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The Flexible Socket System as Applied to the Hip Disarticulation Amputee

Michael Madden

INTRODUCTION

It has long been recognized that the greatest rate of prosthesis rejection among lower limb amputees occurs at the hip disarticulation and hemipelvectomy levels. Patients will often regress to alternate forms of ambulation rather than struggle with uncomfortable and cumbersome prosthetic devices. A poor fit, improper choice of components, or the misapplication (alignment) of components, can lead to inadequate function of the prosthesis. This will often lead to an inability to achieve acceptable levels of activity in daily living.

The first major concern in fitting the hip disarticulation amputee is comfort. The hip disarticulation amputee bears weight on the gluteal musculature, as well as the ischial tuberosity, in both the active and passive stages of prosthetic wear. The entire pelvis is generally encompassed within the prosthesis, meaning that the surface areas involved are far greater than those with any other level of amputation. Accommodation must also be made for the symphasis pubis, illiac spines, as well as the spinal vertebrae and any residual head or neck of the femur involved. Scar tissue and other sensitive areas must also be considered in socket design.

The next four areas of concern are interrelated, and can be considered simultaneously. These are alignment, expenditure of energy, weight, and mobility. It is generally accepted that improper alignment and excessive prosthesis weight may cause a greater expenditure of energy, resulting in decreased mobility. These circumstances can make the difference between acceptance or rejection of a prosthesis. The application of the flexible socket principle to this level of amputation can increase the overall comfort, as well as reduce the weight of the prosthesis considerably.

CASTING AND MODIFICATION

Using a casting platform with a firm 1/4" Pelite® base, set the patient's height and angulation to achieve a comfortable balance between the ischium, gluteal musculature and the non-amputated foot. The Pelite® will allow a prominent ischial tuberosity to be better defined in the cast.

Run the plaster bandage around the patient's waist from just superior to the lower aspect of the rib cage, to just below the iliac crest. Using a length of plaster bandage formed into a rope, wrap it around the pelvis, over the iliac crests, pulling it firmly horizontal past the iliac spines, being careful not to create excessive lordosis in the lower back. The roping will help to prevent rotation of the residual limb, serve as a guide in donning the prosthesis, and also greatly reduce pistoning during ambulation. Secure the rope with additional wraps, and complete the negative impression with minimal weight bearing through the residual limb.

Using two blocks with a 45° angulation, position one in the anterior and one in the posterior at the distal aspect of the residual limb. Place the posterior block parallel to the body's axis, while slightly rotating the anterior block externally. (The external rotation of the anterior block reduces pressure on the pubis.) If the head or neck of the femur is present, reduce the rotation to parallel of the body's axis. Use enough force to create a wedge affect, displacing fleshy tissue laterally, while keeping the ischial tuberosity in firm contact with the casting platform. This will help to distribute body weight, transferring it antero-posteriorly, thereby reducing the constant pressure present on the ischium. It will also help to increase the patient's control of the prosthesis.

The amount of modification to the positive model should now be reduced. A slight reduction of the antero-proximal area of the abdomen as well as the gluteal muscles is necessary. This will provide a slight pressure to these areas.[1] Since the motion of the prosthesis is activated by pelvic and trunk motion, tilting the pelvis slightly posterior provides greater anteroposterior control of the prosthesis. Relieve the pubis, iliac spines, as well as the area superior to the roping channel and the lower aspect of the rib cage. This will prevent excessive pressure from the proximal brim of the socket.

FABRICATION

The first step in socket fabrication is the vacuum forming of the flexible inner shell. The material best suited for this purpose is Surlyn.® Because of its co-polymer properties, it resists shrinking better than low density polyethylene, which could also be applied.

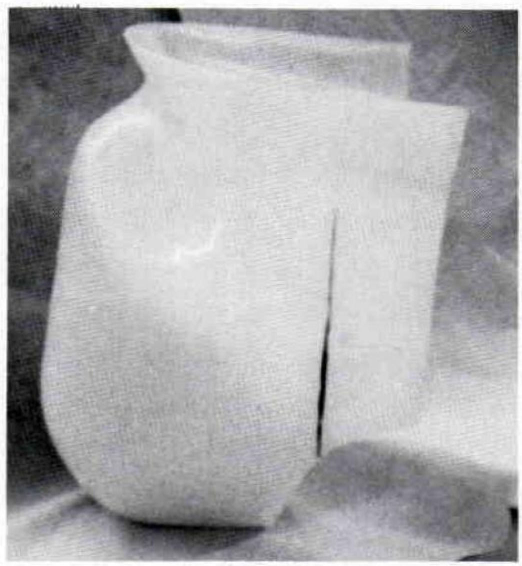

Figure 1. The flexible inner shell. Low density polyethylene or Surlyn® can be used.

After the "inner shell" is formed and allowed to cool, trim it laterally to both the anterior and posterior midlines. The extended anterior section will act as a tongue. The posterior section will provide a flexible lumbar support, thus allowing the medial posterior trim line to be lowered on the frame. By trimming the flexible "inner shell" to just past the midpoint of the model, the adverse effects of any of the plastic's shrinking properties will be minimized. It will also eliminate any separations which occur between the "inner shell" and the outer frame on the contralateral side due to the differing flex rates of the materials. Lastly, it will help to reduce the overall circumference of the socket.

Over the inner shell, laminate a one-half rigid, one-half flexible outer frame. The use of acrylic is highly recommended because of its superior "marriage" characteristics and its resistance to delamination, a property common with polyester resins.

The layup should consist of three layers of perlon stockinette, to create the inner surface. Over this, place a "half shell" of two layers of fiberglass stockinette, ex-

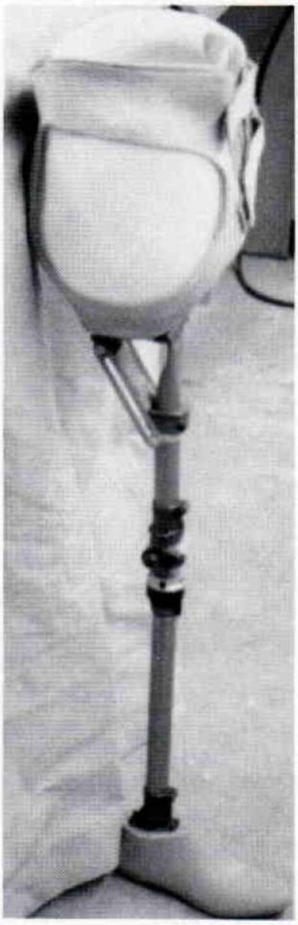

Figure 2. The flexible inner shell mounted in the outer frame of an endoskeletal set up. A pelite liner was used, but did not cover the flexible window, so as not to reduce heat transference.

tending from the anterior midline, to lateral to the posterior midline on the contralateral side. Pull two layers of perlon stockinette over this. Place the hip joint attachment plate in position with fiberglass matting and pull over this two more layers of perlon. Place two more fiberglass "half shells" as before and follow this with three more layers of perlon.

If extra strength is required, additional layers of fiberglass and perlon can be added in the layup. The use of one inch carbon fiber tape can also be added if extreme strength and rigidity are desired.

Laminate over the positive model so that the outer frameworks gradually form a rigid frame on the ipsilateral side to a flexible lamination on the contralateral side. After the lamination has cured, remove the outer frame, being careful not to damage the "inner shell."

Trim the proximal brim of the frame, just inferior to the lower aspect of the costal margin. Lower the trimline at both the anterior and posterior midlines to allow greater movement in bending and sitting. To create the "flexible window," trim the frame only from the lateral most aspect of the pubis on the ipsilateral side, to just lateral to the anterior iliac spine on the same side. Extend the "window" from just inferior to the iliac spines, to just superior to the ischium.

Attach the inner shell to the outer frame, and align and finish the prosthesis with the conventional methods applied to modular prosthetics.

SUMMARY

It has been observed that the comfort of the prosthesis and the application of a total contact socket with suprailiac crest suspension gives the patient a sense of the prosthesis being considerably lighter than the conventional Canadian style prostheses. This, along with the weight reduction achieved with the flexible socket, increased the overall performance of the prosthesis. With the addition of Titanium components, which are now available, it will be possible to reduce the weight even further.

DEDICATION

To John Neilson, C.P., who for the first 15 years of my rehabilitation saw to it that despite everything, I was provided with the best care possible.

Special thanks also to all the people at Otto Bock Inc. (especially Lawrence Mott), I.P.O.S., and Durr Fillauer, for all of their technical assistance and direction in developing this technique.

AUTHOR

Michael Madden has been a hip disarticulation amputee for 20 years. He is a graduate of the 916 Area Vo-tech program and is in the prosthetics program of the N.Y. State Dept. of Labors Apprenticeship program. He is presently head of prosthetic fabrication—under the supervision of Timothy Lacy, CP—at LaTorre Orthopedic Lab of Schenectady, New York. He is working on his baccalaureate degree as well as certification in prosthetics.

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