5th-grader tests 3-D printed robotic arm to help other kids

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The soon-to-be 11-year-old left the Washington University School of Medicine lab with an instruction manual for her new robotic arm. Don't get it wet. Turn it off when not in use. Change the two 9-volt batteries.

But for a girl who has adapted to living a life with a left arm that ends just past her elbow, there's no instruction manual for how to incorporate this new technology into her day. That will be up to her to figure out.

And researchers at the biomaterials laboratory will be studying her, trying to figure it out, too.

Delanie Gallagher of Spanish Lake is the first of 10 children researchers plan to enroll in a study trying to determine how to develop a prosthetic that is useful for children born with all or part of a limb missing, or who lose a limb through trauma or surgery.

Most end up living without a prosthetic because it lacks function and only gets in the way. Of the more than 540,000 Americans living with upper limb amputations, only about 20 percent use a prosthetic.

Delanie's new arm incorporates myoelectric technology - sensors that detect when muscles in the stump contract and signal parts in the prosthetic to move. Prosthetics with this technology typically cost from $25,000 to $50,000, making them unfeasible for fast-growing children.

The WashU lab created a hard plastic arm using a 3-D printer at a cost

of just a few hundred dollars. The myoelectric technology was kept simple enough to keep the prosthetic low-cost and lightweight, with one sensor that signals the hand to either open or close, or the wrist to turn.

Nick Thompson, a scientist in the lab, hopes the simple route will make arm prostheses more accessible and useful to children.

"Tons of people are doing this now, but they are reaching for the fruit high in the tree, trying to develop something with the most functionality that is the closest you can get to your biological limb," Thompson said. "We are going the opposite. We are looking for something quick that can be made and modified quickly. That is our goal."

But the big question is how useful it will be. Delanie is proof of how children overcome. She had difficulty thinking of something that she can't already do.

What does she hope her new prosthetic will help her do?

"I don't know," Delanie said. "I don't know what I can do."

ROSY PINK PETUNIA

Delanie's mom, Janet Gallagher, remembered when Delanie was a baby and got her first prosthetic to help her crawl. "She just dragged it along," Gallagher said. It was quickly tossed aside.

Delanie has had two other prostheses, used only to help her steady and steer her bike, hold up a fishing pole or brace her bow and arrow.

"It didn't help her," Gallagher said. "She could do better without it."

Using her stump, Delanie figured out how to color, use scissors, tie her

shoes, braid her hair, put her hair in a ponytail and play the piano.

On a recent day at school at the Gateway Science Academy in south St. Louis, she needed no help. She carried her books in a shoulder bag rather than a backpack. She held a pencil sharpener in the crook of her elbow as she turned her pencil.

She played with a piece of clay, molding it into a flower between her stump and hand. She twirled her hair with her stump, raised it high when the teacher sought answers from the class.

At lunch, Delanie ripped open bags with her teeth and braced her Capri Sun against her body so she could stab it with a straw.

When the English teacher read a book aloud, no one batted an eye at a quote by a character who lost part of her leg from a land mine: "Every day, I wished I had it back."

Delanie's fifth-grade classmates say they are excited about her new robotic arm, but they are used to how she is. "It's going to be cool, but she does so much without it," her best friend, Georgia Collier, said. "It's going to be different."

Gallagher said Delanie sometimes worries about her future. She wonders how she will drive a car, if she will be able to take care of children.

As she enters her preteen years, she's figuring out new things like how to hold a blow dryer, put on makeup and curl her hair.

Delanie definitely likes how the new arm looks. She asked that it be pink, engraved with her initials. She named it Rosy Pink Petunia Gallagher.

Dr. Charles Goldfarb, a WashU orthopedic surgeon at St. Louis Children's Hospital who cares for children with amputated limbs, said a prosthetic can have social benefits.

"Can we help her do more things a little similar to her peers?" Goldfarb said. That may become more important as she gets older. "A teenager wants to be like any other teenager," he said.

SYDNEY SYNDROME

The Minimally Invasive Surgery Biomaterials Lab opened on the medical campus just over three years ago. Its focus was using a 3-D printer to create and test bioabsorbable surgical mesh.

In 2014, the lab learned of three engineering students whose senior project involved using a 3-D printer to create a prosthetic for 13-year-old Sydney Kendall who had lost her arm six years earlier in a boating accident.

That sparked the start of the lab's work with prosthetic arms. "We asked, 'Can we take this up and improve what the students have worked on?'" Thompson said.

A wire in the arm the students created for Sydney was connected to a sensor in her shoulder. Shrugging her shoulder caused the hand to open or close. The wire was cumbersome, she told the scientists, and difficult to use.

So, the lab printed a prosthetic with a myoelectric sensor inside its socket that could move the hand and wrist and gave it to Sydney. She found it needed a stronger grip and was heavy. They refined it again, printing her another last spring. The process offered promise.

"It justified to do this type of study on pediatric patients," Thompson said. "That's where we are now."

Scientists hope a study of more children will give them feedback on how to overcome what they refer to as "Sydney Syndrome" - the prosthetic sitting in a drawer collecting dust.

Participants will complete questionnaires three months, six months and a year after getting their prostheses.

"Now we feel we have a design that is of high enough utility to try on multiple patients to see if there's any benefit from using them," Thompson said. "The patients will tell us what directions we need to go in to make it better."

SUPERHERO ARMS

The study is funded by a $10,000 grant from the St. Louis Children's Hospital Foundation. Low-cost 3-D printing makes it feasible.

A 3-D printer works like a regular ink printer, but instead of ink, it prints layers of heated plastic to create models designed with a computer program.

The technology dates to the 1980s and was used in manufacturing to make machine parts. In the 2000s, consumers began buying home printers to make jewelry or toys.

In the past several years, surgeons have created models of organs and tumors to plan for surgeries. And researchers are experimenting with using materials to print heart valves, stents and skull fragments.

The science is advancing rapidly. "The concept of 3-D printing has

flipped the prosthetic world over," Goldfarb said, not just in terms of the possibilities, but also in its purpose.

"For forever, our goal with a prosthetic has been to make something unobtrusive and unnoticeable with the same skin tone. But it doesn't do much," Goldfarb said. "These prostheses look nothing like your arm. They look like superhero arms. They are bold and distinctive looking.

"The difference philosophically is we're making arms that say, 'Hey, look at me. I've got a great, cool arm; and I'm not trying to hide it. It's part of who I am.' ... It's a different concept, and it's helpful for a lot of kids."

LEARNING CURVE

Back in the lab, as technicians tested the myolectric sensor in Delanie's new arm, the sensor wasn't consistently picking up the signal to move the wrist.

After more than an hour of trying to find the problem, they determined Delanie will have to figure out how to best position the arm so the sensor picks up the signal from her muscle.

"That's the learning curve for her. No one can do it except her," Thompson said. "As she wears it more and more, she'll figure out how it feels when it's in the best spot."

Delanie's dad, Joe Gallagher, joked she's not allowed to hold eggs with it yet.

"If she gets to move it three times out of 10, that's a good thing," her father said. "It's a learning process."

While the family is wondering how the robotic arm might help Delanie with what she can already do, they don't have expectations that the science will be life-changing - at least for her.

But with Delanie's help, scientists could someday develop a useful prosthetic for a child who suddenly loses an arm. Or one that a child with a congenital defect could use as a toddler.

Delanie is excited, her parents said, mostly about helping other kids.

"She says, 'I'm helping make an arm for people who lose it or for people who are born like me,'" her mom said. "She's looking at it as, 'I'm making history, and helping makes lives better.'"

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