Orthotics & Prosthetics East Inc.

Above and Beyond the Rest

NEWS

Current Trends and Developments in Orthotic & Prosthetic Rehabilitation No. 12

Keeping Prostheses out of the Closet

Socket Function, Comfort Largely Determine Prosthetic Success Level

The prosthetic socket, essential point of integration between human tissue and replacement limb, is most often also the place where degree of prosthetic success is defined.

Sockets

• It is the socket that accepts and transfers to the residual limb the stresses of weight-bearing, suspension and ambulation.

• It is the socket that encompasses and accommodates the often irregular and tender tissues of the residual limb and thereby helps determine how well, and for how long at a time, an amputee can function in the prosthesis.

• It is the socket that can, through intimate and comfortable fit, smoothly deliver the advanced gait performance promised by today's sophisticated upper- and lower-limb prosthetic componentry.

In other words, a prosthetic limb may incorporate the most sophisticated, technologically advanced and expensive components available, but if the socket does not fit well and allow the residual limb anatomy to function to its capabilities, the result will be less than optimal, the user will not be happy, and the prosthesis may well stay in the closet.

Transtibial PTB socket with locking pin suspension
Courtesy Willow Wood

For this reason, our prosthetic staff devotes paramount attention to designing and fabricating the best possible socket for each amputee we serve.

Transfemoral limb prosthesis
Courtesy Fillauer Inc.

Sockets are as unique as the people who wear them; no two are alike, but certain principles proven to enhance comfort and functionality are built into many current-day designs:

• **Total contact**—Through careful creation and modification of a positive model of the residual limb, our prosthetic team forms the unique optimal socket shape for that individual. For most amputees, our goal is total contact between limb and socket.

A total contact socket enhances venous return, limits edema and reddening/inflammation on the distal end of the anatomic limb, and helps distribute the load somewhat.

Courtesy Motion Control Inc.

• **Total surface bearing**—A total surface weight-bearing socket expands on this concept by distributing forces across the entire residual limb surface. Advantages include reduced pressure on any given limb tissues, better sensory feedback to the user, improved circulation and increased proprioception.

• **Reduced weight**—Lightweight, high-strength sockets enable amputees to do more with less energy expenditure. One way this can be achieved is with a flexible inner socket within a laminated or rigid plastic outer frame. The outer frame covers the primary weight-bearing areas of the residual limb, while pressure-sensitive tissues and bony prominences are encompassed only by the softer inner socket.

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O&P East Spotlight

Orthotics and Prosthetics East proudly introduces the newest addition to our clinical staff, Tim Foster, PT, CO. Tim has more than 25 years of clinical experience with orthopedic and neurologically compromised patients.

Tim Foster, P.T., C.O.

Tim was graduated from the University of Louisville physical therapy program in 2002 and attended the orthotics program at Northwestern University. He is attending the N.U. prosthetics program this year.

For more information on Orthotics and Prosthetics East, visit our web site at **www.oandpeast.com** or call us at **252-215-2215**. We are located at 2485A Hemby Ln., Ste. A in Greenville, N.C.

Suspension — How Prosthetic Limbs Stay Attached

Creating a prosthetic socket involves two major decisions: (1) the design and shape of the socket itself and (2) the method by which the prosthesis is held onto the residual limb, i.e. the suspension. More than any other aspect of prosthetics, socket design and suspension strategy usually spell the difference between prosthetic success and the closet.

Suction Suspension

For appropriate patients, using an atmospheric vacuum to hold the residual limb in the socket can provide a superior outcome. Suction options — whether provided by "pure" suction or a roll-on liner, possibly with some type of vacuum assist — limit limb movement within the socket and provide the best level of proprioception and greatest range of motion among current suspension methods.

With **pure suction**, precise socket fit enables residual limb skin to remain in full contact with the socket wall and thus preserve the vacuum created at donning. Donning typically involves actuating an expulsion valve at the distal end of the socket to evacuate air as the residual limb enters. A vacuum pump may be employed to enhance the suction once the residual limb is established in the socket.

Harmony® e-pulse transtibial vacuum system
Courtesy Otto Bock Health Care

Contraindications to suction include bony or irregular residual limb contours, often encountered with transtibial amputation levels; significant residual limb volume fluctuation; residual limb skin challenges; and physical or mental impairment that interferes with donning or removing the socket.

Roll-on **suspension liners** can overcome most of these obstacles, protecting the residual limb from shear forces, providing an easier donning method, and compensating for irregular skin contours.

Alpha® Hybrid transtibial locking liner
Courtesy Willow Wood

"Cushion" liners can enhance a pure suction suspension and improve amputee comfort; more common are liners incorporating some type of locking device — locking pin and shuttle lock, lanyard or locking strap — to securely attach the liner to the socket.

Prefabricated liners, available in a variety of materials, designs, and sizes, will work for many patients, while custom liners can be created for patients with major residual limb issues or special needs.

Other suction suspension aids include elastic suspension sleeves, which cover the proximal end of a transtibial socket and extend over the knee to the thigh; and vacuum-assist, which sustains the negative pressure in the socket and helps compensate for residual limb volume fluctuations.

Anatomic Suspension

When suction methods prove unfeasible, suspension utilizing anatomic structures frequently provides a viable alternative, particularly in transtibial and knee disarticulation limbs.

ICEROSS Seal-in transfemoral suction liner
Courtesy Össur

Supracondylar suspension is accomplished by extended medial and lateral socket walls that fully encompass the femoral condyles and a compressible, contoured wedge that fits snugly above and against the medial condyle.

Other anatomic suspension options include constructions that take advantage of congenital protuberances, often involving a cutaway section of the socket and a "door" panel to ease donning and doffing that is applied after the residual limb is in place.

Straps, Belts and Hinges

When suction or anatomical suspension is unavailable for various reasons, some older suspension methods may be employed. Strap suspension schemes, often used in combination with a waist belt, are relatively easy for the wearer to adjust and therefore are sometimes a good choice for individuals likely to encounter substantial changes in residual limb volume, as in the weeks after amputation surgery.

Suspension

A suprapatellar cuff, which encircles the thigh over the femoral condyles and attaches to the socket with straps, may be a good choice for transtibial patients who have good knee stability. It is normally used with a waist belt. A thigh corset with metal side joints, may be prescribed for transtibial amputees with a delicate residual limb unable to withstand full weight-bearing loads.

Short transfemoral liner with waist belt
Courtesy Otto Bock Health Care

For transfemoral amputees who cannot use suction, a silesian belt, total elastic suspension (TES) belt, or hip joint and pelvic belt may be used for suspending the prosthesis.

Courtesy Motion Control Inc.

Upper-Limb Suspension

Suspension methods for upper-extremity prostheses may utilize suction, intimate fit around anatomic structures, a liner, one of several harness suspension methods, or a combination of these.

Harness systems are generally easy to don and remove but can significantly restrict range of motion, and strap chafing is common. Pure suction, where applicable, can provide excellent suspension and is a desirable choice for an externally powered system that does not require a harness for body control.

Gel liners can be used for both above- and below-elbow systems and function mostly like lower-limb liners. A pin and shuttle lock may be used for short-to-medium transhumeral and transradial limbs, while a lanyard system is generally indicated for long transradial and wrist disarticulation levels.

Why Do Check Sockets?

In these times of managed care, cost containment and Medicare caps, the idea of creating one or more preliminary sockets to evaluate design and fit before fabricating a final socket may seem unwarranted and perhaps even wasteful. So why do it?

From the initial socket design, a check socket fabricated of transparent thermoplastic enables us to visualize the all-important interaction between residual limb and socket. Variations in skin color indicate areas of excess pressure or absence of total contact, likely to produce skin breakdown in the future. Movement of the residual limb within the socket forebodes less-than-optimal gait, suboptimal weight-bearing distribution, reduced comfort, increased fatigue and likely skin problems.

In addition to static evaluation, check sockets can also be attached to alignment components and evaluated dynamically as the patient ambulates.

In the absence of check socket evaluation, patients are much more likely to have problems with their prosthesis and require subsequent modification and medical care due to improper fit. This additional step in the prosthetic process may add some additional time and cost up front, but it can head off significantly greater expense and lost time down the road.

Socket Optimization: A Challenge We Welcome Every Day

Laminated transtibial socket

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Transtibial Sockets

Today's below-knee sockets are of two primary types: The "old reliable" **patellar tendon-bearing (PTB)** design focuses weight-bearing stress on certain pressure-tolerant structures, such as the patellar tendon and medial tibia flare, and relieves pressure-sensitive areas. The PTB socket is still preferred by many patients, notably those with shorter or bony residual limbs. It generally is not a good choice for patients with residual limb scar tissue and/or chronic skin breakdown.

The principal alternative transtibial design is a **total surface-bearing socket (TSB)** with a gel interface of some type (silicone or polyurethane liner, gel socks, etc.), which spreads the pressure across the entire residual limb surface at a level comfortable for the wearer.

A hydrostatic weight-bearing socket is a specific version of the TSB design, cast in a compression environment to achieve uniform pressure distribution across residual limb tissues. This design encourages tissue elongation within the liner, increasing padding at the distal residual limb and reducing potential for skin breakdown.

Double wall transfemoral socket
Courtesy Otto Bock Health Care

Transfemoral Sockets

Contemporary above-knee designs typically employ some variety of ischial containment (I.C.) strategy, which has largely replaced the once-common **quadrilateral** (quad) shape. I.C. sockets feature a narrow medial-lateral dimension with the ischium encapsulated within the socket instead of sitting on the brim.

Quad sockets are still applicable for various patients, both for a preparatory prosthesis and as the socket of choice for patients who have worn a quad for many years and do not wish to change.

A particular I.C. design, the Marlo Anatomical Socket®, originally an effort to eliminate the socket brim outline clearly visible under the clothing of female above-knee amputees, also provides increased range of hip motion and may provide added comfort for appropriaate patients.

MAS socket

Upper-Extremity Sockets

Upper-extremity prosthetic limbs are controlled by one of two primary methods: body-powered incorporating a harness and control cables, and externally (electrically) powered, typically with myoelectric control. Body-powered systems may be either harness-suspended, in which straps hold the prosthesis close to the body, or self-suspended, wherein the socket must be closely contoured to the residual limb to encompass bony anatomy or maintain suction. In either type, special care in designing and fabricating the socket is essential for maintaining control and suspension throughout the entire range of motion.

Regardless of limb or amputation level, all socket designs have benefits and drawbacks. Discerning and fabricating the best choice for any particular patient is accomplished only after thorough analysis of the individual's physical condition and capabilities, clear understanding of his/her functional goals and careful anatomical measurements.

It's a challenge we welcome every day.

Wrist disarticulation inner socket

Note to Our Readers

Mention of specific products in our newsletter neither constitutes 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.

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From Disney World to Parallel Bars

Bryce W. is an all-American kid whose idyllic childhood was interrupted by the cruel reality of cancer. On a long-awaited family trip to Walt Disney World in 2009, Bryce, then 8, suddenly could not walk due to pain in his left leg. A few days later, his stunned parents heard for the first time a word that would soon change their lives... *osteosarcoma*.

Down to Cases

Less than four months later, the third-grader and his family learned another new word...*disarticulation*, as a surgeon amputated his left leg through the knee to prevent the malignancy from spreading.

There followed 12 more rounds of chemotherapy (he'd had six previously), additional surgery on his amputated limb and at length transition to a prosthetic leg. In the two years since his diagnosis, Bryce spent 99 nights in the hospital.

The nightmare began to subside upon completion of chemo. With return visits to his prosthetic team and learning to walk again with the aid of parallel bars, Bryce began to gain control of and confidence in his new limb. An active boy in the 99th percentile in height and weight for his age, he requires a sturdy componentry set and still keeps his prosthetist busy.

Eighteen months after receiving his first prosthesis, Bryce, now 11, is making up for lost time. He wears his leg 12 hours a day, runs, rides his bike and plays soccer and drums. Not surprisingly, he is already on his third leg and has gone through three prosthetic feet and two knees...because he wears them out.

Bryce's rehabilitation has been assisted by various national and community organizations that support those with physical challenges. In mid-2011, he attended a camp sponsored by the Challenged Athletes Foundation (CAF). Initially adamant about not attending, he was equally upset at having to leave after an "awesome" experience.

Bryce with CAF mentor and U.S. Paralympic athlete Blake Leeper.

While not every pediatric amputee is able to do as well as Bryce, it is most rewarding to prosthetic practitioners when we can help achieve outcomes that are this positive. He still has the occasional not-so-good day on his prosthesis, but the trend is steadily upward.

More importantly, he once again has a promising future ahead of him, and he and his family have their lives back.

The Prosthetic 'Tune-up'

A prosthetic limb is like a new car in some respects: It's fine tuned and shiny when it leaves our "showroom," but use and time take a toll to the point that periodic servicing becomes necessary if the "driver" wants to continue to enjoy top performance.

As a general rule, we recommend a prosthetic tune-up every six months, more often if the client has undergone weight gain/loss of five or more pounds, changed activity level, or is experiencing significant discomfort or functional problems with the limb.

During this maintenance visit, we will:

- evaluate socket fit and integrity;
- ensure all components are in good shape and provide replacements or adjustments as needed;
- evaluate limb performance and check alignment for gait optimization; address any questions or problems the client may raise; and
- assist with any needed prosthetic supplies (suspension sleeves, liners, limb socks, etc.)

The socket should be replaced if it has become significantly worn, discolored or cracked; if it no longer fits intimately due to changes in residual limb size or shape; or if the wearer has undergone additional residual limb surgery. Most patients can expect to receive several sockets during their lifetime.

To schedule a tune-up, call our office.