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A Material for Direct Forming of Prosthetic Sockets

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For a number of years, prosthetics research groups have been attempting to develop a method of forming sockets directly on amputation stumps, in order to reduce the time required to produce a satisfactory socket and to eliminate the messy working conditions inherent in the use of plaster of paris *(1).*

Direct forming requires a material that: (*a*) is plastic at temperatures moderately above ambient, but which requires reasonably high temperatures for subsequent softening; *(b)* is easily handled under conditions found in most limb shops; (*c*) exhibits minimum creep or deformation under normal loads, even at temperatures slightly above body temperature; (*d*) is nontoxic; and (*e*) has a reasonable strength-to-weight ratio.

Recently, research and development groups in Canada and the United States have developed successful techniques for direct forming of some types of sockets by using a synthetic balata, Polysar[1] X-414.

Polysar X-414 has been found to possess the properties most essential for direct forming: (a) it becomes plastic at temperatures between 160 and 180 deg F; *(b)* it can be applied to the amputation stump within a minute or two after heating; (c) it remains reasonably plastic after its surface temperature drops 20 to 30 deg; *(d)* after it cools and becomes nonplastic, it maintains its shape, even under stress and subsequent heating to temperatures of 120 deg F; and (e) it can be reheated and reformed to permit socket modification after fabrication. In the plastic state, it exhibits cohesive properties which facilitate fabrication. It yields a slightly flexible socket which is considered desirable by most patients, and it is practical to use all conventional components and accessories with Polysar X-414.

Clinical findings indicate that the sockets remain durable, provided they are not exposed to excessive heat *(e.g.,* leaving the prosthesis in the sun, in the trunk of a car on a hot day, or leaning against a house radiator). Also, excessive contact with perspiration may cause erosion of the material in a year's time; however, stump socks normally provide an adequate barrier.

The socket-forming procedure is relatively simple. The need for making a plaster-of-paris wrap cast, pouring a positive cast, and modifying the positive cast is eliminated. Thus, not only is fabrication time reduced, but the chance of the errors that are likely to occur when fabricating a socket with conventional materials also is lessened.

LOWER-EXTREMITY SOCKETS

A practical method for direct forming of sockets over the below-knee stump has been developed recently at the Veterans Administration Prosthetics Center. Early attempts included the use of a pneumatic bag over a tube of synthetic rubber to provide the pressure necessary for forming the socket over the stump (Fig. 1) (2), a procedure which worked satisfactorily for bony, mature stumps but which often produced sockets that were too loose when molded over flabby stumps. Further experimentation resulted in a technique in which pressure is provided by wrapping pressure-sensitive tape spirally around the tube of Polysar X-414 and molding it with the hands as the tube cools (Fig. 2).

This method, described in the article

[1] Registered trademark of the Polymer Corporation Limited.

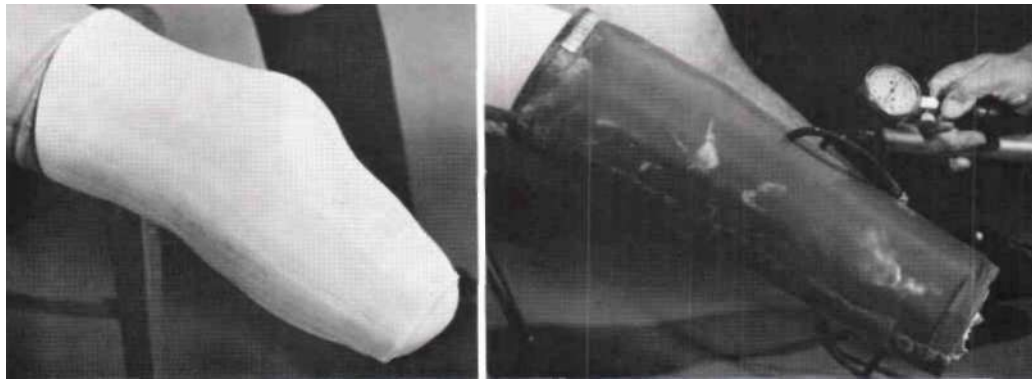

Fig. 1. Pneumatic pressure was applied to the softened synthetic rubber to form the socket on the stump.

Fig. 2. Direct forming of a below-knee socket with a pressure-sensitive tape wrap and hand molding of the softened synthetic rubber tube.

beginning on page 57, has proved to be successful in a number of clinics, especially for use in temporary, or preparatory, prostheses. If a pylon is used, the patient can be provided with a well-fitted prosthesis in a very few hours. If subsequent socket modifications are required, they can usually be carried out readily, and if one of the adjustable pylons is used, alignment can be changed easily when required. A satisfactory cosmetic effect (Fig. 3) can be achieved relatively easily, to provide a "permanent" prosthesis. Such a prosthesis has proved to be quite successful as a "permanent" prosthesis for many patients in the old-age group.

Because of the size of the above-knee socket and the usual need for rather drastic modification of the socket with respect to the shape of the stump, a successful method of molding sockets directly over the above-knee stump has not yet been developed. However, work is continuing at VAPC.

UPPER-EXTREMITY SOCKETS

A technique for satisfactorily forming sockets for permanent prostheses directly over below-elbow stumps has been developed, also at VAPC. Again, extruded tubing of Polysar X-414 is used. All pressure necessary for forming is provided by the prosthetist's hands. Several types of cosmetic coverings are available when further cosmetic treatment is desired. The time required for fabrication of a typical below-elbow prosthesis can be reduced by half. The VAPC technique is described fully in the article beginning on page 65.

The Ontario Crippled Children's Centre, Toronto, Canada, has been routinely using Polysar X-414 in fabrication of the open-shoulder, above-elbow socket, described in *Artificial Limbs* for Autumn 1969. Sockets preformed roughly to the shape required are heated and applied over the stump.

Fig. 3. A "permanent" below-knee prosthesis, consisting of a synthetic rubber socket, adjustable pylon, foam-block covering (note cutout for access to the adjustment mechanism), and stocking.

The Prosthetics Research Center, Northwestern University, has developed a successful method for forming more conventional above-elbow sockets directly over the stump. An article describing this technique is scheduled for publication in the next issue of *Artificial Limbs.*

IMPLICATIONS

Forming sockets with synthetic balata offers the prosthetist and orthotist the opportunity to provide quicker service to the patient, and also opens up many possibilities for improving the designs of sockets and orthotic components. The use of temporary prostheses can now be made routine, giving the clinic team ample time to determine the optimum prescription for the patient. Errors can be rectified easily, and new ideas can be tried with a minimum expenditure of time. Orthotists are already using synthetic balata for cuffs and molded supports. It is expected that many more uses for this remarkable material will be developed in the future.

LITERATURE CITED

1. Committee on Prosthetics Research and Development, *Fracture bracing,* A report of a workshop, National Academy of Sciences, Washington, D.C., February 1969.

2. The Staff, Veterans Administration Prosthetics Center, *Direct forming of below-knee patellar-tendon-bearing sockets with a thermoplastic material,* Orth. and Pros., 23:1:36-61, March 1969.