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ADDING STRENGTH TO THE SYME PROSTHESIS

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The contemporary prosthetist realizes the importance of durability in all phases of his practice.

The attachment point between the socket for a Syme amputation stump and the prosthetic foot has been the weakest link in Syme prostheses, and consequently there have been many techniques developed in an attempt to overcome this problem. Leather-socket, metal-frame Syme prostheses seemed to break with alarming regularity despite the large heavy bars used in their construction. Plastic Syme prostheses with SACH feet tend to break at the attachment between the socket and the foot. Of all the maintenance difficulties that confront a prosthetist, none probably causes more headaches than a Syme case in which the socket has separated from the foot. A Syme prosthesis in this condition requires a complete new fitting to effect repair, and therefore a new foot must be modified to the proper depth to prevent length discrepancy, after which the prosthesis must be aligned dynamically and refinished.

For the past two years, we have been using a finishing system on all Syme, Chopart, and long-below-knee prostheses which has virtually eliminated breakage of the prosthesis.

A standard socket lay-up is used, its thickness depending upon the prosthesis type—long-below knee, Syme, or Chopart, and the type of use—heavy, average, or light duty. Laminac 4110 modified by 5 percent Laminac 4134 polyester resin[2] is used in the socket fabrication.

The exact composition of the lay-up, which commonly consists of nylon stockinette with fiberglass cloth sandwiched between each nylon layer at the distal end of the socket, is determined by the use anticipated. Fiberglass roving is sometimes incorporated at the proposed trimline for the medial or posterior opening to provide additional strength at the corners of the window. The lay-up is laminated under 15 psi vacuum.

A SACH foot is carved out to the proper depth, and the socket is attached to the foot with two No. 6 wood screws, 1 in. long, through the socket and into the keel of the foot in order to maintain bench alignment. The commonly used adaptor and bolt are not used. A small amount of fast-setting epoxy resin (Ciba DP116 and Araldite 6020)[3] is placed between the socket and the foot to assist in maintaining the bond during dynamic alignment.

Once the prosthesis has been fitted, a mixture of slow-curing eposy resin (Ciba #502 Araldite and #951 Hardener)[3] and chopped glass cloth is packed between the socket and the SACH foot. It is important that this mixture completely fill the areas between the socket and foot and that no voids are left.

For the most part, the procedure described so far is very similar to fabrication techniques used

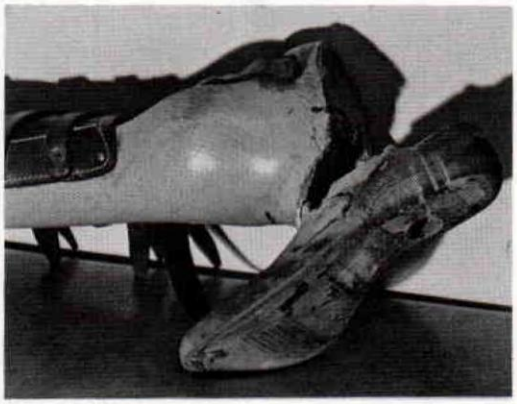

Fig. 1. Typical failure between socket and foot in posterior-opening Chopart prosthesis of standard construction.

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[2] Available from Specialty Plastics, Baltimore, Md.

[3] Available from Ciba Products Corporation, Resins Department, Ardsley, New York.

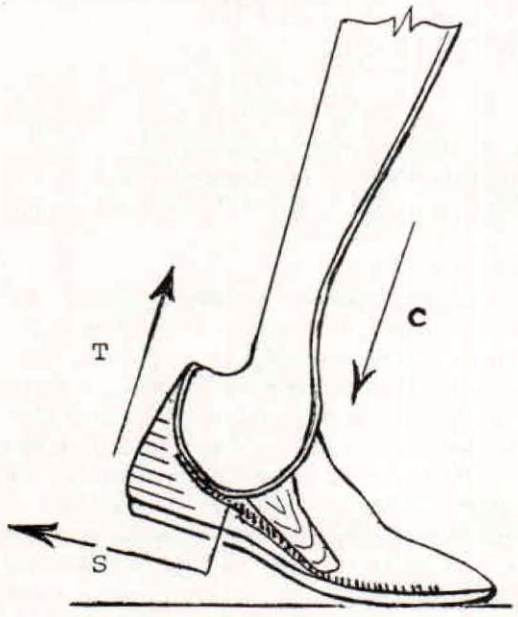

Fig. 2. Schematic diagram showing types of stress involved in Syme prosthesis during stance phase of walking. *T* - tension; *C* - compression; *S* - shear.

by most prosthetists. However, once the bonding resin has cured between the socket and the foot, the prosthesis is considered to be completed.

Figure 1 illustrates the Chopart prosthesis with a posterior opening that has failed at the junction of the socket and the SACH foot. This particular failure is typical in that the posterior tension force generated during push-off is quite large.

The loads on a Syme prosthesis during push-off are shown diagrammatically in Figure 2. Compression is developed in the anterior section, tension in the posterior section; and shear along the socket-foot bond. The shear force is critical

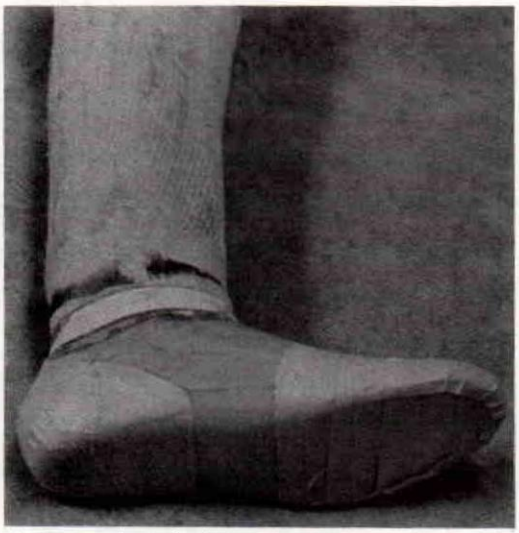

Fig. 3. Prosthesis for long-below-knee amputation. The glaze on the socket has been removed by sanding. The SACH foot has been prepared for final lamination by covering the heel wedge and forefoot with masking tape to protect them from the resin.

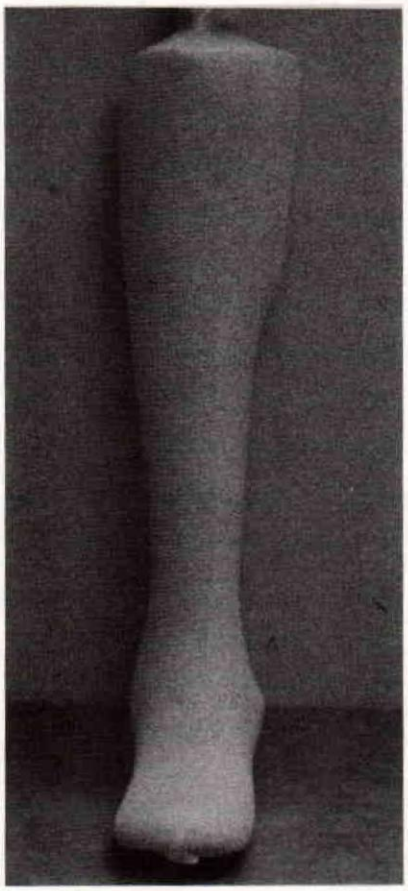

Fig. 4. Medial-opening Syme prosthesis, with two layers of nylon stockinette over entire socket and foot, ready for final lamination. Note that the sewn section of stockinette is in the forefoot trim-out area.

because different materials are being held together by the bond. A procedure to improve the mechanical bonding of the dissimilar materials, to alter the load force on the socket-foot bond, and to make the overall prosthesis more homogenous in the force-absorbing areas, has been developed.

A long-below-knee prosthesis which has been assembled as described above is shown in Figure 3. The socket has been sanded completely so that no glaze remains on the surface to prepare it to receive another, or finishing, laminate. The SACH foot has been prepared for lamination by using masking tape on the heel wedge and the forefoot section. The tape does not cover the entire base of the foot, but leaves exposed the area from the attachment bolt hole to a point within 1 in. of the end of the keel. The tape protects the areas of the foot which are not to be included in the final laminate. Its edges represent the trimlines for the final lamination.

A length of stockinette long enough to cover the entire prosthesis twice is sewn across at the center, and pulled over the entire prosthesis to provide a double layer. When the sewn segment reaches the bottom of the foot, it is pulled snugly to the base of the foot and in front of the end of the keel so the sewn part can be trimmed off. The second half is reversed and the ends of both tied to the mandrel (Fig. 4).

A PVA bag is pulled over the lay-up and the laminating procedure is carried out using 2 psi of vacuum. Prior to the gelling of the polyester resin (Laminac 4110) pressure-sensitive tape is placed over the PVA along the edges of the intended trimlines (Fig. 5).

After the resin has cured, it is trimmed along the edge of the pressure-sensitive tape. Final trimming is completed by cutting back to the edge of the masking tape that was placed on the SACH foot to protect the heel wedge and forefoot.

Figures 6, 7, and 8 show a Syme prosthesis after the initial trimming. It is obvious that the finish-

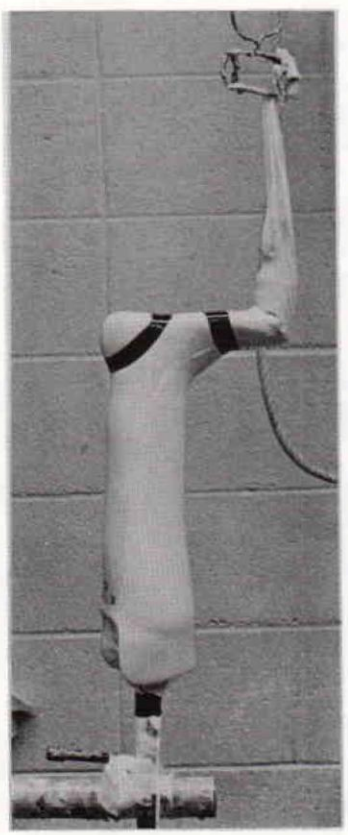

Fig. 5. Prosthesis for long-below-knee amputation undergoing final lamination. Pressure-sensitive tape is placed over the PVA at the intended trimlines on the foot.

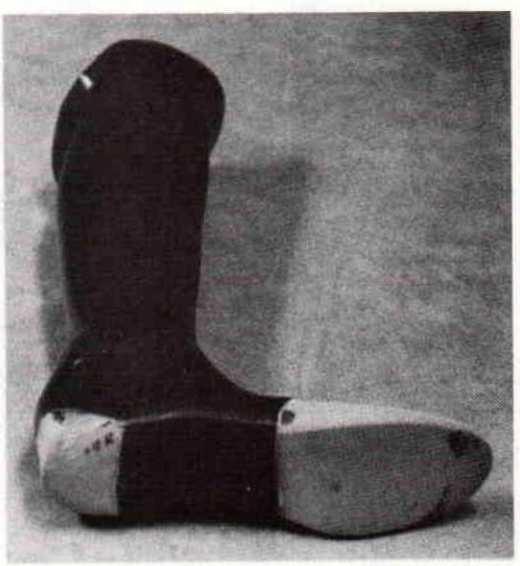

Fig. 6. Medial-opening Syme prosthesis after initial trim of final lamination. Plantar surface of SACH foot from bolt attachment hole to within 1 in. at end of keel has been encased by final lamination.

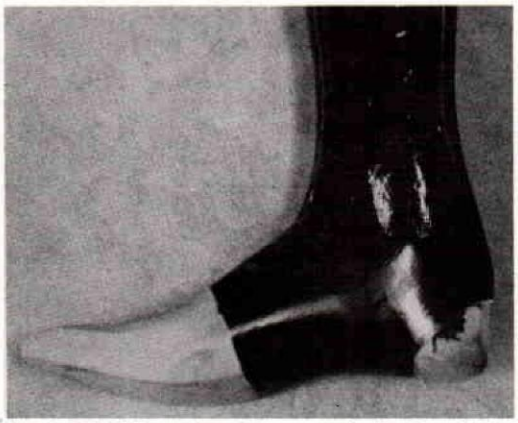

Fig. 7. Medial-opening Syme prosthesis after initial trim of final lamination. Medial view illustrates continuous fiber of stockinette from socket onto SACH foot.

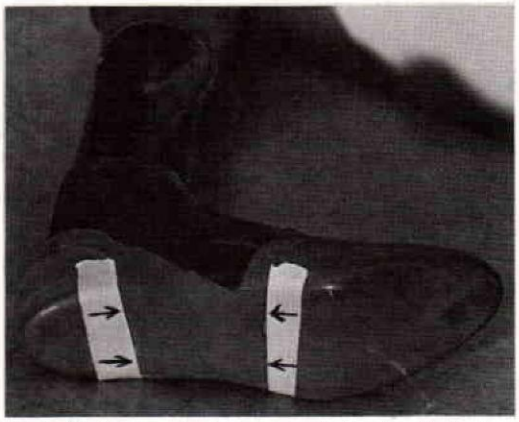

Fig. 9. Medial-opening Syme prosthesis after final trimming and application of Kingsley Kover Kote on the SACH foot. Arrows indicate length of plastic on plantar surface on finished prosthesis.

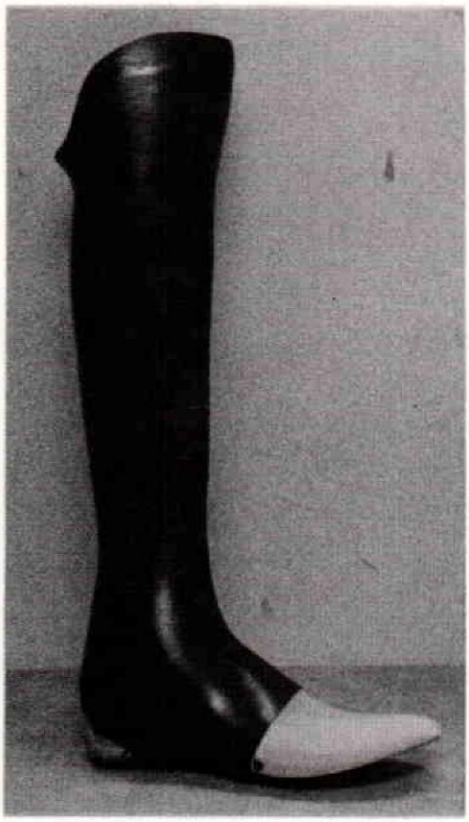

Fig. 8. Medial-opening Syme prosthesis after initial trim of final lamination. Lateral view illustrates a large area of foot which has been bonded by final lamination. Heel and forefoot are trimmed to allow normal foot function.

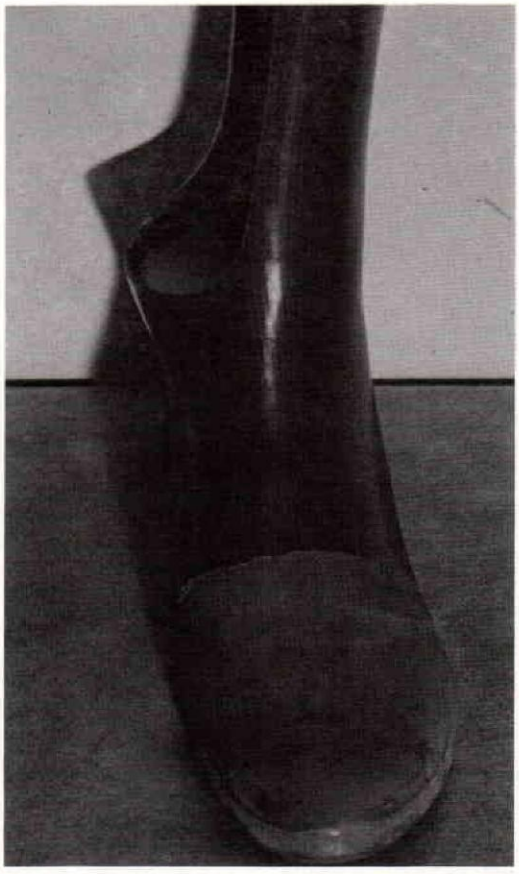

Fig. 10. Finished medial-opening Syme prosthesis. The SACH foot and approximately 1/2 in. of the plastic trim edge has been painted with Kingsley Kover Kote.

ing lamination creates a bond between the socket and foot which covers much larger areas on both units as well as taking advantage of the strength provided by the continuous fiber structure of the stockinette. The continuity of the fibers on the top, sides, and base of the foot creates a mechanical "vise" which assists in maintaining socket-foot attachment. Figures 9 and 10 show the completed prosthesis.

We have used this procedure as standard practice on all prostheses requiring the setting of the socket into the SACH foot or very near the top of the foot. Since adopting the technique, we have experienced no breakage in our Syme, Chopart, and long-below-knee prostheses. There has been no separation of the socket-foot bond. We have used standard SACH feet at all times with this technique and find it unnecessary to use SACH feet manufactured specifically for Syme prostheses only. An improved cosmetic appearance is also obtained as a result of the concealment of the two segments of the prosthesis.