

GLOBAL HEALTH

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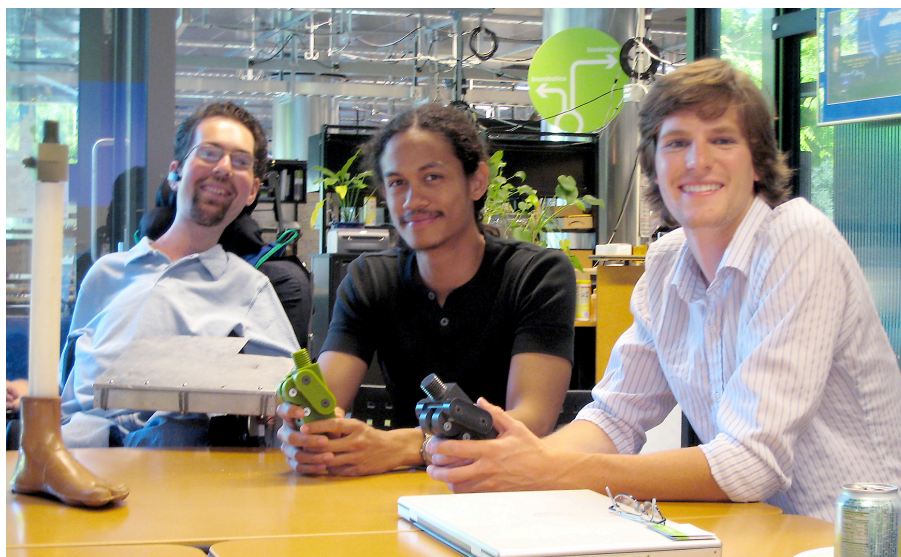


Photo by Christine Kurihara

Angelo Szychowski, Joel Sadler, and Eric Thorsell of the JaipurKnee team (not pictured L. Ayo Roberts)

THE JAIPURKNEE PROJECT I: Getting the Need Right

STANFORD, CALIFORNIA AND
JAIPUR, RAJASTHAN, INDIA

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THE PROBLEM/SOLUTION SPACE

Around the world, more than 20 million people have had limbs amputated due to natural disasters, trauma caused by accidents or war, and diseases such as diabetes. Of these amputees, 80 percent live in a developing country and are unable to afford modern prosthetics, which can cost from \$10,000 to \$100,000 depending on their level of sophistication.¹

Low-cost prosthetic leg systems have been developed, but they typically are based on suboptimal or out-of-date technology. For example, many prosthetic legs use single-axis knee joints that operate much like a door hinge and have a limited range of motion. When users walk on them, especially over uneven terrain, they can be unsafe.² For instance, the joints are often unstable and can buckle under the user's weight, causing falls that can be physically and emotionally damaging to an amputee.³

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ABOUT THE JAIPURKNEE PROJECT

Seeking to better address the needs of India's 1.65 million above-knee amputees,⁴ Bhagwan Mahaveer Viklang Sahayata Samiti, Jaipur (BMVSS) reached out to Stanford for assistance with designing a new low-cost knee joint that it could use in its clinics. BMVSS, which was commonly referred to as the JaipurFoot Organization, was an India nonprofit that provided a variety of mobility solutions to the "physically challenged, particularly the financially weak among them."⁵ Professor Tom Andriacchi assigned this challenge to four students in his Medical Device Design class, including Joel Sadler who was studying engineering in a Master's program at Stanford. This was the first global project that Andriacchi and his students would tackle as part of the course—usually they partnered with major medical device manufacturers on first-world problems.

ONE CHALLENGE: GETTING THE NEED RIGHT

As a first step in the design process, Sadler and his teammates connected with representatives from JaipurFoot. "They came to us and said, 'We need a really cheap knee joint for our clinic that can be produced locally for roughly \$35 per unit.' It was a very simple statement that focused on a technical problem that we could dive into. We were Stanford engineers so we started thinking right away about the technical aspects of the solution. But then we pretty quickly figured out that they already had a knee joint they were using that cost about \$25. So this wasn't an unmet need."⁶ The team members realized they needed to look more deeply at the problem to identify the real need and why it was not being adequately addressed by the current solution.

THE SOLUTION: "PEELING THE ONION"

Looking back on the team's experience, Sadler noted that, "What people tell you up front is almost never the actual problem." He likened needs in the developing world to an "onion with a whole bunch of layers" that the design team had to peel away to truly understand what kind of solution was required and would be practical taking into account all the constraints of the users and their environment.

So the problem we were trying to solve started to evolve from simply designing a cheap knee joint to helping the user feel more confident walking, and to reducing the fear of walking on a prosthesis.

Sadler and his colleagues threw themselves into research mode, reviewing all the literature they could find on prosthetics. They pressed the representatives from JaipurFoot for more information and also directly began to understand the limitations of current solutions from watching YouTube videos of amputees walking with the help of low-cost knee joints. "It became clear that even though JaipurFoot had a cheap, cost effective, locally manufactured knee joint, the performance was lacking," Sadler said. By studying the differences between single-axis knee joints and the high-end titanium knee joints sold in markets

such as the U.S.,⁷ they started to appreciate the technical factors that could improve performance. "But we had to look at the problem from more than just a mechanical or engineering perspective," he continued. "There was a psychological issue for these amputees when they walked on these really cheap knee joints. It boiled down to the fact that they were really scary to use. So the problem we were trying to solve started to evolve from simply designing a cheap knee joint to helping the user feel more confident walking, and to reducing the fear of walking on a prosthesis."

To help the team make the challenge even more concrete, “We formulated a vision of the person we were designing for,” recalled Sadler. “And, as we went along, it became more and more concrete.” They focused on the needs of a young male amputee living in rural India in pretty rugged, harsh conditions. He was relatively poor and needed a way to support himself and his family despite his disability. He still had strength in his limbs (unlike some of the elderly amputees the team might have chosen to design for). However, he also might have tried a prosthesis previously and had a bad experience. “You can imagine that if you’ve fallen a couple of times, you may be very hesitant to try a certain kind of mechanism or knee joint again,” Sadler noted. This target persona—which represented a relatively large segment of the Indian amputee population—was also concerned with how comfortable the knee joint would be to wear for extended periods, as well as its cosmetic appearance to some extent.

During the very early stages of the project, the team was not able to visit India to talk directly with users. Sadler acknowledged this as a limitation of their preliminary work. “There’s no real substitute for being on-the-ground,” he said. However, they actively sought creative ways to make the most of their development time before their first trip to India. The team immersed themselves in the psychology of the user by speaking with amputees in the U.S. prosthesis. Eventually, they even acquired a specialized device



Kamal, the first patient fitted with the early JaipurKnee joint

Courtesy of ReMotion Designs

that a team member could strap to one of his bent knees to simulate a prosthesis. Walking on this device allowed each of the engineers to experience first-hand what it was like to depend on an artificial limb. “It was terrifying,” Sadler remembered. The Jaipur team also used the U.S.-based amputees as a sounding board for ideas. This was especially helpful in conjunction with what Sadler called “decoupling the problem,” or explicitly identifying the work that could be most effectively performed in the U.S. before making the first trip to India. For example, the team believed that certain basic engineering and prototyping tasks could just as easily be performed locally. “There are only so many ways to design a [prosthetic] leg,” Sadler said. “If we had a question

about how the joint would make contact with the leg, we could answer that with an amputee in the U.S.” he explained. “But if the question had anything to do with how the product was going to be culturally accepted, then that was much harder to figure out here. We had a sense of what was going on with amputees in India, but it was nowhere near as good as actually being there.”

One aspect of the need that did not change as the team’s understanding of the situation evolved was JaipurFoot’s preference to avoid dependence on a for-profit supplier. “The importance of that didn’t really sink in until we started to get to know the partner better,” said Sadler. “The JaipurFoot Organization is a charitable entity. They give away all their stuff for free. They depend on donations and government funding, so the last thing they want to deal with is having to order 1,000 knee joints at a time from some manufacturer that can raise the price or delay shipping. They’re going to feel intimidated if they don’t know how to make this in their own shop.” The implication of this requirement was that whatever the team designed had to be incredibly simple and producible from locally available materials and on equipment that could be found in a rudimentary machine shop. “We figured out that anything we made for them had to be computer-optional,” Sadler noted.

The team saw this capability in action when Sadler and Thorsell made their first visit to Jaipur, bringing their designs and a fully functional prototype with them. The prototype was far enough along that the JaipurFoot Organization immediately made several copies in its machine shop, proving that it could be manufactured locally. Within 24-hours of the team’s arrival, the joint had been fitted to a young male patient named Kamal. “Our initial assumptions allowed us to get it as close as possible without actually meeting the user,” Sadler said. Then, once on-the-ground, he and the team were able to quickly shift gears and begin working on the cultural aspects of the solution to propel their work forward. As for Kamal, he was able to walk with the device within a day, and he soon found a job delivering food to patients and staff at the clinic that fit his knee.⁸ ♦

NOTES

- 1 “Designing Solutions to Improve Health for All,” NCRP Reporter, Winter/Spring 2011, http://www.ncrr.nih.gov/publications/ncrr_reporter/winter-spring2011/innovations.asp?p=all (February 15, 2011).
- 2 “JaipurKnee: Need,” D-Rev, <http://www.d-rev.org/projects/remotion/need.html> (February 15, 2012).
- 3 “Designing Solutions to Improve Health for All,” op. cit.
- 4 Ibid.
- 5 “Organization: Who Are We?” JaipurFoot.org, http://www.jaipurfoot.org/01_org_whoarewe.asp (February 15, 2012).
- 6 All quotations are from an interview with Joel Sadler conducted by the authors in February 2012 unless otherwise cited.
- 7 “VR Interfaces: JaipurKnee,” Virtual Worldlets, <http://www.virtualworldlets.net/Shop/ProductsDisplay/VRInterface.php?ID=93> (February 15, 2012).
- 8 “JaipurKnee: Need,” Ibid,