O&P BusinessNews™
WITH CLINICAL INSIGHT FOR EVERYDAY PRACTICE
November 2012

New Technologies Poised to Increase Upper Limb Prosthetic Acceptance

A cosmetically lifelike prosthesis can give a patient a distinct psychological advantage in accepting it as an extension of their body.

As an upper limb prosthetic rehabilitation specialist, helping patients become confident and satisfied prosthesis users is the purpose of my work. New technologies that are emerging from publicly funded research projects, private labs and prosthetic manufacturers are bringing increasingly sophisticated components and advanced clinical techniques to upper limb patients. Yet one of the fundamental challenges in upper limb prosthetics remains: Research indicates that about 46% of people with acquired or congenital upper limb loss choose not to wear a prosthesis at all. This means that almost half of those with unilateral upper limb loss come to rely primarily on their remaining hand to complete most manual tasks. Those with bilateral upper limb loss do not have this option and are more likely to wear a prosthesis on at least one side.

John Miguelez, CP, FAAOP, aims to combine the best features of body-powered, myoelectric and multi-articulated prostheses.

In our centers we spend a lot of time trying to understand the factors that influence acceptance and successful use of an upper limb prosthesis. Some of these are the type of prosthesis; the fit and comfort of the prosthetic interface; the occupational therapy and prosthetic training the patient receives; and the type of terminal device that is selected. Whether it is a mechanical hook, electric greifer, passive restoration or myoelectric hand, the terminal device is the key component that every upper limb prosthetic user must learn to live with. We are seeking to replace the human hand — a marvel of biomechanical design that encompasses 27 bones, 29 joints, 33 muscles, 22 axis movements, and a protective epidermis that is both durable and flexible. This level of complexity, function and appearance are extremely difficult to replicate.

Recent breakthroughs in multi-articulating compliant hands have advanced functionality while retaining the natural appearance of a human hand. These components are an excellent example of the impact new technology may exert on upper limb prosthetic acceptance. I hypothesize that if research scientists and clinicians can incorporate the strongest features from body-powered, myoelectric and multi-articulating designs into one prosthesis, the rate of prosthetic acceptance would increase. More people with upper limb loss would be able to achieve increased function, thereby integrating their prosthesis intuitively into their daily lives and body image.

Combine what works

Each type of upper limb prosthesis has specific advantages and disadvantages. Whereas body-powered prostheses may be aesthetically lacking, the cable driven terminal device is fast and responsive. Conversely, myoelectric hands are aesthetically superior, yet with slightly less responsiveness and speed than body-powered hooks. It is an unfortunate sort of irony that each of these designs embodies attributes that another is lacking.

What we often see with patients at our centers is that they do well using their prosthesis when responding to the functional guidance of their prosthetist or occupational therapist. However, once they're in their natural environment, such as at home or work, it becomes more of a struggle to incorporate the prosthesis into daily activities. With body-powered devices, users like knowing that when they activate the harness by moving their shoulder, the prosthesis will respond immediately, predictably and consistently. But over time, they may end up feeling dissatisfied with its mechanical appearance, low grip force and uncomfortable harness system.

The difficulty in operating the terminal device above or below the horizontal midline of the body is also a negative. With myoelectric devices, users like the appearance, comfort level and grip force. However, if they have previously used a body-powered design, they may notice a slower speed and response time with the hand. They "think" the action they want to make, give the muscle signal, and the hand moves after a slight delay. For the patient, this experience can result in a subtle yet important sense that the hand is not as reliable as it could be. This may limit their confidence in the prosthesis, which in turn may prevent them from developing natural, fluid patterns of use that mimic a natural hand.

Whether it is a body-powered or myoelectric prosthesis, the net result might be that the prosthesis is worn less frequently. In some cases the prosthesis is rejected altogether because it is simply more efficient to perform tasks with the remaining hand instead of the prosthesis.

Multi-articulating hands have taken myoelectric hands to a higher level, incorporating multiple grip patterns, individual finger movement, rotating and flexible wrists, and in one case, an electric opposable thumb. New technologies such as these seek to unite the positive features of body-powered and myoelectric designs while eliminating most of the disadvantages. Going forward, as we integrate new control schemes, including pattern recognition, both the speed and responsiveness of myoelectric hands can be increased. The overarching theory is that multi-articulating hands of today and in the future can become natural, intuitive extensions of a person's body, thereby having the power to positively impact long term patient acceptance.

Appearance matters

Years of observing and talking with patients have substantiated my belief that when a prosthesis closely resembles a human hand, it can be a key factor in improving acceptance rates. I believe this phenomenon is connected to the many ways we use our hands to interact with other people and the world in general. When one or both hands are absent, it is a highly visible loss.


Multi-articulating hands can become more natural extensions of the human body and encourage patient acceptance.

Terminal devices like body-powered hooks and electric greifers, although functional, look completely unnatural as a replacement for the human hand. While passive cosmetic restorations usually mirror the appearance of the sound hand, they offer minimal function outside of a stable surface to brace an object against. Myoelectric hands combine good function with the natural appearance of silicone cosmetic gloves. The three newest multi-articulating hands offer the highest degree of functional advantages, while also retaining the realistic shape and appearance of a human hand. Each one has innovative mechanical qualities that augment the natural appearance through lifelike movement.

Of these three new prostheses, I believe the Michelangelo hand may have the greatest impact on patient acceptance because of its significantly higher speed, grip force, responsiveness (ability to switch directions quickly), and advanced proportional control.

These attributes, combined with an electronically positional thumb, allow patients to perform bimanual tasks by using their contralateral hand or body to preposition the thumb to achieve different grasp patterns.

Prostheses that look like hands, and include a range of both subtle and profound natural movements, give patients a distinct psychological advantage in accepting the prosthesis as an extension of their body.

Issues of acceptance

The fit and comfort of the prosthetic interface is another key factor that influences acceptance and successful use of an upper limb prosthesis. At our centers we are making a real impact on comfort and range of motion with custom fabricated silicone interfaces that allow patients to wear their prostheses for longer periods of time. We use two types of silicone: injected or room temperature vulcanizing (RTV) silicone, and rolled or high temperature vulcanizing (HTV) silicone. Injected RTV silicone interfaces are supple and dynamic, moving synergistically with the residual limb. Rolled HTV silicone offers increased durability and high tear strength.

Miguelez advocates occupational therapy be incorporated into every phase of prosthetic rehabilitation.

Silicone is a biocompatible material that poses no risk of injury, toxicity or rejection by the immune system. Custom silicone interfaces are particularly beneficial for people with sensitive skin, allergies, scar tissue or bony prominences. Silicone has the potential to be used in a range of prosthetic applications. For example, accessories and components such as distal pins, batteries, wires, fabric and ports can be imbedded in the silicone.

As new technologies advance the state of upper limb prosthetics, the importance of occupational therapy is underscored. Therapists who specialize in upper limb rehabilitation address many patient issues that include psychosocial concerns, physical challenges and functional ability. I believe it is critical for therapy to be incorporated into every phase of prosthetic rehabilitation, with therapists and prosthetists working together as part of a comprehensive team. Therapists combine clinical knowledge with expertise in prosthetic components to develop refined techniques for prosthetic training. This allows patients to optimize the rehabilitation potential offered by new technologies.

As new technologies, materials and techniques emerge, people with acquired or congenital upper limb loss will have access to increasingly refined prosthetic devices. I envision a better myoelectric prosthesis — a broader, multilayered solution that combines sophisticated prosthetic hand function with highly realistic appearance, advanced comfort, and precise therapy and training. Ultimately, the more closely we can replicate the function and aesthetics of the human hand, the greater the impact will be on upper limb prosthetic acceptance. — by John Miguelez, CP, FAAOP

Disclosure: Miguelez is president and senior clinical director of Advanced Arm Dynamics.