FORMING SOCKETS DIRECTLY ON BELOW-ELBOW STUMPS [a]

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Forming sockets directly on the stump is considered a potentially valuable procedure because it offers several advantages over the conventional method. Some of these advantages are: possibilities for improved socket fit, easier socket modification, substantial reduction in fabrication time, and techniques which are more readily mastered than those used in conventional socket fabrication. The entire procedure is dependent completely on the use of a material which: (*a*) is highly ductile at moderate temperatures, (*b*) is easily worked under conditions found in most limb shop facilities, and (*c*) has a "poor memory," i.e., once set, its shape remains the same.

In addition to these three fundamental properties the required material must also be nontoxic, odorless, relatively light, and of adequate strength.

Polysar X–414,[a] a synthetic rubber, possesses most of the necessary properties mentioned above. It is quite ductile at temperatures between 160 deg. F. to 180 deg. F., it gives up heat readily and thus can be applied to the amputation stump within a minute or two after softening, and it remains reasonably ductile after its temperature drops 20 to 30 deg. Also, laboratory tests indicate that it maintains its shape even under stress in ambient temperature up to 120 deg. F. Other tests have shown that conventional fastenings, rivets, and screws are adequately retained so that it is possible to use all conventional components and accessories with this socket material.

This particular synthetic rubber is used in the form of tubes to make sockets. Tubes extruded with a wall thickness of $\frac{3}{16}$ in. and in circum-

[a] Registered trademark of the Polymer Corporation, Ltd., of Sarnia, Ontario, Canada.

ferences of 4¾ in., 5½ in., and 6¼ in. have provided the best results in fitting below-elbow sockets.

Actually, forming sockets of this synthetic rubber directly on the stump is a very simple technique. It requires one step as compared to the whole process of fabricating a conventional below-elbow prosthesis and makes it unnecessary to make a plaster-of-paris wrap cast, to pour a positive cast, then modify the positive cast, make a wax check socket, and finally to laminate.

All the other fabrication procedures, such as wrist fittings, elbow hinges, harnesses, and control systems, are unchanged.

Hot water is the most practical method of softening this tubing, as the surfaces of the material will not stick together in water. Softening in an oven requires a separating material such as stockinet, silicone treated release paper, or similar material, to prevent the tubing from adhering to itself.

Because this synthetic rubber conforms faithfully to surfaces over which it is drawn, it replicates the ribs of the stockinet conventionally used to cover the stump producing a relatively rough inner socket surface. To avoid this possibility a closed end rubber sleeve is drawn directly over the stump. The rubber sleeve compresses the tissues producing a firm stump for precise fit, and makes it easier to pull the tube onto the stump. The rubber sleeve is reusable.

Below-elbow prostheses fabricated with synthetic rubber sockets are best finished by donning prefabricated flexible cosmetic covers. Although less convenient they may also be finished by conventional laminating procedures. However, this will tend to stiffen the socket and reduce the yielding property of synthetic rubber. It is therefore not recommended.

The only special equipment required for this procedure consists of a hot plate, tote pail, and thermometer. The synthetic rubber tubing, the rubber sleeves, and the cosmetic covers are available from prosthetics suppliers.

The following three steps occur in the basic procedure for forming a below-elbow socket in the synthetic rubber tubing: (*a*) recording prosthetic information, (*b*) preparing the stump, and (*c*) forming the socket. All the prosthetic information required for fabricating conventional sockets is also recorded for forming sockets directly on the stump. However, the stump is prepared differently.

The stump is prepared for socket forming by applying a rubber sleeve to it. Most below-elbow stumps are accommodated by the sizes of rubber sleeves—3 in. × 6 in. × 14 in., 3½ in. × 6 in. × 14 in., 4 in. × 6 in. × 14 in. The rubber sleeve is selected that best conforms to the stump. It is pulled snugly over the stump. The proximal end is fastened

with Yates clamps to a below-elbow Figure 8 harness and the entire sleeve is lubricated with IMS silicone (Fig. 1).

A synthetic rubber tube is selected whose circumference is closest to *but under* the circumference of the stump at a point 2 in. from the distal end. The three tube sizes which accommodate most below-elbow stumps are 4¾ in., 5½ in., and 6¼ in. The tube is cut to a length 3 in. longer than the lateral epicondyle to distal stump end measurement. The internal surface of the tube is cleaned to remove loose particles and the tubing is immersed in a container of water heated to approximately 180 deg. F. The softened tubing is removed from the water and the entire internal surface lubricated with silicone. The tube is drawn up on the stump to a point where the proximal brim is about 1 in. above the olecranon process (Fig. 2). To seal the open distal end of the tube, a nylon cord encircling it is gently pulled until the tube conforms to the end of the stump and is completely sealed (Fig. 3). The excess tubing is cut with a pair of scissors distal to the nylon cord.

The socket is molded and formed on the stump to produce the desired contours. The properties of the synthetic rubber provide a working time of approximately 5 minutes. A rough trim line is marked on the socket according to the socket plan and trimmed with bandage scissors while the tube is still soft (Fig. 4). Before removing the socket from the stump, the tube is allowed to cool, a process which can be expedited by immersing the socket-covered stump in cold water. Hand and finger pressure may be used to hold contours while the tube is immersed to maintain precision of fit. After removal, the socket is trimmed to final shape. Areas requiring reshaping may be resoftened by immer-

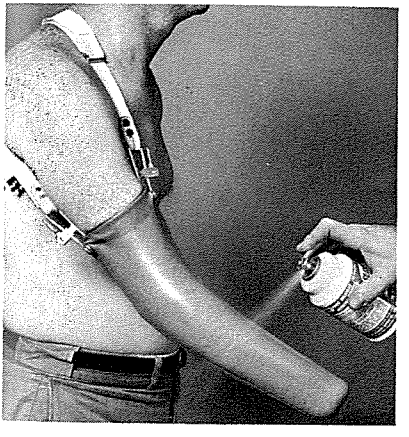

FIGURE 1.—Preparing the stump to receive synthetic rubber tubing.

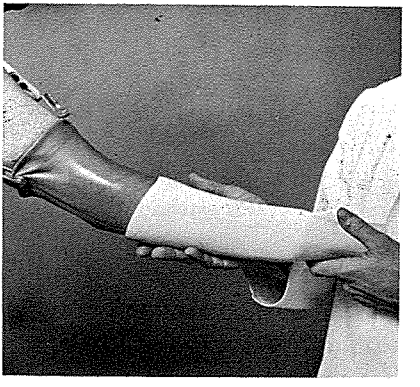

FIGURE 2.—Forming the socket by drawing the softened tube on to the stump.

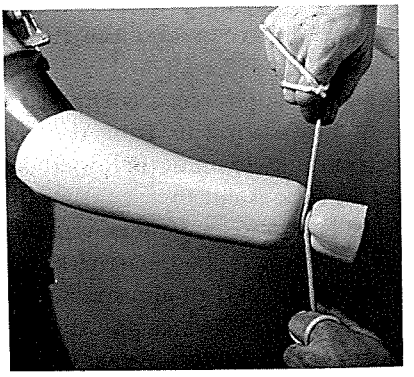

FIGURE 3.—Distal end is sealed by use of nylon cord.

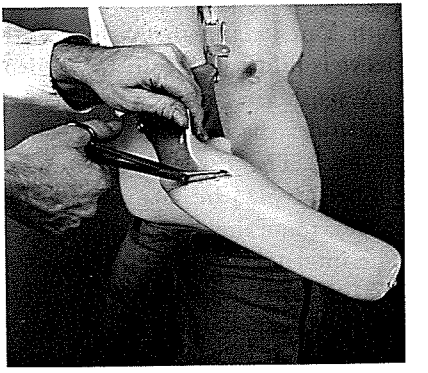

FIGURE 4.—Trimming is accomplished while the tube is still soft.

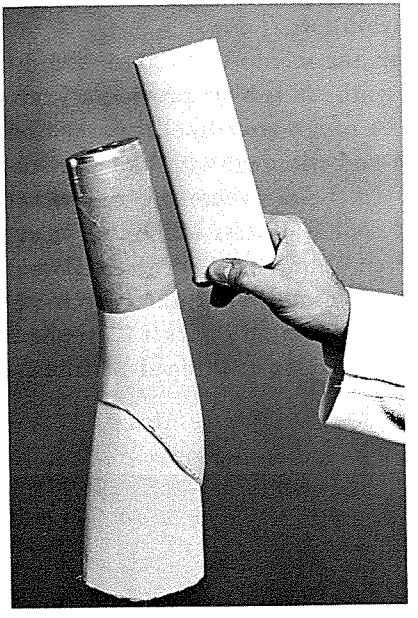

FIGURE 5.—A length of tube is cut to form the forearm extension.

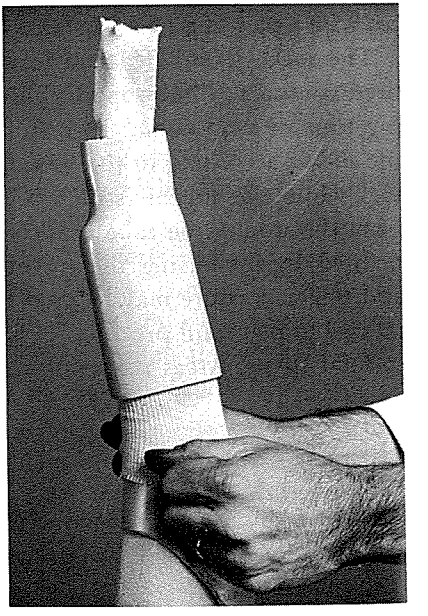

FIGURE 6.—Forearm extension is pulled over manila cone leaving a 1 in. overlap at the distal end.

sion in hot water although smaller areas may be softened by use of a heat gun[b] and reshaped on the stump.

A manila folder is formed into a cone and incorporating the desired

[b] When using heat gun on the synthetic rubber tubing it is advisable to use the heat gun adapter.

wrist fitting, provides a forearm extension. The length of the cone is equal to the epicondyle to ulnar styloid measurement and its proximal end flairs into the socket approximately 3 in. over the distal end. A length of tube approximately 2 in. longer than the cone is cut and immersed in hot water until soft (Fig. 5). Then a section of 2 in. stockinet, twice the length of the tube, is pulled through the softened forearm extension and the softened tube is pulled over the cone using the stockinet as a "pull sleeve." The tube is pulled proximally until the proximal brim overlaps the proximal end of the manila cone by 1 in. (Fig. 6). The tube extension is then cooled by immersing the entire assembly in cold water.

The forearm extension is removed after reference lines are marked on both the socket and extension for realigning the forearm extension to facilitate replacement.

The extension is replaced on the socket after the socket area covered by the extension is sanded lightly and wiped with trichloroethylene. The proximal 3 in. of the extension is heated until soft, without allowing the socket to become soft (Fig. 7). The softened end of the extension is compressed until it adheres evenly to the socket. Then the socket and extension are immersed in cold water.

The distal 1 in. of the extension is immersed in hot water until soft and the wrist fitting is inserted into the softened distal end. The tube around the wrist fitting is compressed with pressure-sensitive tape as shown in Figure 8. After the alignment is checked and adjusted the entire socket is cooled in water.

FIGURE 7.—Proximal 3 in. of extension is heated until soft and positioned.

FIGURE 8.—Tube around wrist fitting is compressed with pressure-sensitive tape.

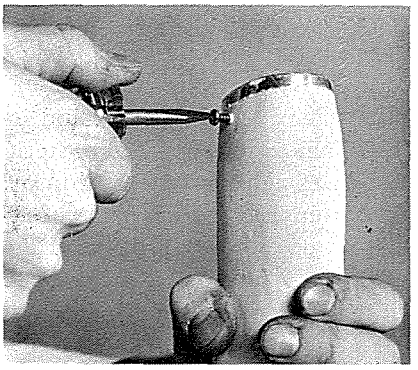

FIGURE 9.—Wrist fitting is secured with self-tapping sheet metal screws.

The protruding extension lip is faired and the wrist fitting is secured with sheet metal screws (Fig. 9). After the proximal socket brim is buffed with a felt wheel and wiped with trichloroethylene to produce a smooth surface, the prosthesis is ready for finishing.

Metal or leather joints are aligned and fastened with speedy rivets. All other components (cable system, etc.) are installed in the conventional manner.

Although several types of cosmetic coverings can be applied for final finishing of the prostheses, we recommend the use of a specially prepared arm stockinet supplied in two colors and distributed by the White Swan Hosiery Co., 317 Grand St., New York, N.Y. 10002. The arm stockinet is furnished with one end finished and the other end unfinished. To prepare the cosmetic cover, the unfinished end is sewn closed. The stockinet is pulled over the socket with the unfinished end toward the wrist fitting from which the washer and plate have been removed. After donning the stockinet, the washer, plate, and the terminal device are attached.

Eighteen patients have been fitted to date with highly promising results. A formal evaluation of the new material and technique is presently being studied at New York University.