Flexible Above Knee Socket Made from Low Density Polyethylene Suspended by a Weight Transmitting Frame

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INTRODUCTION

Ten years ago, a bilateral amputee came to us to be fitted for new prostheses. The prostheses he was wearing consisted of external brace joints, hyperextended knees, Sach feet in plantar flexion (to compensate for the hyperextension of the knees), and laced leather sockets. Suspension was provided by hard lacing and shoulder straps. His residual limbs were in bad condition, distally and proximally. They were rather long, with the patellas fixed under the femurs which had been cut just above the epiphyses.

The new prostheses which we fabricated for him consisted of more acceptable alignment, total contact suction sockets, and multi-axis feet. Although the patient's old sockets were uncomfortable while standing, they were comfortable when he was seated. Being employed as a goldsmith, a great deal of his work day was spent sitting. The patient was also used to tactile feedback accommodated from the leather sockets. The sockets on his new prostheses were rigid plastic, and compared to the old ones, extremely uncomfortable when he sat. Because of this, the patient rejected the new prostheses and asked us to make leather sockets similar to his old ones to replace the rigid plastic. Because of this, we began to look for a socket material that was a compromise between the rigid plastic and leather socket materials. This led to a flexible socket attached to an external rigid frame, the subject of this article.

SILICONE SOCKETS

The flexible sockets were fabricated using soft laminating resins like silicone, polyester, acrylic, polyurethane, and lynadure. The laminates were usually made up of nylon stockinette with one or two layers of fiberglass stockinette between each layer. This, in combination with silicone resin, yields a flexible socket which is relatively unstretchable. In the beginning, the rigid frame had both medial and lateral bars to connect the distal socket to the proximal brim. The use of carbon fibre allowed us to eliminate the lateral bar. When we started using low density polyethylene as a socket material, we also deleted the lateral quarter of the brim, ending up with a fork-like structure which is used today.

FABRICATION METHODS

Socket

The socket is vacuum formed with a low density polyethylene sheet by conventional technique. We heat the sheet in an infrared oven and drape it over a moist plaster of paris positive model. An O ring and double adhesive tape are placed over the valve ring, which then is placed in position over an air channel that has been drilled through the length of the positive model. Polyethylene has a rather large shrinking coefficient. To overcome this problem, we usually make the positive model for a flexible socket slightly larger than for a rigid socket. At this point, a check socket should be used to insure a good fit between the socket and the frame. However, if this is done the socket cannot be placed back on the positive model, so it will need to be refilled with plaster before laminating.

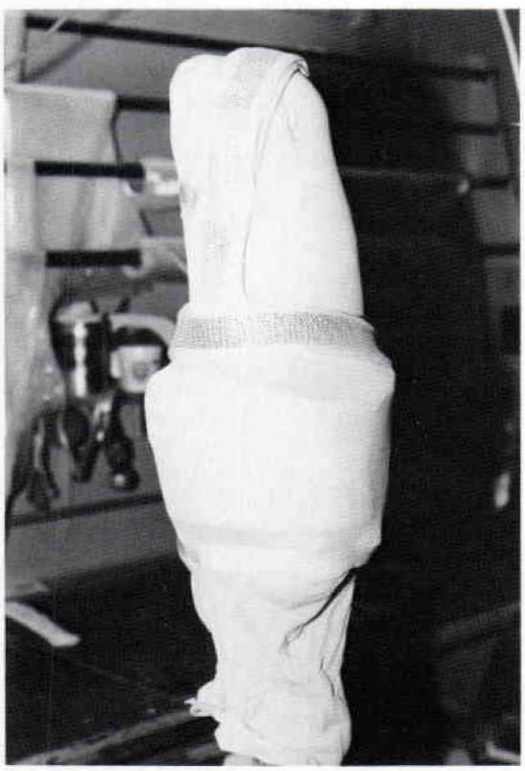

Fig. 1. The fiberglass and carbon fibre lay-up for the socket frame.

If one does laminate directly over the newly molded socket, expect a loose fitting between the socket and the frame, as the socket shrinks after being removed from the positive model. To date, we are not familiar with any techniques for eliminating this shrinkage factor.

Frame

The frame is laminated with nylon stockinette, several layers of fiberglass and about ten layers of carbon fibre tape (Figure 1). We use acrylic resins, but polyester resin works as well. The socket and the frame are riveted together. In Stockholm and Uppsala, double adhesive tape is used to fix the socket to the frame, without rivets. As the rigid frame covers less than 40 percent of the socket, it is easy to add or

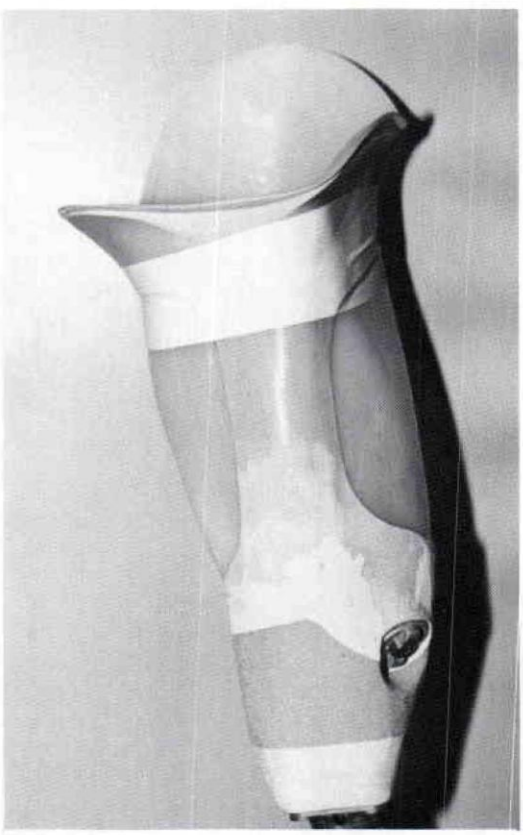

Fig. 2. Medial view of the carbon fibre and fiberglass reinforced acrylic frame. The frame has only a medial strut connecting the proximal socket to the distal end. Less than 40 percent of the socket surface is covered by the frame.

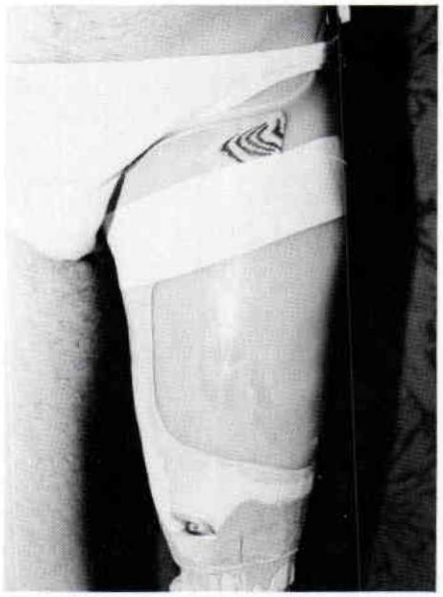

Fig. 3. Patient wearing the flexible above knee socket. Note that the frame extends only to the center of the rectus femoris channel anteriorly. The flexible low density polyethylene socket can conform naturally to the muscle expansion and other forces.

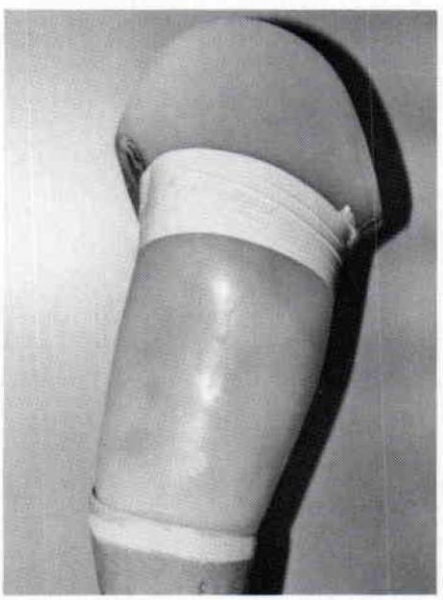

Fig. 4. Lateral view of the flexible socket. In this view tape is seen holding the socket to the frame for the fitting. When finished, the socket is fastened to the frame either by riveting or using double face tape. Over 300 of these sockets have been used, mostly in Stockholm.

remove material from the positive model. If the length of the positive model is not altered, and if build-up material has not been added or removed at the proximal brim area, a new socket can be fabricated over the altered positive and, of course, will fit the original frame.

It is usually unnecessary to alter the alignment when a smaller socket is replacing a larger one, which is obviously an advantage when dealing with a new amputee regarding the rapid volume decrease. Our observations indicate that atrophy in the residual limb is somewhat less with the use of a flexible socket than it is with the use of a conventional rigid socket. These are, however, only observations and have not been statistically confirmed.

Finishing

Conventional methods are used to finished the prostheses; however, we do not laminate over the socket. When the patient is not concerned with cosmesis, the polyethylene socket is left uncovered, thus providing for rapid heat exchange, tactile contact, and better dynamic interaction between the residual limb and socket. Also, the socket exchange is simple and inexpensive with this type of appliance.

SUMMARY

Approximately 300 prostheses with this type of socket have been made, most of them in Stockholm. To date only two breakdowns have occurred, both due to lamination failures.

Our goal in using a socket of this type is to achieve a socket with excellent suspension, one that adapts itself well to the various contours of the stump during ambulation, and one which is simple and relatively inexpensive to change.

There are four fitting centers involved in this project. To date, there have been no reports of undue maintenance requirements or dissatisfaction on the patient's part with a flexible socket over a conventional rigid one.

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