A POROUS, FLEXIBLE INSERT FOR THE BELOW-KNEE PROSTHESIS

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When an amputee using a total-contact patellar-tendon-bearing (PTB) prosthesis or one of its variations perspires excessively his stump becomes immersed in a pool of fluid, a condition that produces not only discomfort but, also, a potential cause of skin maceration and breakdown. It is the purpose of this paper to present an approach to the solution that permits retention of "total contact" while allowing for escape of the fluid from the stump-socket interface.

BASIC SOCKET DESIGN

The positive model of a BK stump is modified by removal of ⅛" of the distal portion. A soft insert of Cordo (1,7) with a distal end of nylon mesh is fabricated over the model and thus an open space is retained in the distal end of the socket to act as a fluid trap. An external lip, added to the proximal end of the insert, overlaps the socket brim and prevents distal displacement of the insert within the socket as the patient bears weight during the stance phase. As weight is borne over the stump the elastic compression of the mesh against the stump aids in expressing fluid from the intervening stump sock into the compartment below.

The insert with the nylon mesh is shown in Fig. 1. The space beneath the mesh has been made excessively large in this transparent polycarbonate socket for demonstration purposes. Laxity of the mesh without weight-bearing and total contact upon weight-bearing, left and right, respectively (Fig. 1), can be seen. An accumulation of liquid perspiration outside of the insert and in the trap after several hours of wear can be seen in Figure 2. The nylon mesh should be flushed each evening with a solution of soapy water and allowed to dry overnight. The trap should be wiped dry.

CASE HISTORIES

Five patients have been fitted over the past two years; one case, a bilateral was fitted on both sides.

CASE NO. 1

J.K.B., a 53-year-old part-time grocer with a 6" left BK amputation stump, secondary to shell fragment wounds sustained in WW II, was seen by the VAPC clinic team on July 15, 1971, when he presented with two abrasions over the distal stump. He had been using an open distal-end prosthesis with a thigh corset. After a period of not wearing the prosthesis and soaking the stump regularly, the lesions cleared up, only to recur shortly after he began using the prosthesis again. In view of the recurrent episodes of abrasions of the distal stump area associated with a tendency to perspire a great deal, the clinic team decided to try to achieve total contact and, at the same time, minimize the adverse macerating effect on the skin produced by constant immersion of the stump in a pool of perspiration.

On November 10, 1971, the patient received a supracondylar-suprapatellar prosthesis with an open-mesh distal-end soft-socket insert. The stump has remained in good condition and abrasions have not recurred. At the date of most recent examination, April 20, 1973, he stated that he no longer had a problem with perspiration. Stump shrinkage had occurred and the patient

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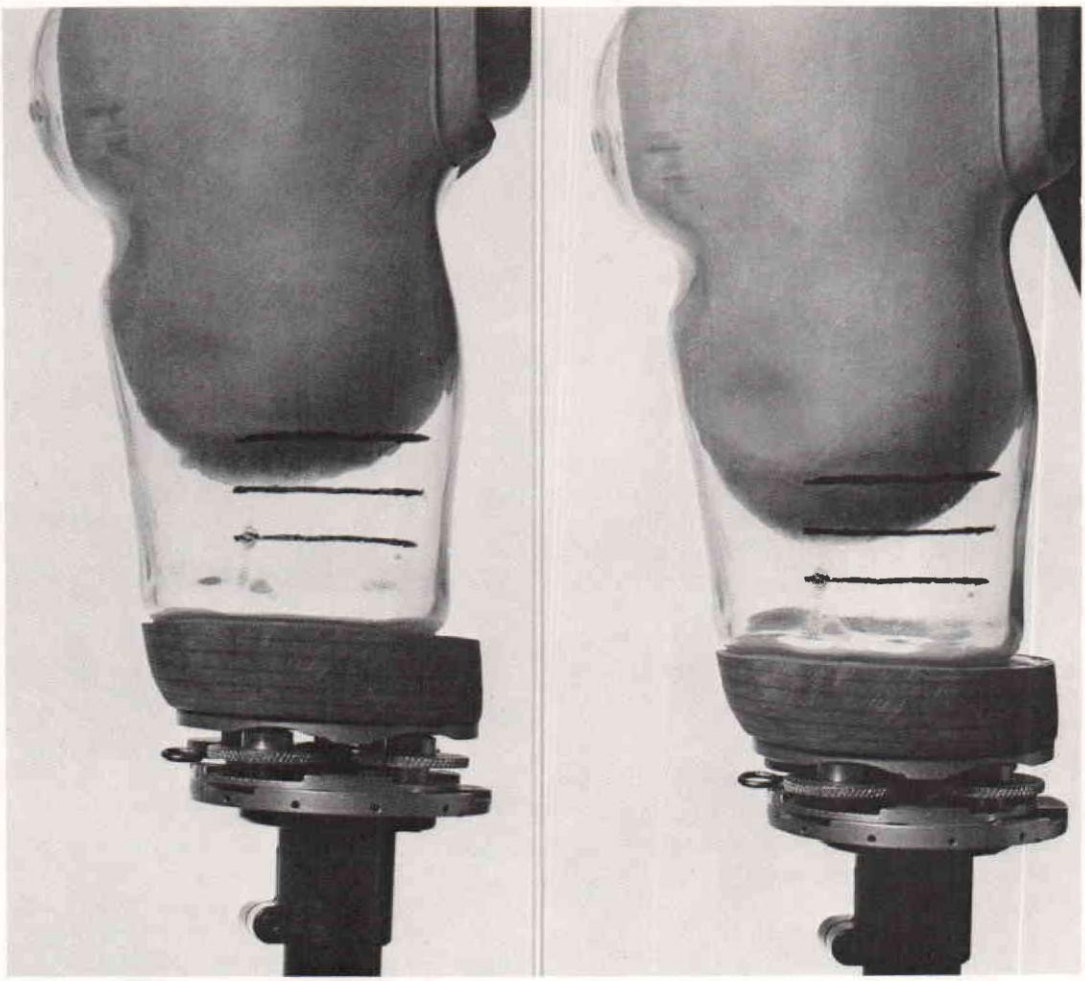

Fig. 1. The porous, flexible (open-mesh) insert for a below-knee prosthesis shown installed in a transparent polycarbonate socket. Left, the stump is not bearing weight; right, the stump is bearing weight.

requested a new limb fabricated in a similar manner, and this was prescribed.

CASE NO. 2.

C.A.R., a 27-year-old bilateral BK congenital amputee, is a research physiotherapist. The patient consented to participate in the program involving the open-mesh socket because there was a tendency toward excessive perspiration of the stumps. The prostheses were prescribed July 31, 1972, and delivered on October 14, 1972. When last examined April 20, 1973, the following note was recorded by the clinic team:

> "The patient was pleased with the open-mesh distal-end soft socket inserts and demonstrates a perspiration pool in the trap below the mesh on each side. It was estimated that two tablespoonfuls of fluid were removed from each socket trap every night."

CASE NO. 3.

J.S.F., a 32-year-old elevator operator was amputated on the right side below the knee in May 1969, following an injury by a land mine. His stump was revised in September 1969, to a 7½" length. An Ertl procedure (3, 4, 5, 6) was carried out. When he was seen by the clinic team on November 19, 1970, he complained of pain in the distal part of the stump. Only a limited amount of weight-bearing could be tolerated in spite of the Ertl procedure. A PTB prosthesis with a Plastazote distal pad was prescribed. In February 1972, an ulcer appeared on the distal end of the stump. The ulcer healed finally, after several socket adjustments, by June 1972, but the distal end continued to cause discomfort. An open-mesh distal-end soft-socket insert was prescribed. The prosthesis was delivered on September 5, 1972.

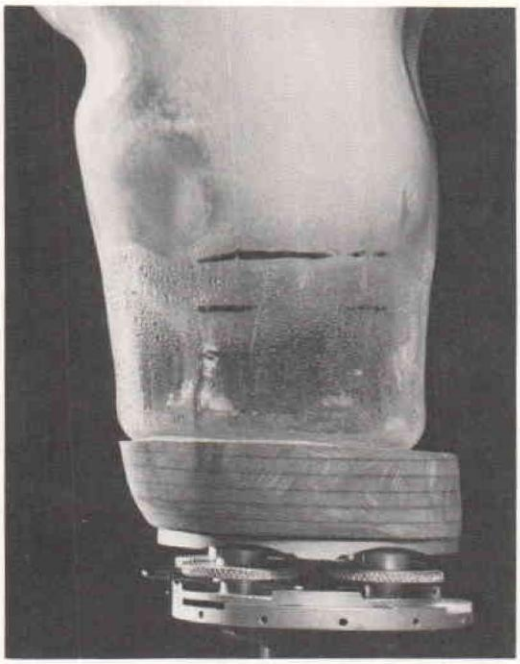

Fig. 2. Photograph showing accumulation of fluid in the distal compartment.

On re-examination December 14, 1972, it was recorded by the clinic team that the patient was pleased with the open-mesh socket. He was referred to Internal Medicine for treatment of generalized edema, ascites, and a palpably enlarged liver. The stump was in good condition, fitted well in the socket, and was not edematous. After he was placed under medical care, his generalized edema was controlled.

When examined February 5, 1973, he reported that, although he formerly had noted a good deal of perspiration in his socket, he no longer had had this problem with use of the open-mesh insert. His stump sock was damp in the evening, but not wet.

At his last examination, April 23, 1973, he indicated that he was pleased with the insert, stated he had no problems, and requested a similar type for a spare. The stump was in good condition.

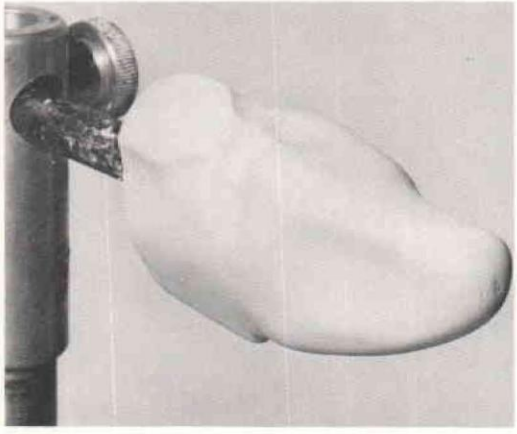

Fig. 3. Modified positive model of the below-knee stump.

CASE NO. 4.

M.C.S. is a 50-year-old, unemployed BK amputee whose left leg was amputated in September 1971 for Buerger's disease. A once-inch-wide split-thickness skin graft had been used to achieve closure along the entire transverse length of the fishmouth scar. The stump was in good condition otherwise. In September 1972, the right side was amputated, also at the BK level. On this side there was tenderness at the distal end, and the patient could not tolerate total contact. A prosthesis with an open-mesh distal-end socket insert was delivered to the patient in September 1972 for the left leg. In view of the distal pain, the right side was provided with an open-end socket. On January 8, 1973, it was recorded by the clinic team that his left stump was relatively free of moisture.

On February 28, 1973, the clinic team reported that, after the amputee used his prosthesis for four hours, about a tablespoonful of fluid was accumulated in the compartment below the mesh on the left limb. The stump sock felt damp, not wet. The patient's stump was shrinking progressively and a new prosthesis of the same type was prescribed.

CASE NO. 5.

R.LaC., a 50-year-old clerk sustained a post-traumatic amputation below the knee in 1944. The stump was revised in 1949. The patient did not have a problem with excessive perspiration, but he did have a fitting problem. By February 9, 1971, two months after he had been converted from a thigh-corset side-joint limb to a PTB with a foamed-in-place distal end he developed an ulcer over the distal end of the stump. The patient was very cooperative, and extremely anxious to discard the thigh corset. On February 17, 1971, a precursor of the open-mesh distal-end socket was fabricated for him. Cordo-impregnated nylon mesh was used with a view to simulating the air-cushion socket (8), yet with retention of the ability to modify the socket or replace the insert. This approach failed, although there was some improvement in the condition of the stump. However, the ulceration did not heal completely and he continued to have discomfort.

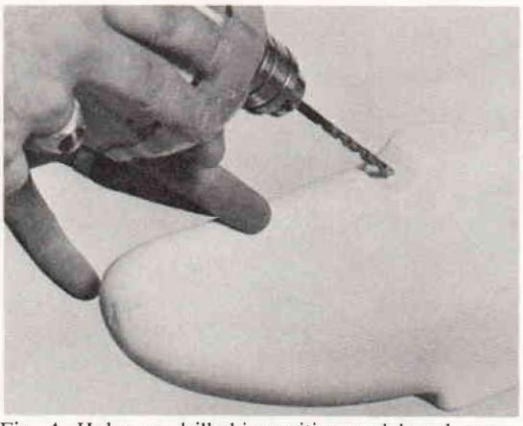

Fig. 4. Holes are drilled in positive model so that use of vacuum pump will avoid bridging of laminate.

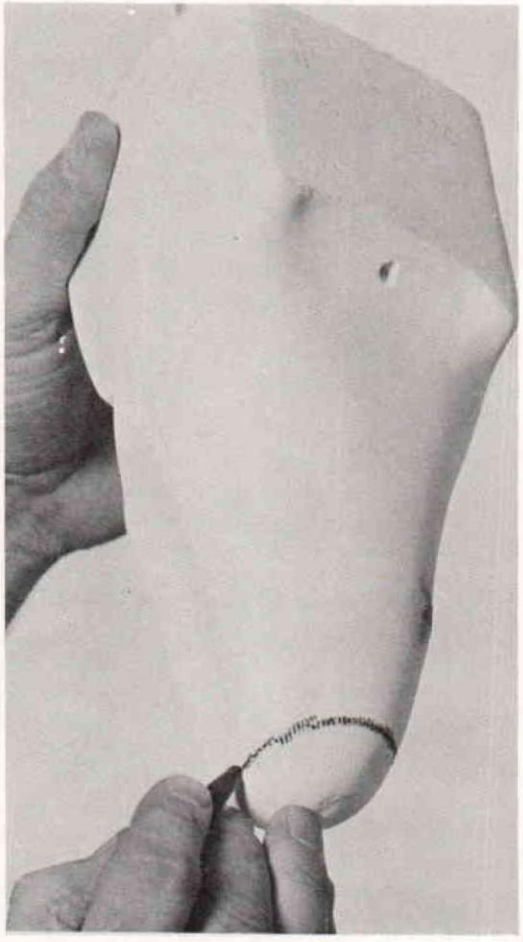

Fig. 5. Making the circumferential line to delineate the area of the open mesh.

He reverted to the thigh-corset limb, but persisted in his wish to have a PTB.

On October 20, 1972, a PTB with an open-mesh distal-end soft socket insert was delivered to him. He could not obtain comfort with this and, when last seen in April 1973, he had finally accepted the thigh-corset side-joint prosthesis as the most comfortable limb for him. This patient is considered a failure although it is quite evident that the problem was one of inability to obtain comfort without a thigh corset rather than failure of the open-mesh procedure.

FABRICATION OF THE OPEN-MESH LINER

For the open-mesh liner to function properly the usual modified male model of the stump must be modified further by the removal of ⅛" of plaster from the distal end of the male cast (Fig. 3).

A ⅛" diameter hole is bored in the patellar tendon area and another in the popliteal area to the inside of the cup to permit maximum use of a vacuum pump during lamination (Fig. 4).

A circumferential line is made one inch proximal to the distal end of the cast (Fig. 5) to delineate the area for location of the open-mesh. Obviously this area should not be coated with "Cordo" at any stage in the procedure.

A woman's nylon hose is then placed over the cast to prevent damage to the latex balloon that is then invaginated over it (Fig. 6).

Two coats of "Cordo solution plain" are applied directly to the latex balloon, but not extended past the mark on the distal end of the cast. A shrinker sock is rolled onto the cast over the balloon (Fig. 7). Care should be taken not to bridge the popliteal or patellar tendon areas with the shrinker sock. The shrinker sock is coated twice with "Cordo solution plain" up to the marked area, leaving the distal end free. As indicated previously, the free end of the shrinker sock will constitute the flexible open-mesh distal end of the completed insert.

A length of tube gauze, closed at the distal end, is pulled over the liner and coated with two applications of "Cordo solution 50", again leaving the distal end uncoated (Fig. 8).

The distal end of the gauze is cut along the previously outlined circumferential mark and discarded (Fig. 9).

A second layer of tube gauze is applied and coated in the same manner. This layer is trimmed to a level ¼" proximal to the trim line of the previous layer. Two coats of "Cordo solution 50" are applied. This procedure is repeated, re-

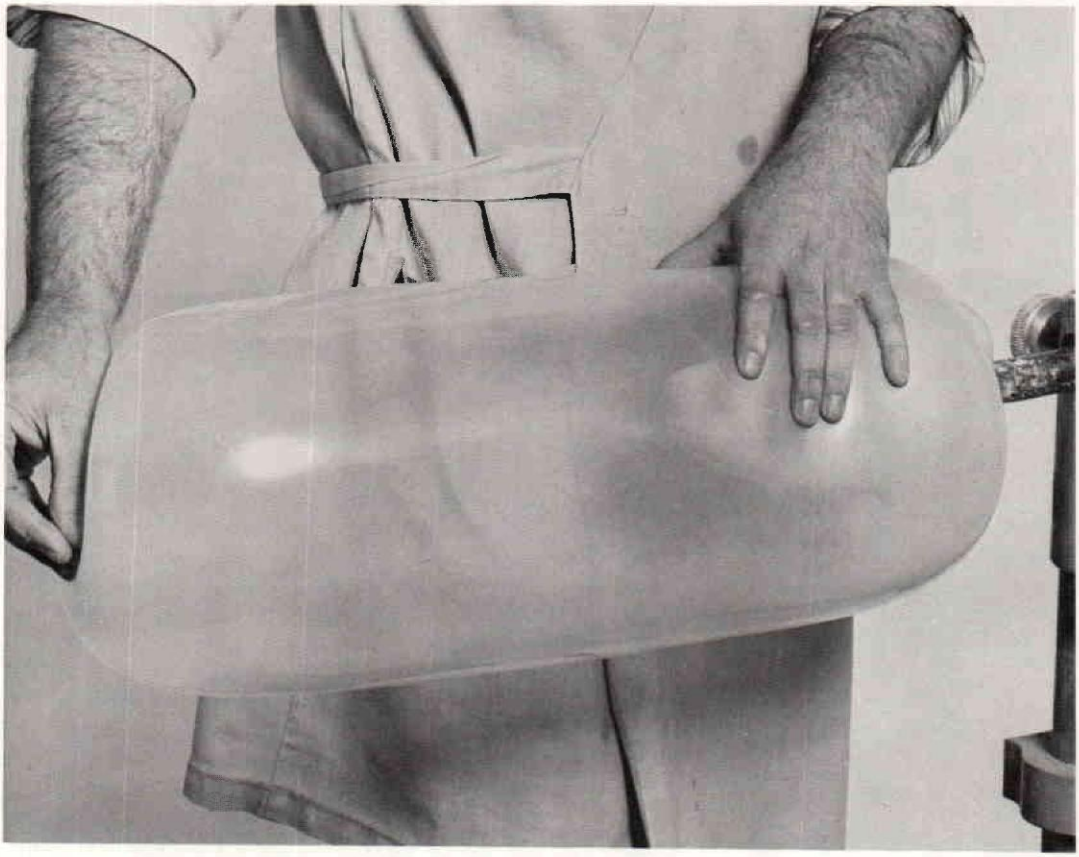

Fig. 6. Invagination of the balloon that acts as a separating agent, over the positive model.

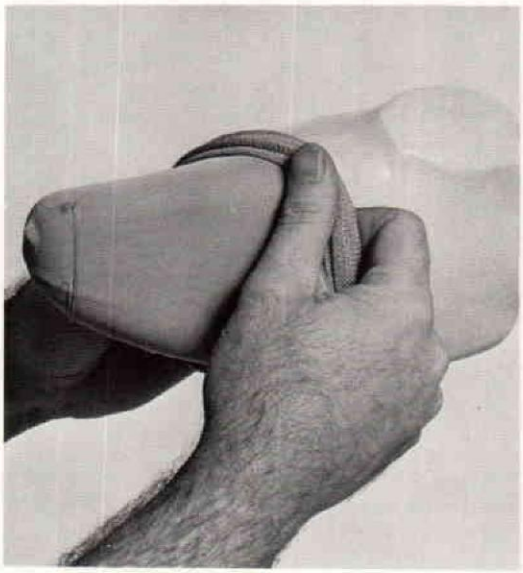

Fig. 7. Application of shrinker sock after application of two coats of "Cordo solution plain".

Fig. 8. Application of "Cordo solution 50" to the tube gauze that has been applied over the shrinker sock (Fig. 7).

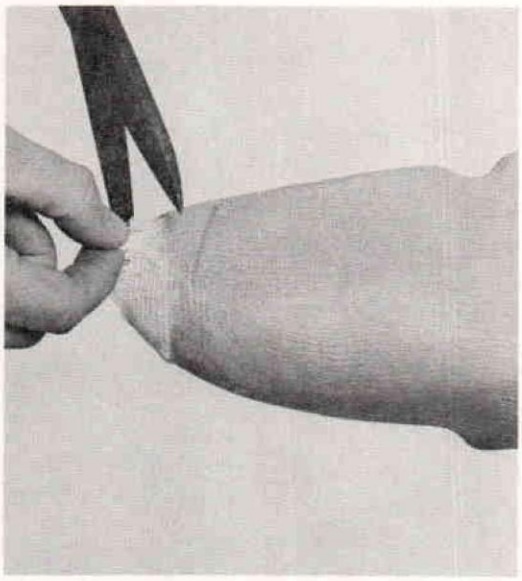

Fig. 9. Cutting of the tube gauze, so that the distal end can be removed to expose the open-mesh area.

treating proximally at ¼" increments until a total of six layers of tube gauze have been applied, each with two applications of "Cordo solution 50" (Fig. 10).

Finally, a prosthetic sheath or a woman's stocking is applied and similarly coated with "Cordo." The liner is allowed to air cure for at least five hours to insure that the ketones have evaporated fully. Curing can be done in less than two hours by use of a convection type of oven with a high-speed blower. The temperature should not exceed 125°F.

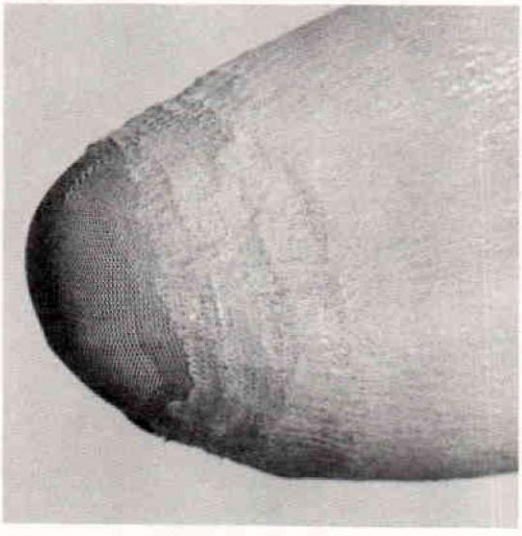

Fig. 10. View of distal end of liner after successive layers of tube gauze have been applied, each about ¼" above the other to develop a tapering distal end.

Upon completion of the liner, and prior to lamination of the socket, a ½" thick cap is placed over the distal end of the liner, which, when removed after lamination of the socket, will leave an open space beneath the distal end of the mesh to provide a perspiration trap. The cap may be made of either plaster of Paris or polyurethane foam. For each, the fabrication technique is essentially the same. A sheet of PVA is stretched over the distal end of the liner to protect it from the foam or plaster of Paris. A polyethylene bag or PVA sheet is then wrapped around the distal end of the liner and polyurethane rigid foam (or plaster) is poured into the extension. This is shaped to the contours of the cast to provide the ½" extension required (Fig. 11). The liner and cast are laminated in the conventional way. The male cast should be knocked from the liner, because when it is pulled delamination of the liner may occur.

Because the relationship of stump to socket is crucial, the ⅛" differential built into the distal end of the liner must be protected against any slight downward displacement of the entire insert within the socket. This could occur during the stance phase when stump pressure is applied intermittently. To prevent such displacement a supporting lip that overlaps the socket brim is built into the brim of the insert. The liner is trimmed to the same contours as the socket but a ⅜" extension above the socket brim is left. A tracing of the proximal portion of the socket is made and a paper pattern developed to be used in cutting a piece of moding leather that will follow the contours of the ⅜" extension (Fig. 12). The leather and the liner are coated with a cement such as Superbond. After the cement has dried, the leather is soaked in water until it is pliable, and then it is attached to the liner and sewn into position.

The fit of the prosthesis may be checked by X-ray. The liner will show up distinctly if the exposure is not too heavy, as in Figure 13 left, or it may require demarcation with a coin in the bottom of the socket as in Figure 13 right.

SUMMARY

A BK soft socket with an open-mesh distal end has been presented. This insert will retain total contact while allowing the escape of perspiration fluid bathing the stump of the patient with hyperhidrosis. The insert has been successfully employed for four patients. One patient is included as a failure, but the failure was not due

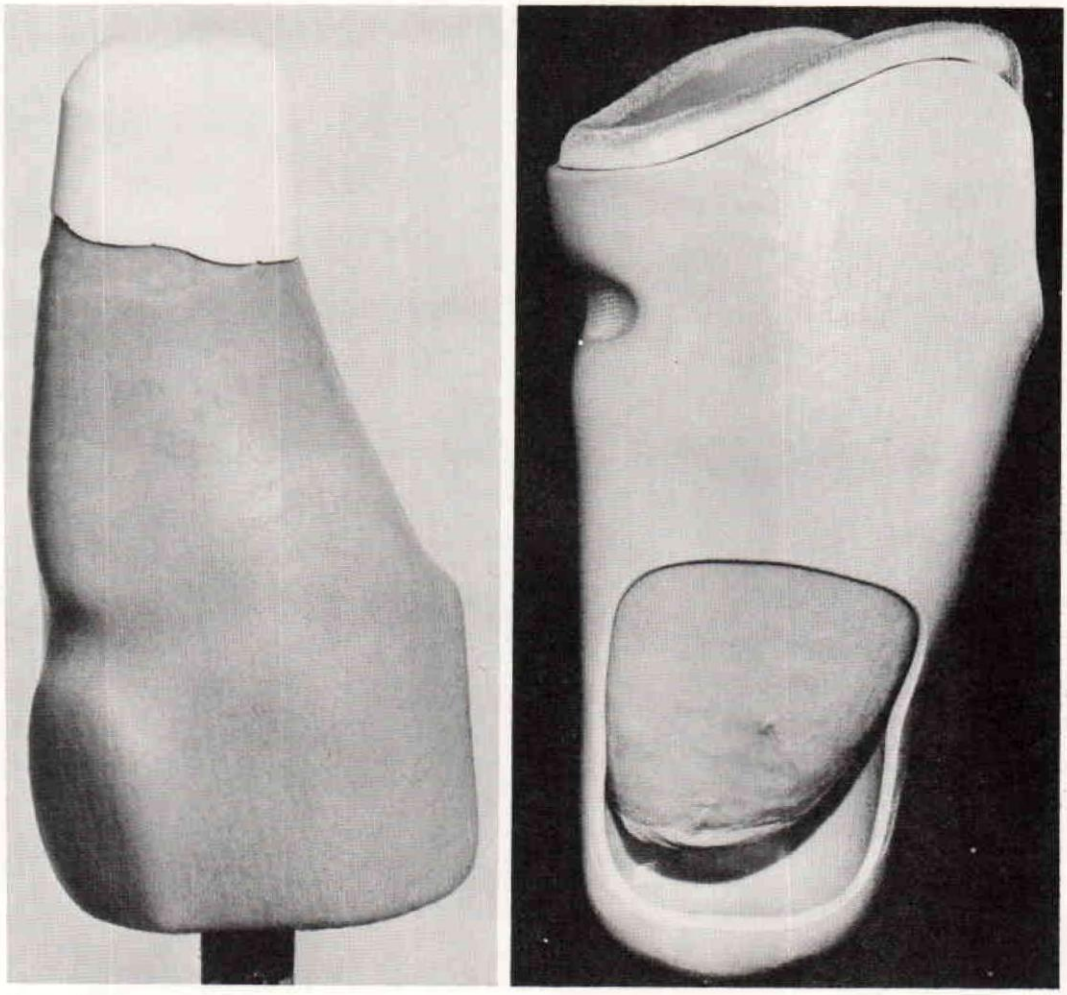

Fig. 11. Left, cap applied over distal end of liner-mold to provide space below liner in finished prosthesis; right, cutaway view of finished socket showing space between end of liner and the bottom of the socket.

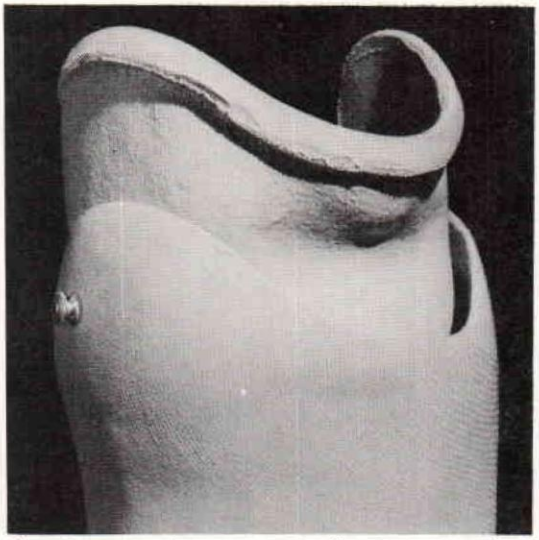

Fig. 12. View of the supporting lip. See, also, Fig. 11.

to dissatisfaction with the open mesh but rather inability to adapt to the change from a thigh-corset side-joint prosthesis to a PTB type. The liner has also been fabricated successfully for PTS and thigh-corset types of prostheses as well as the standard PTB.

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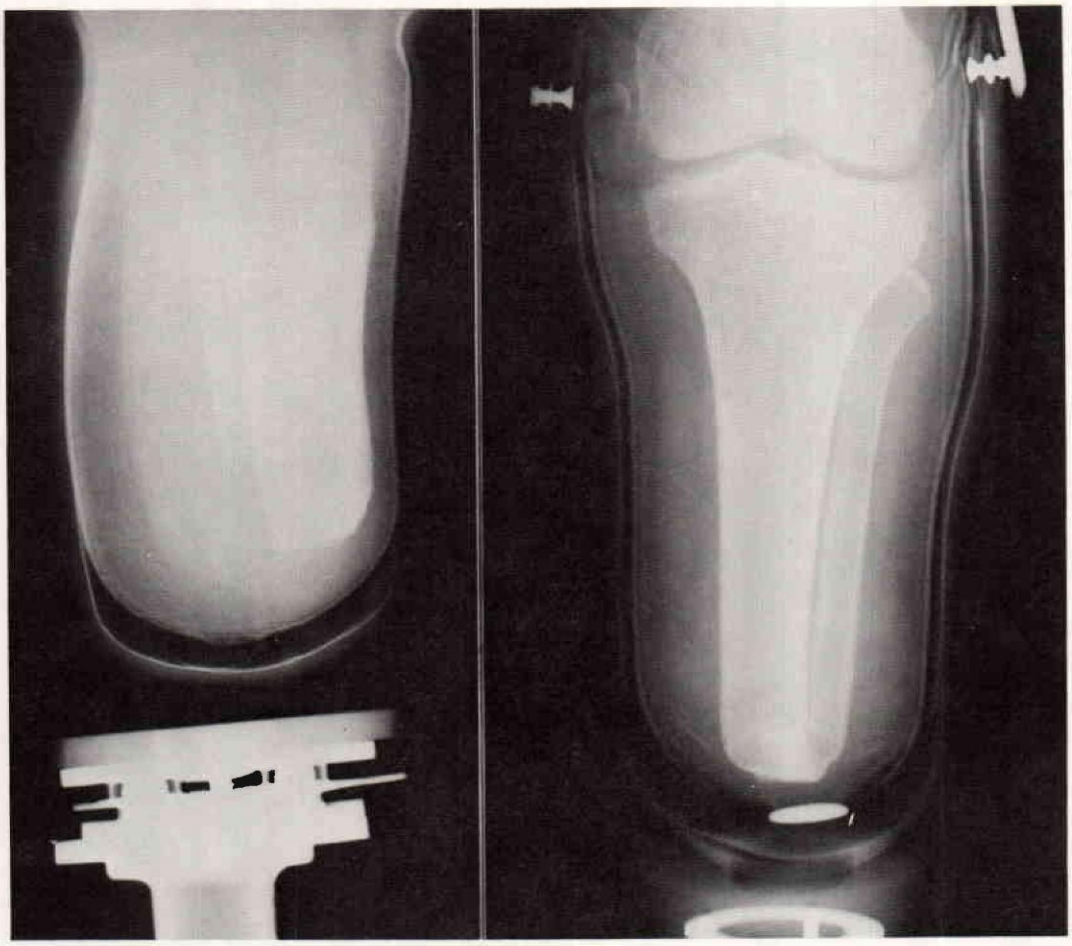

Fig. 13. X-ray views of patient in the prosthesis. On the right a coin has been placed on the distal end of the stump for reference.

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