A Lightweight Laminated Below the Knee Prosthesis

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INTRODUCTION

Lightweight prosthetic designs become more important each year as people are surviving vascular disease and living longer lives. However, these people often are debilitated and lack the strength to handle a conventional prosthesis.

Previous work on "ultralight" below knee prostheses by Moss Rehabilitation Hospital and Rancho Los Amigos Hospital involved the use of thermoforming and other unconventional prosthetic materials and techniques. An "ultralight" below knee prosthesis came to be known as a design allowing the total prosthesis to weigh less than two and one half pounds. These designs did not gain wide use because of difficulty in fabrication and doubts regarding the durability and strength of the prosthesis. However, these designs did encourage prosthetists to become more conscious of the weight of prostheses, and to develop lightweight prostheses using more conventional materials and techniques.

Presented here is a design using wood and a laminated PTB prosthesis with a Pelite insert that weighs about 2⅛ pounds and has normal SACH foot function (Fig. 1). This design utilizes balsa wood and an external keel SACH foot.

FABRICATION

Fabricate a Pelite insert in the normal fashion. The socket lamination should be kept as thin as possible. Set the socket in a balsa wood block with polyurethane foam (Fig. 2).

Moisture in the moist wood attacks the foam and prevents it from proper curing. Whenever foam comes in contact with normal bass wood, it gets gummy; however, with balsa wood this is not a problem.

Bond a one inch thick piece of regular bass wood to the balsa wood block with resin for a stronger attachment of the alignment fixture. This wood plate will be removed when transferring the alignment. Attach the socket to an alignment fixture. A Symes foot* is used on the prosthesis. The foot is not bolted onto the shank. Instead, the external wood keel is glued and laminated into the prosthesis, eliminating the weight of the bolt and adapters.

The top of the foot is cut and sanded flat until the top is horizontal and level with the shoe on (Fig. 3).

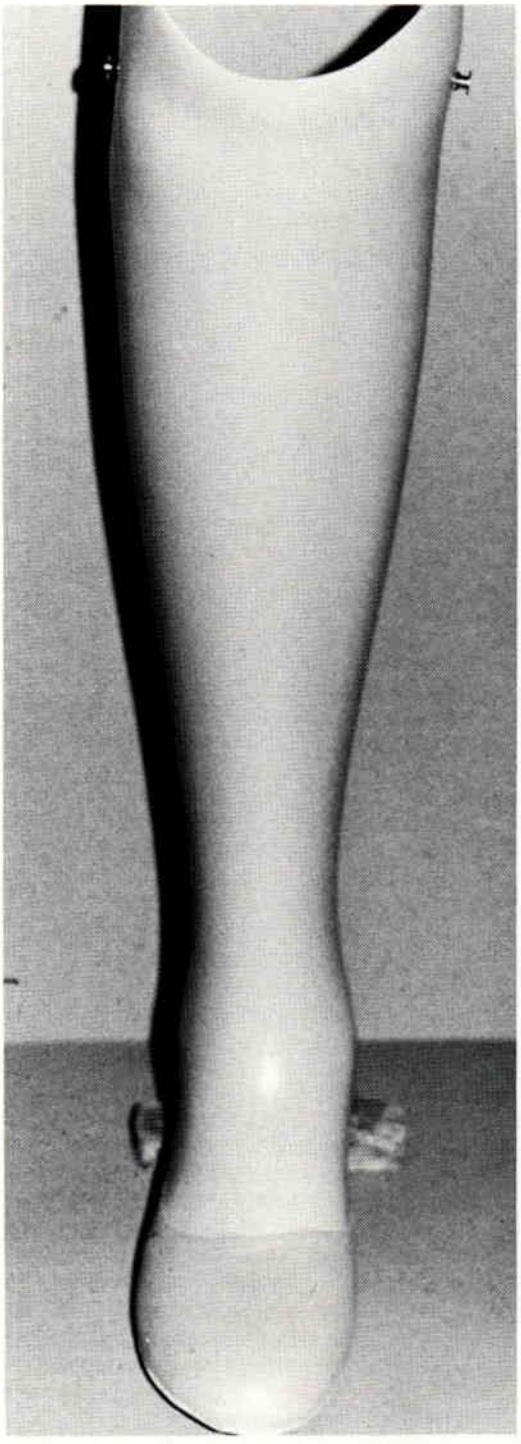

Fig. 1—Completed lightweight PTB prosthesis. The prosthesis weighs 2⅛ pounds when a balsa wood structure is used.

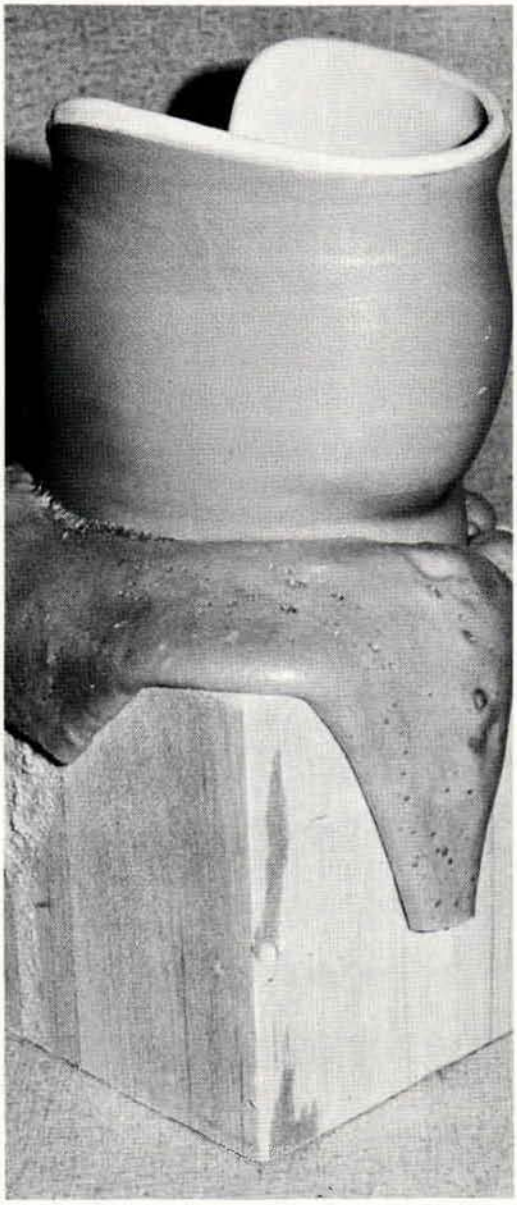

Fig. 2—The socket is set into a balsa wood block with polyurethane foam. The balsa does not have to be sealed with resin as polyurethane foam has excellent bonding properties with balsa wood.

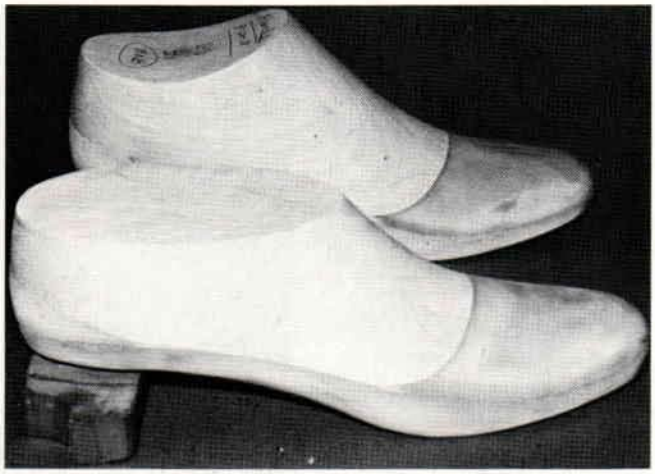

Fig. 3 – The Symes SACH foot (Otto Bock). Rear: Foot before it is leveled. Front: The top of the foot is leveled, allowing for the proper heel height.

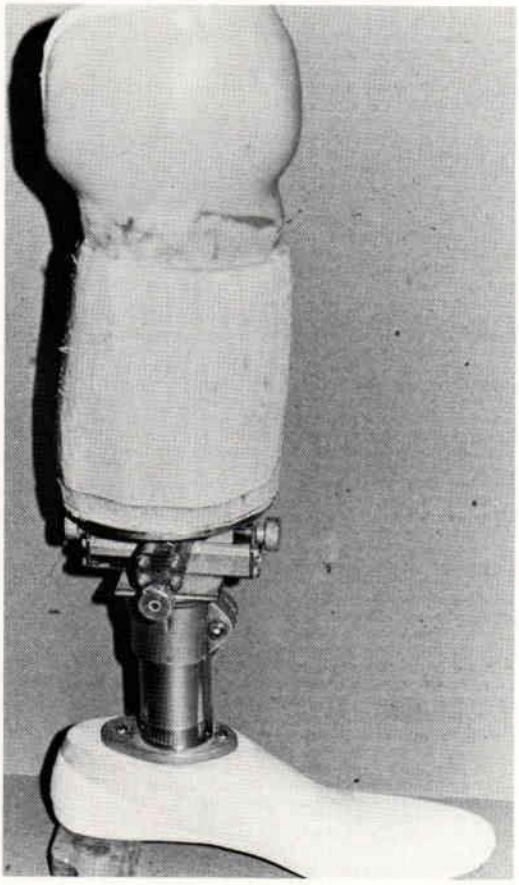

Fig. 4 – Static alignment. An end seal is bonded to the balsa for attachment of the alignment fixture.

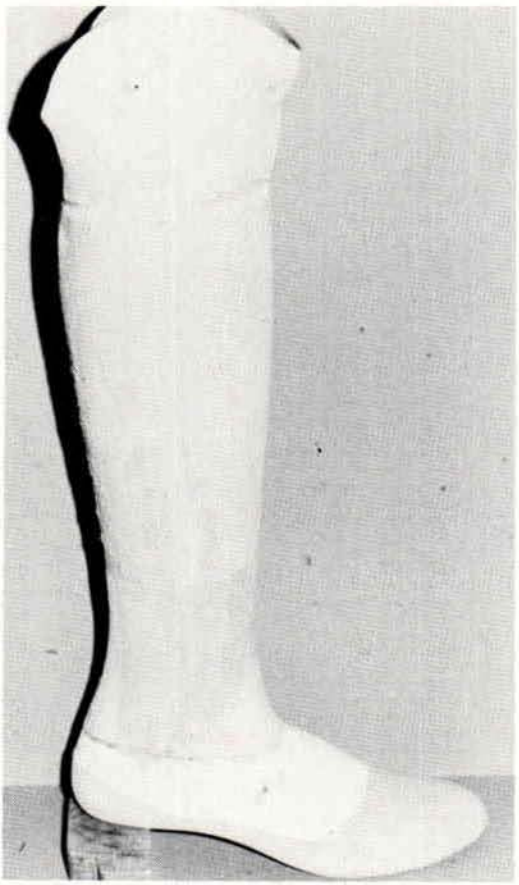

Fig. 5 – Following dynamic alignment, the alignment fixture is transferred for balsa wood.

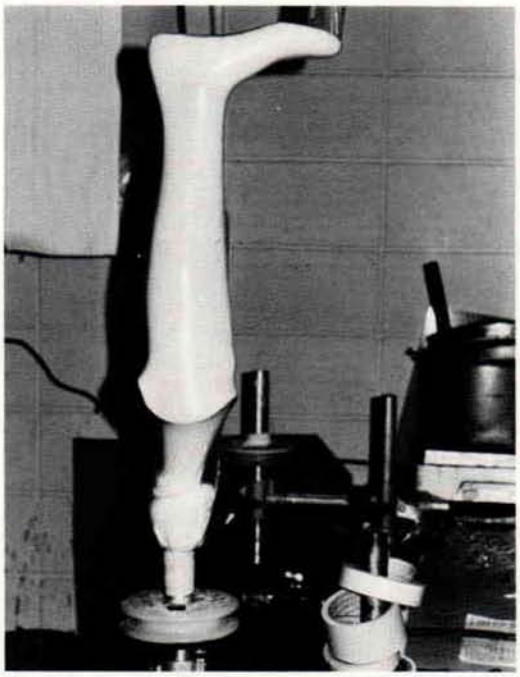

Fig. 6 – Final lamination. A layup of three layers of nylon stockinette is used.

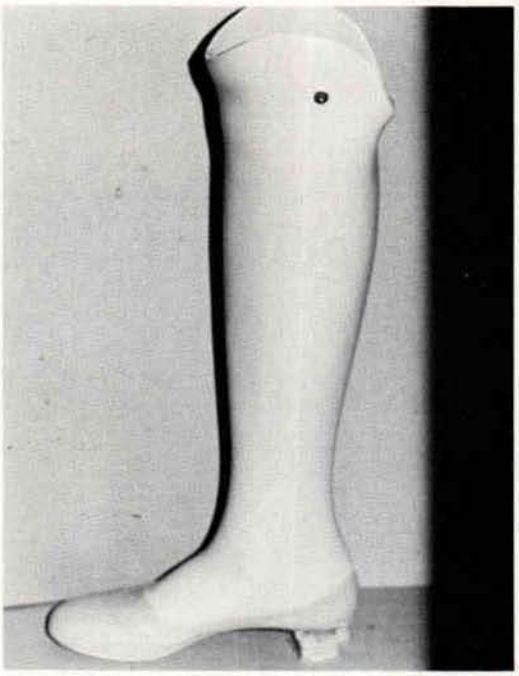

Fig. 7 – The lamination is beveled at the edges of the keel and leather is used to finish the foot.

The foot should be modified to provide better function. It was originally designed to be used for a Symes prosthesis and has a very small heel cushion. A larger, thicker and longer cushion should be installed. Heel wedges are commercially available that are the proper size needed for good heel compression.

A SACH foot plug is screwed securely to the foot and the alignment fixture is attached (Fig. 4). Dynamically align the prosthesis in the usual manner. Transfer the prosthesis in a vertical transfer device. After the alignment fixture is removed, a balsa wood block is glued to the top of the foot to make the ankle block. Then this is attached to the socket. Plastic resin should be used to glue the pieces together. Shaping is done in the normal fashion (Fig. 5).

Three thin nylon stockinettes are used to finish laminating the prosthesis. The lamination extends over the instep and malleoli covering all exposed wood (Fig. 6).

To finish the foot, the lamination is beveled by sanding around the edge of the sole, toe and heel wedge, and a leather cover and sole are used to cover the foot (Fig. 7).

DISCUSSION

This prosthesis is lightweight, cosmetic and uses conventional prosthetic fabrication techniques.

By carefully choosing the appropriate patient, you can make a very light, durable prosthesis. Balsa wood is recommended to be used for less active and lighter patients.

For the more active person, using standard bass wood with a Symes foot and a thicker, stronger lamination can result in a light, strong, cosmetic prosthesis. This usually will weigh about 2¾ pounds including a Pelite insert. When regular bass wood is used, the prosthesis should be hollowed out to a thickness appropriate for the weight of the patient, usually about ¼″ to 3/8″ thick.

Proper application of this technique will result in a weight reduction of 50–100 percent on many patients. Decreased prosthesis weight will ease suspension problems, and has the obvious potential of decreased energy expenditure during ambulation.

*Otto Bock 1P5 symes foot

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