

Flexible Socket Systems

by David J. Jendrzejczyk, C.P.

Over the past two years there has been impetus towards the use of the flexible socket interface in above knee prosthetics. For our purposes here, it is widely accepted that the flexible socket is of multiple benefit to the patient. We will concentrate on discussing the different systems available.

The history of flexible sockets dates back a number of years. The article by Charles Pritham, C.P.O., et. al. "Experience with the Scandinavian Flexible Socket"¹⁰ provides a concise summary of this train of development.

At the present time, there are numerous flexible socket systems being used in the United States and throughout the world. These sockets differ in design in two major areas: flexible socket interface and the outer hard socket. The flexible socket is currently being used with three types of support mechanisms:

1. Total hard socket as the support
2. Hard socket with strategic fenestrations
3. True frame design

The prosthesis discussed by R. Volkert in the

article, "Frame type Socket for Lower Limb Prosthesis"¹² is constructed with a frame outer socket and an elastic stocking interface. This system can accommodate stump volume changes, therefore, it appears to be most useful with early amputees.

The TC Couple Socket⁶ above-knee prosthesis used a polyethylene flexible interface and an external polypropylene socket. There are no fenestrations in the outer socket, so it doesn't have some of the benefits of sensory feedback as a fenestrated outer socket would. The advantage of this system is its light weight polypropylene outer socket.

Work done at the Institute of Rehabilitation Medicine, New York University Medical Center, is detailed in "Flexible Prosthetic Socket Technique."⁸ Two systems are described in the article, both have a hard outer socket with windows cut out in strategic locations (Figure 1). The interface is either of thermo-formed polyethylene or of silicone elastomer lamination.

Currently, in the United States, the external

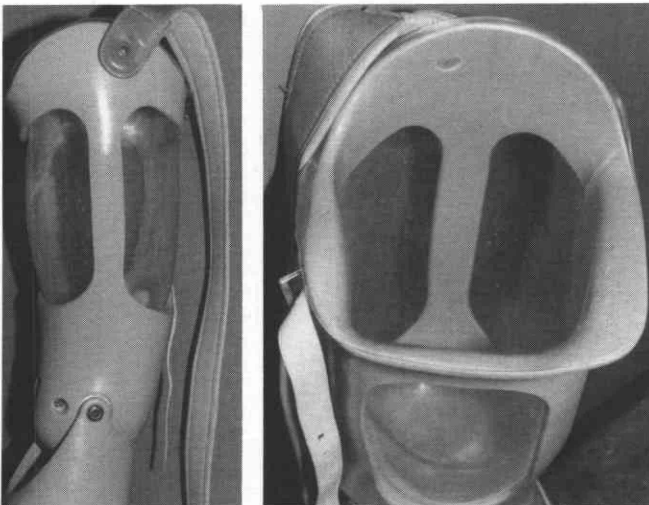


Figure 1. Prosthesis incorporating a flexible Polyethylene socket in a support with fenestrations in selected areas as fitted at the Rusk Institute of Rehabilitation Medicine (Photo courtesy RIRM).

frame with the thermoplastic interface seems to be the most commonly used. There are three major fabrication techniques for the frame system described. They are the IPOS System (Figure 2),^{1,2,13} the ISNY (Figure 3),¹⁴ and the SFS System (Figure 4)⁷ (Fillauer Technique).^{10†}

The intention of this article is to describe the differences and similarities of the above three systems.

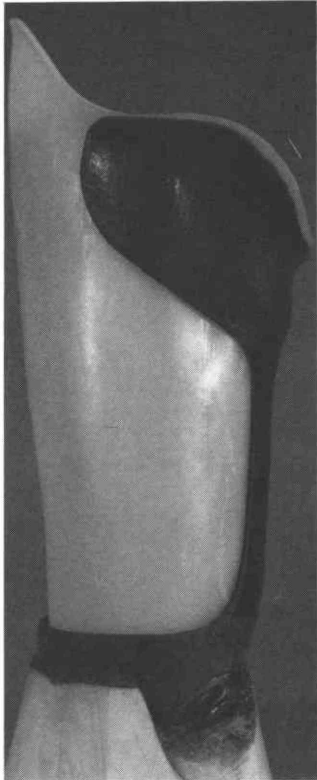


Figure 3. Icelandic Swedish New York (ISNY) flexible socket (Photo courtesy NYU).

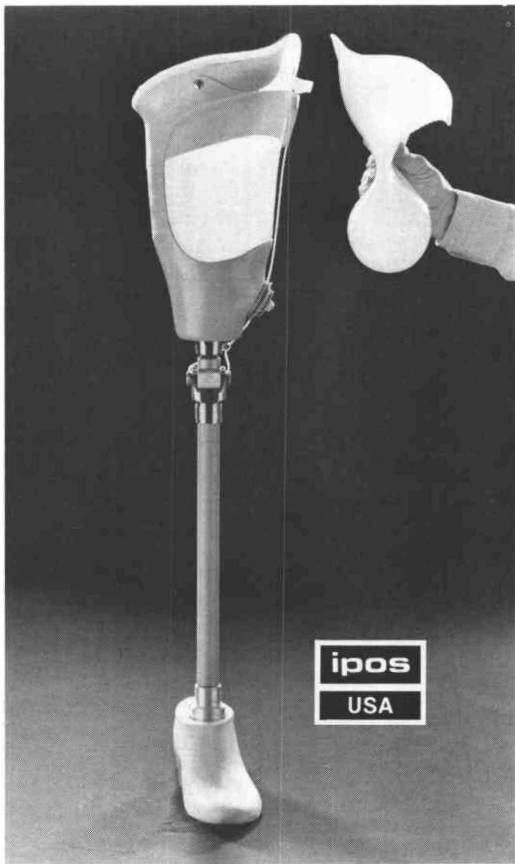


Figure 2. Flexible AK socket as fabricated by IPOS (Photo courtesy IPOS).

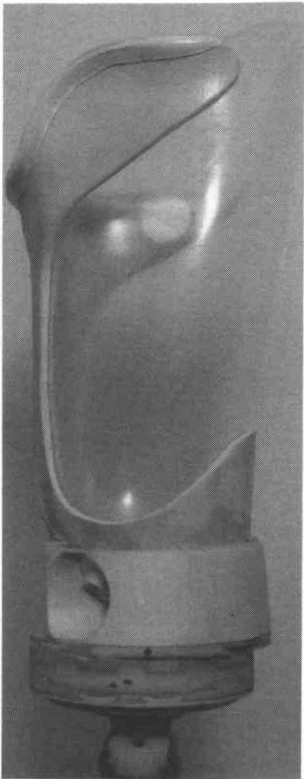


Figure 4. Scandinavian Flexible Socket (SFS) (Photo courtesy Durr-Fillauer Medical, Inc.).

† Further reference to the SFS system will be as it is fabricated by Durr Fillauer Medical, Inc.

SOCKET INTERFACE

All three systems use a thermoplastic material for their inner socket.

IPOS uses ipolen,² which is a specially formulated polyethylene and which reportedly provides a uniform socket thickness and has little shrinkage. The resulting socket is translucent.

The ISNY system prefers polyethylene which has a tendency to shrink. NYU reports that the shrinkage is not a problem. This socket is also translucent.

The SFS system recommends Surlyn®, but polyethylene can be used. Surlyn® is a thermoformable plastic which shrinks little and provides a transparent socket.

The thermo-forming method for the interface is basically the same for all three systems. The only difference is that IPOS recommends that you preheat the vacuum forming frame, and they prefer a dry cast. If a wet cast is used, they recommend that an IPOS sheath be pulled over the cast before the thermo-forming. The SFS system recommends a warm, wet mold for Surlyn®. ISNY states no preference.

FRAME (Structural Element)

The most variation occurs in the fabrication of the frame. Materials and lay-up have a wide range of variation (Table 1).

IPOS laminates on the positive model with the flexible socket in place. Carbonacryl, which has been specially formulated to use with carbon fibers (13-1), is laminated over the appropriate layers of nylon stockinette, carbon-glass stockinette, fiberglass matting, and fiberglass stockinette. Total lay-up is seven layers for the average size patient of 120 to 180 pounds.

The ISNY system laminates on the positive model with the flexible socket in place. Their recommendation is for 100 percent rigid polyester, acrylics if desired. A polyester lamination is done over the appropriate layers of nylon stockinette, fiberglass stockinette, and 1" and 2" unidirectional carbon tape. The total layup is 26 layers in both directions. In addition, they recommend adding dacron felt "to insure sufficient thickness in strategic areas."¹⁴

SFS laminates their frame over the positive

Frame Lay-up Comparison		
SFS	ISNY	IPOS
1 Nylon stockinette 2 ³ / ₁₆ " round Polyethylene rod medial wall 1 Nylon stockinette 2 Fiberglass stockinette 1 -6" Nylon folded lengthwise on anterior, medial and posterior of proximal brim 1 Fiberglass—Carbonroll* medial wall proximal to distal 1 Fiberglass—roll proximal brim 1 Fiberglass—Carbon roll* medial wall proximal to distal 1 Fiberglass—Carbon roll*—Proximal brim 2 Fiberglass stockinette 2 Nylon	1 Nylon stockinette 1 -1oz. Dacron distal end 1 Nylon stockinette 4 -2" Carbon—(Medial Struct.) 1 -1" Carbon—(Proximal Frame) 12 Fiberglass 4 -2" Carbon 1 -1" Carbon 1 Nylon Stockinette <i>Add Dacron felt and smooth transition and insure sufficient thickness in strategic area.</i>	1 Stretch nylon stockinette 1 Carbonglass stockinette 2 Fiberglass matting (on medial strut and anterior posterior phalange) 1 Carbonglass stockinette 1 Fiberglass/nylon stockinette 1 Stretch nylon stockinette <i>For the average size patient, 120 to 180 lbs., the lay-up remains constant.</i>
<i>Acrylic resin with 10 percent thinner.</i>	<i>100 percent Rigid polyester acrylic if desired.</i>	<i>Carbonacryl Resin</i>

* Roll = 6 Fiberglass and 31" carbon tape.

Table I.

model, which has been built up with varying layers of stockinette used as a filler in place of the flexible socket. An acrylic lamination is done over the appropriate layers of nylon stockinette, fiberglass stockinette, and 1" unidirectional carbon tape. Total lay-up at the proximal brim is 25 layers, and 26 layers at the medial brim.

In the ISNY and SFS systems care must be taken in the lay-up of the medial/proximal brim where the materials overlay to avoid excessive thickness.

FRAME DIMENSIONS

There are some variations in the final trimlines of the frame. The medial strut on the SFS and ISNY are approximately 2¹/₂" and 2³/₄" wide. The medial strut on the IPOS frame extends around the anterior and posterior medial edge by one centimeter.

The proximal trimlines on the SFS, anteriorly and posteriorly, are ²/₃ the medial/lateral width. The proximal trimlines of the ISNY extend to the anterior and posterior lateral socket corners. The proximal trimlines of the IPOS extend around the anterior and posterior lateral corner by 2 centimeters.

In the SFS and IPOS systems, the distal trimline cups around the lateral distal femur. The ISNY does not. All systems tell you to take care to have an adequate radius on connecting edges between the medial strut and the proximal and distal trimlines.

COMMENTS AND CONCLUSIONS

The afore-mentioned indicated that there are many questions still unanswered. The varying lay-up design makes for varying flexibility and weight difference in the frames. At Newington, we question why the severe differences in build-up exist and as a result are undertaking a research project with some students at the Engineering Department at the University of Hartford. As a senior research project, they are planning an evaluation of the mechanics and structure of the three strut designs as well as the flexible socket material.

It should be noted that if there are severe undercuts on the positive model, removal of the finished strut from the model can cause stress cracks in the frame.

Problems have been noted by Newington and

others of the flexible socket breaking after delivery to the patient. Care must be taken in fabrication of the socket that all flares are built into the positive mold. This will help reduce the stress in the molding process. Another recommendation to remove the stress from the finished flexible socket is an annealing process. We have yet to evaluate its effectiveness.

In conclusion, there has been some confusion as to the different systems. Our purpose here has been to clarify the systems and their differences. As with any new system, questions and confusion are to be expected.

It is still a subjective evaluation. As long as the patient benefits, use the system (or combination of systems) with which you are the most comfortable.

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Technical Article

Flex-Frame Sockets in Upper Extremity Prosthetics

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The development of various new plastic materials has brought about a rapid change in the design and fabrication of lower extremity prosthetic sockets. We can now expect most of these revolutionary developments to overflow into other areas of prosthetics and orthotics. The most natural area next to be influenced is upper limb prosthetics.

We at Rusk Institute of Rehabilitation Medicine have been trying various socket frame configurations with all levels of upper limb amputees, from wrist disarticulations to above elbows, including the humeral neck amputation.

The following is a brief "technical note" describing the technique we use for fabricating the flex-frame socket for the upper limb prosthesis and a sampling of various socket designs.

BELOW ELBOW SOCKET

When the below elbow socket model has been modified and smoothed, a flexible socket is made by vacuum molding, using Surlyn or Ethalux polypropylene (Figure 1). A thin socket is then laminated in the conventional fashion over the flexible socket (Figure 2). This socket will act as a frame for the flexible socket and will allow for the secure attachment of the forearm extension and wrist unit. Upon completion of the thin laminated socket, the P.V.A.

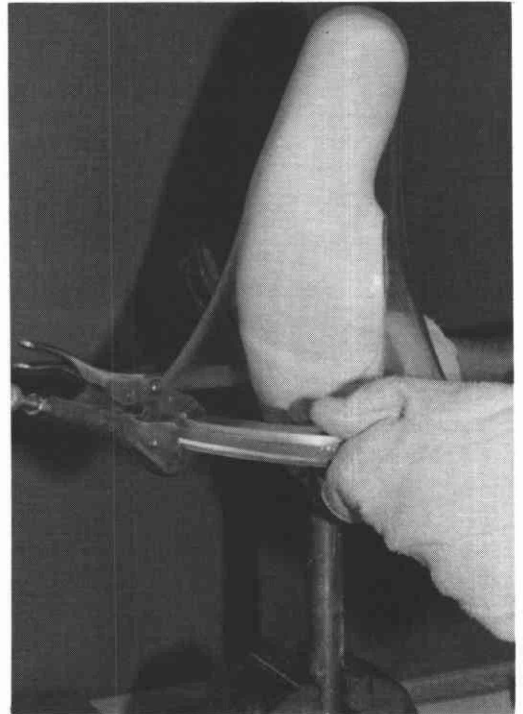


Figure 1. A flexible socket is made by vacuum molding, using Surlyn(R) or Ethalux polypropylene.