The Hinnant Prosthetics Quarterly

Experience Our Road to Prosthetic Excellence

Autumn 2006

Prosthetic Solutions for Distal Amputations

The rehabilitation community has long debated the merits of "distal amputations,"—partial foot and Syme's (ankle disarticulation) surgery—for trauma, congenital issues, and disease affecting the foot. As compared with the more common transtibial and higher levels of limb removal, distal amputations offer positive functional benefits, including:

- preservation of end weight-bearing
- substantially better proprioceptive feedback;
- significantly reduced duration of prosthetic training;
- a more efficient gait with less energy consumption; and
- distinct psychological advantages resulting from a less-severe change in body image and less-conspicuous prosthetic gait.

The improvements in medical technology and surgical technique that have widened the population of distal amputees have been paralleled by progress in prosthetic design and materials.

This newsletter explores prosthetic options for distal amputees. Our professional staff is prepared to provide quality custom devices designed to maximize functional outcomes for these patients.

We invite you to explore the possibilities.

Partial foot restorations can provide highly lifelike cosmesis in a variety of attachment styles. *Courtesy Prosthetic Research Specialists*

Syme's Surgery Offers Prosthetic Advantages

For various reasons, the Syme's ankle disarticulation has not found widespread acceptance among surgeons as an alternative to transtibial amputation for patients who would be candidates for either procedure. Perhaps a re-evaluation is in order.

The procedure, introduced more than 150 years ago by Scottish surgeon Dr. James Syme, retains the heel pad and allows end weight-bearing, which preserves proprioception and near-normal sensory feedback. As a result, Syme's amputees typically require less training and ambulate more efficiently and with considerably less energy expenditure than comparable transtibial patients. Moreover, the procedure allows continued growth of an immature residual limb and precludes bony overgrowth—significant advantages in pediatric applications.

Contemporary Syme's prosthesis features laminated socket and ultra-low-profile foot.

Long reserved for trauma cases, the Syme's disarticulation has more recently been shown to yield good results among the dysvascular geriatric population as well. These patients demonstrate superior gait velocity, oxygen consumption and endurance relative to similar patients with higher-level amputations.

Some Syme's amputees even apply weight directly to the residual limb and ambulate about the house without donning their prosthesis.

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75 Years of Prosthetic Care

This year, Hinnant Prosthetics celebrates 75 years of service to amputees in North and South Carolina. Since 1931, it has been our philosophy to provide the best possible prosthetic management through a compassionate, comprehensive and technologically advanced team approach, at all times keeping our patients' desires and expectations in mind.

Our facility and staff are American Board-Certified and members of the American Orthotic and Prosthetic Association, International Society of Orthotics and Prosthetics, North Carolina Academy of Orthotists and Prosthetists, and the South Carolina Society of Orthotics and Prosthetics.

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Improved Research Enhances Partial Foot Solutions

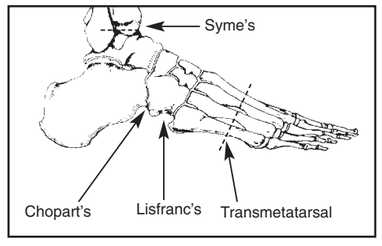
The body of knowledge for managing patients with partial foot deficiencies has grown substantially in recent years. Because surgeons throughout modern history have generally avoided foot or ankle amputations in favor of a transtibial (or higher) procedure, restoring function and cosmesis to individuals with distal limb loss has not been a research and development priority, and thus prosthetic design has been based on somewhat limited observation and experience.

Prosthetics Today

Supramalleolar low-profile partial foot prosthesis. Unfinished device at right shows energy-storing footplate.

But with partial foot surgery now being performed more frequently than in the past, we have seen a commensurate increase in research investigation, including objective gait analysis of patients with different amputation levels using various types of partial foot replacements. These studies provide new insight into how loss of foot architecture affects gait and what types of replacement foot components work better in different situations.

For example, we now have a better appreciation that a partial foot amputee's desired activity level can be as important as amputation level in selecting a replacement device. We also have come to understand that, though leaving a "long" residual foot, transmetatarsal surgery can have nearly as severe an effect on post-amputation gait as a mid- or hindfoot amputation.



These considerations directly affect how we select and design replacement devices for partial foot patients.

From Shoes to "Prosthoses"

Some partial foot solutions can be accomplished solely with shoe modifications. Others involve purely prosthetic devices, while many incorporate elements of both prosthetic (limb replacement) and orthotic (limb support) componentry and thus are sometimes termed "prosthoses."

Partial foot replacement design varies widely with the level of surgery. In general, the more proximal the amputation, the higher the trimlines and greater the complexity of the replacement. Regardless of the level, partial foot amputees generally retain weight-bearing on the residual foot with near-normal proprioception, a major advantage for regaining function and learning to walk again. In an emergency and for short-term household ambulation, many partial foot amputees can get around without a prosthesis at all.

Custom "prosthosis" provides rigid anterior lever arm and dynamic response footplate to help restore function to partial foot amputees.

Courtesy of Custom Composite Mfg.

A key factor in the partial foot amputee's ease of resuming a normal gait pattern is preserving as much of the toe lever as possible, provided adequate tissue remains to protect the residual limb. One approach to that end is performing, where possible, a longitudinal ray amputation (toe and metatarsal) in lieu of a transverse procedure. At the transmetatarsal level and higher, the normal weight-bearing structure of the foot is effectively destroyed, and active push-off is lost.

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The recent growth in distal amputations and the application of new lightweight plastics and energy-storing metals to prosthetic fabrication have produced an array of new, lighter and more functional partial foot designs.

Toe and Forefoot Solutions

Toes— Amputation of one or more of the lesser toes has relatively little effect on overall foot function. Loss of the great toe does limit the final push-off, although not to the degree once thought. Toe prostheses generally consist of a foam shoe filler, which serves to protect the amputation site and keep the residual foot stable within the shoe. If the great toe is involved, the lost propulsive function can be addressed by adding a dynamic-response footplate.

Rays— The prosthetic need after a ray amputation is to distribute the forces of physical activity over the remaining surface area as evenly as possible and in the case of a first or fifth ray removal to counter lost mediolateral stability. The usual approach is a custom-molded shoe insole, which may be laminated to enhance durability. For more extensive ray amputations a foam filler may also be used to maintain shoe fit.

Custom partial foot covers can provide an amazingly lifelike finish.

Courtesy Health Related Products/Realastic

Transmetatarsal — At this level and higher, partial foot solutions are determined to a large extent by the desires and capabilities of the patient. The choice may be a basic foot orthosis with toe filler in a walking shoe for a patient with only household ambulation goals, or a supramalleolar prosthesis incorporating an energy-storing footplate and custom-molded arch support in a custom shoe for a community ambulator.

It is worth noting here that highly active forefoot amputees are generally disappointed by the lack of push-off available from current technology and recurrent residual limb damage from repetitive high-impact activity. Even silicone prostheses, considered to offer the best protection for residual limbs, are not always sufficient for these applications. Though the resulting limb loss would be significantly greater, a transtibial amputation and prosthesis, in lieu of a partial foot procedure, are worthy of consideration for these patients.

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Down to Cases

S. L., 46, presented with a three-year-old amputated right forefoot and complaint of residual limb pain, which was affecting his gait and ability to maintain balance when standing.

Examination revealed his existing prosthesis was providing insufficient protection for his residual foot, which exhibited a well-developed callus on the distal plantar lateral aspect. Further investigation showed the anomaly to be a result of abnormal pronation and supination during gait, a common outcome of forefoot lever arm loss.

S. L.'s prosthetist recommended a new "prosthosis" consisting of a carbon-fiber ankle-foot orthosis with custom toe filler.

AFO with toe filler is becoming a popular partial foot option.

Upon delivery and fitting, S. L. subsequently demonstrated substantial improvement in the condition of his residual limb as well as his walking performance and standing balance. The prosthosis restores a large measure of his pronation-supination stability and provides an effective lever-arm with dynamic response to enhance toe-off propulsion.

This patient now demonstrates a more normal gait with reduced energy expenditure.

Syme's Procedure Can Lead to Better Functional Outcomes

(Continued from page 1)

So with all these benefits, why isn't the Syme's operation more prevalent? The reasons can be boiled down to three:

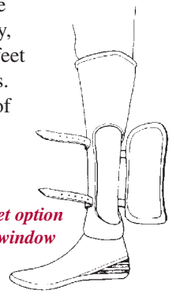
• **Surgeon's preference.** The Syme's disarticulation is generally regarded as being more difficult than a routine transtibial amputation and in times past has suffered a greater wound failure rate, which has declined substantially in recent years.

• **Limited prosthetic designs.** Because Syme's surgery was performed infrequently for many years, prosthetic design and materials improvements lagged the innovations being applied to more common amputation levels; Syme's prostheses tended to be heavy and bulky. Syme's systems have since come a long way, with the introduction of dynamic-response Syme's feet and high-strength, lightweight materials and designs.

Syme's feet feature ultra-low profile. *Courtesy Össur*

• **"Fat ankles."** The usually bulbous distal end of a Syme's residual limb causes the resulting prosthesis to appear substantially larger than a normal contralateral limb.

Designing and fabricating a Syme's prosthesis entails both challenges and advantages. On the plus side, the majority of Syme's amputees achieve prosthetic success and tolerate the prosthesis well. The long lever arm of the Syme's residual limb produces decreased limb pressures within the socket and less skin breakdown than most lower limb systems. Moreover, the characteristic bulbous distal end of the residual limb enables most Symes's prostheses to be self-suspending.



One Syme's socket option incorporates medial window for donning, doffing.

A Syme's lower limb is typically larger than a normal limb.

On the other hand, introducing that bulbous extremity into the narrower areas of a Syme's socket typically requires some special engineering. One method utilizes a window cut-out at the narrow part of the socket, generally on the medial aspect, which can be opened for donning and doffing. Another approach, sometimes used when the distal residual limb circumference has been reduced during surgery, employs a flexible inner socket within the rigid outer shell.

Syme's Pros and Cons

Pros

- End weight-bearing
- Self-suspension
- Excellent proprioception
- Better gait velocity, cadence and oxygen consumption [1]
- Less skin breakdown [1]
- Less therapy and training required [1]

Cons

- More-complex amputation surgery
- Slightly higher wound failure rate
- Prosthetic limb is cosmetically larger than contralateral limb

[1] - as compared to transtibial amputees

Shaving the malleoli during surgery to produce a more cosmetically pleasing outcome can reduce residual limb distal circumference by up to one-third, which may require an alternative suspension method, such as silicone suction.

Because Syme's amputees as a whole exhibit a higher activity level than other amputees, they tend to be harder on their prostheses, thus heavy-duty construction is indicated. The trick is to balance strength and weight to match the abilities and needs of the patient.

In the final analysis, many Syme's candidates who currently undergo transtibial amputation instead could enjoy a significantly better functional outcome with this approach. With its inherent surgical complexity and cosmetic deficiency, the Syme's disarticulation certainly is not for everyone; however, for many, the functional benefits will far outweigh the deficiencies.

In considering a Syme's level disarticulation, please know that our practice is prepared to apply the latest in prosthetic design and fabrication technology to the rehabilitation effort. We welcome your calls.

Every Partial Foot Design Is One of a Kind

(Continued from page 1)

In the approaches heretofore described, the prosthesis is usually maintained in correct relation to the residual foot by the patient's shoe. For the more proximal levels, a socket approach is typically employed to prevent relative motion between the residuum and the prosthesis resulting from the dorsiflexion moment created when weight is applied to the forefoot.

Midfoot, Hindfoot Solutions

Courtesy
Otto Bock Health Care

Patients with a Lisfranc's- or Chopart's-level amputation experience additional challenges due to their very short, bony residual limb, which cannot tolerate the stress of active push-off. Moreover, lack of full dorsiflexion control at these levels invites development of an equinus deformity. Preserving ankle motion for midfoot and hindfoot amputations is a choice first for the surgeon, then for the prosthetist based on the patient's ability and aspirations.

Lisfranc's (tarso-metatarsal) — The next level proximal to a transmetatarsal amputation, this midfoot disarticulation removes more of the foot's weight-bearing capability and control of ambulation forces.

Chopart's (mid-tarsal) — This level is perhaps the most demanding with regard to prosthetic restoration, because there is less surface area over which to distribute weight-bearing forces and upon which the socket can gain purchase. Prosthetic ankle stabilization is often employed.

Two primary prosthetic approaches are available for these more proximal levels. Both involve a custom-molded flexible socket, either in the form of a total-contact plastic enclosure or an ankle-foot orthosis (AFO).

Below-ankle or "slipper-type" prostheses are appropriate when ankle function is stable, patients are in reasonably good mental and physical condition, and when activity levels are not particularly demanding. As a rule, these designs are more comfortable and cosmetically acceptable to patients. We generally recommend them for patients who can tolerate plantar surface weight-bearing and will not have suspension problems with a below-ankle system.

Lisfranc's- level socket and slipper.

High-profile above-ankle designs are frequently employed for both Chopart's and Lisfranc's as well as transmetatarsal amputees to resist the dorsiflexion moment created during weight-bearing through counterforces at the heel and anterior brim. The new generation of thin, carbon-fiber AFOs enables us to design a prosthosis that incorporates a strong anterior lever-arm, provides assist for push-off and can accommodate a separate silicone cosmetic foot if desired.

Every Partial Foot Is Different

And that's the point: Every partial foot amputee's situation, abilities, and desires are unique, thereby requiring a unique prosthetic solution. Our role is to understand each patient's specific needs and to create the most appropriate replacement device to meet those needs.

We invite your comments and questions, both in a general sense and with regard to specific patients.

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:

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