The Hinnant Prosthetics Quarterly

Experience Our Road to Prosthetic Excellence

Winter 2002

Upper-Limb Prosthetics—2002

Prosthetics Today

Restoration of manipulation and grasping functions lost to upper-limb amputation (or creating those abilities where none previously existed in the case of congenital defect) is one of the most fascinating and challenging aspects of rehabilitative medicine.

An estimated 12,000 major upper-limb amputations occur each year in the U.S.; the needs and capabilities of every patient are different from all others. Creating a new prosthesis requires a series of decisions regarding the type and construction of the socket, method of suspension, control scheme, and terminal device. The process is as much art as science.

Patients referred to our practice for evaluation, prosthesis design, component selection, fabrication, fitting and follow-up go through a detailed process designed to provide the most functional and practical prosthesis for their individual situation, needs and desires.

Management

Experience has shown that the longer an upper-extremity amputee has to become accustomed to the idea of being one-handed, the less his/her motivation to put forth the effort to learn to use a functional prosthesis. Therefore, early fitting is generally recommended, other factors permitting. A preparatory system provided soon after surgery encourages the new amputee to develop a positive outlook before despair or resignation can set in.

Ideally, the new amputee can be managed by a rehabilitation team consisting of the amputating surgeon or alternatively a physiatrist as team leader; certified prosthetist for component selection, fabrication and fitting; physical therapist for residual limb care; occupational therapist for prosthetic training; other professionals as needed, and the patient's family. Of course, the most important team member is the patient himself.

Otto Bock SensorHand
(see page 4)

Socket/ Suspension

Though neither end-bearing nor weight-bearing, an upper-limb socket must still provide a firm attachment point for the prosthesis while protecting the tissues of the distal residual limb. A total contact design is generally used to control residual limb edema and enhance proprioception. The exact construction will depend on both the length of the residual limb and factors related to the physical capabilities and functional desires of the patient.

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Dear Friends:

We are pleased to bring you this *Hinnant Prosthetics Quarterly* focusing on upper-limb prosthetic systems. We hope you find this information interesting and professionally relevant.

This issue also gives us an opportunity to mention the recent success we have enjoyed with the new ICEROSS Upper-X suspension liners. These new transradial and transhumeral liners are achieving near-100% acceptance among our upper-limb patients, including some who had been satisfied users of custom silicone liners for many years but are now impressed with the enhanced comfort and stability of these new interfaces.

Kale

Upper-X liners can be stretched up to 60% radially to comfortably accommodate all shapes and sizes of residual limbs, yet their vertical stretch remains less than 1% to prevent pistoning.

We welcome your comments, questions and referral inquiries.

– M. Kale Hinnant, C.P., FAAOP

Upper-Limb Prosthetic D

(Continued from page 1)

Many upper-limb prostheses are suspended by a combination of intimate socket fit and a strategically positioned upper-body harness, which in body-powered systems also anchors the cable(s) controlling the terminal device (and possibly an elbow unit). Design and construction of the harness vary with the level of limb absence and the build and capabilities of the patient.

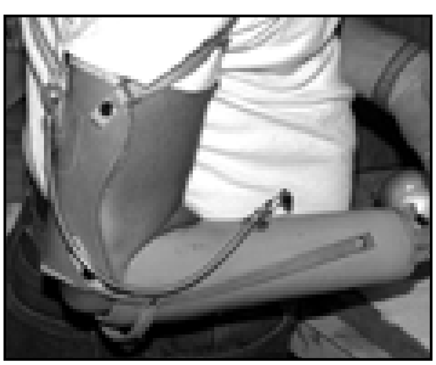
Suction suspension has become a viable alternative when patient anatomy and physiology will allow. The roll-on silicone socket with shuttle lock, originally introduced for lower-limb applications, is now being applied to upper-limb systems as well.

Conventional Control Systems

The conventional or body-powered upper-limb prosthesis utilizes movement of the residual limb and shoulders to actuate a terminal device, prosthetic joint or locking device. This force and motion are delivered by a cable and harness, which crosses the chest or shoulders. Each level of limb absence presents different prosthetic challenges; in general, the higher the level, the greater the challenge:

Partial-hand—Because any retained prehensile capability and sensation are preferable to the best prosthesis, surgeons normally seek to retain even the slightest functional part of the hand whenever possible. Partial-hand prostheses are usually designed to (1) provide opposition for one or more residual digits or segments and/or (2) restore cosmetic wholeness. Each prosthesis is custom-designed to the needs of the particular patient.

Transradial—Prostheses for amputation levels between wrist and elbow are generally single-control systems, using a stainless steel cable actuated by shoulder motion on the amputated side to open or close a terminal device.

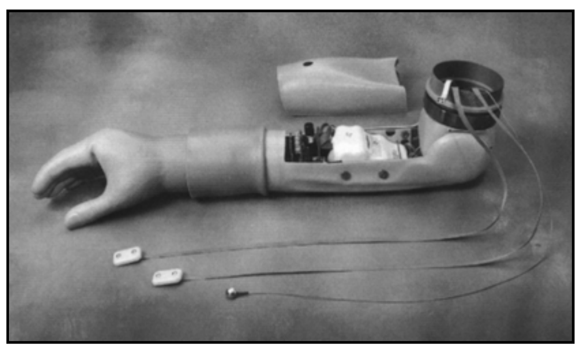


Transradial body-powered prosthesis.

Transhumeral—The addition of an elbow joint adds to the complexity of the prosthesis. The most common approach is to incorporate a second, independent control cable to lock and unlock the elbow unit. In this type of arrangement, movement of the primary cable while the elbow is unlocked generates elbow flexion/extension. Once the lock is actuated by secondary cable action, further primary cable travel is transferred to actuate the terminal device. In special designs, the lock may be actuated by movement of residual limb muscles.

Shoulder/Forequarter—In the absence of upper arm movement to help control the prosthesis, functional restoration for this level of amputation is rather difficult but certainly possible for the well-motivated individual. Prosthesis design at this level is highly individualized.

Bilateral—Other than having two independent systems to deal with, the only major additional hurdle faced by bilateral upper-limb amputees is the complete absence of sensory feedback for prehensile activity. In fact, some bilateral amputees are capable of remarkable "dexterity." For ease of donning and overall comfort, a single harness that controls both systems is usually preferred over two. Generally, the more functional hook-type terminal device is used.



Liberty Technology's myoelectric Boston Elbow prosthetic limb.

Externally Powered Systems

With a myoelectric system, electromyographic (EMG) signals generated by muscle contraction in the residual limb and sensed by electrodes in the socket are used to control the action of a battery-powered terminal device, possibly in conjunction with a wrist rotator and/or elbow flexion unit.

The signal is amplified and fed to microprocessors, which route power to a motor that actuates the hand, wrist or elbow component.

Alternative means of controlling an electrically powered prosthesis include residual limb muscle actuation of a touch pad within the socket, movement of a switch outside the socket, or action of a harness pull switch (servo).

A primary advantage of an externally powered prosthesis is that an external cable is no longer necessary, although a harness may still be required for suspension of transhumeral systems where suction suspension is not feasible.

Disadvantages include increased weight, more frequent and intricate maintenance, the need to maintain visual contact with the prosthesis during actuation, and expense—an externally powered system can cost several times more than a body-powered prosthesis.

Sometimes, patients are best served by a hybrid system incorporating both conventional and externally powered components.

esign Enters New Decade

Pediatric Systems

Experience shows that children fitted with a prosthesis at an early age exhibit the greatest potential for success. A passive prosthesis can usually be introduced when the child is able to sit alone (about six months) and a body-powered system with the advent of muscular coordination (2-3 years).

Most upper-extremity components and terminal devices come in children's sizes; myoelectric systems for young patients are also offered. Training can be more difficult in children, but with solid parental support they can become proficient with their prosthesis in a relatively short time. From then on, children frequently become more adept with their prosthesis than comparably able adults.

For the 2000s: Better and Smaller

In this new decade, noteworthy improvements in upper-limb componentry can be found primarily in a variety of myoelectric innovations produced by experienced manufacturers. For example, Liberty Technology's VariGrip II is a new microprocessor controller for operating up to three powered prosthetic devices such as hands, wrists and elbows—most controllers are limited to two.

Motion Control has introduced the next generation of its Utah Arm above-elbow and ProControl below-elbow myoelectric systems. The Utah Arm 2 features all-new circuitry for elbow and hand control and the new ServoPro controller option, which enables high-level amputees—even those with a shoulder disarticulation—to operate a Utah Arm system.

The ProControl 2, only one-third the size of the original version, is now small enough to fit into almost any prosthesis. It also has the new capability to calibrate its sensitivity to electromyographic (EMG) signals automatically.

Also new is a lithium ion battery pack, which provides three times the power of previous NiCad batteries but takes up no more space and can be fully recharged in about three hours.

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The 2000s are bringing new opportunities for upper-limb-deficient patients, and we are prepared to help realize them.

We welcome your inquiries, questions and referrals.

Hooks, Hands Define Upper-Limb Success

Aside from patients whose sole objective is cosmetic restoration, the primary motivation for wearing an upper-limb prosthesis is to regain the missing hand's prehensile functions: holding, carrying and manipulating.

Except for partial-hand devices, which take advantage of a certain degree of retained prehension capability, all upper-extremity prostheses involve some form of hand substitute or terminal device, broadly classified into "hands" and "hooks." Nearly two-thirds of amputees in the U.S. use hook devices.

Amputee Golf Grip

Hand components are more cosmetically pleasing but as a rule are less-functional, heavier and less-durable than hooks. Hands may be either voluntary-opening or voluntary-closing, utilizing either relative body motion or external power to overcome static elastic force. Many options, ranging from relatively inexpensive passive models to intricate electrically actuated systems, are now available.

Hooks come in many configurations and sizes, including models designed for heavy-duty vocational activities, farming, etc. In general, hooks permit better visibility of prosthesis movement than hand devices, an important functional consideration given the absence of normal sensory feedback. Most hooks are designed for body-powered systems; however, electric hooks, capable of up to 22 pounds of force, are also available.

A wide selection of hook designs and sizes is available.

Another group of terminal devices addresses the special requirements of athletes and outdoor enthusiasts, notably golfers, cyclists, fishermen, and ball players of all types. Active individuals may in fact use several terminal devices matched to their varying activities—all devices manufactured in the U.S. use a standard mounting stud for mating with the prosthetic forearm and thus are readily interchangeable.

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A Terminal Device for Most Every Need

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Hosmer Dorrance Corp., long a leader in the manufacture of quality terminal devices, offers an intriguing array of special-purpose tools and implements. From baseball mitts to potato peelers, these terminal components enable and simplify difficult and precise chores and hobbies for people with upper-limb absence.

The **Hosmer Driving Ring**, for example, attaches easily to steering wheels of automobiles, boats and aircraft, providing a sure connection seldom achieved with a standard hook or hand.

The molded silicone rubber **Skiing/Fishing Hand** resembles a closed fist and grasps either a ski pole or fishing rod. It is available in right or left models and several sizes, and remains pliable in sub-zero temperatures.

Hosmer's **Baseball Glove Attachment** has thumb and forefinger steel extensions that hold and firmly grip a first baseman's mitt. Knobs on the finger extensions allow the glove to be securely attached.

The **Bowling Attachment** is inserted into a hole in a bowling ball where a rubber expansion sleeve expands under spring pressure to "hold" the ball. The same action used to operate a conventional hook causes the device to release the ball during forward swing.

Hosmer's **Hayden-Preston System** combines the Preston Terminal Device (PTD), which features a 45-degree range of motion and 360-degree rotation with an assortment of Hayden tools and implements to enable upper-limb amputees to continue the activities of their pre-limb-loss lifestyle. Hayden implements feature push-button release end-pieces that quickly and easily insert into and extract from the universal PTD.

Implements include box-end or open-end wrench sets (metric or standard), plier and file sets, and adjustable-wrench sets. Among individual cutlery and kitchen tools are a cheese grater, melon baller, pizza cutter and vegetable peeler, all dishwasher-safe. Carpenter and garden tools, and hunting and fishing items are also available.

New for the 2000s

One of the greatest problems for a patient with upper-limb loss is being "out of touch," i.e. not having the constant innate awareness that he/she is applying the appropriate amount of pressure to hold or manipulate an object without dropping or damaging it. A newly introduced terminal device seeks to eliminate that concern.

The Otto Bock SensorHand™ gives patients an increased sense of confidence knowing they have a stable grip on any object in hand, notably fragile items and liquid-filled containers. If the object is about to slip, a sensor in the thumb detects changes in the object's weight or center of gravity.

This information is transmitted to an on-board microprocessor, which adjusts the grip force automatically. As wearers become confident in the system, many find they no longer need to keep constant watch on the object being held.

The SensorHand incorporates a proportional control system that regulates hand speed and grip force.

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Quick-disconnect wrist units make it possible for upper-limb prosthesis-wearers to maintain and use a variety of terminal devices based on their needs, desires and lifestyle. We are prepared to help patients obtain and become proficient in their use and thereby begin to enjoy life again.

For details, call our office.

Hinnant Prosthetics

Prosthetic Specialists Since 1934

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