



MOVING AHEAD

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Without Comfort, Little Else Matters

To the people primarily involved in the process of providing a new lower-limb prosthesis—the clinical team, the amputee and his/her family—the key aspects of the finished product may be viewed with different priority.

For the amputee's family, cosmesis (the appearance of the finished limb) and presenting an image of physical wholeness may be of paramount importance. To the prosthetist, prescribing physician, therapist, and other members of the clinical team, providing the ut-

most in restored function is frequently the primary concern. To be sure, both of these considerations are generally important to the patient as well.

But while an amputee, his/her family and the attending clinicians can all evaluate and appreciate the inherent functionality and external finishing of a prosthesis, there is a third factor, which only the patient can appreciate, that can render the others inconsequential: Comfort.

If the prosthetic socket does not provide a comfortable and healthy environment for the residual limb, the patient may be unable, or may simply choose not, to wear the prosthesis. At that point, all the advanced functional components and careful finish-

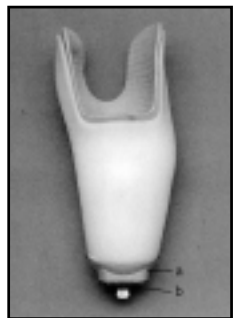
ing crafted into the limb essentially become worthless. A well-fabricated but unused prosthesis is a waste of talent, time, technology and financial resources.

This issue of our newsletter delves into contemporary lower-extremity socket designs and technology of the early 21st century. We hope you find the discussion worthwhile.



Where Prosthetic Success Is Defined — Transtibial Socket Designs —

Today's transtibial amputee has more socket options, and thus greater opportunity for a successful prosthetic outcome, than ever before. The wide range of materials and varieties of liners now available enable our prosthetic team to design and fabricate a replacement limb closely matched to each patient's physical and mental capabilities, residual limb condition, and lifestyle needs, desires and expectations.



Patellar tendon bearing socket with soft liner.

In particular, the development of gel liners, distal suspension methods, and total surface-bearing and hydrostatic weight-bearing designs have enabled many formerly non-ambulatory amputees to forego their wheelchair and become independently mobile.

These breakthroughs provide a better-fitting, more comfortable and more secure interface between residual limb and prosthesis, which in turn increases patient

confidence, stamina and proprioception, the amputee's ability to sense where the prosthetic limb is in space.

Primary Design Choices

We now can choose from among three primary weight-bearing options for transtibial amputees:

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About Moving Ahead

Moving Ahead is a professional newsletter published by Swanson Regional Orthotic & Prosthetic Research Center to inform health care professionals of developments in the orthotic and prosthetic disciplines.

Swanson offers three board-certified practitioners and three state-of-the-art laboratories. The practice has a solid reputation for quality care and patient satisfaction throughout Northwest Ohio and Southeast Michigan and has been in business for more than 22 years.

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Compliments of: Vern Swanson, C.P.; Jeffrey Kuehn, C.P.; and Jon S. Eberlein, CPO.

Socket Innovation Enhances Amb

(Continued from page 1)

Patellar Tendon Bearing (PTB / Specific Weight Bearing) —

The time-proven PTB design focuses weight-bearing stress on certain pressure-tolerant structures, notably the patellar tendon and medial tibia flare, and relieves pressure-sensitive areas. Now well past its 40th birthday, the PTB socket is still viable for, and preferred by, many patients, notably including those with shorter residual limbs, bony limbs and requiring additional knee stability.

This socket may not be a good choice for patients with residual limb scar tissue, and those who experience chronic skin breakdown. Further, a PTB socket does not provide the best fit if used with a silicone or gel liner, thus a pelite or foam liner is often used. It also restricts range of knee motion due to its requisite high posterior brim.

Total Surface Bearing (TSB) — In this design, weight-bearing forces are distributed as evenly as possible over the entire residual limb surface, including areas once considered pressure-sensitive. This socket usually involves a gel interface of some type—silicone

or polyurethane liner, gel socks, etc.—incorporating variable flow characteristics.

It is a primary option for patients with residual limb inconsistencies and can be used for all residual limb lengths. Drawbacks include potential hygiene issues for some wearers and the cost of replacement liners, particularly for “high maintenance” patients.

Hydrostatic Weight-Bearing — This socket is a specific version of the TSB design, incorporating a gel liner and cast in a compression environment to achieve uniform pressure distribution across the residual limb tissues. The design encourages tissue elongation within the liner, increasing padding at the distal residual limb.

For various amputee patients, the advantages of this relatively new design include less potential for skin breakdown, a comfort-

able fit due to nearly equal force distribution across the residual limb, and the security of distal suspension. It has been shown to be a good choice for some patients with pronounced bony prominences in their residual limb.



Ossur ICECAST compression casting bladder

Conversely, hydrostatic sockets are not appropriate for long residual limbs, patients prone to perspiration, and those who for reasons of either advanced age or medical limitations are unable to stand up to the rigors of donning a distal suspension prosthesis.

Suspension Methods

As the adoption of viscoelastic gel materials has broadened socket options for transtibial amputees, so has it significantly improved their suspension choices. While some PTB sockets are still suspended from the patella and femoral condyles or even a thigh cuff, pure suction and suction with distal locking have emerged as the most popular suspension methods.

Hydrostatic Design Rated Against Venerable PTB

The hydrostatic socket purportedly provides a more amputee-friendly residual limb-prosthesis interface than older, specific-weight-bearing designs. A 25-patient study reported in the *Journal of Prosthetics & Orthotics* (1999 Vol. 11, No. 4) measured skin pressures during weight-bearing as well as patient preferences between the relatively new hydrostatic approach and the time-honored patellar tendon bearing (PTB) design. Patients were cast and provided with custom sockets of each type fabricated under controlled criteria and were then asked to wear each for one week.

Results confirm the viability of the hydrostatic socket, revealing significantly fewer pressure peaks during ambulation than with the traditional PTB. Moreover, 68 percent of the study patients preferred the hydrostatic interface design. Reasons cited included uniform pressure distribution across the entire residual limb, increased range of knee motion and a perception of lower prosthesis weight with the hydrostatic socket.

By comparison, 16 percent of the participants expressed a preference for the PTB socket, citing familiarity with the design from past use, preference for a pelite (foam) liner frequently used with PTB sockets, and/or affinity for supracondylar suspension methods often incorporated into a PTB socket.

The remaining 16 percent of study participants rejected both designs.

Though covering only a small sample, this study suggests that hydrostatic sockets potentially offer new comfort and functional improvements to many amputees. The results point to continuing development and increased utilization of the hydrostatic socket design in the future.

Note to Our Readers

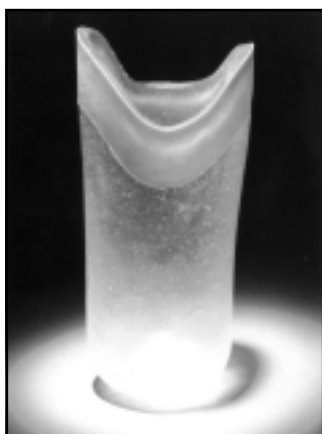
Mention of specific products in our newsletter neither constitutes endorsement nor implies that we will recommend selection of those particular products for use with any particular patient or application. We offer this information to enhance professional and individual understanding of the orthotic and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

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

*Ohio Willow Wood • Ossur • Otto Bock Health Care
TEC Interface Systems*

Amputation Potential

Suction suspension — In a pure suction socket, a socket interface such as an Ossur Iceross liner, Ohio Willow Wood Alpha liner or a TEC urethane liner is worn over the residual limb and inserted into the outer socket, generally with the aid of a one-way expulsion valve fabricated into the socket wall. Opening the valve while donning the prosthesis, then closing it when the residual limb is well-seated in the socket creates a secure negative pressure atmosphere within the socket. An auxiliary suspension sleeve then is pulled over the over the amputee's thigh and socket to create an airtight proximal seal.



Polyurethane cushion liner

Locking suspension — This method mechanically mates the prosthesis to the end of the residual limb by a serrated locking pin extending from the end of the liner to a locking device built into the socket. Another option is a lanyard extending from the liner and anchored to the socket.

Because locking pin suspension requires some strength, flexibility and manual dexterity to use efficiently, these systems work best with patients in good physical condition. They are not always a good choice for geriatric, diabetic patients or people with bilateral deficiencies.

The Future

This is an exciting time in prosthetics as product innovation and technological improvements are appearing with greater frequency than at any time in history. The comparatively new total surface-bearing and hydrostatic sockets of today may well be museum pieces in just a few years.

One concept that has met with initial success in other parts of the world, osseointegration, could someday replace prosthetic sockets altogether for many patients. In its prosthetic application, osseointegration anchors a prosthetic limb to a titanium implant surgically placed in the residual limb. Because bone firmly attaches to the inert titanium, a prosthesis can be directly and reliably attached to (and removed from) an extension of the implant extending through the skin.

Should this concept prove successful over the long-term, it could eliminate many of the inherent difficulties of wearing a socket to connect prosthesis to residual limb—increased energy expenditure and perceived limb weight...residual limb daily volume fluctuations...poor proprioception and prosthesis control...skin breakdown due to perspiration and socket irritation...donning and doffing difficulty...and others.

We strive to manage all these challenges today by creating the optimum customized socket possible for each patient while staying attuned to new ideas and technology. We welcome your comments, questions and referrals.

Why a Check Socket?

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 cost up front, but it can head off significantly greater expense down the road, especially in the dysvascular population.

Making the Right Choices

The accompanying discussion confirms that there is no lack of designs and options available for creating a transtibial socket. From this broad spectrum of possibilities, how do we decide what is best for amputee patients?

That's where the knowledge and experience of our board-certified prosthetic staff make a major difference.

Every amputee, every residual limb, presents a new situation...a new challenge. Each patient brings his or her own circumstances, lifestyle and expectations into our office. Our role is to provide the best, most practical substitute limb we can create to achieve the best possible outcome.

Some patients do well with the PTB hard socket and wool socks routinely provided 25 years ago. Others present with an extremely difficult residual limb or other complications that require the most up-to-date protective socket design and interface we can provide. No standard recipe will work in this profession...each limb we create is unique.

Our prosthetic staff thoroughly evaluates each new patient—physically, biomechanically and personally—before embarking on a limb design. We encourage physician, therapist and family participation in that process.



Achieving Functional 'Harmony' Between Prosthesis and Anatomy

With all the advances that have occurred in prosthetics over the past decade or two, the reality of daily residual limb volume changes created by pressure on soft tissues within the socket remains a significant challenge for prosthetists and their patients.

Studies have shown that active lower-extremity amputees wearing a prosthesis incorporating a typical liner, sealing sleeve and expulsion valve lose 6-12 percent of their residual limb volume during the course of a typical workday. (This daily change is independent of the limb shrinkage that gradually occurs with maturation following amputation surgery.)

Such regular fluctuation presents an obvious problem: A socket that fits snugly on the residual limb at the beginning of the day will gradually assume a looser fit, making the

prosthesis more difficult to control, reducing proprioception and increasing pistoning during the gait cycle with resulting skin insult. One solution is to add additional sock layers during the day, but this regimen can be annoying and time-consuming for busy amputees and confusing to the new amputee.

Another approach developed by a leading liner innovator offers a less-intrusive solution. The Harmony Vacuum-Assisted Socket System employs a vacuum pump actuated by amputee ambulation to maintain an elevated vacuum between the liner and socket wall, which promotes natural fluid exchange and thereby minimizes residual limb volume loss.



Harmony vacuum cylinder

The crux of the Harmony is a cylinder incorporating an air-spring piston. Weight-bearing on the system generates up and down movement of the piston during the gait cycle, which in turn maintains negative pressure within the socket and provides shock absorption to further protect the residual limb. The negative socket pressure minimizes movement of the limb within the socket, thereby enhancing performance.

Specifically, the Harmony is designed to:

- enhance the connection between the limb and the prosthesis, creating a secure and consistent fit;
- promote a more natural gait and improve proprioception;
- reduce friction between limb and liner and liner and socket, preventing blisters and skin abrasions and extending liner life;
- dispel perspiration for improved comfort and skin viability; and
- offer vertical shock absorption.

Like many new products, the Harmony is still under evaluation, thus its ultimate applicability for different types of amputees is still being determined. However, early research involving amputees tested under a high vacuum level within the socket revealed a daily volume loss of less than one percent. Also typical of new products incorporating new technology, the Harmony is not inexpensive; however, the device now qualifies for Medicare reimbursement.

For further details on the Harmony system, call our office.



What's New

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