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Dynamic Splinting of the Rheumatoid Hand

by F. Richard Convery, M.D.,* J. Pierce Conaty, M.D. and Vernon L. Nickel, M.D. *Rancho Los Amigos Hospital, Downey, California*

The effect of orthotic devices in the modification of hand deformities in rheumatoid arthritis is essentially unknown. Immobilization of acutely involved joints has long been known to provide symptomatic relief, and it was recently shown that immobilization also results in local improvement of joint involvement. **(Fig.1,2)** Beyond this, however, little is known about the prevention of deformities caused by rheumatoid diseases.

There is little agreement as to the significance of multiple factors in causing rheumatoid hand deformities, but there is a consensus among most authorities that synovitis, capsular distension and instability are the primary etiologic features. Mechanical stresses and various types superimposed upon an unstable joint then result in progressive deformities. **(Fig. 3,4,5)** Intimately associated with the soft tissue involvement is the destruction of articular cartilage and bone.

Many clinicians believe that prolonged splinting to protect diseased joints from the adverse effects of mechanical stress might prevent or retard the development of typical deformities. This contention, however, has not been established. The ideal splint, as described by Bennett, "must permit the normal planes of motion necessary for essential function, but block all faulty planes that result in functionally significant deformity." **(Fig. 6)**

For the past seven years, a dynamic hand splint designed to maintain motion, improve function, relieve pain and prevent the progression of deformity has been used on the Rheumatoid Arthritis

* Fellow, Southern California Chapter, Arthritis Foundation.

Service at Rancho Los Amigos Hospital. This device **(Fig. 1)** is similar to the paralytic splints found to be valuable in the rehabilitation of patients with residual deficits from poliomyelitis and spinal cord injuries. The splint **(Fig. 2)** has an action wrist, an action metacarpophalangeal joint with extension assist and plastic loops to support the proximal phalanx and apply a radial deviation force.

MATERIAL

During the period 1959 to 1965, sixty-one patients with definite rheumatoid arthritis were fitted with this splint. Ten patients who later underwent surgical procedures were not included in the series. Twenty-two patients (42%) wore the splint for more than one year and thirty-one patients (58%) used the splint for less than a year. Of these thirty-one, nineteen patients (36%) would not wear them at all.

Twenty-seven hands in seventeen patients, who wore the splints one to five years with a mean use period of thirty-four months, are available for review. Thirteen hands in eight patients, who were fitted but did not use the splints and were evaluated more than one year after fitting with a mean follow-up of thirty-two months, are available for comparison. The mean age of the splinted group was forty-six years, and of the comparison group forty-eight years.

RESULTS

Function:

The splint is bulky and cumbersome, and in many cases hand function was reduced. The patients with the least deformity were the ones who disliked the splints the most. It seemed that the splints decreased function in inverse proportion to the degree of deformity present. Despite many attempts, it was not possible to document increased hand function while using the splints.

Wrist:

The splints adversely affected motion in those wrists that had good extension at the beginning of the program **(Fig.**

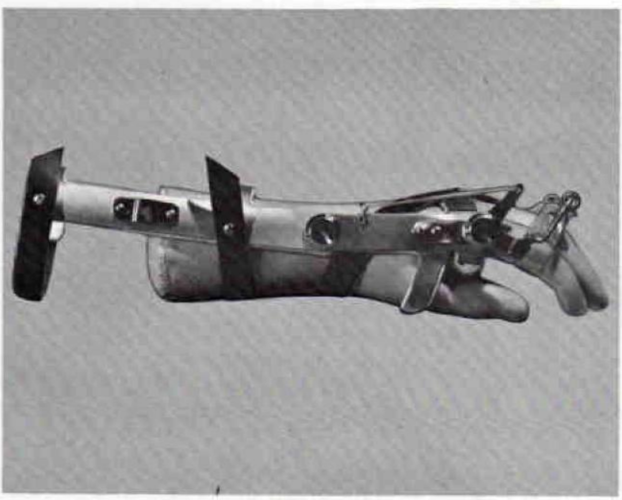


Figure 1

Figure 2

3-A). Thirteen wrists were in this group — eleven lost extension, eight lost flexion range, and three developed significant deformities. The mean loss of total range in this group was forty-seven degrees.

In the wrists with pre-existing deformity (**Fig. 3-B**) the adverse effects were not so apparent. One wrist in fourteen was improved, but there was progression of deformity in three others. The mean loss of total range in this group was only eight degrees, which is probably not a significant figure, but does indicate that wrist motion was not increased.

In the comparison group the mean extension range was thirty-two degrees initially and at final evaluation of twenty-seven degrees — a mean loss of extension of five degrees with a mean loss of total range of only seven degrees.

Metacarpophalangeal Joint:

The development of metacarpophalangeal deformities was not prevented. Nineteen per cent of the metacarpophalangeal joints that had full passive extension at the beginning of the study developed flexion deformities (**Fig. 4**). In addition, thirty-nine per cent of these joints lost flexion range with a mean loss of total passive motion of fifteen degrees.

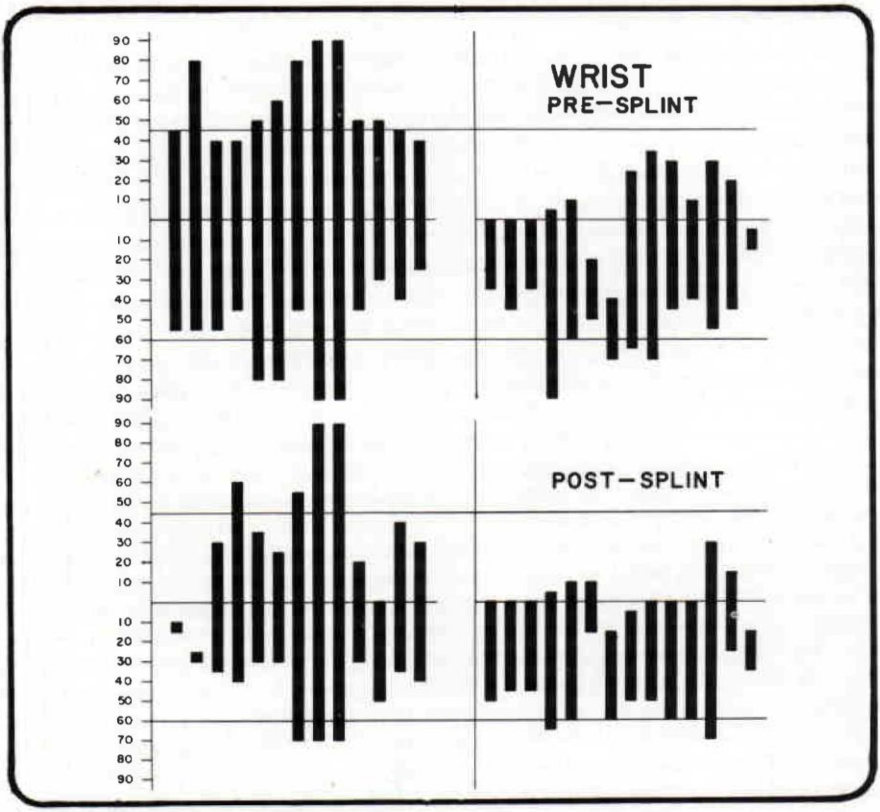
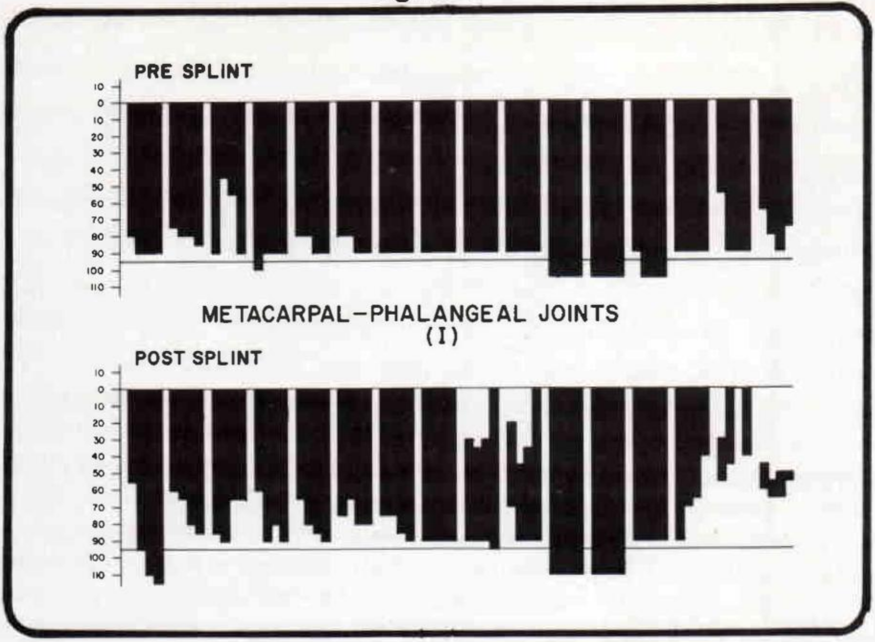


Figure 4



Correction of flexion deformities of the metacarpophalangeal joint was not consistently achieved **(Fig. 5)**. Nineteen metacarpophalangeal joints had a flexion deformity at the onset of the splint program. Of these, eight improved, eight were worse and three did not change. In addition, five more joints developed flexion deformities during the splinting program. The mean loss of total motion in this group was thirteen degrees.

In the comparison group twelve per cent of the metacarpophalangeal joints developed flexion deformities and thirty-two per cent lost flexion range. The total range, however, was essentially unchanged.

Proximal Interphalangeal Joint:

The proximal interphalangeal joint was not directly splinted, but the mechanics of this joint were altered by the splinting of the metacarpophalangeal joint. Splinting seemed to adversely affect this joint also, in that there was a mean loss of total range of fifteen degrees, which can be compared to a mean loss of seven degrees in the group that would not use the splints. This may not be a significant change.

DISCUSSION

It must be emphasized that this is a very select group of patients. The fact that these patients were cared for at Rancho indicates that their disease was more often of severe magnitude, of prolonged duration, and usually not amenable to out-patient management. Furthermore, an artificial selection occurred, in that most data was recorded during in-patient treatment, which eliminated some patients that were in remission or lost to follow-up.

The data recorded throughout was that obtained by passive motion. There are many deficiencies in this method, particularly at the metacarpophalangeal joint. It was felt, however, that because of the wide variations in active motion, depending upon the amount of pain present, that passive motion was a more consistent and thus reliable figure.

The group of patients used for comparison is extremely small. The term "control" has been purposefully and carefully avoided, for in no sense of the word can this group be considered a control. The difficulties involved in attempting to match patients with rheumatoid disease for control purposes have been widely stated. Many of these patients were fitted bilaterally and some had surgical procedures on the opposite hand, thus eliminating the opposite hand as a control. However, the comparison group does match well in terms of age, duration of follow-up and presumably the nature of their disease.

All of the patients in this series, in addition to being splinted, underwent a regular in-patient regimen of occupational and physical therapy designed to increase motion and strength, as well as correct or prevent deformity. It is not possible to separate the effects of this program as distinct from those occurring as a result of splinting. The comparison group also took part in this program, but the number of variables and size of the group prevents any real observation in this regard.

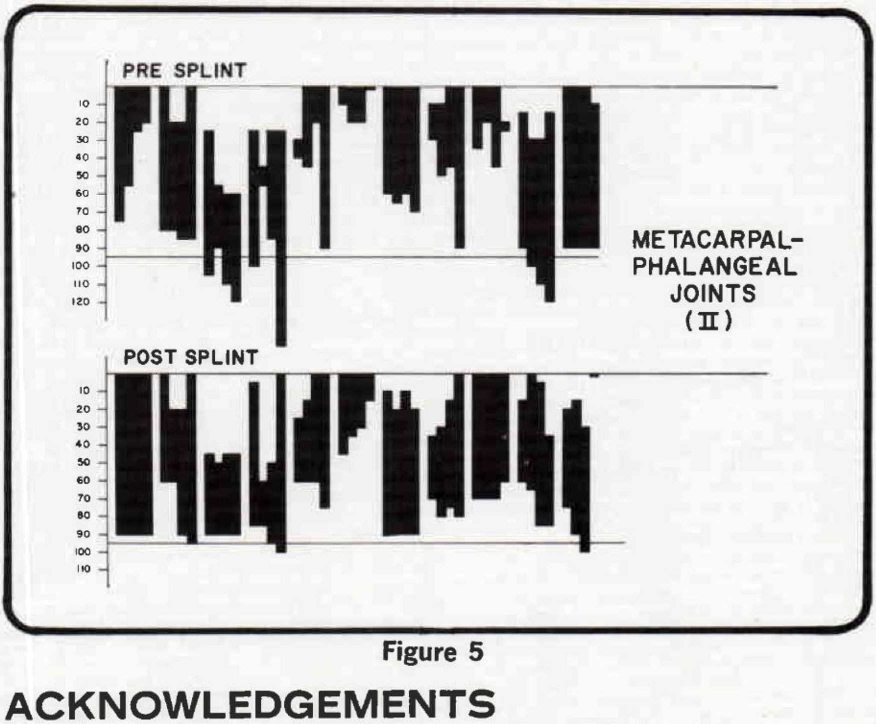


Figure 5

ACKNOWLEDGEMENTS

The conscientious and dedicated effort of the occupational therapists of Rancho Los Amigos Hospital must be acknowledged. Without their frequent, tedious and laborious recording of joint range this paper would not be possible.

CONCLUSIONS

A review of fifty-one patients with rheumatoid arthritis that were fitted with a dynamic hand splint, designed and used on the Rheumatoid Arthritis Service at Rancho Los Amigos Hospital, suggest the following:

1. Hand function was not increased while using the splints.
2. Progression of deformity was not consistently prevented.
3. Correction of pre-existing deformity was not effectively achieved.
4. Limitation of joint motion occurred that was probably greater than would be expected if the hand had not been splinted.

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Myoelectric Control for a Quadriplegic*

by

Worden Waring, Ph.D., Daniel Antonelli, E.E., Dale Fries, C.O.
Margaret Runge, O.T.R., E. Shannon Stauffer, M.D., and
Vernon L. Nickel, M.D.
Downey, California

May, 1967

As long ago as 1952 the possible use of myoelectric signals for controlling a prosthesis was investigated by Berger and Huppert;[1] in 1955, Battye, Nightingale, and Whillis demonstrated the feasibility of such control.[2] Further developments resulted in the construction of the "Russian Hand" [3] and similar devices elsewhere, including one commercially available now in the United States.[4]

There was also some discussion of the need for such a control system for orthotic devices. But, although the feasibility of controlling hand splints by myoelectric signals was demonstrated in Houston [5] and Cleveland,[6] there was little other use of this technique until very recently, except in the earlier pioneering work at Vanderbilt [7] [8] where poliomyelitis patients were enabled to control their respirators. While the present report was being written, an article appeared in this Journal describing recent achievements in Cleveland;[9] this report presents our own first fitting to a quadriplegic.

Our subject was 15 years old in 1956 and a passenger in a pickup truck which went out of control and rolled over several times. He suffered a spinal cord lesion at the C4, 5 level and so was immediately quadriplegic. He did manage to finish high school, but was unable to go on to college. After ten years of complete dependence on others for his care, he came to Rancho Los Amigos Hospital in November, 1966. It was believed that orthotic devices developed within the past few years could give him sufficient physical assistance to permit his going on to college and in other ways living a fuller life.

---

* This work was supported, in part, by Grant No. RD-1751-M, from the Vocational Rehibilitation Administration, Department of Health, Educaton and Welfare, Washington, D.C.

All authors are on the staff at Rancho Los Amigos Hospital, where Vernon L. Nickel, M.D., is Medical Director.

On arrival at Rancho Los Amigos Hospital he presented on the right side a fair-to-good trapezius and deltoid, with good biceps and fair plus brachioradialis and supinators. Below this he had no strength except a trace in the long wrist extensor. On the left he had zero deltoid, fair plus to good trapezius, nothing but a trace biceps below the shoulder. It was decided to fit him with an electrically powered flexor hinge hand splint on the right.

He seemed a good candidate for myoelectric control of the splint, since signals from the wrist extensor could in principle be used to control the action just as with the usual wrist-driven splint: an easily-learned, rather normal wrist motion. But examination for myoelectric activity showed that during the years post onset, having no functional use of the wrist extensor, he had lost isolated control and now used the extensor simultaneously with the supinator. This caused signals whenever he supinated and would have given undesired opening or closing of the splint. Since the left arm was not expected to be functional, it was decided to utilize control signals from the left biceps. We felt it was important not to select a muscle which would be used in other motions and so give undesired signals.

Figure 1 shows the electrode assembly which is used; the larger metal plate is a ground or reference electrode, and signals from the two textured domes go into the differential amplifier of the input circuit. The control circuit, shown in **Figures 2** and **3**, was developed here. It uses a three-level control from the single muscle, like the circuit of Dorcas and Scott.[10] A small effort closes the splint, a moderate one opens it, and relaxation causes it to hold whatever position it is in. The levels of effort were adjusted to the subject's preference. The batteries, motor, and control circuitry are at his left in **Figure 4**; the electrode strap can be seen on his left biceps.

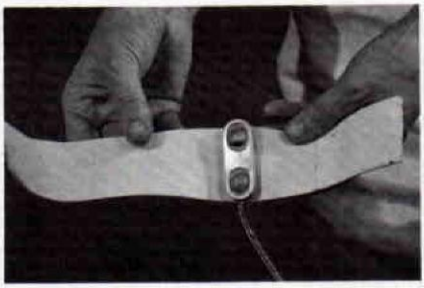

FIGURE 1—Surface electrodes used over left biceps.

Because the myoelectric control was new and he lived some distance from this Hospital, he was also given a shoulder switch control as an alternative if some trouble should occur. He was trained in the use of each control. Evaluation after a month's training showed his performance in various test tasks requiring grasping and transferring objects was about equivalent by each control system. One major advantage of the myoelectric control is that he does not have to maintain a particular position in his

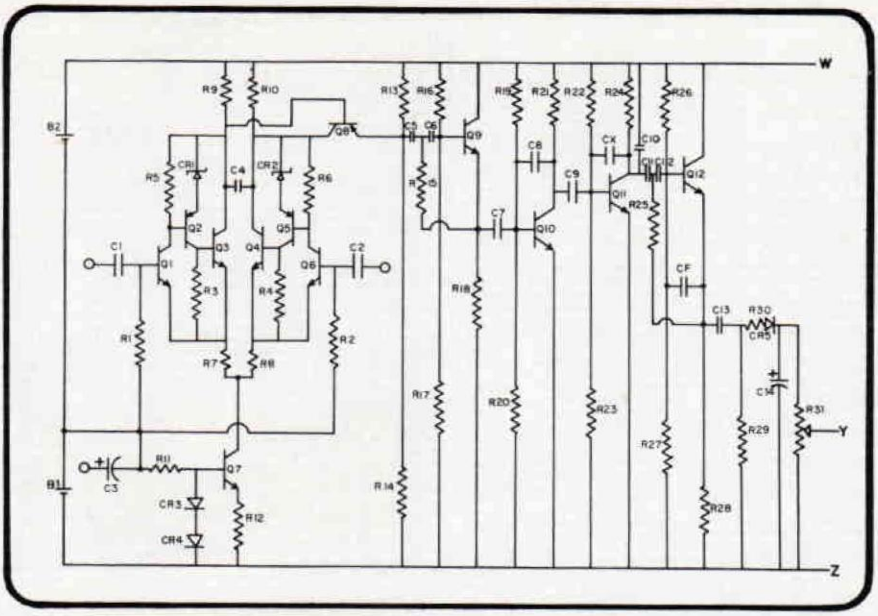

FIGURE 2—Control circuitry, input and amplification.

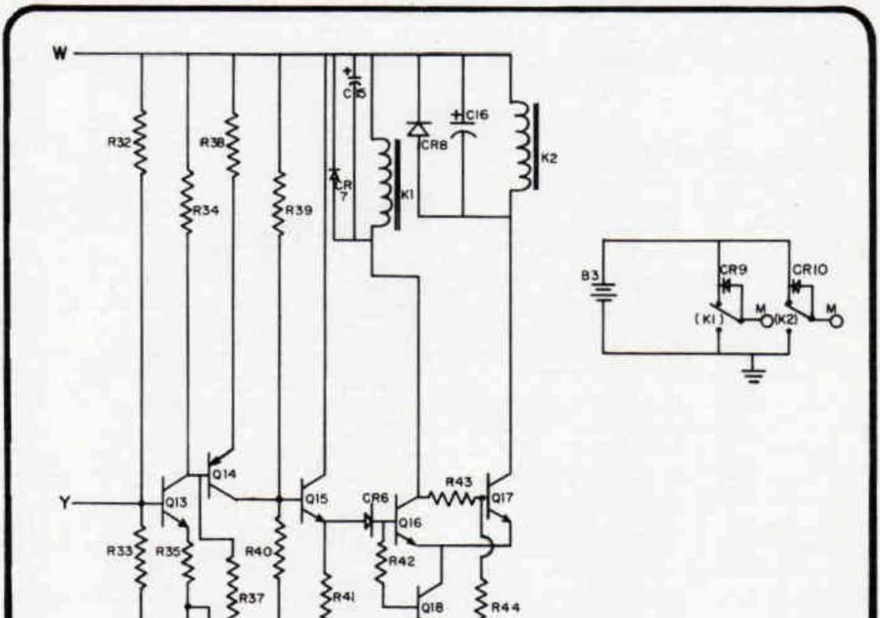

FIGURE 3—Control circuitry, level separation and output to relays. Signal circuit is separated from motor circuit by relays.

wheelchair in order to operate the control; he can shift his position, and can even wear the myoelectric control in bed or wherever he wishes. On the other hand, his electric razor generates so much electrical interference so close to the electrodes and circuitry as to cause trouble. Also, leaning forward on his left elbow causes biceps tension and unwanted signals, so this control technique is not yet a solution for all problems!

In continuing our program, implied in some earlier comments in this field,[11] we are now fitting two other people who have cervical lesions, and we plan to follow the experience of all these who have this kind of control system.

FIGURE 4—Subject with splint, power, and controls.

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Some Experience in Hemipelvectomy Prosthetics

by Herbert W. Marx, *Prosthetist, Prosthetic and Orthotic Laboratories, Institute for the Crippled and Disabled, New York*

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-

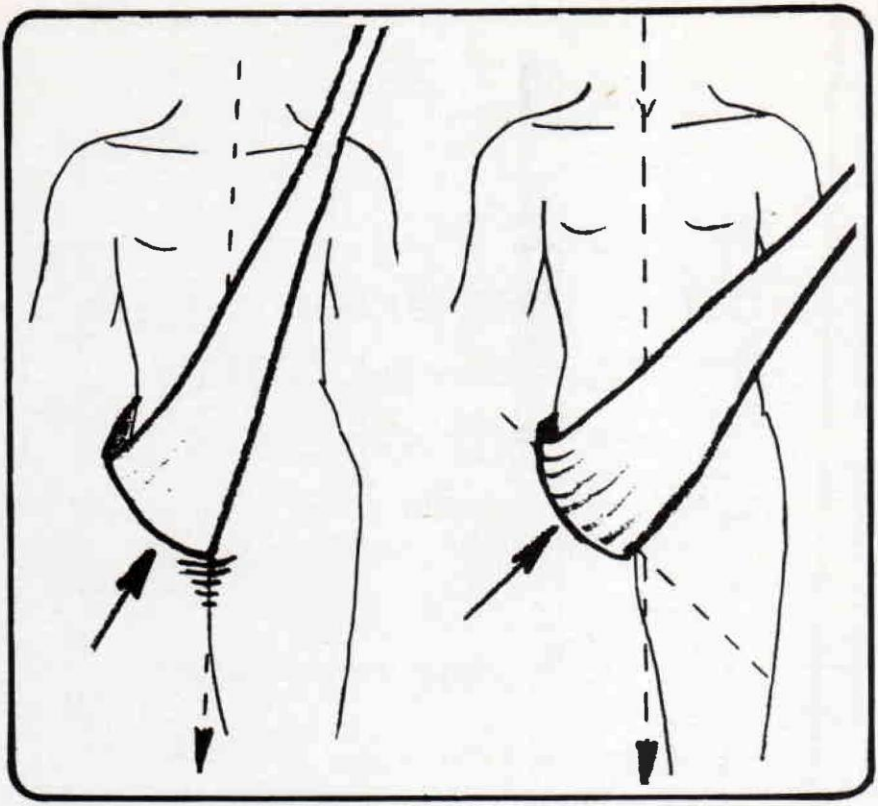

Figure 1 Figure 2

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.

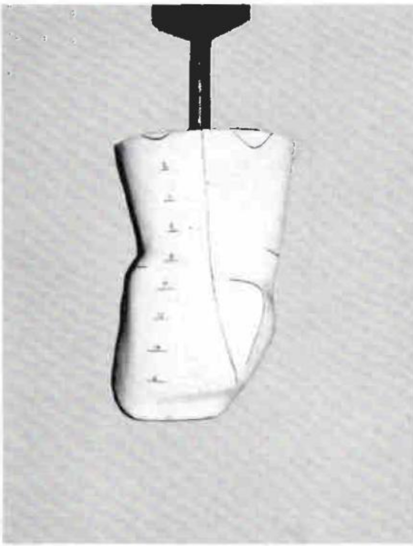

Figure 3

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.

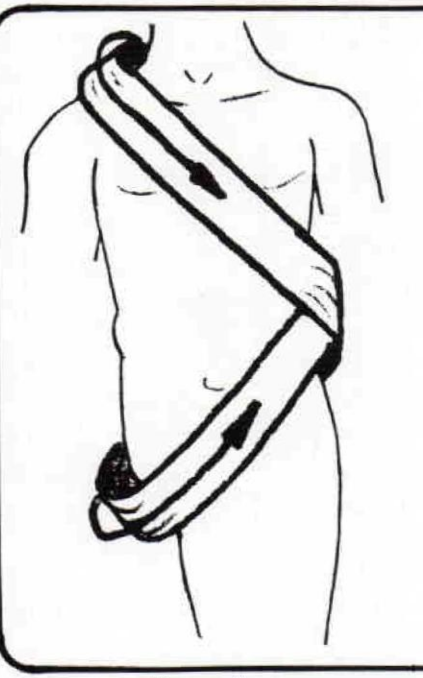

Figure 4

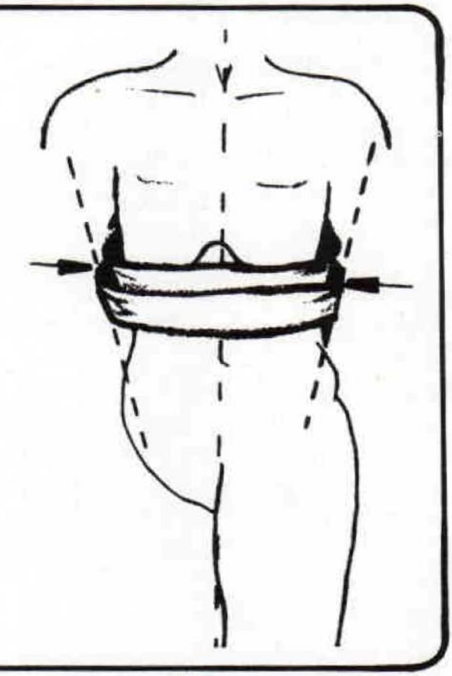

Figure 5

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 ampution) 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.

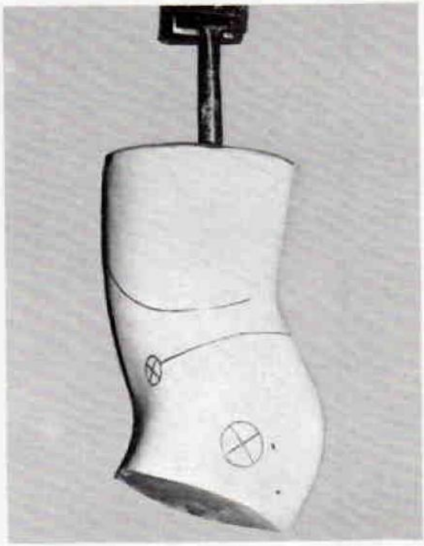

Figure 6

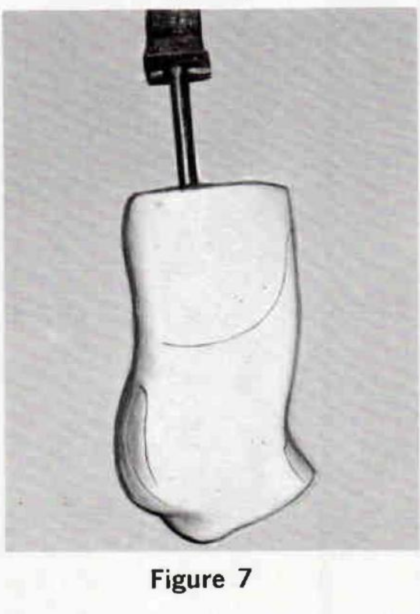

Figure 7

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)**

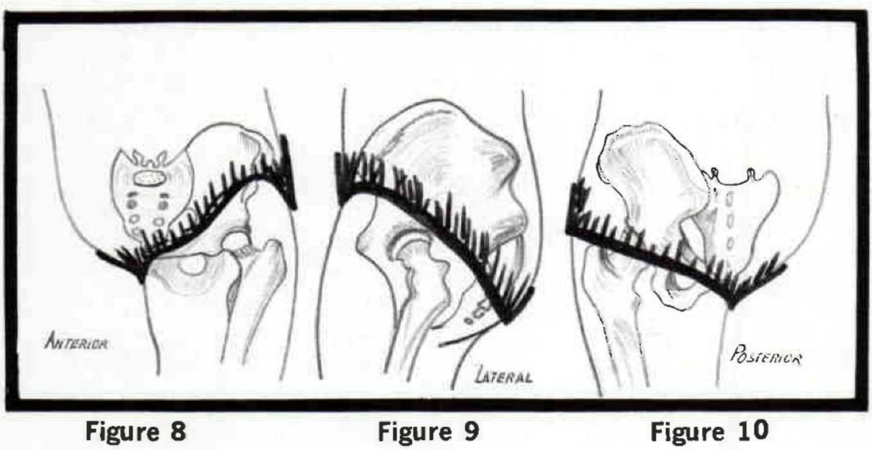

Figure 8 **Figure 9** **Figure 10**

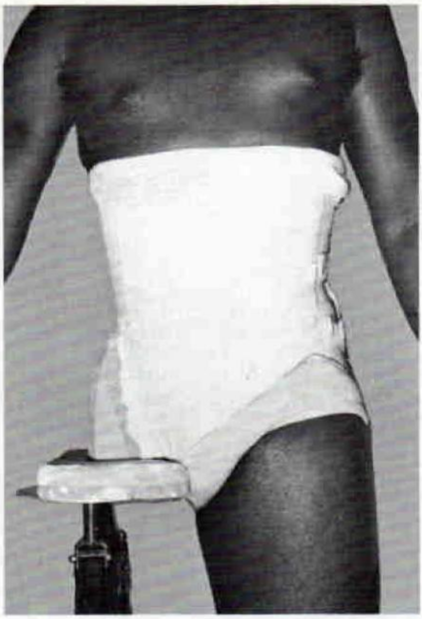

Figure 11

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 1/8 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 fitting, 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 excel-

Figure 12

lent 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.

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.

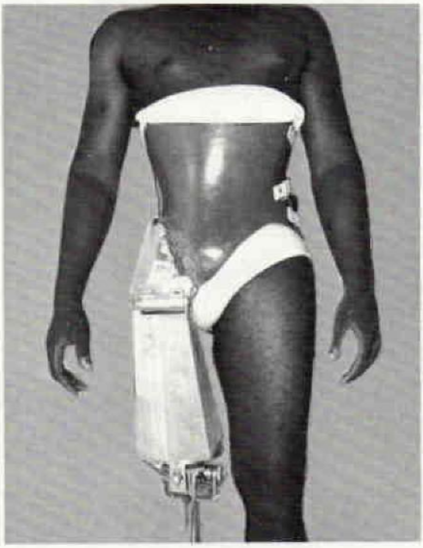

Figure 13

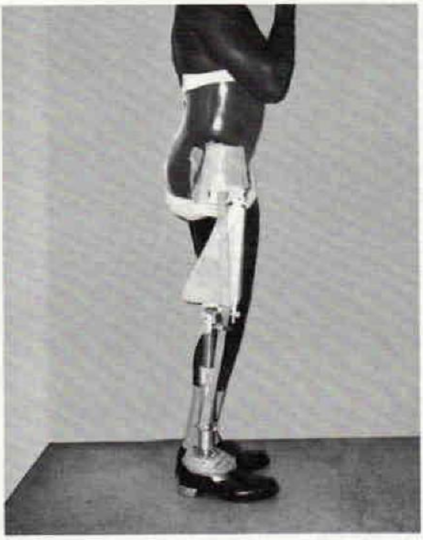

Figure 14

Figure 15

Figure 16

Figure 17

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Comments and observations on article entitled "Some Experience in Hemipelvectomy Prosthetics" by Herbert W. Marx, Prosthetist.

Comments and Observations Regarding Hemipelvectomy and Hemipelvectomy Prosthetics

by Lawrence W. Friedmann, M.D. *Director, Medical Services Institute for the Crippled and Disabled, New York*

The experience in hemipelvectomy prosthetics at the Institute for the Crippled and Disabled, reported by ICD Prosthetist Herbert W. Marx, describes a method of fabrication which attempts to distribute the forces of standing and walking in such a way that they are spread both in time and space so as not to be uncomfortable or to cause damage to the amputation area.

Hemipelvectomy is one of the most extensive types of amputation known. It is also one of the most serious, inasmuch as the necessity for this ablative procedure is almost invariably a malignant tumor.

Until relatively recently, hemipelvectomy was rarely performed due to the high mortality. The mortality was due not only to the malignancy necessitating the surgery, but also to the poor pre-operative and post-operative care available. The first known successful hemipelvectomy was performed in 1895.

Ariel (Irving M. Ariel, M.D., Bulletin of the Hospital for Joint Diseases, Volume 20, page 37-47, April 1959) states that the indications for hemipelvectomy may be classified as:

1. Primary malignant neoplasms of the innominate bone.
2. Primary malignant neoplasms of the femur which have invaded the hip joint or innominate bone.

3. Cancer of the soft tissues of the upper thigh, buttock or inguinal region, which have invaded the hip joint or extended through to involve the pelvic walls.

4. Metastases to the iliac region, which have infiltrated the hip joint, the pelvic walls, or have extended so as to exclude the possibility of cure by less radical procedures.

5. Massive benign tumors of the innominate bone or the pelvic walls.

6. In certain cases of generalized metastases with severe pain not controlled by other procedures.

7. Certain specific infections and trauma uncontrolled by other procedures. Tuberculosis is a prime example.

The term is used to describe an operation removing the entire lower extremity with its contiguous buttock and most or all of the innominate bone. The present surgical mortality is probably around 10 per cent. Various modifications of the technique, originally described by J. H. Pringel in 1916, have been described. The technique described by Ariel (see above) is presently preferred.

Skin preparation is routine. In cases where the indication for the surgery is a malignancy, it is inadvisable to attempt to squeeze blood out of the lower extremity, in order to avoid the possibility of dislodging tumor cells. A Foley catheter is inserted into the bladder, the anal opening is closed with a purse string suture, and in a male, the scrotum is sutured to the opposite thigh. The incision extends from pubic tubercle laterally, posteriorly, and superiorly to an area about five centimeters superior to the iliac crest, parallel to but above the inguinal ligament. Ariel points out that extending the incision posteriorly should be done later in the procedure to avoid turning during the surgery more than is necessary. The anterior muscles are detached from the bony pelvis. This includes the rectus abdominis, the obliques, and the inguinal ligament. The spermatic cord is retracted. The peritoreum and the abdominal contents are retracted superiorly and medially. The urinary bladder is retracted medically and inferiorly. The external iliac artery and vein are lighted and divided. The femoral nerve is severed after local anesthetic injection to prevent shock. Delayed ligating the venous return from the leg may require a decrease in the amount of blood transfused, but may increase the spread of malignant emboli.

The pubic symphysis is exposed and divided. The division should be through the symphysis and not through the pubic arch. The quadratus lumborum and levator ani muscles are divided. The sacroiliac joint is exposed from the front. Disarticulation is performed at the sacroiliac joint. Shock due to blood loss may be frequent at this stage.

The patient is turned toward the contralateral side. The incision is then carried posteriorly from the superior margin of the incision down laterally over the buttock. The incision is carried over the buttock to eventually join the inferior border of the anterior incision. The posterior attachment of the gluteal muscles are divided. The sciatic nerve trunk and the ligaments of the sacrum are ligated and severed, as are the obturator and superior gluteal arteries. The lumbo-sacral plexus is transected with a sharp new blade, and permitted to react. The flap is closed after revision and the wound is closed with a drain at each end of the wound.

If it is necessary to ligate the common iliac artery, the posterior flap frequently becomes necrotic. Skin grafting may repair the resultant lesion, but this complicates prosthetic fitting considerably. If the skin has been damageed by radiation therapy for the tumor, this will also tend to make prosthetic use difficult.

Variations of the above technique may involve leaving part of the ilium. This provides another point of fixation which is useful. If the gluteus maximus is sutured to the anterior tissues, this assists with prosthetic force application. If the entire gluteus has been resected, force application in this area is extremely difficult. If the tumor has invaded the skin of the region and an adequate full thickness pericle flap cannot be developed, prosthetic usage is limited, at best.

Normal, sensate, full-thickness skin is needed in order to bear all of the patient's body weight during stance phase. Since the weight of the body must be maintained as a vertical component of forces applied obliquely, shear stresses are considerble.

In order for a patient to utilize this type of prosthesis, it must first be ascertained whether the patient's remaining leg is in good condition. His cardio - respiratory reserve must be equal to the demands to be placed upon him, since the use of this type of prosthesis demands considerable energy expenditure. Frequently it is advisable to let the patient utilize crutches and not fit him with a prosthesis at all, if the patient has no padding from the gluteus maximus and/or has limited weight bearing because of the skin problems mentioned above. Few patients can tolerate all of their weight being supported by the rib cage except for short periods of time. Thus, the hemipelvectomy patient with poor skin at the amputation sight is forced to bear weight as does the hemicorporectomy patient. In these cases the use of the wheelchair with a contoured pad to support the pelvis for ease in sitting may be preferable to an attempted sitting with a hemipelvectomy prosthesis. The patient must be looked at as a whole to see whether the criteria for prosthetic prescription have been met, and that significant contradictions to prosthetic usage do not exist.

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1967 CERTIFICATION EXAMINATION RESULTS

The Examination Committee of the American Board for Certification held a meeting at the National Assembly in Miami Beach to complete its grading of this year's Certification Examination Candidates.

The greatest percentage of Candidates in recent years passed both the Prosthetic and Orthotic Examinations. Of 33 Prosthetic Candidates 27 qualified, and of 39 Orthotic Candidates 21 qualified.

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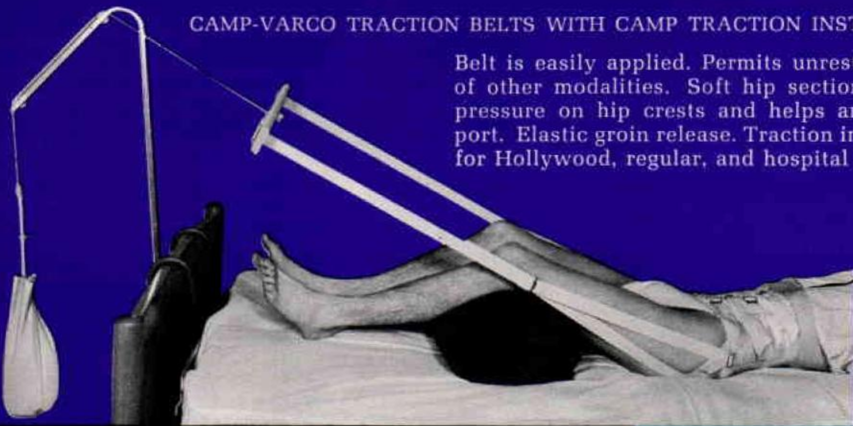

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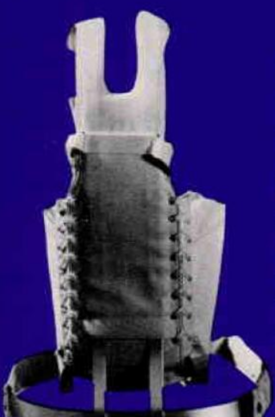

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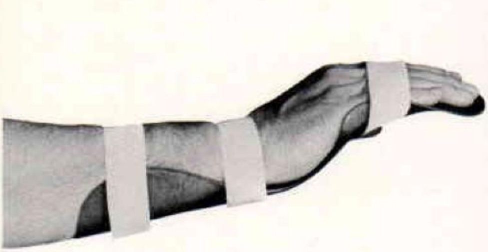

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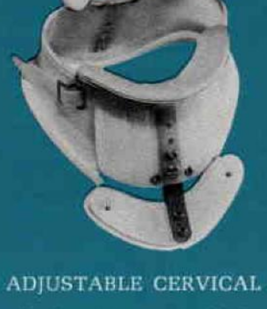

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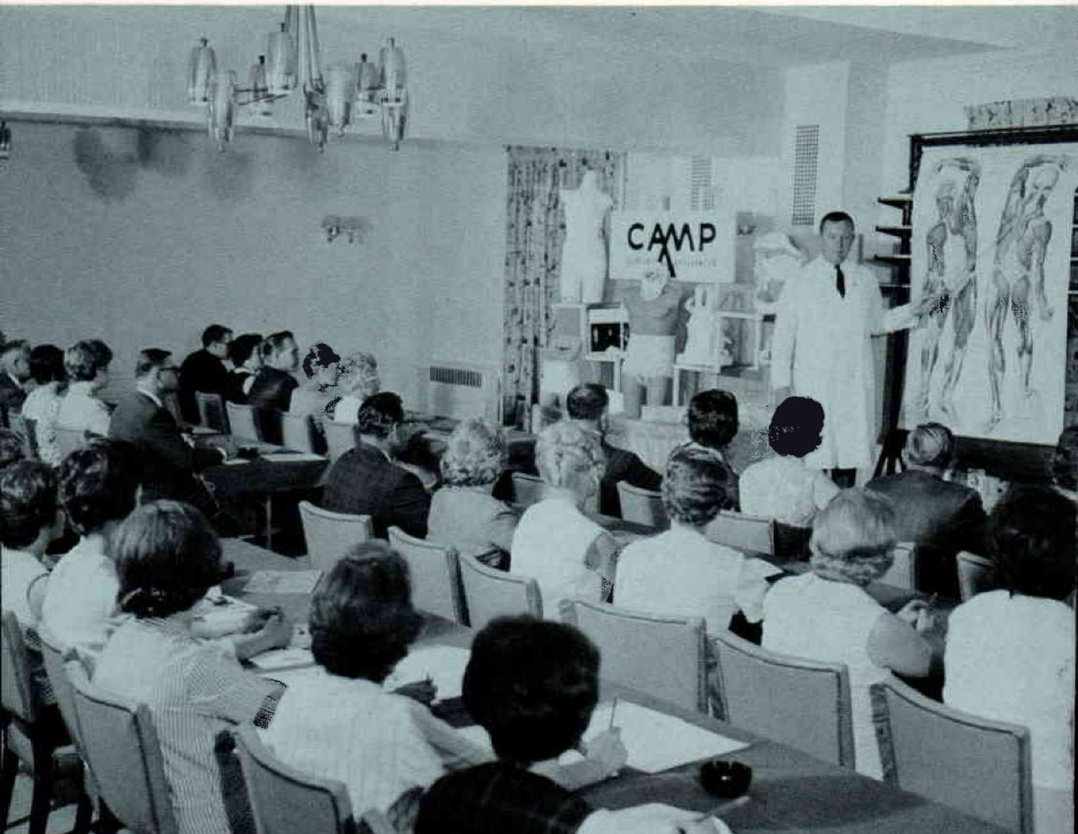

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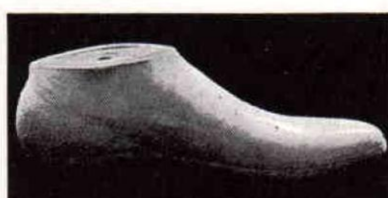

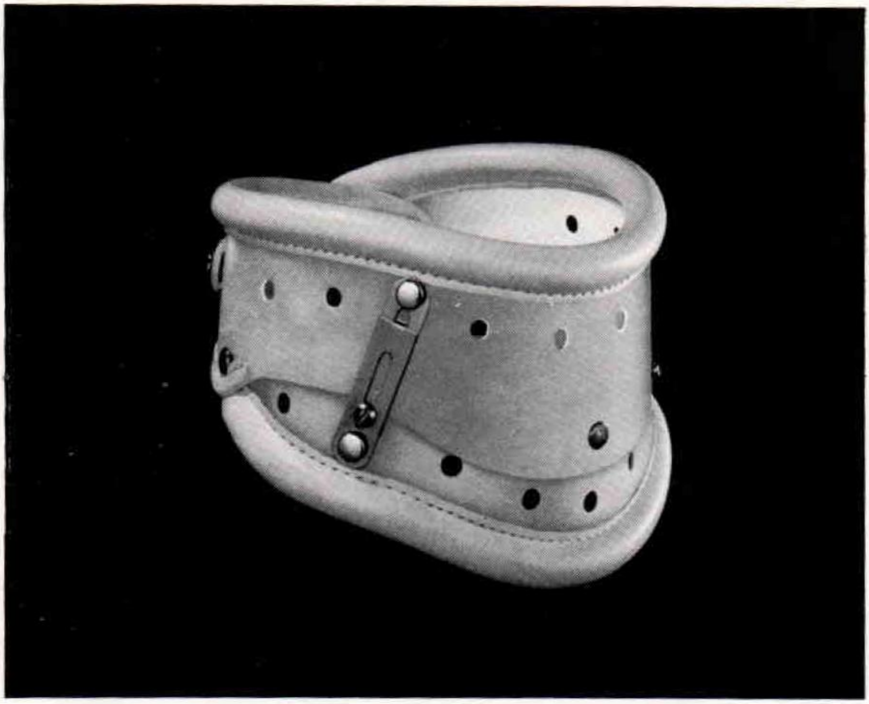

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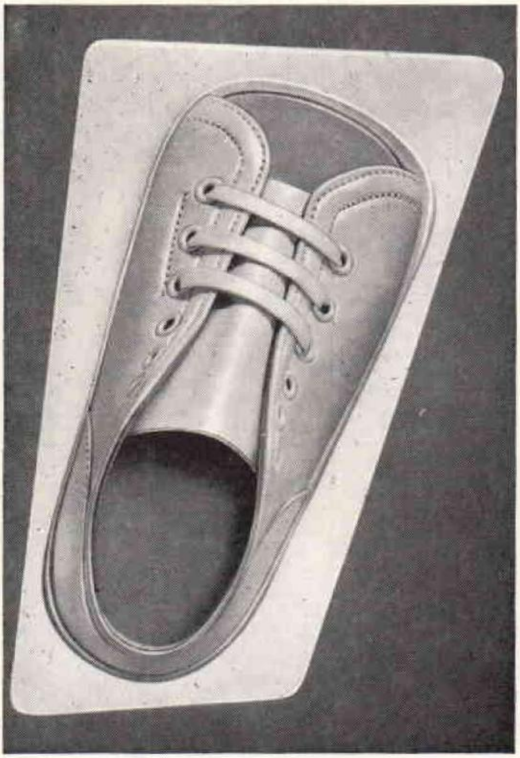

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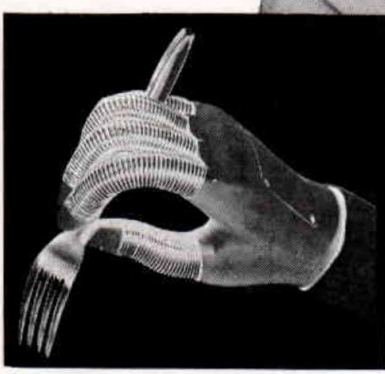

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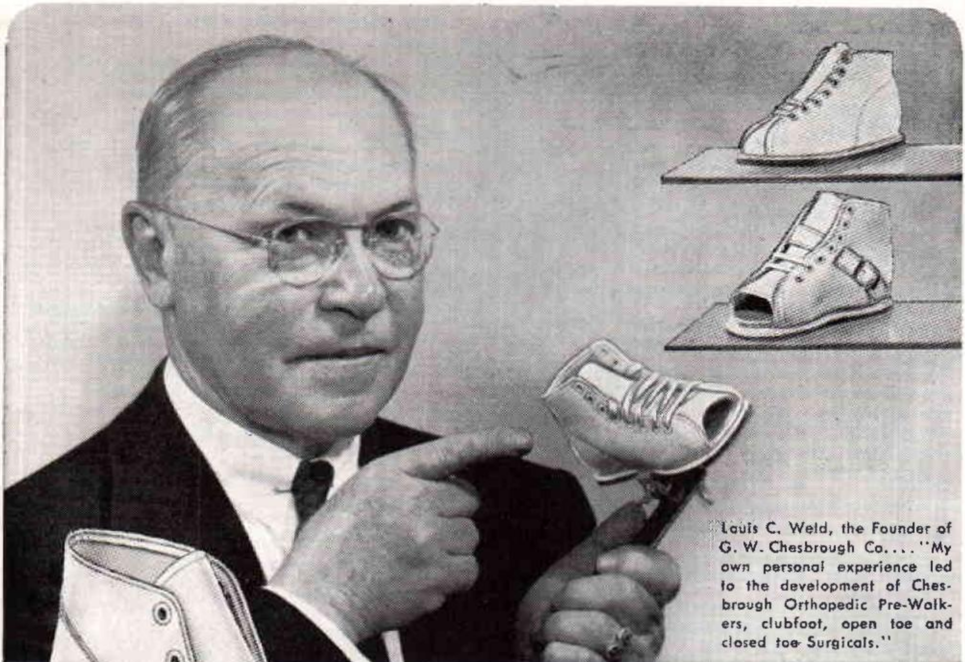

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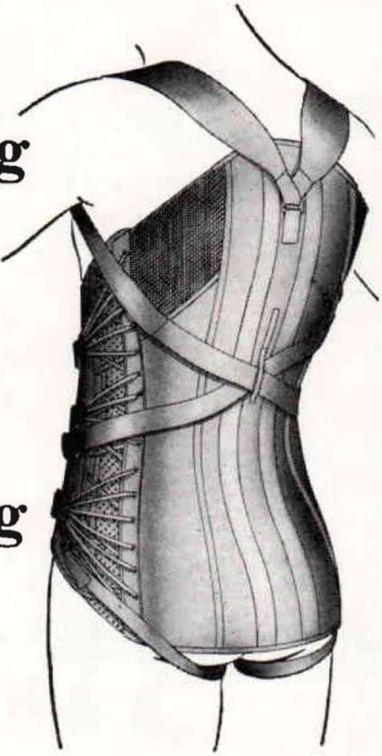

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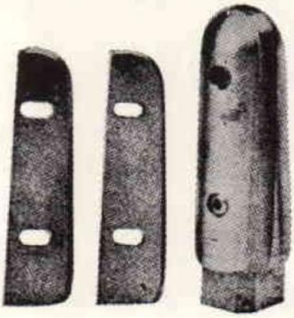

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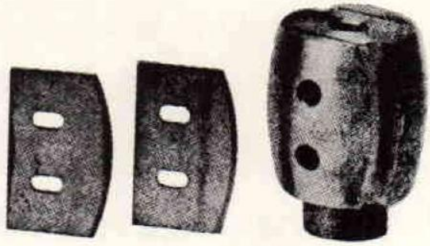

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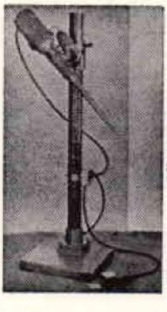

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