

# Partial Foot Prostheses/Orthoses

by Melvin L. Stills, C.O.

## Introduction

Prostheses and orthoses prescribed for partial foot amputations vary in design and principle. Authors have described the need or the lack of need of toe lever arms, extensions above or below the ankle, and hard and soft sockets. Almost every design violates a principle thought to be a requirement of the other designers of partial foot prostheses/orthoses. The purpose of this paper is to describe some of the designs now being advocated and to give the rationale for their use.

## Above the Ankle

Many authors and designers believe that the proper management of a mid-transverse metatarsal amputation, or more proximal, must include an extension above the ankle. Many of these designs take the form of an ankle-foot orthosis (Figure 1). This orthosis may be fabricated from thermoplastic materials (polypropylene), thermoset plastics (polyester or acrylic) which may be incorporated with graphite or other space age materials to reduce weight and increase strength (Figure 2), or may be incorporated into conventional metal and leather types of orthoses. Those devices fabricated from thermoplastics and thermoset materials are generally formed over a positive model of the amputated extremity. The portion of the device contacting the foot is designed to achieve total contact and is generally lined with a soft interface material to increase comfort and/or provide better distribution of forces. The normal profile of the foot may be restored during the initial fabrication process or added

later as a buildup of foam. This foot buildup acts as an extension of the foot lever arm, or in some instances may only act as a shoe filler. If an attempt is made to extend the foot lever arm, it may be necessary to complete shoe modifications which would include a full length spring steel shank cushion heel and walker sole. It is considered that this combination of prosthesis,



Figure 1. Polypropylene ankle-foot orthosis with foam toe filler.

orthosis, and shoe will provide a smooth transition from foot flat to heel off and permit an effective push off.

Tarso-metatarsal amputations may require a solid ankle device. This device employs similar methods of construction with the addition of an anterior section extending from the level equal to the height of the posterior section and distally to the dorsum of the remaining foot. This addition acts to lock the foot and lower leg into

the posterior section and eliminates ankle motion. The shortened foot is difficult to retain in the posterior section, and the addition of the anterior shell provides better purchase and retention. The proximal region of the anterior section may take the form of a patellar tendon bearing socket, or extend to midcalf, or in some designs extend only to the area just above the ankle. Variations of all three commonly exist, and the amount of ankle control will be determined by the design selected. If a design is selected which limits ankle motion, most authors agree that shoe modifications are required to achieve normal gait. A cushion heel applied to the shoe will permit smooth transition from heel strike to foot flat. Prosthetists who routinely employ these designs have reported good results with successful ambulation.

### Below the Ankle (Slipper Type)

A number of designs exist that do not extend above the ankle joint. They appear to be divided into the following categories: (1) rigid, (2) semi-rigid, (3) semi-flexible, and (4) flexible. All of these systems are fabricated on a positive model of the residual limb. The positive model is modified to increase loading of good tissue and to relieve or decrease pressures on sensitive areas prior to the forming of the definitive socket.

The rigid and semi-rigid systems are based on a laminated or thermoform socket. Limited flexibility is built into these systems, using flexible resins in fabricating the semi-rigid shells. A foam lining is generally employed to act as an interface between the rigid walls of the socket and the skin of the residual limb. The profile of the foot is restored with a build-up added to the socket. Complications may be encountered in using the rigid/semi-rigid designs when motion occurs inside the socket. Breakdown on the distal plantar surface of the residual limb is not uncommon, and this complication has led to the development of the semi-flexible and flexible designs.

Semi-flexible designs utilize a combination of material, generally having a base of urethane elastomer. One such system which is semi-flexible in nature and utilizes a laminated rigid University of California-Berkley shoe insert as its base. The insert is bonded to a modified monoelastic cushion heel foot and the entire



**Figure 2.** Graphite reinforced laminated posterior prosthetic shell for transtarsal amputation.

system is laminated together with a urethane elastomer.<sup>1</sup> The resultant system does not interfere with normal ankle motion, and authors report good acceptance (Figure 3).

Another semi-flexible design uses solely a urethane elastomer for fabrication of the socket and foot. This design is referred to as a slipper-type elastomer prosthesis (STEP). The STEP design is somewhat complex in its design and fabrication. Permanent tooling is developed for each individual patient and may be retained by the patient for possible fabrication of replacement devices at a later date. This tooling consists of a permanent polyester resin positive model of the residual limb and a negative mold of the finished prosthetic foot. This device is fabricated using semi-flexible urethane elastomer.<sup>2</sup> If a pressure point is noted on the residual limb, modifications are made to the prosthesis by removing material from the exterior surface of the prosthesis in order to reduce rigidity in that area and to insure a smooth socket interface. Good results have been reported from the use of this prosthesis.

### Flexible Foot Prostheses

A flexible cosmetic prosthetic foot (Figure 4) has been developed which utilizes only reinforced silicone materials. A negative weight bearing alginate impression is made of the residual limb and contralateral foot. An exact de-

tailed dental stone positive model of the residual limb is made from this impression. A wax check socket is fabricated on this model and checked for comfort and fit on the patient. Modifications are made to relieve sensitive areas and to load appropriate surfaces. Appropriate loading is based on the prosthetist's impression of soft tissue density and how much pressure the patient can tolerate. A mirror image model of the sound foot is sculpted from wax and checked for sizing against the patient. A negative model of the sculpted foot is then made using a lost wax method. The resulting negative model of the foot may then be used in conjunction with the rectified model of the residual limb to produce the prosthesis. The material employed is a pure reinforced silicone that is precolored to match the patient's skin tones. At the fitting, the detailed colored matching is achieved using the sound side as a model for cosmetic restoration. To date, approximately 100 patients have been fit with this flexible silicone cosmetic prosthetic foot, and patient acceptance has been almost 100 percent. The developer<sup>3</sup> initially intended the prosthesis solely as a cosmetic device (Figure 5). However, patients reported they had increased comfort and functional levels with the reinforced silicone prosthesis.

Requests for cosmetic restoration by males are almost equal in number to those requested by females. The psychological effect of cos-

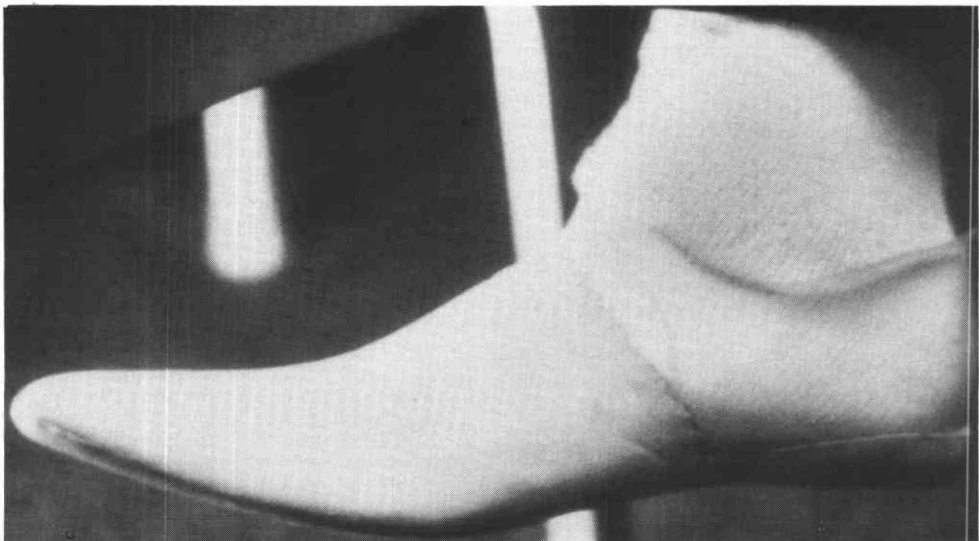


Figure 3. UCBL thermaformed shoe insert with Lynadure forefoot.

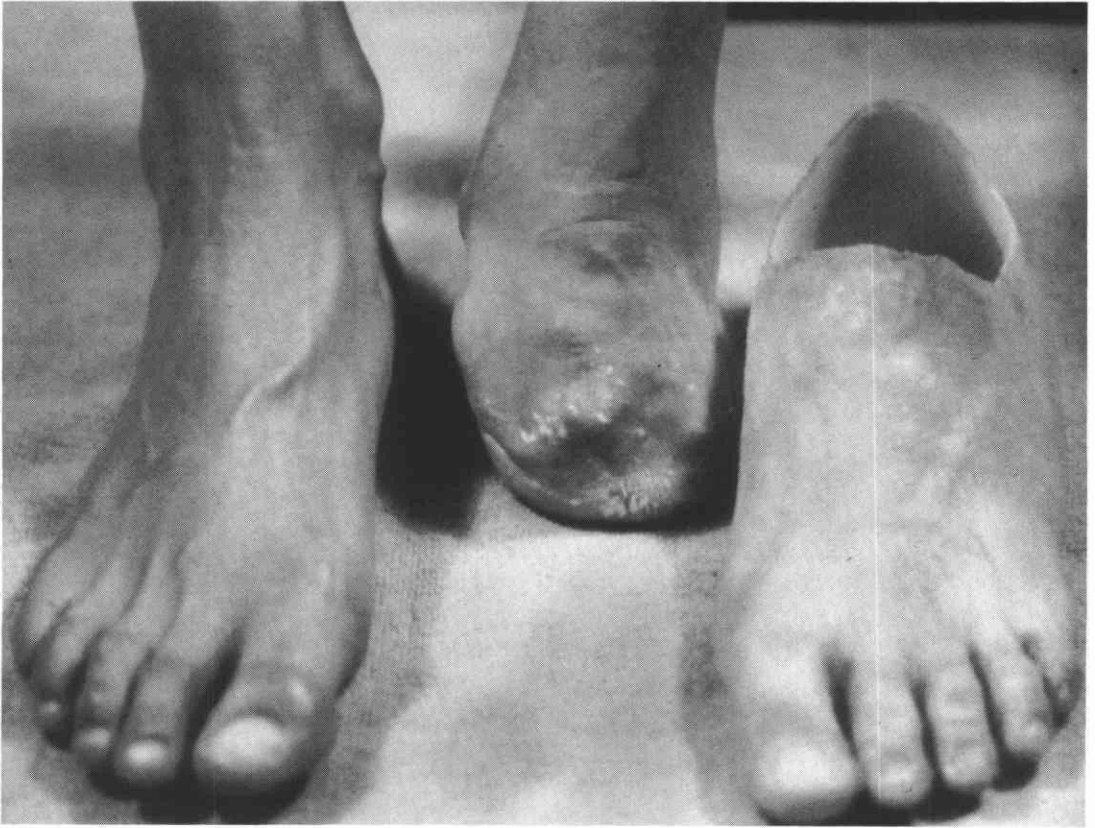


Figure 4. Reinforced silicone slipper type prosthetic foot. See Figure 2 for earlier fitting.



Figure 5. Cosmetic functional silicone foot prosthesis.

metic restoration has not yet been evaluated; however, it is probable that this has some influence on the functional acceptability of the prosthesis by the patient. Many of the patients fitted with a flexible silicone cosmetic prosthetic foot have previously been fit with partial foot prostheses of the types previously described. Mechanical comparisons of function of these designs would be valuable, but to my knowledge, have not yet been done.

## Summary

A balanced foot is almost a necessity for successful fitting of any of the prosthetic systems. Trauma related amputations apparently do well with the slipper-type prosthesis, and the developer of the silicone system reports successful fitting in diabetic patients as well. The need for the prostheses to extend above the ankle appears to be limited to those patients with very short amputations, but successful fittings have been demonstrated with the slipper-type, sometimes using an ankle strap for suspension.

There is no definitive statement that I can make recommending any one system over another. It appears that many partial foot amputees are being successfully managed with prostheses that do not extend above the ankle. It also appears that a higher rate of success is occurring when semi-flexible and flexible prostheses are being fit. It is believed by many that partial foot amputation can offer significant functional improvement over Symes level amputations and the use of this surgical technique needs to be reevaluated in light of the new technologies and materials available today for providing the partial foot amputee with a functional prosthesis.

## Acknowledgements

A number of talented individuals have contributed to the information and materials presented in this paper, and in order to avoid inadvertently omitting someone's name, I wish to thank them all as a group for their assistance.

## References

- <sup>1</sup> Lynadure, Medical Center Prosthetics, Inc., Houston, Texas.
- <sup>2</sup> Calthane 1900, Cascade Orthopedic Supply, Inc., Chester, California.
- <sup>3</sup> Mr. H. Buckner, C.O.T., Life-Like Laboratory, Dallas, Texas.

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## Author

Melvin L. Stills, C.O., is with the University of Texas Health Science Center, Division of Orthopedics, 5323 Harry Hines Blvd., Dallas, Texas 75235.