

A World-First in Prosthetics

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An expert team has put steel to the test, creating the largest, strongest artificial limb in the world, one that can carry the weight of an elephant.

Deep in the rural landscape of northern Thailand, a young amputee is navigating her adolescence, learning to live without a leg as she matures into adulthood. Maimed by a land mine as a baby, she is like many other innocents injured on the Thai-Myanmar border, a region dotted with land mines left over from a decades-long ethnic conflict. But this particular amputee is unlike others in one crucial way: she’s a 2,000-kg Asian elephant.

Mosha, a resident at the elephant hospital founded by the Friends of the Asian Elephant Foundation in Lampang, owes her life to the kindness of a surgeon with a mission: to make the world’s first prosthetic limb for an elephant.

Mosha’s Story

In Thailand and much of Southeast Asia, elephants hold deep historic and symbolic meaning. Elephants were revered as the property of kings, and white elephants were considered sacred. They were domesticated as far back as 3300 B.C. and used as instruments of war and draft animals.

Today, this legacy is exploited and elephants comprise a large part of forced animal labor in Southeast Asia, typically used to haul timber in the logging industry. Some suffer addiction to amphetamines, which they’re fed to continue working late into the night. After a lifetime of work, when they become too old for physical labor, they are often sent to “elephant sanctuaries,” where they continue working by entertaining tourists.



Dr. Therdchai Jivacate made Mosha’s leg in his lab in Chiang Mai, Thailand.



Mosha has her leg fitted for her every time she wakes up. She has taken to her new leg very well.

Mosha could have had a similar fate. But 10 years ago, when she was just seven months old, she stepped on a land mine as she was out walking with her mother. Mosha's right foreleg was blown off up to the knee.

Mosha's owner rushed her to the elephant hospital in Lampang, roughly four hours away by car. At the hospital, under the watchful care of Soraida Salwala, the hospital's founder, and a team of veterinarians, Mosha spent two years recovering from her wound and trying to adjust to a life lived on only three legs.

When Mosha was two years old, she caught the eye of Dr. Therdchai Jivacate, an orthopedic surgeon, humanitarian, inventor and winner of the Ramon Magsaysay Award (considered Asia's highest honor for selfless service) in 2008 for his innovative, charitable work in prosthetics.

Jivacate applied his 40-plus years of knowledge in human prosthetics to design the world's first elephant prosthesis. His work with Mosha has provided unique lessons in prosthetic design and the abilities of cost-effective resources when put to the test.

"One day about eight years ago, I went to visit Motala [another amputee elephant at the elephant hospital] and I happened to see Mosha," recalls Jivacate. "She had lost her right forefoot, and I noticed that she had a curved spine, caused by carrying all her weight on one foot."

He noticed that the knee joint in her good foreleg had become curved and damaged, and the cartilage was becoming worn down on one side. "If the cartilage was destroyed, she wouldn't be able to walk," he says. "We decided that we should do something."

With Jivacate's help, Mosha received her first, functional prosthetic limb when she was two-and-a-half years

old. Her new leg not only allowed her to walk again, it also made the difference between life and death.

The World's Strongest Prosthesis

Mosha weighed roughly 600 kg when she received her first prosthetic leg. Today, she is 10 years old and has tripled her weight. But Asian elephants don't reach their full size until they are roughly 17 years old. This means that Mosha, at 2,000 kg, is still growing. The consequences of her growth without proper support are dire: her good legs will suffer immense damage and she will develop scoliosis, from which she could suffer major complications and even die.

Although the fundamental principles of designing an elephant prosthesis are the same as those for humans, the weight that needs to be supported by the device presented problems for Jivacate. While human prostheses are commonly made of lightweight materials such as carbon fiber, an elephant prosthesis needs to be six or seven times larger and has to carry thousands more kilograms of weight.

"An elephant carries two-thirds of their body weight on the forelegs," Jivacate says. This means that when Mosha reaches her full size and weight of 3,000 kg, her forelegs will have to support roughly 2,000 kg.

This prosthetic is under a huge amount of pressure, so it had to be steel. Anything else would have bent under Mosha's weight, according to Jivacate. But in his work, steel is not only used because it is strong and hard-wearing, it is also crucially readily available.



Mosha's prosthetic leg helps her to live a normal life.

The leg Jivacate designed is made of three basic parts: a socket for Mosha's stump made of high-density polyethylene with a foam lining for comfort; an extension made of steel pipe; and a “foot” made with a steel plate and polyurethane. Jivacate says he chose these materials mainly for their strength and durability.

As Mosha grows, to accommodate her normal growth spurts, Jivacate and his team continue to improve the leg, making it bigger and sturdier. They recently added steel support beams to the extension to hold up the weight in the socket.

Mosha's current prosthetic leg, her ninth, is approximately 103 cm long from the top of the socket to the ground. The steel support pipe makes up just under half of that length, and is around 3 inches in diameter. This central length of steel is supported by four steel rods, which strengthen the structure and help hold up the socket. These are approximately $\frac{3}{4}$ inch in diameter.

“At first it was trial and error,” Jivacate says. “But when we found the proper alignment, Mosha could walk. She could use her leg to play.”

The Future of Prosthetics

Mosha's prosthesis has not just ensured the well-being of one elephant, but it has also offered potential solutions for other animals and situations. Motala, who has been a resident at the elephant hospital for 16 years, became the second elephant in the world to receive a prosthetic limb. Because she is much older, at 56 years old, Motala is not as adept on her new leg as Mosha. But it has allowed her to walk more normally, relieving the strain on her body.

Motala, Mosha and the other elephants are all cared for by their own mahout (person who tends to elephants) and, as well as being the elephant's closest allies, the mahouts also play an essential role in the continual improvement of the prosthetics.

“They observe the elephants every day,” says Dr. Cruehtong Kayan, a veterinarian at the elephant hospital. “If they notice abnormalities in the way the elephants walk, then they'll report it to the vet. We make careful records of any changes and even take videos.” The hospital then alerts Jivacate or Dr. Boonyu Thippaya, a prosthetics technician, that it's time for a new leg.

Today, Mosha is a permanent resident at the elephant hospital, cared for daily by her mahout, Palahdee. She spends most of her time eating, walking, napping, bathing and interacting with Palahdee.

Every time she wakes up or goes to sleep, Palahdee and another mahout help her into or out of her prosthesis, which weighs about 20 kg. First, they cover Mosha's stump with talcum powder, then Palahdee puts on her special sock. Finally, he fits her leg into the prosthetic socket and secures it with buckles. Mosha trusts Palahdee more than anyone. “We're very close,” Palahdee says. “We're like father and daughter.”

Although Mosha will never be able to live unassisted, her prosthetic leg continues to save her life as she grows. With proper care, she could have a long life ahead of her: Asian elephants can live to be 60 years old.

Mosha has blazed the trail for amputee elephants. The Friends of the Asian Elephant Foundation has established its own prosthesis factory to manufacture new legs more quickly and cost-effectively. Currently the factory contains a metal cutter, a plastic melting machine and plaster for making molds. Only Mosha and Motala's legs are constructed here for the time being, but there is scope for more to come.

“We're trying to replace what they lost,” says Cruehtong. “And we're just trying to make Mosha's life a happy one.”

This and other stories are available at stories.worldsteel.org. ◆