Tailor-made prosthetic liners could help more amputees walk again

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Dr. Elena Seminati, John Roberts, Matt Young and Dr. Vimal Dhokia display a bespoke prosthetic liner. Credit: University of Bath

Researchers at the University of Bath have developed a new way of designing and manufacturing bespoke prosthetic liners, in less than a day.

This potentially life-changing project combines advances in computer science with an innovative manufacturing process to create affordable new personalised prosthetic liners for lower limb amputees.

There are more than 45,000 people in England alone who rely on prosthetic limbs, with more than 5,000 people each year having new lower-limb amputations. For these individuals, the interface between their residual limb (the amputation site) and their artificial limb is of critical importance for maintaining healthy, active lives, and a good fit could make the difference in whether or not they walk again.

Following an amputation, a person's residual limb constantly changes in shape and size during the healing process, which can last between 12-18 months. This variation can result in the liner fitting poorly, leading to tissue damage, causing pain and discomfort for amputees. This is exacerbated by patient activity levels and environmental conditions such as hot weather. This discomfort can lead to patients abandoning their prosthesis and rehabilitation regime, instead being forced to rely on a wheelchair.

This project, drawing on the expertise of a multidisciplinary team of researchers from the University of Bath's Department of Mechanical Engineering, Department for Health and Centre for the Analysis of Motion, Entertainment Research and Applications (CAMERA), is a new approach to providing the liners which fit inside the prosthetic socket that attaches to the artificial leg.

Amputees must currently return to their NHS prosthetist every time their limb changes size for their socket to be replaced or adjusted; many times in the first year following amputation. By providing a series of personalised liners of different sizes, that all fit within the same prosthetic socket, the frequency of these visits can be reduced, improving patient well-being and saving the NHS time and money.

Using a state-of-the-art scanner which quickly captures 3-D shape, the research team precisely scans an amputee's residuum. The scanned data is then used to create a full digital model of the residuum which is subsequently used to design the personalised liner. The liner is then manufactured using a cryogenic machining technique, negating the need for complex and time consuming moulds.

At Bath, the researchers are using a soft polymer neoprene-like material—similar to that used in wetsuits—for the liner, which is more comfortable than the silicon liners used by the NHS. The entire process takes less than a day from scanning right through to the physical liner being fitted.

Case study: John Roberts

The Bath researchers are currently trialling this approach with an amputee volunteer John Roberts. He was born with one leg shorter than the other, but despite multiple operations, he suffered years of chronic pain before finally electing for amputation in 2017. After lifelong pain, John found living post-amputation a relief, but as his stump healed, it changed shape over time and the socket of the prosthetic limb began to rub, causing blisters and irritation.

To help his socket fit his stump, he currently wears multiple socks and a silicone layer, but with the new liner he can just simply wear this next to his skin because it fits perfectly.

This not only gives a more comfortable fit, but makes it easier and faster to fit the limb, meaning John can quickly put on his prosthetic if he needs to get out of bed at night or in the case of a fire.

John said: "I've been quite active since the amputation, enjoying walking and gardening again, so my stump has changed shape a lot, meaning I have to wear up to six layers of socks to make sure the prosthetic still fits properly.

"I've had a few issues with rubbing causing blood blisters with my socket. But with this new liner, blisters aren't really a problem.

"The other really good thing is that I can put on my leg quickly in an emergency. I was very impressed with the new liner, it's amazing what you can do with technology!"

To test the new liner, the researchers inserted pressure sensors inside the socket to check the fit of the liner and used motion capture technology to monitor John's gait.

Dr. Elena Seminati, Lecturer in Clinical Biomechanics at the University of Bath, said: "We use pressure sensors inside the liner to check that the pressure is not too high, which could cause skin damage.

"Secondly we use motion capture technology to check that the movement of John's lower limbs is symmetrical and we also measure him walking across force plates to ensure there is no overloading in his knee, ankle and hip joints.

"We've found this new liner reduces the pressure on the stump significantly, reducing the risk of skin damage and making it more comfortable to walk.

"We hope this technology will help many amputees in the future."

Lecturer in the Department of Mechanical Engineering, Dr. Vimal Dhokia, said: "There's a window of around 18 months where an amputee decides whether to use prosthetics to learn to walk again or use a wheelchair. Unfortunately this is a time the residuum changes in size and shape as part of the healing process, making it difficult to get a good fitting.

"Our technology will help achieve a comfortable fit for the patient and really make a difference in helping them walk again and improve their quality of life."

CAMERA Centre Manager, Matt Young, added: "By working closely with the NHS rehab team at the Bristol Centre for Enablement we've learnt a lot about the real issues faced by amputees.

"This project came about from conversations with amputees and prosthetists and is focused on providing a new solution that has genuine potential for adoption for the majority of users—rather than just a lucky few with comprehensive health insurance."

The researchers are continuing to test and develop this approach, working with John as well as other volunteers joining the study this autumn, to further improve the process and fit of these liners.

They hope to demonstrate this approach is economically viable for use in the NHS and believe this can reduce the burden and costs on the NHS as well as dramatically improve the quality of life of amputees using prosthetics.