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A Partial Foot Prosthesis for the Transmetatarsal Level

by Jack N. Collins, C.P.O.

Introduction

Traditionally prosthetists and orthotists have faced the problem of partial foot amputations with the skills, materials, and observations gained from past experiences or from others in the field. The author is not aware of any extensive research in prosthetics for partial foot amputations. Attempts to provide a suitable prosthesis have ranged from a simple toe filler with arch support, to an ankle immobilizer at P.T.B. level, and lace-on fillers of many descriptions. In the author's observation, any prosthesis that goes above the ankle results in the buildup of unwanted forces.

The late Charles Childs, C.P.O.,[1] made the greatest breakthrough in partial foot prostheses. I attended his seminar in late 1978 and was very impressed with the entire approach demonstrated, especially the cosmesis and fit at shoe level height. Unfortunately, after a few weeks wear, the rubber material used in the fabrication of the prosthesis did not retain its shape and support against the extreme forces exerted in walking. The forces developed on the short lever arm, the foot, in walking are greater than at any other level of amputation. These forces applied in walking and running are not confined to the plantar surface of the residual foot, but are transmitted in part to the entire surface of the prosthesis. In turn, some of these forces are applied to whatever footwear is worn. Thus, the footwear applies a resistant force to the prosthetic appliance, quite often to the detriment of the appliance and the residual foot.

It must be stated at this point that the prosthesis about to be described has not been evaluated with foot amputations at the Lisfranc or Chopart level, but only on transmetatarsal level. And from our limited experience, developed over the past 7 to 8 years, a mid-transmetatarsal amputation presents fewer problems in toe-off than amputations at a greater or lesser length. With this in mind, the evaluation, casting, and fabrication techniques used will be described.

Evaluation, Casting and Fabrication

Evaluation is made in routine manner, for amputation level, range of motion at ankle, contractures, cut bone covering, abrasions, callosities and sensitive areas.

With patient seated in a chair, invaginate a casting balloon over the residual foot with a short piece of plastic tubing on the dorsum of the foot. Mark with indelible pencil all boney prominences, callosities and sensitive areas (Figure 1). Very carefully roll on a 4″ roll of plaster in a manner to cover the entire foot to the inferior edge of the lateral malleoli and with a thickness sufficient to retain its shape on removal. While the plaster is still soft, have the patient place his foot on the floor, with the knee at 90°, foot in neutral position (not in valgus), and with the weight of the leg on the plaster. Make marks with indelible pencil on the cast at 90° across the plastic tube. With a cast saw cut down the tube to remove the cast. If care is taken in applying the plaster, you will have a

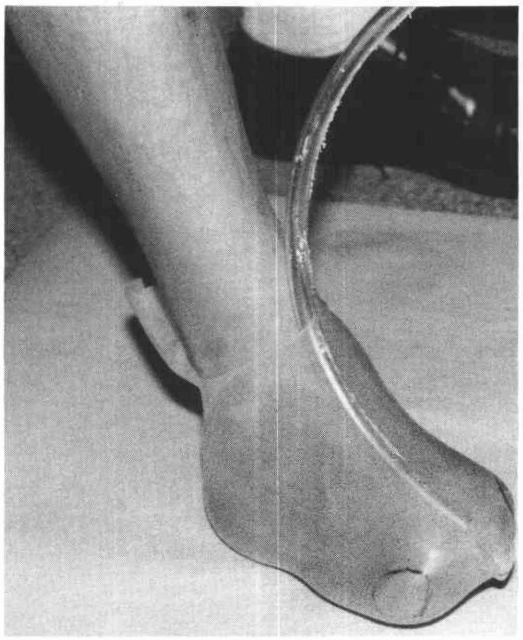

Figure 1. Foot ready for casting with casting balloon and plastic tubing in place.

very smooth and detailed cast on removal (Figure 2).

Close the cast carefully with plaster wrap, apply the release agent, and pour the cast with mandrel in place about 45° to vertical. This makes it easier to apply P.V.A. and stockinette. Remove the plaster wrap from the model.

Very little modification should be necessary. Add about ⅛″ plaster buildup over the boney prominence at the distal end and over any callosities or other sensitive areas. It is not necessary to modify as in the U.C.B.L. Shoe Insert casting method. Using a Scarpas knife, remove about 3⁄16″ to ¼″ plaster from the plantar surface ½″ proximal to the metatarsal ends, the width of the metatarsals, and taper in the direction of the heel about 1″ to 1½″ depending on the size of the foot. The anterior edge of cut should have a 5⁄16″ radius (Figure 3). Dry or seal the model.

Pull on one layer of nylon stockinette to allow for the patient's sock. Pull the P.V.A. over cast for vacuum. Tailor a piece of 1 oz. Dacron felt to cover the plantar surface. The felt should extend over the anterior distal end, laterally to cover the base of the 5th metatarsal,

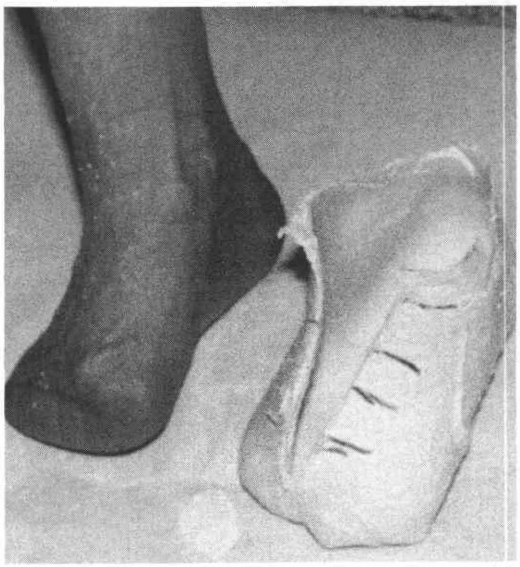

Figure 2. Cast removed

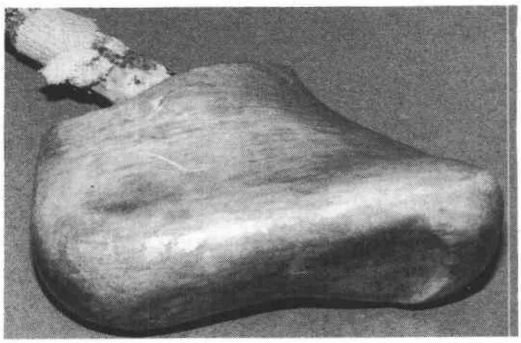

Figure 3. Modified positive model

and medially to cover the scaphoid prominences. Sew one end each of four lengths of nylon stockinette and pull on the model with the Dacron felt in place. On heavier more active patients, one layer of woven glass reinforcement is added between the felt and stockinette. When pulling on the stockinette, take care not to pull out the stretch of the stockinette. The stretch needs to be retained in the silicone laminated areas to allow donning. Take two 4″ P.V.A. sleeves and cut 12″ long pieces from the small end of each to make feeder tubes. Apply a 6″ moist P.V.A. sleeve to the model so as to give a smooth surface all over. Do not tie off the ends, but do dry with a heat gun. Use a tongue depressor to push the small end of one of the feeder tubes under the P.V.A. sleeve at the heel of the model. The tube should

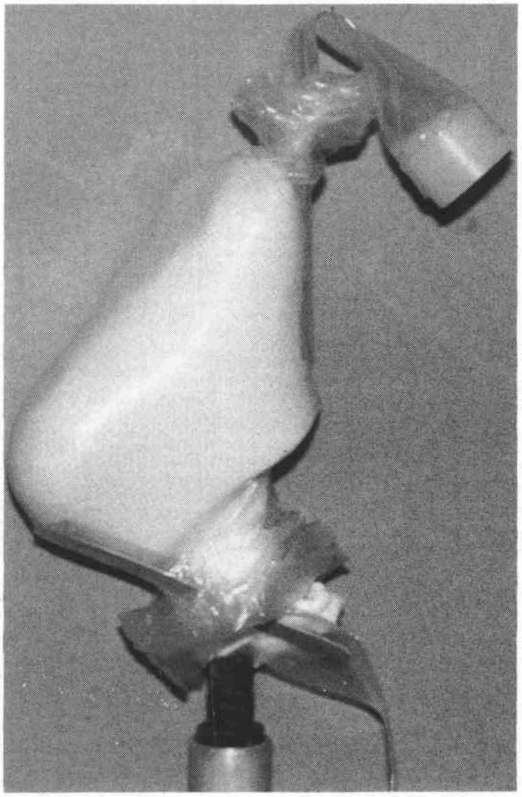

Figure 4. Completed layup with P.V.A. sleeve and feeder tubes in place

be about 3/8" from the plantar surface of the heel. In the same manner, position the remaining feeder tube under the P.V.A. sleeve over the dorsum of the model. The tube should be about 3/8" from the proximal edge.

Roll a 1" wide by 6" long piece of 1/16" thick polyethylene into a funnel and place in the open end of one of the tubes (Figure 4). Mix 80 grams of Dow Corning 382 silicone with 2 or 3 drops of appropriate color and catalyze as directed by Dow Corning, pour into the funnel and very carefully squeeze into the stockinette. On the dorsum of the foot, laminate the section the shoe lace will cover, or a little more area. Squeeze with your finger tips to get a thorough and even penetration working the Silastic, laterally, and distally down to, but not onto the plantar surface. Working with the fingers gives better penetration without spreading the resin to unwanted areas. After this has cured, repeat in the same manner posteriorally. The posterior

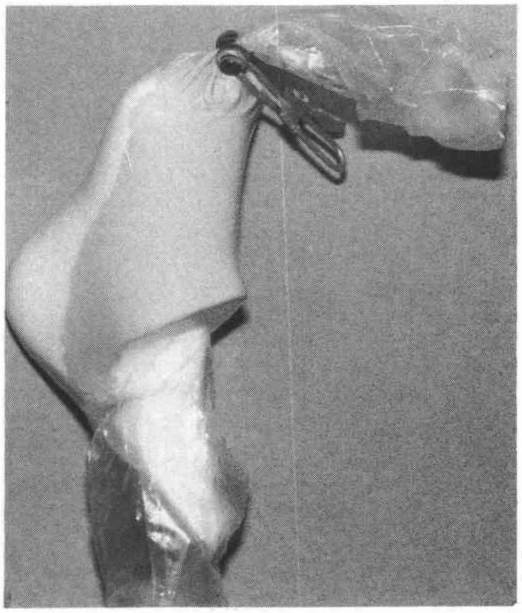

Figure 5. Initial phase of lamination. Dorsum and proximal border of socket have been laminated with Dow Corning 382 Silastic.

portion should extend distally down the back of the heel to the sole and anteriorally along the proximal trimline for a width of 1" distal of the trimline so that it meets the posterior border of the anterior lamination medially and laterally (Figure 5). When the posterior portion has cured and both feeder tubes have been removed, tie off the pipe end of the 6" P.V.A. sleeve and pour in 150 grams of 4110 Laminac that has been catalyzed and pigmented. Saturate the remaining lamination and maintain it under a vacuum until cured. While the polyester is still warm, trim to the shoe top level and remove the prosthesis from model (Figures 6A and 6B). The prosthesis is now ready for fitting.

In weight bearing, check for comfort, undue pressure, and position of the foot. More than likely it is in some valgus, as any foot amputated proximal to the head of the first metatarsal loses its medial support. With small wooden wedges, you can determine the amount of posting needed under the distal end of the first metatarsal to hold the foot in a neutral position. When this has been done, mix a small amount of thickened polyester and add it to the distal plantar surface of the first metatarsal area to establish the desired position. When comfort and

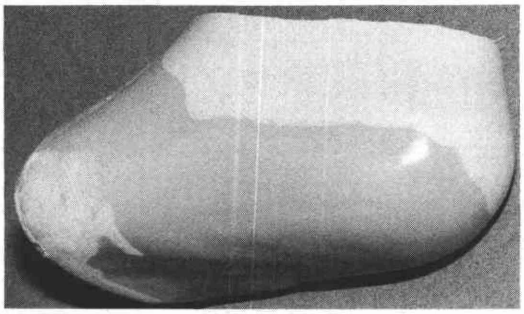

Figure 6A. Socket completed and removed from model, medial view

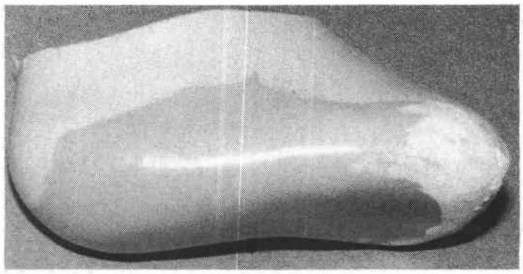

Figure 6B. Lateral view

fit have been achieved, the prosthesis is ready to be completed.

Obtain a shoe from the patient for foot sizing. Take a plaster wrap of the distal portion of an appropriately sized S.A.C.H. foot. When the plaster on the S.A.C.H. foot has cured, remove it from the foot, and inspect the inside for smoothness. Fill any voids and smooth nicely. Dry the plaster and paint the inside with ambroid or celluloid. Spray the inside of the toe cast with silicone release agent.

Rivet with two #12 copper rivets, a 11″ long by 1½″ wide .0035 thick blued steel spring, that has been shaped to the contour of the inside surface of the shoe sole, to the plantar surface of the socket. Shear off the distal portion of the spring so it ends about 1″ from the toe. Drill a hole for a #12 copper rivet and rivet on a small ''U'' shaped piece of leather to act as an anchor for the silicone toe piece (Figure 7). Drill ½″ hole in the distal plantar surface of the toe cast. Wipe the anterior surface of the prosthesis with acetone. It must be clean. Fit the plaster shell over the spring and anterior portion of the prosthesis as far proximal as necessary to obtain proper foot length. Be sure the spring or leather anchor does not come in contact with the inside

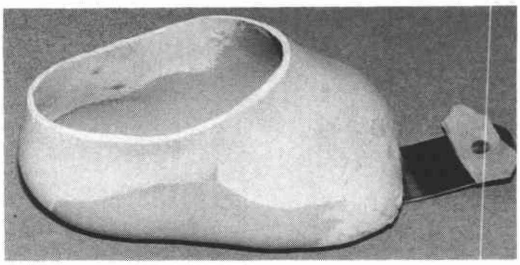

Figure 7. Socket with toe spring and leather anchor rivetted in place

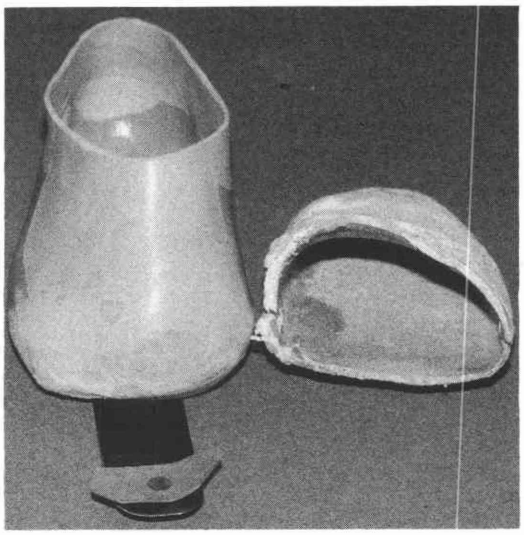

Figure 8. Socket and plaster toe mold

of the plaster mold. When properly positioned, solidly tape the plaster wrap to the prosthesis (Figures 8 and 9).

Mix 65 grams of Dow Corning #382, 5 grams Dow Corning Q74290 Prosthetic Foam, and 2 or 3 drops of appropriate pigment. Catalyze and pour slowly into the ½″ hole in the toe. Stand the assembly on the back of the heel, toe up, and support it in this position until foamed and cured. When the foam has cured, carefully use a thin instrument to pry the silicone toe gently loose from the plaster. It should come off with little effort. Depending on the smoothness of your plaster toe mold, the release agent used, and the foam mixture, the prosthesis should be very presentable (Figure 10). If it is rough and has air holes, sand it smooth and paint on a coat of Pigmented Dow Corning #382.

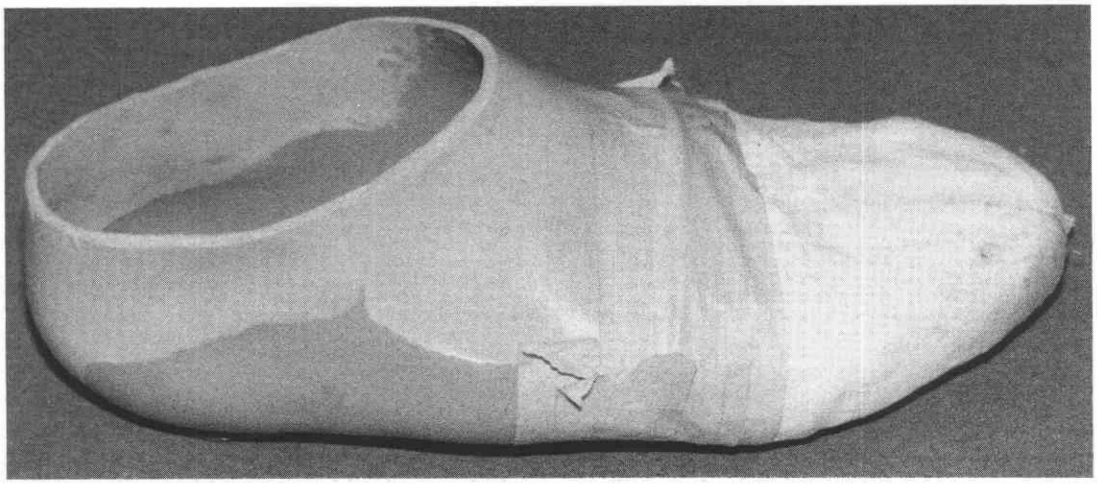

Figure 9. Toe mold taped in place

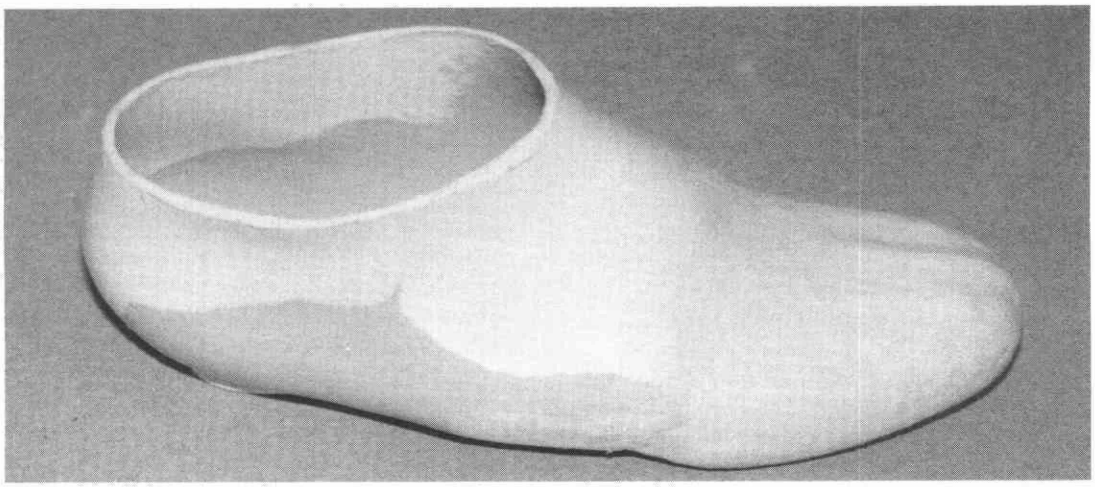

Figure 10. The completed prosthesis

Summary

The rigid control of the residual foot, yet flexible entry and toe off, together with good patient acceptance, cosmesis, and wearibility makes this type prosthesis our choice in the prosthetic management of transmetatarsal amputations. We call this the C.O.S.I. Partial Foot Prosthesis (Collins Orthopedic Service, Inc.).

Addendum

It is the author's opinion that Lisfranc and Chopart level amputations could be approached in a similar manner by extending the distal support and point of toe off to a more normal position. However, this opinion is not based on personal experience with using the C.O.S.I. Partial Foot Prosthesis to fit these level amputations. This would require some thought and quite a bit more effort in the lamination procedure.

Reference

[1] Childs, Charles, Pacific Orthotic and Prosthetic Services, 111 East First Street, Medford, Oregon 97535.

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