Some Experience in Hemipelvectomy Prosthetics

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Early attempts in hemipelvectomy prosthetics

Since the prosthetic application on a hemipelvectomy is a much more recent development than the surgery itself, only a few individual approaches to this problem are known. This reflects the fact that in the last decade there has been a rapid decline in mortality rate and a higher life expectancy for such cases. The earliest attempts were based on the techniques of a hip disarticulation-socket construction. Because of the differences between a hip disarticulation and a hemipelvectomy, a radical change in the basic design was necessary and desirable.

The first method of suppling a partial weight-bearing area for hemipelvectomies was published in 1957. The author described an ischium and/or gluteal bridge which was extended to the sound side. This technique proved to be a partial solution to the problem, since no counterforces could be applied opposing this gluteal bridge.

In 1958, the first biomechanical approach was constructed for a patient whose gluteus maximus was still present and the tissue consistency in the stump region was good, the application of this approach for patients with less desirable stump conditions was not given.

Based on Lyquist's idea, a sling casting technique was developed and described by Fred Hampton in 1960. The technique proved to be excellent for pressure application while casting. In pursuing the goal of the least possible amount of telescoping of the pros-

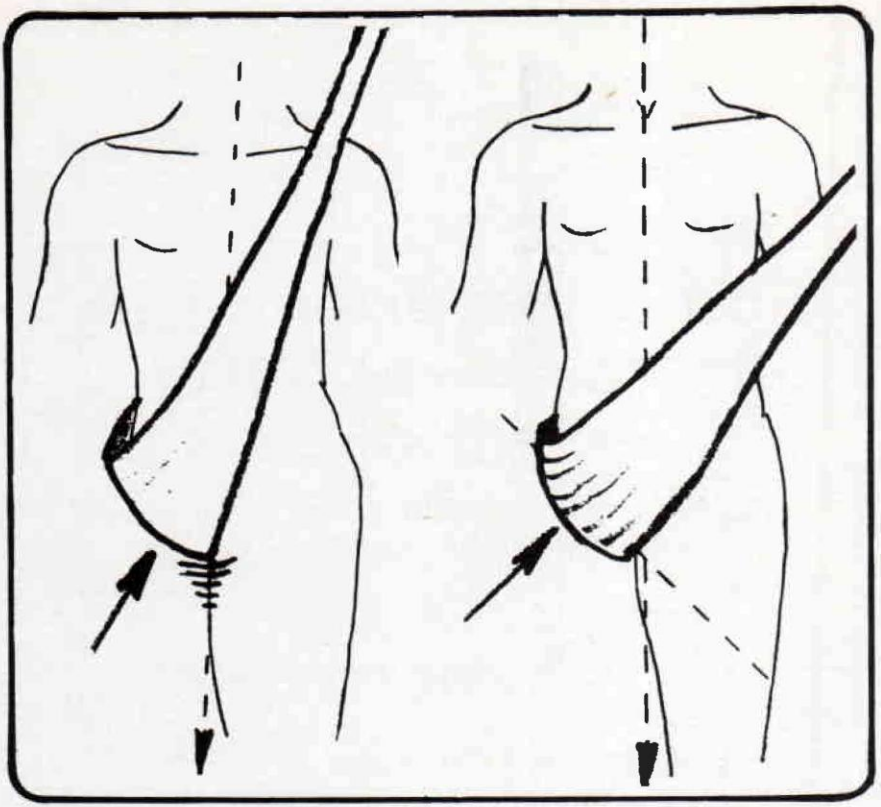

Figure 1

Figure 2

thesis during gait cycle. I was not able to apply this method successfully on my patients. As I pulled the sling in an angulation which would assure the patient excellent balance during casting, the stump contour was far from being close enough to the stump compression for necessary adequate support (Fig. 1). As I pulled the sling so that the stump contour was satisfactory, the patient was completely off balance (Fig. 2). A different method of stump compression and contouring, described below, was applied.

Biochemical considerations

The fitting of a hemipelvectomy socket involves complications resulting from a lack of fully satisfactory support points.

In hemipelvectomy cases, no ischium or other bony structure that could serve as satisfactory support points are available. Therefore, the vertical force has to be resolved into other and more tolerable force components. The stump of a hemipelvectomy tolerates a considerable amount of pressure, but not to such an extent that full body weight can be borne in this area. The pressure in the stump region would

probably be tolerable for the patient, but a telescoping of the leg, in most instances more than 2½ inches, and pressure in the groin and perineum, would hardly be tolerable. To avoid this, a force application at 45° to the saggital plane and opposite forces applied below and above the ilium crest of the sound side, is a first step to the prevention of telescoping and proper basic support of the patient in the bucket. It must be borne in mind, however, that socket construction with such a force application will not of itself give a fit intimate enough to provide a high amount of assurance for the patient.

During walking, and especially in full stance, the pelvis drops 5°, carrying along the bucket suspension above and below the iliac crest on the sound side. Thus, the calculated 45° slope on the amputated side increases to 50°, heightening the tendency of the stump to slide out of the bucket. This action has a resemblance to telescoping and a counterpressure on the sound side is the only way to prevent this. This counterpressure can be created by the construction of a low socket, but this would interfere seriously with sitting. Therefore, a proximal extension of the bucket is unavoidable. An auxiliary support in the sound gluteus and/or ischium region is ineffective for two reasons: Counterforces in the anterior region cannot be applied and walking is interfered with. The contraction of the gluteus maximus between heel contact and toe off will rotate the socket and prosthesis medially. The anterior posterior stability will be derived from intimacy of fit, in the posterior region against the sacrum and anterior counterpressure above the remaining pubis. A convexity in the shape of a hypergastric pad will serve not only as counterpressure pad but also as an aid in preventing the socket from sliding distally.

For these reasons, the socket will have to be extended to encase the thorax or, at least, the lower part of it. The height of this proximal extension will be determined by conditions of the surgery region. If, as mentioned earlier, enough gluteal muscle tissue is present, more pressure can be applied here and the height of the bucket can be kept low, so as to just engulf the lower ribs. If, however, the gluteus had to be removed, the height of the socket should be increased accordingly.

Ultimately, the question of how far the thorax will have to be encased must be answered by the prosthetist who evaluates the patient.

Evaluation and preparation for casting

To avoid subsequent complications, the examination of the hemipelvectomy patient must be thorough and comprehensive. In order for problem areas to be evaluated sufficiently, appropriate x-rays should be

on hand. Since the surgeon leaves behind remains of os pubic and os ilium, these areas require special attention. Remaining bone structures are very sensitive areas and have to be relieved of undue pressure. They can either be built up with ½-inch skived felt patches before casting, or be built up on the positive cast. On one of my patients I found about one half of the ilium crest remaining. Since this bone structure showed average sensitivity, it proved useful for socket suspension. The consistancy of the gluteus maximus should be recorded on the prosthetic information sheet since the consistency of this muscle determines modifications of the positive mold. After these areas have been evaluated and recorded, the circumferential measurements have to be taken. As a general rule, measurements should be taken and recorded starting at the inferior angle of the scapula and working down in increments of 2-3 inches **(Fig. 3)**. This is desirable, whether or not the socket has been planned to apply more pressure in the amputated region, which in turn will affect the height of the socket and therefore the pressure per square unit on the thorax. I prefer to take these measurements, especially the four or five most proximal ones, when the patient has exhaled. This will give consistent measurements and the tension of the bucket can be calculated accordingly. Measurements of distances from scapula to ischium and ilium crest to ischium are taken while the patient is sitting. These have proved to be very helpful in locating the exact position of the ilium crest on the positive mold. The ilium crest location is important for positive modification, inasmuch as undue pressure directly on the crest can be painful. All other measurements required for the construction of a hemipelvectomy prosthesis are similar to those needed for the Canadian-type hip disarticulation prosthesis.

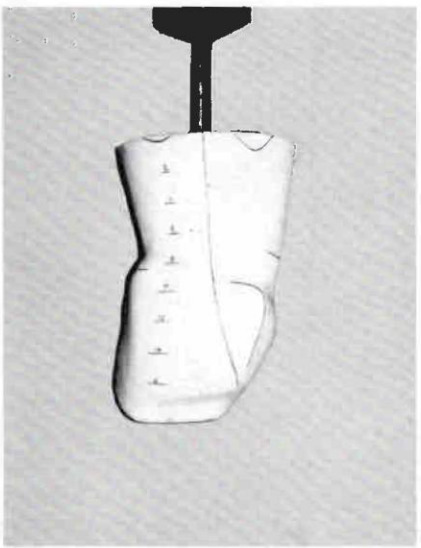

Figure 3

While taking the cast, the tissue in the surgery region has to be compressed in as close to a 45° angle to the saggital plane as stump conditions permit. A 6-inch double-length ace bandage has been found the simplest and most efficient way of compressing stump tissue and indicating ilium crest contour. This method accommodates both the

"hip stick contouring" and "suspension while casting" methods.

The bandage is applied as shown in **Fig. 4**, starting in the stump region, pulling it anteriorly at a 45° angle proximal above the ilium crest (it should under no circumstances rest or press on the ilium crest) posterior over the shoulder of the amputated side going anterior and down towards the ilium crest on the sound side. Crossing the first layer of the bandage and pulling posterior back to the stump region will conclude the figure-eight wrap. Pulling the bandage tightly around the patient will apply sufficient pressure on the stump and give desired contour on the sound ilium crest. Obese patients may require an additional wrap horizontal around the lower rib cage **(Fig. 5)** to precompress this weight-bearing area. After the bandage is properly secured, a pretailored piece of stockinette is applied on the patient and tightly suspended over the shoulders.

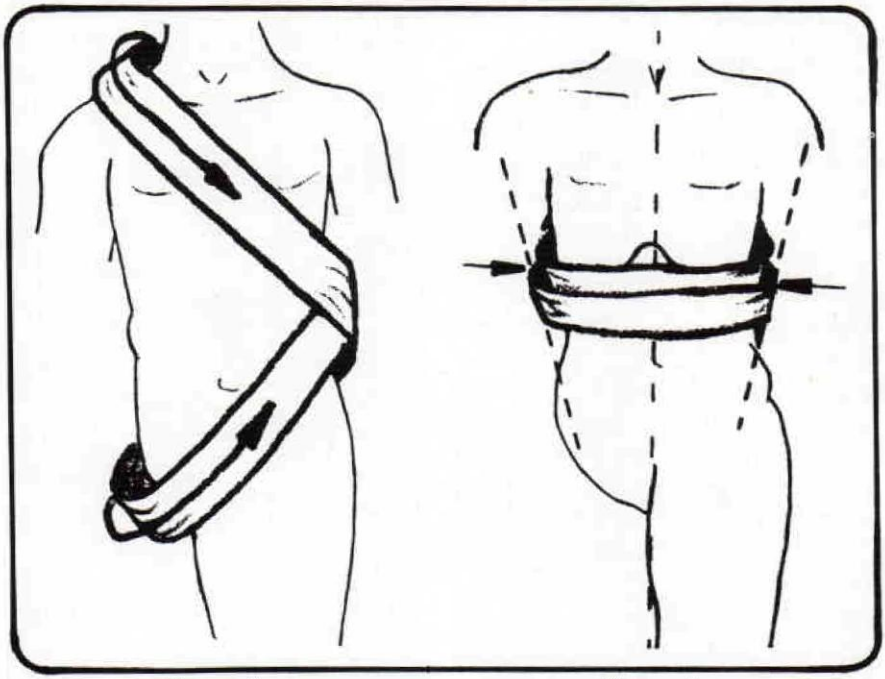

Figure 4

Figure 5

The following bony landmarks and prominences should be outlined with indelible pencil:

a. Anterior superior iliac spine
b. Posterior superior liliac spine
c. Ilium crest
d. Greater trochanter
e. Proximal rim of pubis
f. Sectioning of pubis and ilium
g. Inferior angle of scapula

h. Spine
i. Any sensitive areas in surgery region
j. Lower border of rib cage.

Casting

For taking the negative cast of the patient, seven to ten plaster of Paris bandages are needed, preferably 6 inches wide. The elastic plaster bandage will assure a better cast inasmuch as it counteracts the expansion occurring during the hardening of the normal type of plaster bandage. Parallel bars will give the patient proper balance during casting. If not available, two chairs turned with their backs toward the patient will serve the same purpose. The actual technique is very simple and only requires wrapping under moderate tension, due to the precompression stump tissue and precontouring of ilium crest region that results from the bandage application described above. If no horizontal ace-bandage wrap has been applied around the lower thorax, the tension of the plaster bandages should be increased in this region. Slight angulation of the layers is necessary in the lower portion of the cast. Furthermore, the wrap should extend low enough so as to enclose the sound trochanter and ischium area **(Fig. 6 & 7).** Before the wrap hardens, the ischium has to be indicated by pressing either the right or left hand (according to side of amputation) into the gluteus region and up against the ischium tuberosty. This ischium indication will be helpful in establishing the length of the prosthesis. The cast is removed by cutting anteriorly with a cast cutter. A 2-inch webbing strip on top of the stockinette will help to protect the patient.

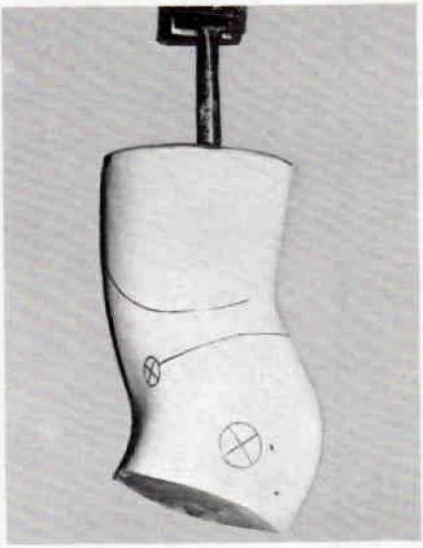

Figure 6

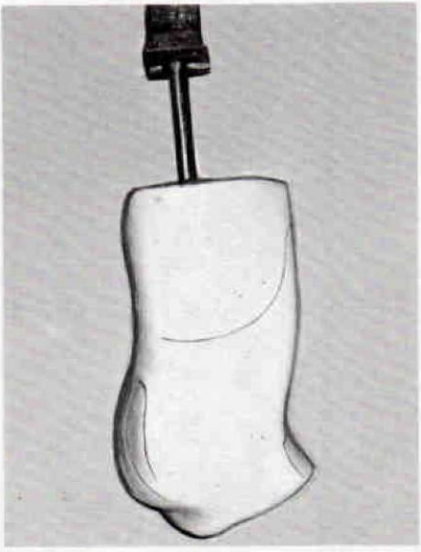

Figure 7

The negative cast

If these steps are followed, the negative cast should come out without need for modification, and only minor modifications on the positive cast will be required. It is not intended that this negative cast be used as a check socket. After sufficient modification of the positive cast, a check socket is constructed.

The positive modification

To maintain the shape of the negative cast, close anterior cut with plaster bandages immediately after the cast has been removed from the patient. The distal part of the cast is also closed with plaster bandages. The cast is filled with plaster of Paris. A 1-inch pipe is inserted for attachment to the suction equipment during lamination. To avoid excessive weight of the positive cast, a slash cast may be constructed. The construction method is described by J. Foort in "Artificial Limbs." After the negative has been removed from the hardened cast, the somewhat faint indelible marks should be redrawn so as not to lose them during cast modification. The cast is then smoothed thoroughly with a Stanley Sur-Form file, with the exception of:

a. Anterior superior ilium spine

b. Ilium crest

c. Sectioning of pubis

d. Sectioning of ilium.

At this point the indication mark for the ilium crest has to be checked for its proper location, especially on corpulent patients. The stockinette with its indelible marks may have shifted during cast wrapping. Since our ischium indentation on the positive mold is not of real value, due to tissue distortion in the region, the measurements "distal scapula-ischium," depending on measurements rather than on ischium indentation, and ischium-ilium crest" will have to be duplicated on the cast and checked against the indelible mark for the ilium crest. If necessary, minor corrections can be made at this point.

Plaster of Paris has to be removed from the positive cast in those regions where pressure and counterpressure is to be applied. In most cases I have found that in addition to our firm wrap in the surgery region, approximately ½ to ⅝ inch of plaster can be removed in this area. Counterpressure will be applied between ilium crest and greater trochanter on the sound side. Between these two points, ¼ to ½ inch of plaster should be removed. The circumference of the lower rib cage should be reduced by 1½ to 2½ inches, according to amount of circumference and tissue consistency.

To assure anterior posterior stability, plaster is removed from the sacrum region and superior to the pubis. The removal of plaster superior to the pubis stabilizes anterior posterior and

relieves pressure on the very sensitive pubis. It should have the size and shape of a hypergastric pad. The depth depends largely on how much pressure the patient is able to take without having the feeling of urinary incontinence. I have found that a pad like this is necessary only on thin patients. In general, a plaster removal of ½ inch provides the necessary pressure.

The areas of the anterior superior ilium spine, ilium crest, sectioning of the pubis, and sectioning of the ilium need little more than smoothing out with sandpaper if the felt pads have been applied on the patient before casting. If no such provision for relief was made before casting, approximately ¼ to ⅜ inch of plaster has to be added to these areas.

The check negative

After the cast has been smoothed completely, the plaster check socket can be constructed. A water-soluble lubricant is applied to the cast as a separator. Two or three coats of "Hi-Glo" or clear lacquer may also be applied as a separator. If, however, modifications on the positive should be necessary after the check negative has been fitted, the coating has to be removed completely to assure a perfect smooth cast.

About eight to ten layers of 6-inch plaster are applied to the cast in strips of cast length. After the bandages are hardened, the check socket is outlined and trimmed. The proximal trimline is determined by the cast and lowered only during fitting. The distal trimline will be determined, as shown in **Figs. 8, 9 and 10**. Cut negative laterally on the sound side and remove from cast. For support during fitting, a wood block is bonded to the negative **(Fig. 11)**. For the donning 1½ inch Velcro straps have been found to be sufficient for fitting and for the final bucket.

During check-socket fitting, have the patient apply equal weight on both sides **(Fig. 11)**

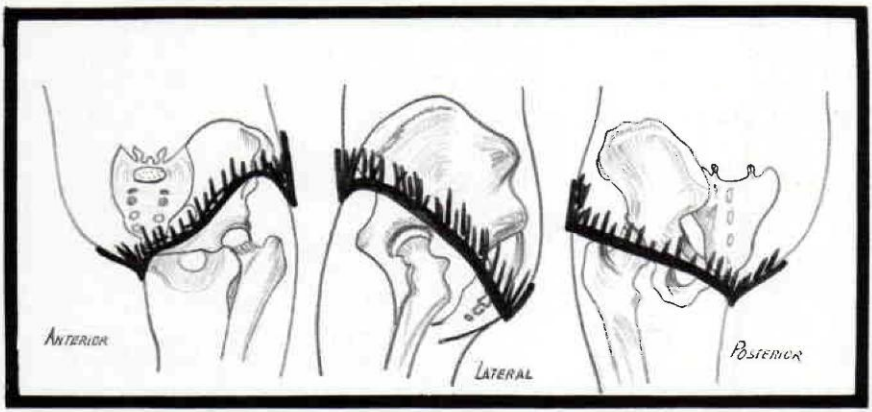

Figure 8 **Figure 9** **Figure 10**

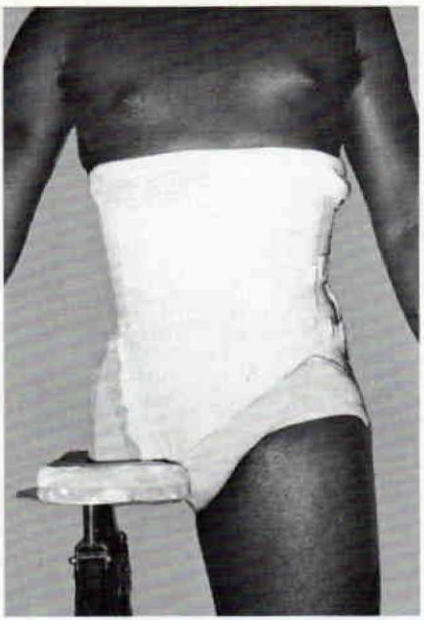

Figure 11

and check the following:

a. Tension on lower thorax.

Check the tissue consistency around the proximal socket rim. The anterior and posterior regions should be somewhat softer than the lateral areas.

b. Proper relief on sectioning of pubis and ilium.

The pubis sectioning can be checked by palpating from the distal border of bucket. Holes should be drilled through the check negative to check the relief area of ilium sectioning.

c. Proper relief on ilium crest and anterior superior ilium spine.

These areas also should be provided with holes to check tension. Under no circumstances should the socket press onto the ilium crest and anterior superior spine.

d. Suspension above ilium crest.

Check same way as "c". If tissue protrudes approximately ⅛ inch through the holes, the pressure should be sufficient.

e. Anterior posterior stability.

By having anterior and posterior distal portion of check socket provided with holes, the tension can easily be checked. Have patient move his pelvis while checking for displacement, if any.

f. Distal trimlines.

The distal trimline is checked while the patient is seated on an average chair. If the socket is too low, restriction will occur below the anterior superior spine.

g. Height of bucket.

The height of the socket may be checked by decreasing it one inch, and checking during this procedure for the amount of telescoping between weight-bearing.

h. Lateral tilt deviation between sitting and standing.

Establish vertical lines anterior and lateral (amputated side) in the standing position while the patient is bearing equal weight on both sides. The anterior vertical line should not vary between sitting and standing.

Final modifications

If relief or pressure increase is found necessary during fit-

ting, it will be done on the positive. The vertical lines established will be transferred to the positive by pushing an awl through the negative into the positive on each end of the vertical lines. Round-head screws or nails driven into the cast at these points will automatically transfer these points to the laminated socket. Transfer proximal and distal trimlines to positive, and remove excess plaster before priming for lamination. Maintain as much of ischium indentation as possible. It will be needed as a reference point for establishing height during bench alignment.

Laminating the socket

The lamination of the socket is done in the conventional way. Eight layers of nylon stockinette and a double layer of Taslon used as reinforcement in the amputated region will give sufficient strength. An area 2 inches wide, anterior and posterior, should be made 60-40 flexible to prevent cracking. The donning will be lateral. If the tongue is laminated as part of the socket, an area of approximately 4 inches in width will also be laminated flexible.

Joint placement

To provide proper anchorage for the hip joint, a block of wood is banded to the socket (Fig. 12). A mixture of epoxy resin and sawdust will give additional strength and provides an excellent bond. After this has hardened, the wood block will be leveled in 90° angle to the transferred vertical lines established during fitting. A saw cut anterior in 45° to the new established plane will give the attachment base for the hip joint. The point should be placed as far in the medial direction as mechanically permissible, since a too-far-lateral located joint will create lateral instability as well as rotating forces during stance phase.

Figure 12

Final lamination

After static and dynamic alignment is completed and the results transferred into the final prosthesis, the missing hip is reproduced with a balsawood build-up. Two layers of nylon stockinette are sufficient for the final lamination. The socket may be perforated with a ½ or ¾-inch Forstner bit or similar available tool.

Outline of our own results in hemipelvectomy prosthetics

Having utilized these methods to fit patients in the 22 to 40 year age range with a variety of tissue conditions ranging from thin to corpulent, I have found that the patient with the least amount of fat tissue is the most difficult to fit, even though the chances of functional telescoping are highly reduced in such cases. The most critical areas on these patients are, as might be expected, the sacrum, pubis and ilium. For one of these patients it was necessary to add ½ inch of foam padding for protection of the ilium crest. The same patient initially seemed to need a padding in the shape of a hypergastric pad superior to the pubis for anterior superior stability. Later, this had to be removed, since the patient experienced urinary incontinence while wearing the prosthesis. Another patient, who after the amputation went back to work on crutches as a construction electrician, felt that his activity was limited when he wore the prosthesis on the job and therefore discontinued its use. The overall result of this type of socket construction was very promising. Of eight patients fitted with a socket of the beforementioned properties, only one refused to wear the prosthesis all day. All other patients, including a housewife, a parking-lot attendant and an office manager, wear the prosthesis actively and consistently. Since in any level of upper or lower extremity the socket is the heart of the entire prosthesis, not enough emphasis can be put on intimacy of fit and proper force application.

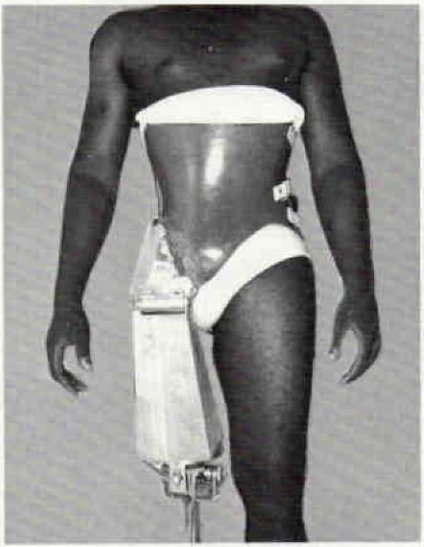

Figure 13

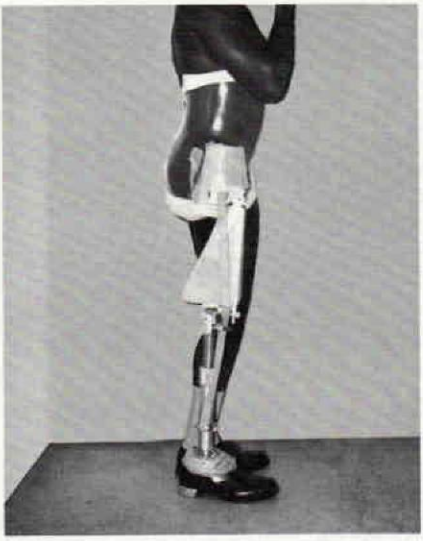

Figure 14

Figure 15

Figure 16

Figure 17

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