Prosthetic Management of Adult Hemicorporectomy and Bilateral Hip Disarticulation Amputees

Charles H. Dankmeyer, Jr. C.P.O.
R. Doshi, C.P.O.

INTRODUCTION

Since the origin of prosthetics, cases of significant challenge or those which are by nature very rare have spurred considerable interest. Cases which were at one time extraordinarily difficult to provide an acceptable prosthetic restoration have now become very manageable. Concurrently, medical technology has provided life saving techniques which have produced classifications and levels of amputations unknown to us only a few years ago. As the surgical techniques which were used to create the following cases become more common, all of us will have to address the best approach to provide prosthetic care for these individuals. The case histories which follow demonstrate the development of our current management system for hemicorporectomy patients.

CASE ONE: HEMICORPORECTOMY PATIENT

The first case is a level L•4 hemicorporectomy due to a traumatic injury. This patient had not been able to be upright since his injury. The distal spine was sharp and extremely sensitive. He was unable to lie on his side because he had no means to maintain himself in that position. He alternated between being prone and supine, neither of which were acceptable for a lifetime. The initial effort in this case was to get the patient erect at a normal sitting height and prevent excessive inferior aspect pressure. The problems were how to suspend him comfortably without any pressure on his distal spine and provide him with balance so that he could lean from side to side as well as fore and aft without tipping over.

On clinical examination this patient could be supported under his ribs with our hands while another prosthetist balanced his upper trunk; rib suspension, not unlike but different from the concept of suspension seating used in orthotics, could therefore be used. However, no distal weight bearing could be tolerated and trunk balance would also need to be provided. Confining the use of this device by mounting it to a wheelchair was restrictive and therefore undesirable.

Negative Mold

A negative mold of the patient was taken by suspending him under his axillae inside a Hoyer lift. This technique was felt to allow for a more natural extension of his lower body and provide an accurate means of determining the proximal sizing of the trunk support. This technique has since been abandoned as this information is not necessary in the negative mold and the casting system is uncomfortable to both patient and prosthetist.

Mold Modifications

Modifying this mold so that the underside of the rib cage is fully supported requires deep undercuts the thickness of the ribs themselves, plus approximately one inch. The undercut followed the natural contour of the ribs and had a generous radius of 1½″ as the mold began to extend distally. The proximal radius, which encases the outer border of the lower ribs where the mold extends proximally was allowed to follow the natural shape of the patient. A small amount of relief was made for the spinous processes. Modifications to this point provide a good weight bearing surface, and an accurate trunk mold.

The next step in modifying the mold was to provide a surface which would allow the patient to sit erect without external support and not be so bulky as to inhibit transfer activities. A base equal to the size of his rib cage in the transverse plane would cause a great deal more effort to be expended in transferring from floor to an armchair, wheelchair to auto, etc., since the additional hollow bulk would cause him to reach farther and lean at a greater angle in order to complete these manuevers. The distal extension was also intended to make his sitting height more normal to make up the trunk length lost. Initially, this extension was designed to house the iliostomy and colostomy containers. We made our extension so that it was 6″ long and from a frontal plane center line extended 30% of the width of the rib cage on each side of center. In the sagittal plane, the extension was made 40% the width of the rib cage to each side of the center. The resultant form was quadrilateral and almost square (Fig. 1). The mold was left high under the arms, over the scapulae, and over the sternum anticipating that the final trim lines would be determined at the fitting.

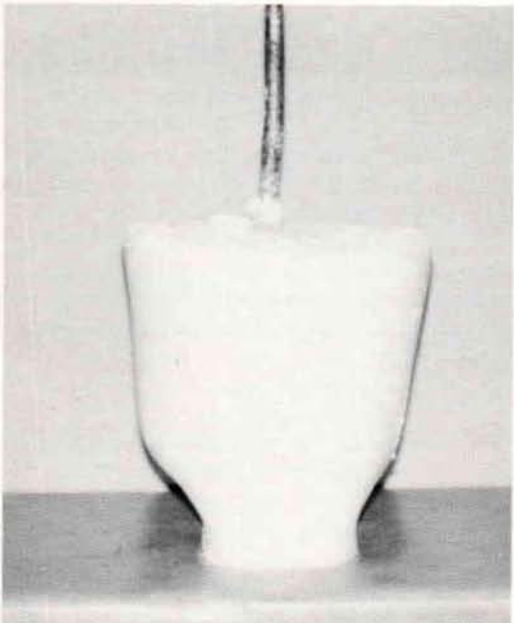

Fig. 1—The modified positive mold for a hemicorporectomy patient. A base extension was added to provide a base of support and was originally intended to house the iliostomy and colostomy containers.

Fabrication

The socket was laminated with polyester resin at 90% rigid, 10% flexible and eight layers of nylon stockinette using fifteen inches of mercury vacuum. After the socket was removed from the mold, it was found that the length of the extension would not be adequate to provide proper sitting height. To correct this, the socket was fitted into a wood block left very long to be adjusted at the fitting (Fig. 2).

Fitting

At the fitting, the proximal trim was cut one inch below the inferior angle of the scapulae. This line was carried under the arms and across the anterior portion just below the nipple line and covering part of the sternum.

Fig. 2 – In the original design, a wood block was added to the socket extension and left long. This would be adjusted at the fitting for proper sitting height. In later designs, it was found that a measurement could provide the correct height so the wood block was eliminated.

In order to don the prosthesis, the patient had to lay supine, raise his lower trunk by pushing downward with his arms, simultaneously inching himself into the socket. This was a slow and tedious process and also caused the iliostomy and colostomy containers to be forced upward and eventually upside down. An anterior panel was cut out of the socket which allowed the patient to raise his trunk and place it in position inside the socket in one swift motion. The inferior edge of the panel was cut to allow two inches between it and the remainder of the socket. This created a small "window" which allowed easy access to the iliostomy and colostomy bags. The panel is held in place with four 1½" velcro straps and metal loops. The anterior panel also allowed some position adjustment for tightness.

With the patient upright in the socket, the height of the extension was modified to allow his palms to touch the table while the elbows were just slightly flexed. This was just enough to allow him to lift the socket up for transfer and also provided a very natural trunk height allowing his arms to fall in good position on chair armrests. Shoulder straps were attached to suspend the socket.The wood block had been almost completely removed which confirmed the original amount we had extended the mold as correct. The patient was able to balance easily on the smallish appearing base and could reach objects in all directions without fear of tipping over (Fig. 3).

The prosthesis was given a finish of two nylon stockinettes impregnated with 90% rigid, 10% flexible polyester resin. The base was covered with a ¼" thick piece of neoprene crepe. Medium density ⅛" thick plastazote was applied over the rib support area to provide some cushioning, but more to increase the friction and prevent slipping in the smooth socket. The sitting prosthesis was then considered complete (Fig. 4). A pair of hand held blocks were made so the patient could clear the floor and move about his house without being in a wheelchair.

Addition of Limbs

After using this device for approximately six months, the patient returned to report that he was able to transfer, move about his house, and drive a car with hand controls. The quality of his life had definitely been improved and he was satisfied with his functional level. He requested that limbs be attached to the prosthesis for cosmetic purposes. A ¼" thick steel plate was fastened to the socket base extending laterally to each side to allow attachment of Otto Bock free motion modular hip joints in a normal position (fig 5). The balance of the limbs consisted of Otto Bock modular safety knees, rotation units, and SACH feet.

The patient was able to ambulate in the parallel bars with a swing through gait as well as twisting gait due to the rotation units (fig 6). This system satisfied the patient's desire to "walk" in parallel bars and his need for cosmesis, but the addition of limbs made the entire system less functional for transfer and mobility at home. The patient gained a significant amount of weight after this modification and returned for a new prosthesis.

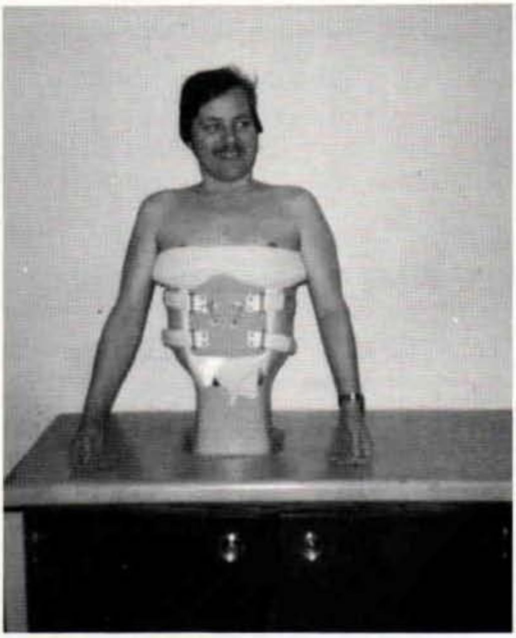

Fig. 3 – The patient was able to balance easily on the smallish appearing base and could reach objects in all directions without fear of tipping over.

Fig. 4A – Wheelchair sitting. The patient could lean back comfortably in the wheelchair.

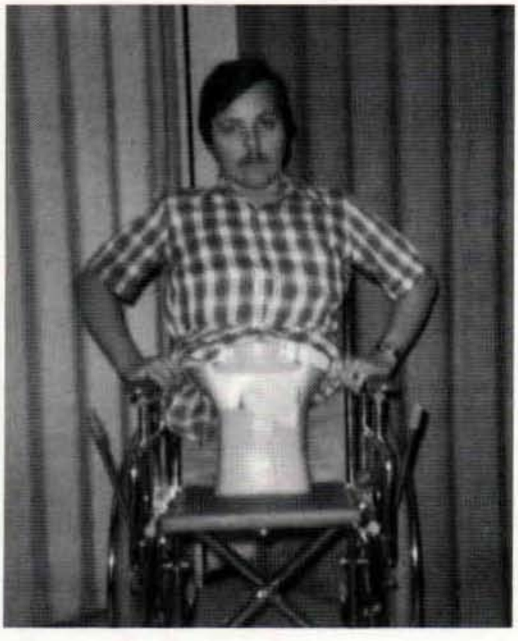

Fig. 4B – Elbow clearance is not a problem and the patients sitting height appears normal.

Fig. 5 – After the sitting prosthesis was in use for six months, the patient requested that the limbs be attached. A ¼" steel plate was bolted to the base and the modular system was attached.

Removable Socket System

Having learned that the socket alone was more functional, but that cosmesis was also very important, the second prosthesis was made in two segments. The new negative was made by a split cast technique. With the patient prone the posterior half was made. This was used for the patient to rest in when turned to supine position. The anterior mold was then made. The casting was easier for both patient and prosthetist. Identification of the lower margin of the ribs was easily formed as the plaster bandage set. This technique was more accurate than the first because the trunk was not suspended freely allowing it to both extend and narrow down.

The modifications were done the same as previously described. No wood block was attached as the proper amount of extension was predetermined. Socket fitting and trim were also done in the same manner. The difference was in providing a system which would permit the patient to use the socket alone or attach it to the modular lower limbs at his discretion.

The socket was placed on the mold and a PVA sleeve pulled over it as a parting agent. A lay up of four layers of nylon stockinette was made over the socket and again laminated with polyester resin. Wood blocks were glued to the thin shell to allow attachment of the Otto Bock modular hip joints in a standard position. The hip attachment plates were attached to the wood and the entire assembly smoothed and given a finished coat of two layers of nylon stockinette. The balance of the modular units were attached and finished to this lower segment. The socket was then able to be easily removed from the cosmetic lower limbs. The square shape of the extension of the socket allows it to key into the prosthesis allowing no relative motion between the segments. This system proved very satisfactory and answered the prosthetic needs the patient required (Fig. 7-11).

Fig. 6—The patient could ambulate in the parallel bars with a swing through gait. The rotator units in the limbs also allowed a twisting gait. The prosthesis was more cosmetic, but less functional with the limbs attached because they could not be removed easily from the socket.

Fig. 7—The patient's second prosthesis had a removable socket which enabled him to use the sitting prosthesis (socket and extension) for maximum function, or to key the socket into the prosthesis for cosmesis. The square shape allowed no relative motion between the segments.

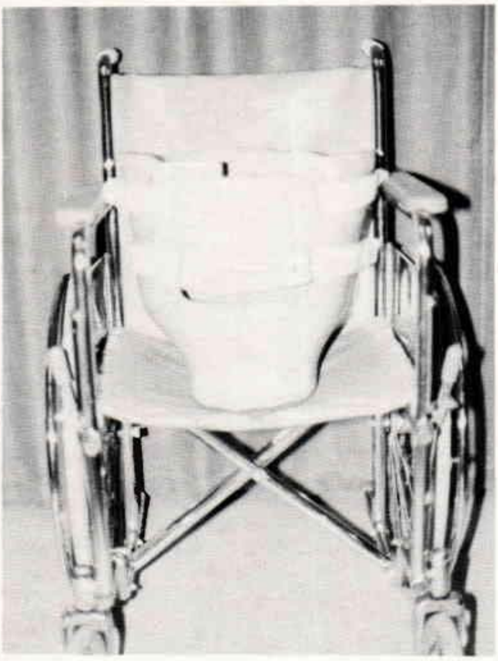

Fig. 8 – The socket in place in a wheelchair. The removable anterior panel allowed ease of donning and adjustability of fit.

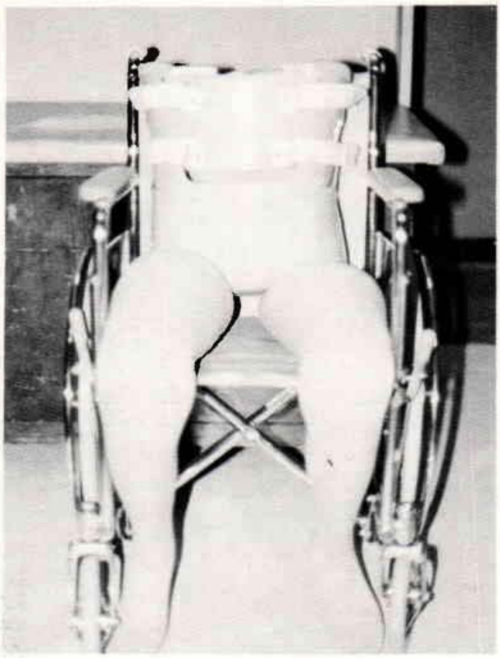

Fig. 9 – The socket keyed into the prosthesis in a sitting position.

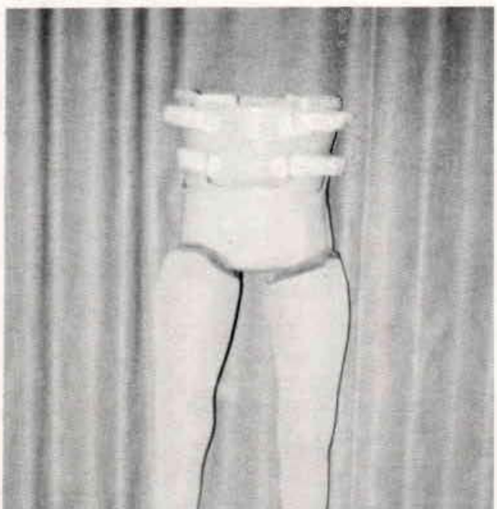

Fig. 10 – The socket keyed into the prosthesis in a standing position.

CASE 2: BILATERAL HIP DISARTICULATION

One bilateral hip disarticulation patient was fitted with this same technique. This patient could not tolerate any distal pressure due to a large ulcer over the sacrum. His amputations were secondary to circulatory problems and diabetes. A minimal amount of extension of the socket was needed as his pelvis was intact and only needed suspension to protect the unhealed area (Fig. 12). This patient did not desire lower limbs. The socket only provided him with protection for his wounds, sitting balance, and ease in transfer. Since there was no trunk length loss, the base of this prosthesis is the full size of the socket.

CASE 3: HEMICORPORECTOMY PATIENT

A second hemicorporectomy was fitted with the complete socket and removable cosmetic limbs. This patient was a high level paraplegic and also diabetic. His amputations were the result of repeated pressure sores from sitting. He had little trunk balance but the high trim lines of his socket provided support. The trim lines were made much higher in this case to provide more trunk support because of the high level paraplegia (Fig. 13). A special "seat base" was also needed to make this patient feel secure from tipping over, again due to the paraplegia. This base was used primarily in the wheelchair and was a female key to the distal square shape of the socket. This keying provided security between the socket and base. After a few months use, this patient returned to us at which time the trim lines were lowered as he now demonstrated improved trunk balance. The posterior trim was brought down to one inch below the inferior angle of the scapulae; The same anterior trim line just below the nipple line has been satisfactory on all cases.

Fig. 11 – Prosthesis as it would appear in normal use.

Fig. 12 – Bilateral hip disarticulation patient. The entire width of the socket was used as the base since there was no trunk length loss.

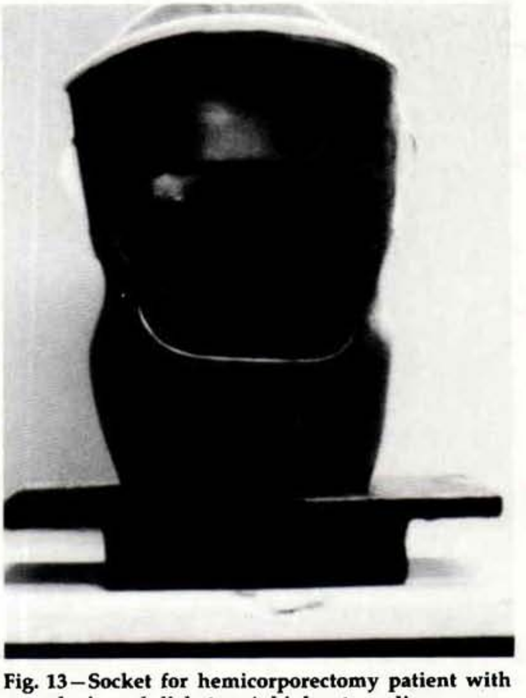

Fig. 13 – Socket for hemicorporectomy patient with paraplegia and diabetes. A higher term line was required for trunk support. A wider base was also needed for more support.

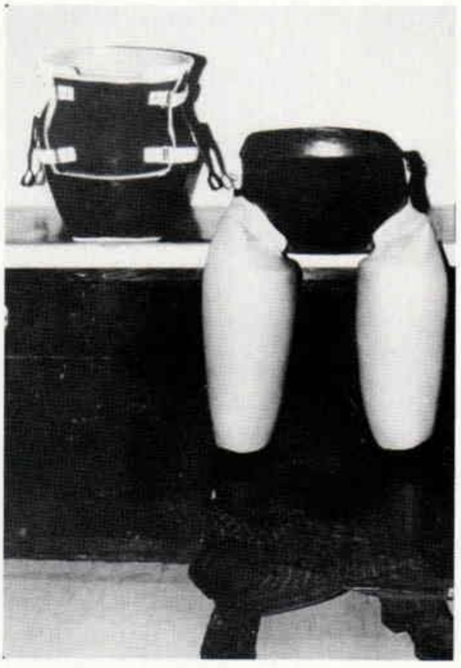

Fig. 14—Removable socket system used on hemicorporectomy patient with paraplegia.

A third hemicorporectomy secondary to parplegia and pressure sores with an unhealed grafted area over the distal spine was also fitted with the socket only to provide him with an upright position, protect the skin graft, and provide mobility. This patient is currently a college student.

A few additional measurements will greatly ease the fabrication of these devices. The length of the extension can be determined by measuring the amount of space from the end of the trunk to the table top while the patient is supported on the palms of his hands with elbows slightly flexed. This length is the amount of extension needed. The diameters of the rib cage, both lateral and anterior posterior will provide a more accurate positive mold modification.