

Flexible Below Knee Socket With Supracondylar Suspension

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with an Introduction by James Foort**, M.A.Sc.

Semi-flexible plastic laminate sockets have been used in the prostheses of fifty BK amputees during the past two years at the Manitoba Rehabilitation Hospital in Winnipeg. These sockets were designed to permit more intimate fit of the socket against bony prominences without damage to the skin, and to permit adjustment of pressure between stump and socket by the insertion of liners between the flexible socket and the supporting structure. We had noticed that no amputee ever complained about discomfort against bony prominences, and seldom complained of discomfort at the end of the stump while standing in the sock during suspension casting of the stump. Also, experience with air cushion sockets

indicated the merit of flexibility in the socket against soft tissue areas of the stump which are compressed by the socket during weight bearing. It has frequently been proposed that bony structures now protected from pressure by relief pockets in the sockets might better be used to increase further support and stabilizing areas between stump and socket.

The present system used in conjunction with the semi-flexible sockets includes a supporting receptacle, a wedge-disc alignment unit pylon and a SACH foot. Cosmesis is obtained either with a custom made plastic laminate shell (semi-flexible), or a sponge polyurethane cover which is prefabricated in standard sizes. Many of these prostheses have been suspended from the medial femoral condyle, and a few with additional suspension from the top edge of the patella.

The receptacle supports the flexible socket so that weight bearing and stabilizing forces are resisted, and stability of the supracondylar

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suspension hook is ensured. The receptacle can also be fashioned so that extra relief space external to the flexible socket is provided over any vulnerable area. Further, since the socket can be pulled out of the receptacle, just as the kemblo liner was removable, adjustments can be made to socket fit by bonding in liners without spoiling the inner surface of the socket. When entry into the socket is difficult, because of inward projection of the supracondylar hook, the socket can be donned and inserted into the receptacle with the stump in place as a means of protecting the stump during its insertion into the prosthesis.

The socket referred to here might well be described as a two-piece socket, as a socket with flexible liner, or as a flexible socket with supporting receptacle. In any event, as far as the stump is concerned, the socket is rigid in areas of support and stabilization, semi-flexible in distal areas, over bony areas, and in any other areas which might require it, and is in total contact. It will be referred to as a flexible plastic laminate socket supported by a plastic laminate receptacle.

The outline that follows indicates the method used to fit and fabricate the flexible socket, and the preparation of the supporting receptacle. All procedures omitted are those which are common knowledge and which are not changed with reference to the particular procedures used.

FITTING THE AMPUTEE

Data Recorded

1. Antero-posterior stump knee

width at the mid-patellar tendon level—knee relaxed.

2. Medio-lateral stump knee width at the tibial plateau level.
3. Distance between extreme outer edges of the tensed hamstring tendons.
4. Supracondylar measurement from above the adductor magnus tendon insertion medially to the tensor fasciae lata laterally.



Fig. 1

Finger Positions During Cast Taking (Medial View).

5. Supracondylar height measured from the mid-point of the medial knee joint line to a point superior to the adductor tubercle of the medial femoral condyle (Insertion of adductor magnus tendon).

MAKING THE IMPRESSION

The Northwestern University's suspension casting technique is used to make the stump impression. The plaster is wrapped as described in the report, "A Pylon Prosthesis System for Shank (B/K) Amputee" by J. Foort (1).



Fig. 2

Finger Positions During Cast Taking (Posterior View).

1. Define the patellar tendon by impressing the thumb tips on either side of it.
2. Exert light counter-pressure across the back of the stump with the fingers of the hand, which is on the lateral side of the stump.
3. The fingers on the medially placed hand are used to define the contour of the medial femoral condyle (Fig. 1). The index and middle fingers are placed anterior to the adductor magnus tendon and the 4th and 5th digits are placed posterior to it. The 5th digit superimposes the medial hamstring tendons (Fig. 2).

Plaster Stump Model Modification

The model is modified in the same manner as described in "*A Pylon Prosthesis System for Shank (B/K) Amputees*," with the following additional features:

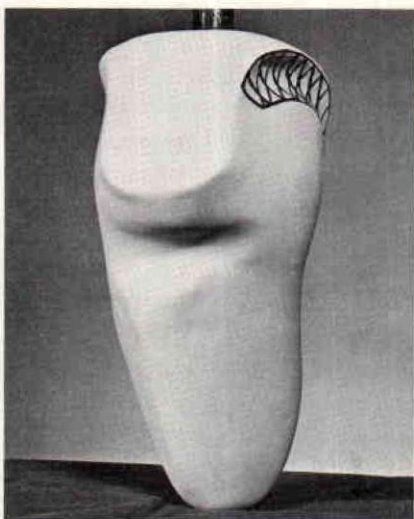


Fig. 3

Antero-medial View of Supracondylar Shelf.

1. The finger indentations outlining the contour of the medial femoral condyle and the condylar height measurement serve as guide in defining the condylar indentation in the plaster model.

The medial supracondylar shelf is approximately $\frac{3}{4}$ " wide from top to bottom. It is approximately $\frac{1}{2}$ " deep at most. It is contoured from the medial epicondylar surface of the femur to encompass the adductor tubercle area toward the femoral shaft to blend with these areas. On reaching the deepest point of the shelf, this smooth radii gradually reverses its direction following the shape of the soft tissue of the thigh (Fig. 3). The suspension hook should be at approximately the superior patella level, so that there is a tissue cushion between the hook and the bony surface of the femoral condyle. The medial patellar area and the medial hamstrings area are fitted intimate-

ly; however, the shelf is flared and contoured in order to prevent interference with their movement or to produce any discomfort (Fig. 4).

2. The model is reduced to $\frac{1}{4}$ " greater than the supracondylar measurement to allow

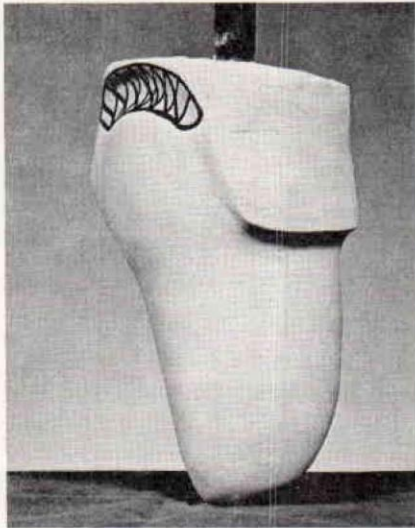


Fig. 4

Posterior-medial View of Supracondylar Shelf.

for wearing a wool stump sock. The lateral aspect of the model is trimmed down in a flaring fashion above the lateral femoral condyle until the desired distance is obtained.

Laminating the Flexible Socket

The vacuum draw technique is always used. The resin combination consists of 75% flexible No. 4134, and 25% rigid No. 4110.

The following procedure is used:

1. Pull a moistened PVA sheet over the plaster cast. A heat gun can be used to aid in removing any wrinkles.

2. Tailor three nylon tricot bags to fit the model.
3. With the vacuum acting on the PVA, put on the first of the tailored tricot bags. Place on three layers of 181 glass cloth in order to give strength

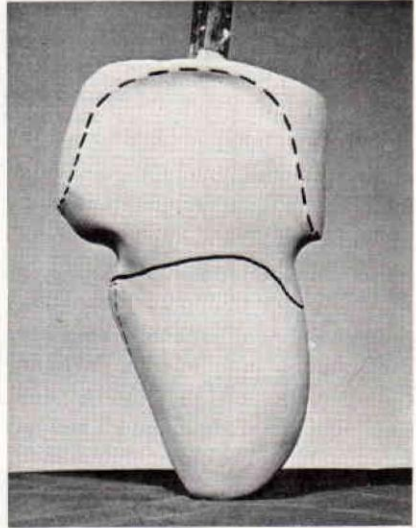


Fig. 5

Medial View of Plaster Model.

to the PTB area, posterior brim area and the medial and

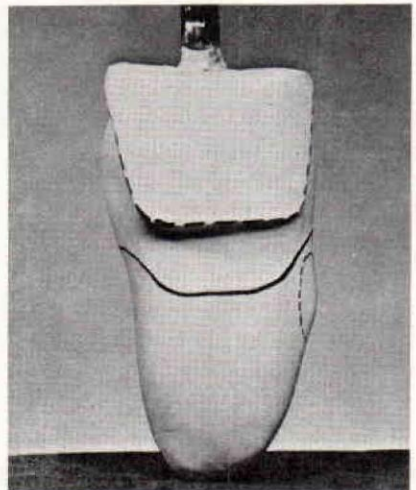


Fig. 6

Posterior View of Plaster Model.

lateral ears of the socket. The glass should include the patellar tendon bar area, but should not exceed the top of the tibial tubercle area. On the medial side it extends from the medial flare region of the tibia inferiorly to the summit of the medial supracondylar shelf superiorly. Posteriorly, it extends 1" below the posterior brim line. Laterally, the glass is so tailored to extend from above the protuberance of the lateral tibial condyle, and from above the head of the fibula to the top of the lateral ear of the socket. The socket must be free from glass in these bony areas to ensure flexibility (Fig. 5, 6, & 7).

4. Put on the other two tricot bags. The seams of the bags are criss-crossed over the inferior aspect of model for strength.

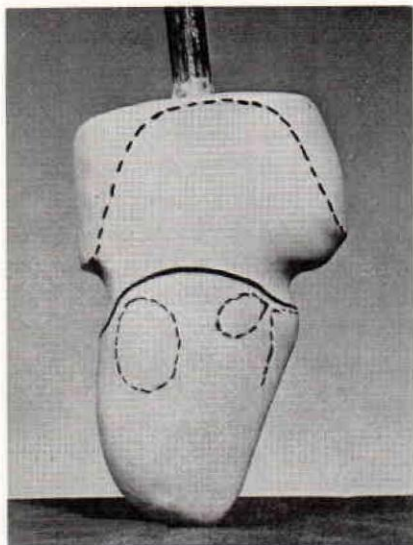


Fig. 7
Lateral View of Plaster Model.

5. Pull a talcum powdered PVA sleeve over model.
6. Add the mixture of flexible and rigid resin and begin

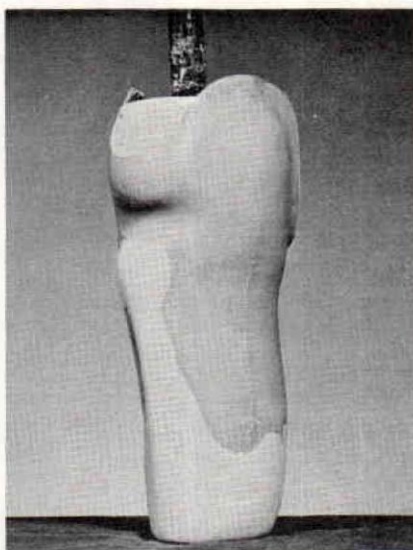


Fig. 8
Medial View of Plaster Build-ups on Socket.

plastic laminating in the usual way. Be sure that any excess resin is removed from the socket, as excess resin reduces the socket flexibility.

Receptacle Construction

The receptacle is custom-built to transmit weight through areas which tolerate weight bearing, and to afford stump stability. Relief areas (spaces) are left between the flexible socket and receptacle in areas which do not tolerate high pressures; mainly, the crest of the tibia and fibular head. The flexible socket is able to distend in these areas of low pressure tolerance, thus cushioning forces against the stump.

To construct the receptacle, proceed as follows:

1. Remove the PVA bag. Place the socket model in a vise and add approximately $\frac{1}{4}$ " plaster extension over the tibia of the plastic socket from the tibial tubercle to the distal end of the tibia. The

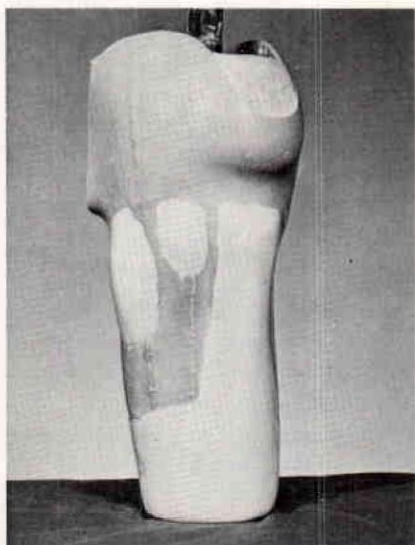


Fig. 9

Lateral View of Plaster Build-ups on Socket.

- plaster is to be feathered from its summit to its junction with the socket (Fig. 8).
2. Add the same amount of plaster over the head of fibula and feather it in. If there are any sensitive areas or if flexibility is desired in any other places, spaces can be made by plaster build ups in a similar manner (Fig 9).
 3. Place the socket model in a vise and adjust it until, with reference to the floor, there is about five to ten degrees of flexion in the socket and about five degrees of lateral tilt.
 4. Add a paper extension which

will allow about $\frac{1}{2}$ to 1 inch of plaster to be poured into it.

5. When the plaster has set, a $2\frac{1}{2}$ -inch circle is scribed with the center as far posterior and lateral as possible.
6. The plaster extending beyond this circle is removed to make the bottom of the socket cup-shaped around the edges.
7. Any excess plaster that has set in areas where contact between socket and receptacle for stump support is desired can be removed by rasp and screen.

NOTE:— It is important that the transition between the plaster build-ups and the flexible socket be smooth and gradual to eliminate areas of high force concentration.

8. Glue $\frac{1}{8}$ -inch aluminum disc to the bottom of the plaster receptacle and pull on the PVA sleeve.
9. Start the lay-up of fabric with a tailored felt bag made of one-ounce felt.
10. Lay on six squares of 181 glass cloth which slightly overlap the base of the plaster. Six strips wide enough to cover the base, and long enough to reach down the PTB bar level are laid on in a rosette fashion.
11. Complete the layups with two thicknesses of nylon stockinette.
12. Add plastic (90 percent rigid and 10 percent flexible) in the usual manner. After the

plastic has been added, a second disc with a hole for the PVA extension is forced against the base and strapped down with tape to form a flat surface on the outside.

After the resin has cured, plaster is removed from the socket and the socket and plaster are removed from the receptacle. The base of the receptacle is flattened on a disc sander, a 1/2-inch hole is drilled in the center and a wrench slot is cut on the side. Excess plastic is trimmed and the edges sanded. The socket with supporting receptacle is ready for assembly with the wedge disc alignment unit and sach foot. (Fig. 10).

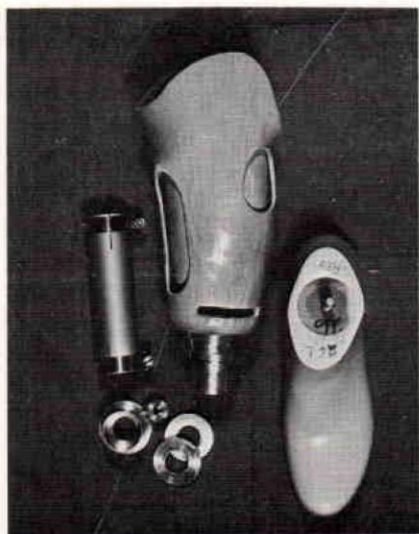


Fig. 10
Components Making Up the Prosthesis.

If small adjustments have to be made, such as allowing a little more relief area or snugging up in an area of the stump, the following can be done:

a. *To relieve an area*—The inside of the receptacle being made of felt

can be ground slightly to allow a relief space for the flexible socket to distend or a hole may be cut in the receptacle.

b. *To snug up in an area*—A patch of leather, felt, or rubber can be placed between the socket and receptacle. The flexible socket will bulge inward in that area giving the stump more support.

NOTE:—The relief areas built into the receptacle may be cut out, making the receptacle frame-like.

FABRICATION NOTE: To allow slight adjustability in the medial supracondylar shelf area, patella tendon bar area, or posterior brim region, a layer of one-ounce dacron felt can be included next to the PVA sheet before placing on the first tricot bag in the lay-up procedure. The felt would be tailored and include the same area as the glass cloth.

In cases where greater than normal distal stump weight bearing is desired, it is advisable to include a patch or two of tricot over the distal end of the socket during the lay-up, to reinforce the crossed seams of the tricot bags.

As an alternate to tricot in the socket fabrication, three layers of nylon stockinette can be used if additional flexible resin is added.

Methods of Donning Prosthesis

1. Remove the socket from the receptacle of the prosthesis.

Put it on the stump. Pop the socket back into the receptacle of the prosthesis (Fig. 11).

2. Leave the socket insert in the prosthesis. With the stump flexed to about 90 degrees approach socket with stump almost 30 to 45 degrees internally rotated to the patellar tendon bar of the socket. Insert the stump as deeply as possible into socket, then rotate the prosthesis medially and rotate the stump laterally as the stump is pushed into the socket (Fig. 12).

Advantages of the Supracondylar Suspension

1. Freedom from straps. (But if auxillary suspension is desirable at times, a fork strap with snap fasteners and waist belt suspension can be added).
2. Improved M/L knee stability.
3. Reduced pistoning of the stump in the socket.
4. Improved knee mobility during sitting.
5. Improved cosmetic effect at the knee both in standing and sitting.

CLINICAL EXPERIENCE

Chart 1 illustrates the number of patients fitted with flexible sockets at the Manitoba Rehabilitation Hospital during the past two years and at Kingston General Hospital during the past six months. The chart indicates whether the patient fitted was a new or old amputee; previous prosthesis and socket type; and present socket type.



Fig. 11
Wearing Socket During Donning of Prosthesis.

The majority of the amputees who were previous prosthetic wearers fitted with flexible sockets commented on the following:

1. More comfortable than previous hard or soft sockets.
2. Could wear the prosthesis



Fig. 12
Donning of Prosthesis.

INFORMATION ON PREVIOUS PROSTHETIC WEARERS

No. of Patients Fitted	Hospital	Present Socket Type***			Previous Prosthesis Type		Previous Socket Type			Previous Socket Material		
		PTB With Cuff Suspension	PTSC*	PTSPC**	With Side Joints & Thigh Corset	Without	PTB	Plug Fit	Other (Specify)	Hard Plastic	Soft (Kembol Liner)	Other (Specify)
23	Manitoba Rehabilitation	8	9 Incl. One Bilat. B/K	8 Incl. One Bilat. B/K	4	21 Incl. Two Bilat.	21 Incl. Two Bilat.	4	—	17 Incl. Two Bilat.	4	4 Molded Leather
7	Kingston General Hospital	1	5	1	4	3	3	3	1 slip	—	5	2 Molded Leather
A Sub-Total		30	9	14	9							

NEW AMPUTEES

No. Fitted	Hospital	Socket Type		
		PTB With Cuff	PTSC	PTSPC
27	Man. Hosp.	7	18	2
8	King. Hosp.	4	3	1
B Sub-Total		35	11	3

Total A & B	Pt's Fitted	Socket Type		
		PTB Cuff Susp.	PTSC	PTSPC
	65	20	35 Incl. One Bilat. B/K	12 Incl. One Bilat. B/K

LEGEND

*PTSC—Patella tendon bearing socket with supracondylar suspension. (Medial femoral condyle)

**PTSPC—PTB socket with supracondylar plus supra patella suspension

***All sockets made of flexible plastic laminate as described in article.

longer daily, before the stump became sore, than with previous prosthesis.

3. Liked this socket type because it had "give" to it.
4. A few commented that they believed the socket was cooler than previous types worn.

Conclusion

A technique has been presented for the fabrication of a flexible socket with a supporting receptacle.

A method of obtaining supracondylar suspension has been outlined. Clinical experience has shown the users of this technique significant advantages for continuing to use this method of socket design.

REFERENCES

1. Foort, J., and D. A. Hobson, A pylon prosthesis system for shank (BK) amputees, Prosthetics and Orthotics Research and Development Unit, Manitoba Rehabilitation Hospital, Winnipeg, November, 1965.