Options in Sockets and Liners

by Kevin Carroll, MS, CP, FAAOP

Anyone who wears a prosthesis knows that fit, comfort and suspension are critical. That’s why it’s important to know your options when it comes to sockets and liners. As the part of the prosthesis that connects directly with your residual limb, the socket is an extension of your body. Prosthetic users are looking for two key attributes here: comfort and the confidence of secure suspension. If the socket doesn’t fit right, is uncomfortable or doesn’t feel secure, the other components of the prosthesis will not matter because you’re probably not going to wear it.
The positive impact of advanced technologies and innovative clinical techniques makes this a good time to be a prosthetic user. But as you learn about new materials and components, it’s important to keep in mind that your situation as a prosthetic user is unique. A socket or liner that is a good choice for one person may not be appropriate for the next person. It’s easy to get caught up in wanting to try every great new item you read about. Instead, consult with your prosthetist and your physician about the best options for your unique situation.

Advances in Materials and Design
In the past 10 years, socket systems for below-knee, above-knee, hip disarticulation and transpelvic (HD/TP) prosthetic users have undergone a real transformation. Urethanes, mineral-based gel liners and silicone have effectively replaced the hard plastics that were used for decades. These advanced materials have an impressive quality known as “memory,” which enables them to respond to varying degrees of pressure. For example, when stepping forward on your prosthetic side, the muscles naturally enlarge and the socket expands; when the muscles relax in swing phase, the socket contracts, holding it securely to your residual limb. The soft and malleable nature of these new, improved materials also prevents surface damage to the underlying skin of the residual limb.

One newer technology that is available for both above-knee and below-knee users is the elevated vacuum socket. It offers more secure suspension for people with a lot of volume change in their residual limb throughout the day. With a regular socket, as the limb reduces in size, the socket can become loose, making it difficult to control the prosthesis and increasing friction on the skin’s surface. An elevated vacuum socket creates a vacuum between the liner and the socket wall, holding the residual limb securely in place and promoting stable limb volume throughout the day. The vacuum pump can also reduce perspiration inside the socket. If you have diabetes or delicate skin on the residual limb, an elevated vacuum socket may be a good way to prevent excess friction and damage to the skin. People who use elevated vacuum sockets can adjust the vacuum during the day with either a control unit on the outside of the socket or a separate remote control unit. This requires a certain “gadget tolerance” that not everyone has. Some people prefer this sort of individual control, while others may not.

Fitting techniques have also improved with the advent of laser scanning technology that captures the precise shape and contour of the residual limb. Three-dimensional images are saved, reviewed and fine-tuned by the prosthetist. In addition to using laser scans for socket design, some prosthetic providers also create custom liners from these computer images.

Lower-Extremity Sockets
For most above-knee users, a highly contoured, flexible, direct suction socket is a good choice. This type of socket actually strengthens the muscle in the residual limb by allowing it to fire freely and painlessly into its own compartment within the socket. One of the goals of rehabilitation is for users to actively fire their muscles with every step. Dynamic suction sockets incorporate two components that work synergistically: a thin, bio-elastic socket and a supportive outer frame composed of carbon fiber.

While many above-knee users prefer the fit and function of a direct suction socket, the fitting process can be quite challenging for the prosthetist and the patient. Starting out with a test socket allows you to work with your prosthetist to decide important details like contouring, trim lines and the best placement of cutouts on the outer frame. The upper trim line of the above-knee socket is a key consideration. People sometimes push for a lower trim line because it is more comfortable to wear. The important issue here is the length and overall health of the femur as well as the condition of the skin and soft tissue. A low trim line places more pressure on the bone, and if you happen to have a weakened femur as a result of inactivity, insufficient bone mass or osteoporosis, this can lead to a bone fracture. Therefore, if you want a low trim line, it is your responsibility to discuss this with your physician and get a bone density test as a precautionary measure. The added comfort of a lower trim line is not worth the ordeal of a fractured bone. It is worth noting that the added suspension of an elevated vacuum socket can sometimes allow for a lower trim line on the socket.

Another important consideration with above-knee sockets is how they feel when you sit down. Flexible sockets relax under the weight of the residual limb and don’t dig into or pinch your soft tissue. A cutout across the back of the carbon fiber frame should expand comfortably when you sit.
The final definitive socket is unique to your residual limb. This means that a person who has a lot of soft tissue on the residual limb will have a socket with a wider side-to-side fit, while someone with a toned and muscular limb will have a narrower side-to-side fit. Direct contact sockets allow you to really feel the prosthesis, and the result is better control. Not all above-knee users will be able to wear a direct suction socket. Some older adults and people with very short residual limbs, significant bony prominences, skin problems or diabetes may do better with sockets that incorporate a liner into the design.

Direct suction sockets are not typically used in below-knee prosthetics. Instead, a contoured socket is usually worn with a gel or silicone liner. This combination reduces friction on the skin when you walk and may provide suction that keeps the socket in place.

Suspension
Both above-knee users who do not wear a direct suction socket and below-knee users in general often wear gel liners over the residual limb. Gel liners can enhance your comfort level and provide an auxiliary means of suspension. If you have scar tissue, skin grafts or bony prominences on your residual limb, it is important to wear a gel liner as a protective layer. The newest gel liners are worn in combination with a socket that has a valve near the bottom. You roll the liner onto your residual limb and as you don the prosthesis, the air inside the socket is pushed out the valve. A sleeve that extends onto the thigh is also worn, sealing the top of the socket and making it airtight. As you walk, air continues to be pushed out through the valve on the socket. There are also gel liners that have a raised silicone ring built-in near the bottom of the liner. The ring conforms to the shape of the socket wall and provides an airtight seal without the need for an external sleeve to seal the top of the socket.

Gel liners with a pin lock system or a lanyard cord are older styles that offer secure suspension. The liner is rolled onto the residual limb, and either a metal pin or a lanyard cord extends from the bottom. The pin snaps into a lock in the bottom of the socket while the lanyard threads out through a hole on the end of the socket and is locked into place. The suction and tackiness between the skin and the gel liner is the primary means of suspension for the prosthesis. Suction may also occur between the gel liner and the socket, improving overall suspension. Since gel liners with pins pull heavily on the end of the residual limb, they may not be appropriate if you have neuromas or other sensitive areas.

As previously mentioned, custom gel liners are also available. These can be very helpful if...
your residual limb is a unique shape that standard liners will not accommodate. Regardless of the type of gel liner you use, the gel thins out over time and may lose some of its protective cushion. On average, gel liners need to be replaced about every 6 months. While gel liners increase comfort and protect the skin, they may reduce proprioception and you may have less control over your prosthesis. For increased proprioception, talk with your prosthetist about using the thinnest liner possible or considering an elevated vacuum socket.

Prosthetic socks are still popular with some users. Prosthetic socks are measured by ply, and the number of ply is easy to adjust throughout the day to accommodate changes in volume in the residual limb. Newer socks are labeled as “silver,” meaning that permanent, antimicrobial, moisture-wicking silver fibers are woven into the fabric of the sock to enhance hygiene.

Finally, many prosthetic users wear suspension sleeves as a primary or secondary means of suspension. The sleeve is rolled on over the prosthesis, extending onto the skin of the thigh and sealing off the top of the socket to prevent air from entering or exiting. The latest generation of suspension sleeves incorporates a valve into the sleeve to release air when you ambulate, sit or stand. Sleeves are both easy and effective to use; however, since the material is vulnerable to punctures, they must be replaced regularly. Because sleeves are meant to be airtight, they can cause problems with perspiration and discomfort if you live in a hot or humid area. Prescription and over-the-counter antiperspirants are available to help reduce perspiration.

Basics Matter

With the continuous development of ever-better technologies and components, it’s easy to lose focus on basic items like sockets and liners. Yet, a comfortable prosthesis with secure suspension is the very foundation of your mobility. Understanding the important role of sockets and liners is central to wearing a prosthesis; it’s worth the extra effort to get it right.

The Defense Advanced Research Projects Agency (DARPA) has funded a two-phase program (Revolutionizing Prosthetics) to design an arm and hand prosthesis for injured military personnel that will perform, look, and feel like a natural limb. The ultimate goal of the second phase, awarded to inventor Dean Kamen’s DEKA Research and Development Corp., is to give amputees an advanced prosthesis “for people who want to literally strap it on and go.” Discomfort caused by the traditional interface (socket) is a key reason why many upper-limb amputees stop wearing their prosthetics. Randall Alley, CEO and chief prosthetist for biodesigns, inc., and prosthetic consultant for DEKA, introduced DEKA’s patent pending High-Fidelity (Hi-Fi) Interface. This new interface with DEKA enhancements is designed to be used with the DARPA arm. In his practice, Alley is already using the Hi-Fi Interface design to improve traditional prostheses for both upper- and lower-limb patients.

The Hi-Fi Interface uses a technique Alley termed Vector Enhanced Compression and Tissue Relief (VECTR). To illustrate the difference between traditional sockets and the Hi-Fi Interface, Alley uses the analogy of a cylinder suspended inside a water balloon.

“If we simply wrap our arms around the balloon to control the cylinder’s orientation and motion, we fail short by a large margin. This represents the traditional approach to interface design,” Alley says. “But if we take the inside edges of both hands and trap the cylinder in between while allowing the rest of the balloon to expand away from the cylinder, we can easily control the cylinder’s orientation and motion. In essence, by using force vectors (targeted compression) along the shaft of the bone, while also allowing relief of redundant soft tissue out of the field of load transmission, we can impart higher levels of compression where it is most needed.”

Photos courtesy of biodesigns, inc.

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Photos courtesy of Hanger Prosthetics & Orthotics.

About the Author

Kevin Carroll, MS, CP, FAAOP, has been a practicing prosthetist for more than 30 years. He is the vice-president of prosthetics for Hanger Prosthetics & Orthotics in Bethesda, Maryland. He travels across the country consulting with and managing the treatment of amputees with complex cases. He also presents workshops on bilateral above-knee prosthetics and other specialized topics. He is chair of the Lower Extremity Prosthetic Society for the American Academy of Prosthetics & Orthotics.