a grain of salt," says Brian of his competitors.

When he stopped racing, Brian gave up the thing he had fought to do for so long. He let his sponsorships go. But he started sponsoring other people in races and competitions, and travelling in person to ski events worldwide to help amputees try out the [knee](#) he still builds himself.

"That's better than winning any race, doing any competition," he says. "That's the new high. Being able to give someone a part of their life

back."

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