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VACUUM-FORMED SOCKETS IN PROSTHETICS EDUCATION[1]

Bernard C. Simons, C.P.O.,[2]
and Alan J. Dralle, C.P.[3]

The mystery of what is occurring inside a prosthetic socket with reference to pressure on the stump has been cleared up, literally, with the advent of transparent polycarbonate, vacuum-formed sockets as described by Snelson *(3,4,5)*.

During the past several years, various methods have been used to evaluate prosthetic socket fit. However, most of these techniques do not provide definite information to the prosthetist and provide even less to students of prosthetics. The use of clay, talcum powder and dye-impregnated stump socks was and is more of a ritual than a scientific method of evaluation. Such things as asking the patient how the socket feels to him and evaluation of stump sock impressions on the skin and observations of reddened skin areas have proven to be at best subjective criteria for proper, comfortable socket fit. Indeed, edema in the distal stump area causes the same kind of discomfort to the patient as does too firm a contact in the same area. Because of a "hammock" effect, stump sock weave impressions on the skin indicate good total contact even when total contact on the distal stump area is not present.

The amount of flexion present in below-knee sockets can affect the fit because, as flexion is increased, the stump migrates proximally and, in extension, the reverse occurs. The critical phase of gait, in reference to socket fit, appears to be at mid-stance as full weight is borne on the stump. However, anterior distal stump trauma can be caused by excessive piston action as a result of insufficient socket suspension during swing phase and lack of proper gait training in the use of hamstrings as a knee extensor after heel contact (closed kinetic chain).

The cause and effect of poor socket fit on the gait of amputees has been, until the advent of transparent sockets, very difficult to ascertain and could only be accomplished by a prosthetist with years of experience. How then could he convey his expertise in a few weeks time to the student? The need for a system that would eliminate most of the intuition has been apparent for years, as evidenced by various attempts to develop a technique for fabricating transparent sockets. Even though many were successful, the cost in time and materials has proven to be exorbitant.

During a meeting at Moss Rehabilitation Hospital *(1)* and a subsequent meeting held at the facilities of Orthomedics, Inc., in Downey, California, both sponsored by the Committee on Prosthetics Research and Development, it was demonstrated that the use of vacuum-formed polycarbonate sockets (Fig. 1) was feasible and does not require excessive demands on the prosthetist's time *(2)*. In fact, the time used in fabricating and using a vacuum-formed check socket is repaid many times over because fewer problems are experienced in the definitive prosthesis. It is recommended that the check socket not be used in the definitive prosthesis, and thus the prosthetist is encouraged to make the last little modification that ensures a socket acceptable to the patient *(3)*.

In the curriculum at the University of Washington, students are required to vacuum-form polycarbonate check sockets for both lower and upper limbs in fitting their assigned patients. The technique not only allows the students to view the areas of misfit, but also allows the instructor to evaluate the students' performance in casting and modification of the model.

The regimen used for evaluation is in a state of flux, and will evolve into a definite plan as time and experience dictate. At the present time, evaluation is carried out as described below.

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[2]Director, Prosthetics-Orthotics Curriculum, Department of Rehabilitation Medicine, University of Washington, Seattle, Washington 98195.

[3]Staff Prosthetist, Department of Rehabilitation Medicine, University of Washington, Seattle, Washington 98195.

When the below-knee patient is bearing weight in a polycarbonate socket supported on a standard fitting stool (Fig. 2) and with the socket flexion angle maintained at 5 deg., it is possible to observe changes in the appearance of the stump-sock weave. In areas of increased pressure, the weave appears to be closer than in those areas of less pressure. A standard corset stay is inserted

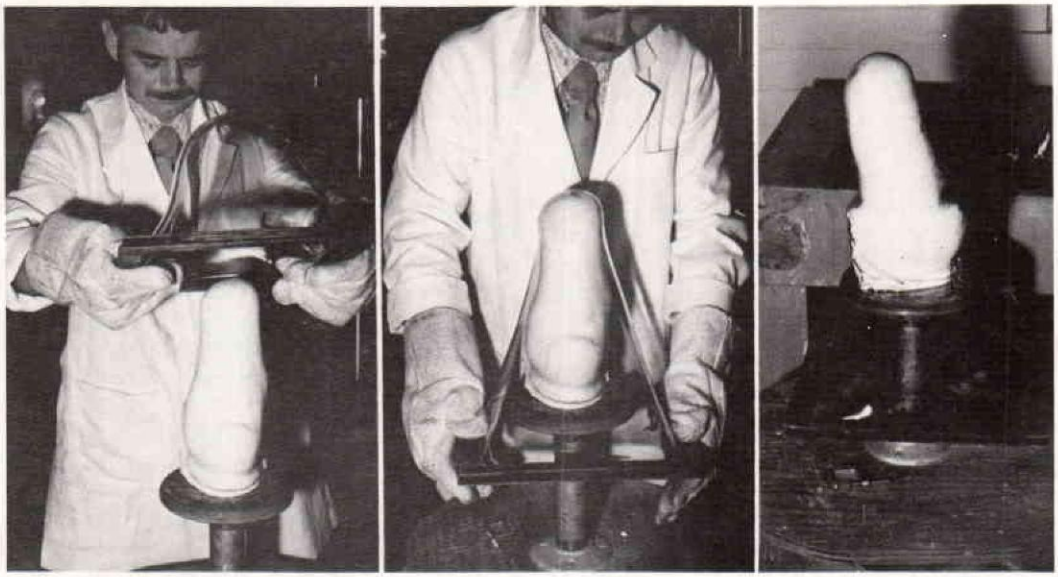

Fig. 1. Forming a transparent socket from sheet polycarbonate with use of vacuum. (*Courtesy Roy Snelson*)

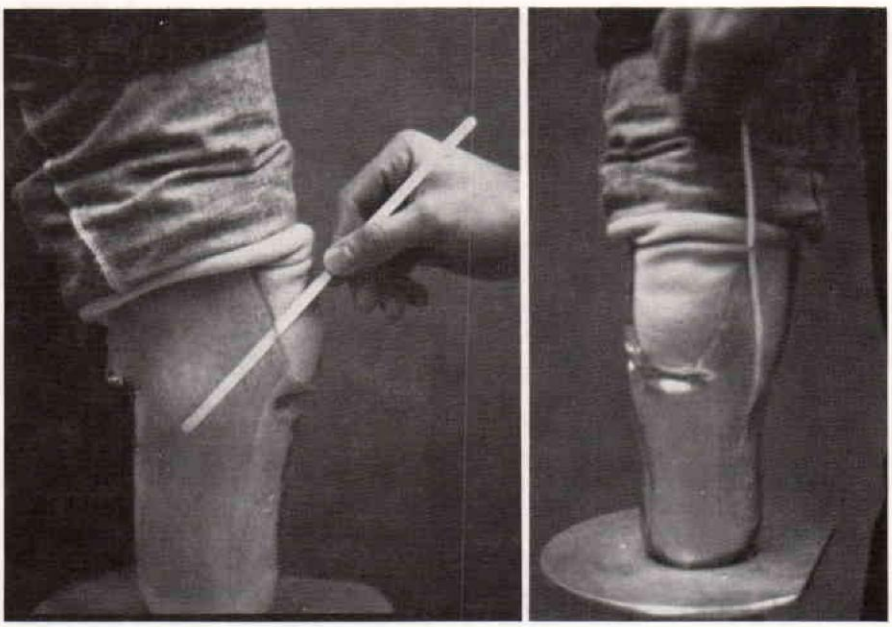

Fig. 2. Use of polycarbonate socket for checking fit. The probe is an ordinary corset stay.

into the socket, and pressure can be felt as a function of the tension on the corset stay as the operator probes in all areas of the socket (Figs. 1 and 2). Weight-bearing areas, as well as areas of relief, can be examined precisely as the exact position of the probe is visible. As potential trouble spots are identified, they are marked with a grease pencil directly on the outer wall of the socket. It is interesting to note that the introduction of clay powder or other substances into a polycarbonate socket will demonstrate the inadequacy of those old techniques although they do indicate gross misfit, especially in the case of excessive relief at the anterior distal tibia.

In the above-knee amputee, the use of a polycarbonate check socket is even more dramatic because changes in overall stump pressure on the skin can be seen (Figs. 3 and 4). Snug areas of contact show a blanched condition and loose areas, or areas not in total contact, redden very quickly, or take on a purple hue. Sometimes both changes occur. Again, marks and notes are placed directly on the outer wall of the clear socket for reference in modification of the new model. The very smooth surface of a polycarbonate socket tends to grip the skin more than a conventional socket; and therefore to assist in removal of the check socket, it should be sprayed with a silicone lubricant.

The equipment used by this University for vacuum-forming is of our own manufacture, and has been very satisfactory for our clinical and teaching needs. The oven used is a double unit obtained from Sears, Roebuck and Co., and is wall mounted. The lower unit is used for drying and storing precut polycarbonate sections and the upper unit for heating to the working temperature.

A standard Hosmer vacuum system is used in connection with a volume storage tank, a one-way check valve and a foot control. The platen stand was fabricated of a 4-ft. length of 1½-in. galvanized pipe and floor flange fittings. Platens are fabricated of ¾ in. plywood with a pipe flange attached for quick change. Squares of polycarbonate (12 in. x 12 in. x ½ in.) are used for below-knee and above-knee check sockets. However, care must be exercised in vacuum forming long above-knee models to prevent the proximal socket section from becoming too thin. By allowing

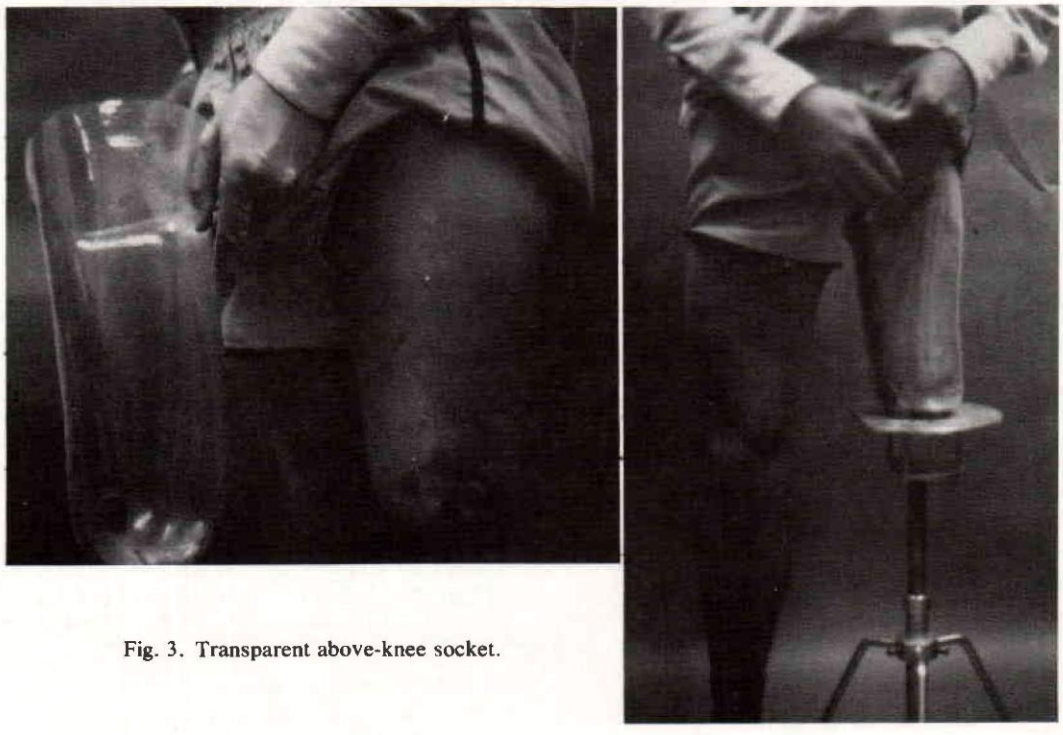

Fig. 3. Transparent above-knee socket.

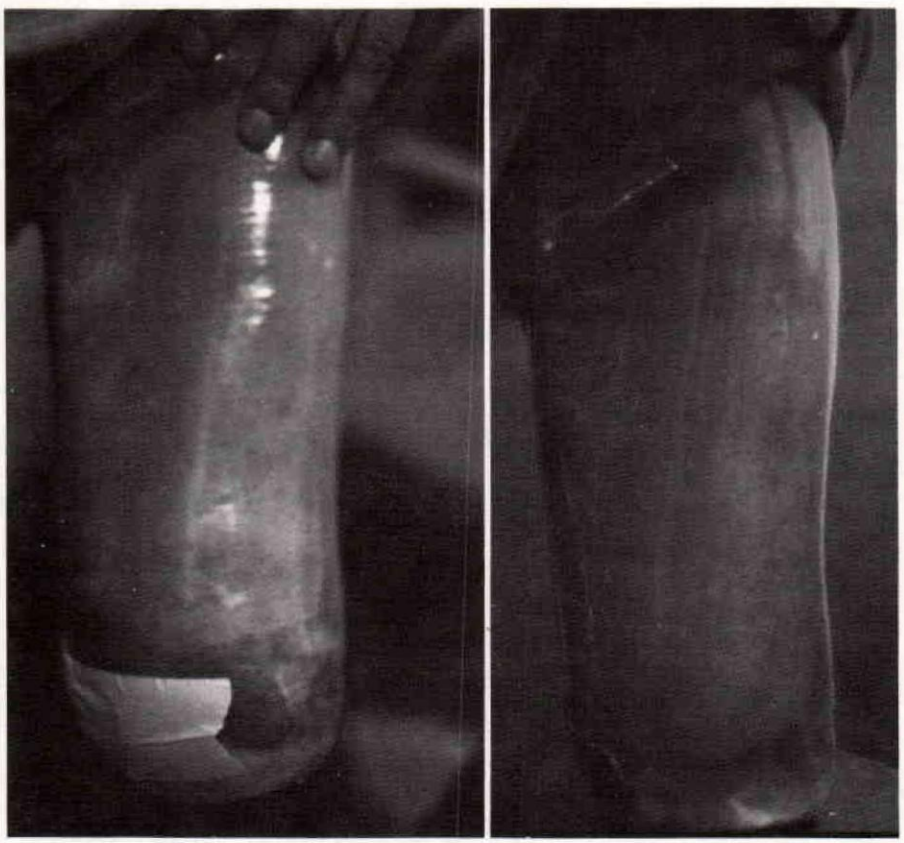

Fig. 4. Closeup views of a transparent above-knee socket.

the plastic to sag a full two-thirds of the total cast length, the proximal portion seems to be thick enough for purposes of socket fit evaluation even under full patient load. In upper-limb sockets, squares of material (6 in. x 6 in. x ½ in.) are adequate for all stump lengths encountered to date.

SUMMARY

The polycarbonate, vacuum-formed check socket is a valuable tool not only for teaching, but also in the clinical management of the amputees, both acquired and congenital. As experience is gained, it will be possible to establish more definite criteria for interpretation of observed conditions.

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