A Terminal Device for Every Patient Need

(Continued from page 2)

Depending on the amputation level, an elbow component may be necessary even when the elbow joint remains intact. Patients with high forearm amputation may not have the residual strength to perform the pronation, supination and flexion movements necessary to support a terminal device; thus, body-powered systems incorporate various types of elbow hinges to help support the prosthesis and allow for the rotation necessary to power it. Electric-powered elbows, such as the Utah Arm, Boston Arm and the Hosmer Electric Elbow, include a friction or alternative turning mechanism to permit rotation of the humerus, as well as a locking feature to assist in positioning the terminal device. The ability to lift objects of some weight is critical, thus elbow component design is focused on providing reasonable lift capacity for the performance of household chores, gardening, sports or manual work.

Active Prehensile Devices — Active components incorporating the ability to voluntarily open or close by means of a cable deliver a much higher level of function than more passive devices. Voluntary opening and closing hands provide a more acceptable cosmetic solution for some patients, while affording a mild to moderate degree of grip and movement.

External Powered Hands and Prehensors — Fulfilling the need for ever more precision in replacing the manipulative power of the natural hand, researchers have developed a wide range of electric hands, hooks and grippers (or “greifers”) to enhance grip and functional capabilities.

Terminal Devices

Regardless of the type and mechanism of an upper-limb prosthesis system, most are designed to replace the intricate manipulation and grasping functions of the normal hand. A hand substitute or terminal device (hands, hooks and work or recreational tools) is adapted to the prosthesis system as needed by the patient.

Passive Devices — Passive, lifelike hands are appropriate for some patients. Some have bendable or spring-loaded fingers, allowing patients the ability to grip objects. Others are specially fitted with a wide array of options to allow for the performance of household chores, gardening, sports or manual work.

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Cosmetic gloves and sleeves are available with some hands to give a more natural appearance for patients who express that preference. The use of silicone-based gloves and sleeves has made them more lightweight and thus more acceptable for use by patients of all ages. The march of technology continues to improve prospects and outcomes for upper-limb amputees.

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Nobbe Orthopedics, Inc.
3010 State St. • Santa Barbara, CA 93105

Building Blocks to Upper-Limb Restoration

Patients referred to our practice for evaluation and restoration of an upper-limb deficiency, whether congenital or acquired, undergo a detailed process designed to provide the most practical and functional prosthesis for their individual needs, preferences and capabilities. Definitive upper-limb prostheses cannot be pulled complete from a box but are unique combinations of socket type, suspension method, control scheme, wrist and/or elbow units, and a terminal (hand substitute) device. The management process is as much art as science.

Early intervention is key to a successful prosthetic upper-limb solution for patients undergoing amputation. Long-range success is normally best achieved with the patient at the center of therapeutic decision-making by a rehabilitative team including the amputating surgeon or rehabilitative specialist as team leader; a certified prosthetist for component selection, fabrication and fitting; physical therapist for residual limb care; occupational therapist for functional training; other professionals as needed, and the patient’s family. Patients may be fitted with a preparatory prosthesis to aid in their adjustment to the replacement limb. The preparatory system can be used to help mold the residual limb in readiness for fitting of a more permanent device.

Componentry

Aside from simple cosmetic solutions, the ultimate goal of upper-limb prosthetics is restoration of manipulation and grasping functions lost to amputation or congenital deficiency.

(Continued on page 2)
Upper-Limb Prosthetics—Both Art and Science

The challenge with body-powered system sockets, with their associated harness and cables, is to sufficiently convey the muscular movements needed to power the prosthesis. For myoelectric systems, the task is to secure electrodes against the skin covering muscle areas to convey signals and allow muscle contraction at the same time.

Newer systems incorporate self-suspending sockets with roll-on liners made of silicone or similar material. These liners provide the high levels of friction necessary to increase suspension strength while maintaining secure skin contact. Advantages of body-powered systems are their relatively light weight, lower cost and high reliability. Disadvantages include the sometimes-exaggerated movements and high energy needed to operate the system. Nevertheless, body-powered systems have been the mainstay of upper-limb prosthetic solutions for decades.

Externally Powered Components — Components whose function is provided by an external power source, typically a battery, are most often controlled by electromyographic signals generated by muscle contraction in the residual limb and sensed by electrodes in the socket. An alternate method of actuating externally powered components involves one or more touch pads strategically built into the socket for actuation by residual limb musculature. Like myoelectric sensors, touch pads are available with proportional speed control: The greater the input signal, the higher the speed of actuation.

Advantages of externally powered components are their more complicated and a more flexible and lightweight design. Nevertheless, body-powered systems have been the mainstay of upper-limb prosthetic solutions for decades.

Wrist and Elbow

A prosthetic wrist allows an amputee to adjust a terminal device for optimal functioning. Both manual and myoelectric models are available. The simplest are friction units that maintain the terminal device in position under load while preventing undesired rotation; however, the amputee can still rotate the terminal device manually. Constant friction wrist units prevent rotation throughout the entire range of motion.

Quick-release wrist units, which allow the amputee to snap various terminal devices on and off quickly and lock them down firmly, are useful for frequent changes of implements for work or hobby activities.

Will Amputees Use Their Prosthesis?

Observations over the years have revealed adult amputees’ acceptance of upper-limb prostheses to be relatively low. On the other hand, practitioners have noted that children fitted with a prosthesis at an early age exhibit great potential for acceptance and success.

Optimal acceptance by adults seems to occur when the initial fittings are performed in the first week to 30 days after amputation. Adults seem to respond best to a comprehensive program wherein they are thoroughly introduced to the prosthetic options with the ability to touch and feel the devices and understand their capabilities.

Therapists on the team are instrumental in evaluating how the patient works, uses his/her hands and arms, learns, and applies new knowledge. When these findings are integrated into an overall therapeutic plan, adult upper-limb amputees can claim a stronger ownership of their prosthetic system and its use.

For the best prosthetic outcome, patients should undergo careful and test socket fittings as soon as feasible after their full evaluation and receive and begin training in their prostheses in the shortest time possible, with regular follow-up and adjustments along the way.

MYOELECTRIC COMPONENTRY COMING OF AGE

Having evolved gradually over the last three decades, myoelectric systems for upper-limb amputees are hitting their stride. Technologic advances in the computer industry, in motor and battery design, and even in cell phones and handheld video wizardry have been put to use in the search for highly functional prosthetic systems.

By means of surface electrodes embedded in the prosthesis socket, myoelectric systems detect and amplify muscle action potentials from voluntarily contracting muscles in the residual limb. These signals control one or more motors to actuate terminal device movement, wrist rotation and/or elbow flexion and extension.

Programmable microprocessor circuits have reduced the need for laborious adjustments in these advanced prostheses. Advanced sensory controls and lighter, more durable batteries are making upper-limb prosthetics more adaptable for the majority of patients and easier to adjust as their capabilities change.

Specialized prosthetic manufacturers have developed comprehensive systems for replacement of hands, wrists, elbows and even shoulders. The two highlighted below have passed through several generations of design and innovation, assisted by feedback from rehabilitation professionals and patients.

The Boston Digital Arm System from Liberating Technologies incorporates a variety of advanced controls, features to augment the function of the company’s core product, the Boston Elbow. The system’s advanced microprocessors can control up to four other prosthetic devices in addition to the elbow—hand, gripper, wrist rotator, shoulder lock actuator, etc. Recent digital improvements now enable settings and adjustments to be made even while the patient is wearing the prosthesis.

The internal microprocessor also allows for monitoring the system as it is being worn. These improvements reduce the need for prosthesis down time for disassembly and adjustments.

Motion Control’s Utah Arm 3, the latest version of the pioneering system that first appeared a quarter-century ago, incorporates micrometer technology and a computer interface to allow either the wearer or prosthetist to fine tune adjustments to the system. The Utah 3 incorporates proportional control, which allows the wearer to move the arm and hand slowly or quickly in any position, providing more natural movement with less effort. A notable advance for the Utah 3 advance is that wearers can control its elbow and hand function simultaneously.

Additional notable componentry innovations include:

What’s New

- The Otto Bock SensorHand SPEED electric terminal device adds a quieter motor and unprecedented opening and closing speed to its SensorHand “Auto-grasp” technology, which senses when an object is held in the hand and applies more grip force, then automatically adjusts tension, such as when filling a glass with water.
- Motion Control’s powered terminal devices for the Utah Arm system include several hand components and a water-resistant hook-type component known as the ETD or Electric Terminal Device (see page 1). The ETD’s hook “fingers” generally permit finer functioning than hand-type fingers. Moreover, its ability to resist liquids allows wearers to engage in “wet” activities of daily living, such as showering, with the device in place.
- Motion Control hands and the ETD all can be equipped with a new option called the Flexon Wrist, which can be set to one of three positions allowing wearer to flex or extend the wrist thus placing the hand in a more natural position for performing specific tasks.
- Liberating Technologies recently introduced the LTI Locking Shoulder Joint for high-level deficiencies is designed to provide a free-swinging joint that can also be locked in multiple positions, as required, with either manual or electronic control. Its lightweight and relatively smaller profile make this component adaptable for both pediatric and adult use.
- As electric prostheses have become more functional, the need for a reliable, longer-lasting power source has become more critical. Recently improved lithium ion battery packs provide all-day power, if used appropriately, from a surprisingly lightweight package.

Note to Our Readers

Mention of specific products in our newsletter neither constitute endorsement nor implies that we will recommend selection of those particular products for use with any particular patient or application. We offer this information to enhance professional and individual understanding of the orthotic and prosthetic disciplines and the experience and capabilities of our practice.

We gratefully acknowledge the assistance of the following resources used in compiling this issue:

- Hosmer Dorrance Corp. • Liberating Technologies Inc. • Motion Control Inc. • Otto Bock Health Care • TRS Inc.

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Socket Design

The interface between residual limb and the prosth-
thesis is vitally important to ensure patient acceptance of
a particular system. Sockets are improved over the past decade, incorpo-
rating more flexible and light-
weight materials, providing secure skin contact while
preserving sufficient protec-
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