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Contents

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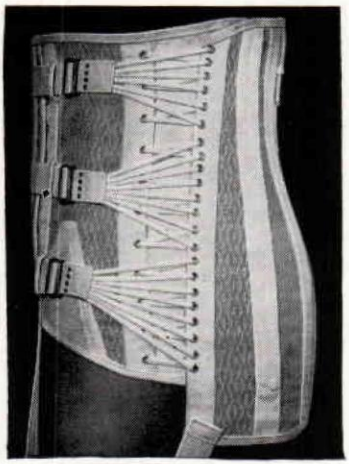

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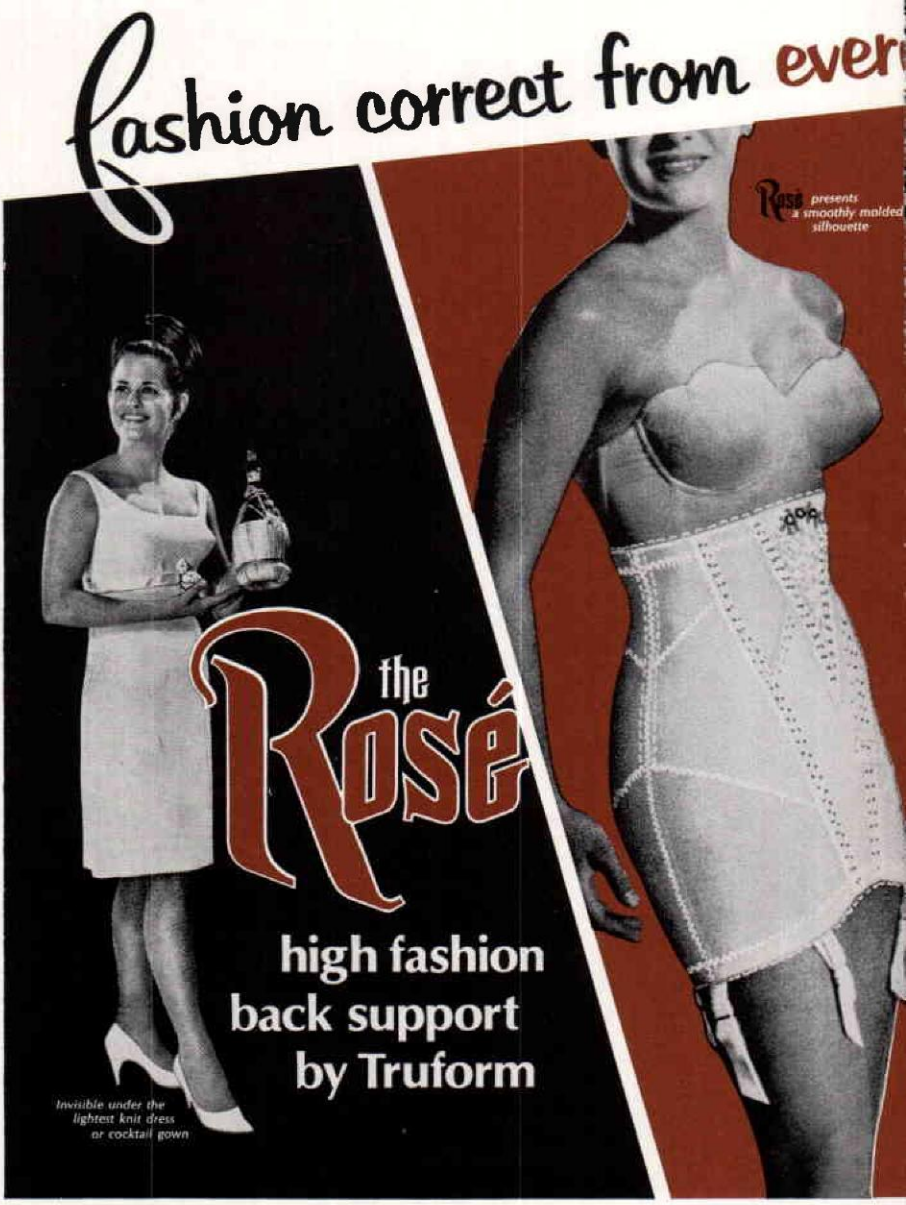
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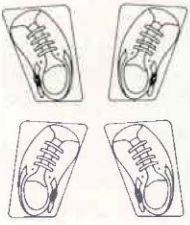

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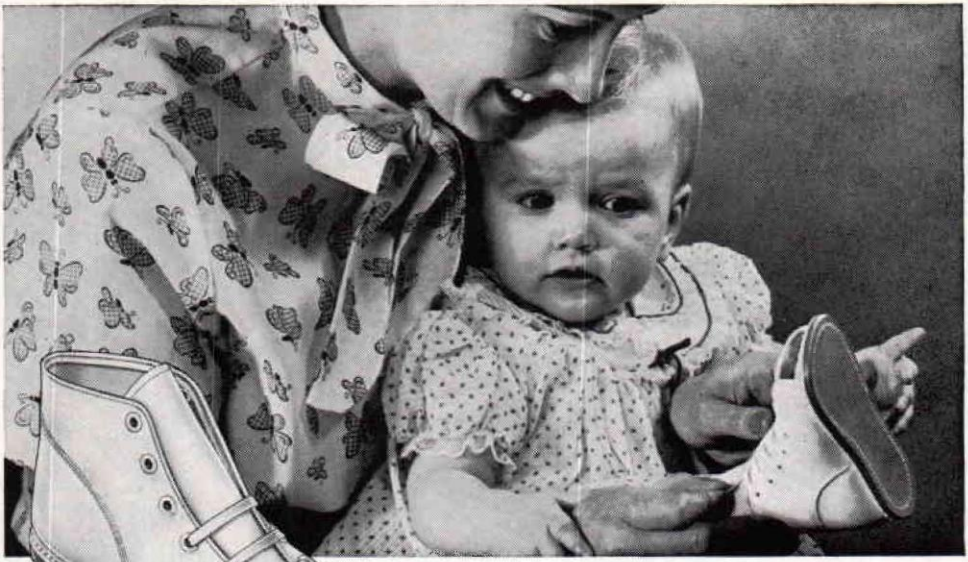

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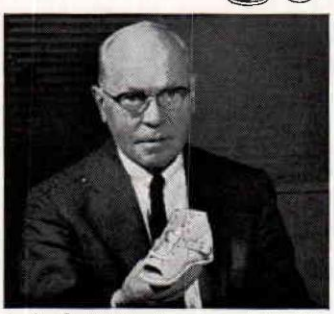

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The New York University Approach To Spinal Orthotics

By Grace Jackson and Warren P. Springer[1]

A major advance in the field of spinal orthotics took place in January of this year when New York University's Post-Graduate Medical School offered its first course in "Spinal Orthotics for Orthotists." The culmination of two years' intensive planning by a team of specialists from various disciplines, the new course imposes a logical, coherent system upon the theory and practice of spinal bracing. According to Sidney Fishman, Ph.D., Coordinator of Prosthetics and Orthotics, "Education in spinal orthotics is finally coming of age, and can now begin to take its place alongside lower-extremity prosthetics and lower-extremity bracing as an ordered field of knowledge."

Actually, as Carlton Fillauer, a member of the planning group, pointed out, "Spinal bracing has been an uncharted area." As a result, the number of spinal braces has been proliferating to such an extent over the years that today an orthotist is confronted by more than thirty, each bearing a different name and often providing only insignificant functional variations. Efforts had been made from time to time to catalogue this multiplicity of spinal devices and to provide a rationale for each. But no concerted inquiry into the essential functions of spinal orthoses had been attempted until the present project got under way.

The Planning Committee

In December 1965, NYU's Post-Graduate Medical School invited a selected group of specialists in orthotics and related fields to meet together in order to develop a solid foundation upon which to base the design, fabrication, and teaching of spinal braces. The situation confronting the planning committee was analogous to that prevailing in lower-extremity prosthetics back in the early 1950s. At that time prosthetists were also

[1] Prosthetics and Orthotics, New York University Post-Graduate Medical School, New York, New York.

offered a number of devices and components under a variety of trade names, which they made use of on a largely empirical basis. Before formal courses in lower-extremity prosthetics could be offered at NYU and other centers, similar groups had to analyze and systematize the field. As a result of their efforts, three new approaches were introduced into the fabrication of lower-extremity prostheses. First, the components were classified in terms of their basic construction and function. Second, a biomechanical rationale was offered for the shape and alignment of each prosthetic component. Finally, measuring procedures were systematized so that prosthetists used essentially the same anatomic landmarks when fitting and fabricating prostheses. The need for a similar process in spinal orthotics became immediately apparent.

The NYU Spinal Orthotics Planning Committee met eleven times over a two-year period, usually for three days at a time. They "argued over details that no one had ever discussed before," according to Mr. Fillauer, "and let fresh air into the field of spinal orthotics for the first time." Although a similar functional approach to lower-extremity bracing had been worked out successfully four years before, the great complexity of the spine made the committee's task that much more demanding.

The members of the Spinal Orthotics Committee were Norman Berger, NYU Post-Graduate Medical School, chairman; John Glancy, formerly of Children's Hospital Medical Center, Boston, and presently with the Department of Orthopedics, Indiana University School of Medicine; Carlton Fillauer, of Fillauer Surgical Supplies, Chattanooga; Charles Rosenquist and Robert Fannin, of Columbus Orthopaedic Appliance Company, Columbus, Ohio; Ivan Dillee, Joan Edelstein, Clauson England, Jeanne Sementini, Warren Springer, and Hans R. Lehneis, of NYU.

The Basic Braces

After consultations with orthopedic physicians and intensive discussion among themselves, the committee arrived at new criteria for classifying spinal braces. First, the thirty-odd presently available spinal braces were reduced to seven basic braces, each of which provides significantly different functions. Second, measuring and tracing techniques were related to surface anatomy, so that each orthotist can now measure his patients in a standardized manner. Finally, uniform fitting techniques were devised, based upon anatomic landmarks and biomechanical principles.

Since a primary purpose of a spinal brace is to restrict motion, the braces were named on the basis of the motions the brace controls and the level of control, as follows:

1. Lumbosacral Anteroposterior Control Brace.
2. Lumbosacral Anteroposterior and Mediolateral Control Brace.
3. Lumbosacral Posterior and Mediolateral Control Brace.
4. Thoracolumbar Anterior Control Brace.

5. Thoracolumbar Anteroposterior Control Brace.
6. Thoracolumbar Anteroposterior and Mediolateral Control Brace.
7. Thoracolumbar Anteroposterior, Mediolateral, and Rotary Control Brace.

From among these basic functional braces, the physician can now select the one that best controls the particular spinal motions he wishes to have controlled, such as anteroposterior or mediolateral motions of the upper or lower spine. In addition to motion control, another primary purpose of spinal braces is to increase intraabdominal pressure. The committee, therefore, spent considerable time discussing and designing the abdominal support (corset or apron) to be used on these braces.

The First Spinal Bracing Course

Once these functional criteria had been agreed upon, it became necessary for the NYU faculty to develop new text materials and an appropriate curriculum. (See course schedule.) The new techniques and materials were introduced into NYU's four-year prosthetics and orthotics undergraduate curriculum in 1967. After further refinements had been made, NYU offered the first postgraduate course in "Spinal Orthotics for Orthotists" from January 22 to February 2, 1968.

The didactic instruction included seven hours of anatomy, five hours of pathology and related medical information, fifteen hours of brace fitting and fabrication, and two and one-half hours of corsetry. The remainder of the class time was devoted to the actual fitting and fabrication of the basic braces and their modifications by the students themselves on a variety of patients (*Figure 1-5*). Each fabrication period was followed by a critique, in which faculty members analyzed in detail each brace and corset fabricated or fitted by a student (*Figure 6-7*). In addition, one day was devoted to the fitting and fabrication of cervical appliances, and one half day to a demonstration and discussion of the Milwaukee brace.

Reactions of Faculty and Students

According to John Glancy, the new approach "has imposed discipline upon a previously chaotic situation. A good deal of dross has finally been dropped from the field of spinal orthotics." He pointed out that "bringing things down to basic principles will help the orthotist to reach a better understanding of the prescriptions he'll receive from physicians in the future. . . . A Pandora's box was opened when the committee began investigating the field of spinal orthotics two years ago. What's left makes sense on the basis of function."

Mr. Fillauer said, "For the first time students are being presented with an orderly arrangement of basic styles of spinal bracing, organized in such a way that the material can be immediately put into practical use." He stressed the importance of the course's emphasis on fitting and fabrication:

"Seeing, feeling, and hearing about what you've actually done yourself is much more valuable than merely listening to a lecture. Also, everybody learns by seeing others' mistakes." Mr. Fillauer believes that the new approach has "simplified the field so that students can go home with confidence, ready to apply what they have learned." He emphasized how great the need has been for organization in spinal orthotics. Approximately 20 percent of an orthotist's patients require spinal bracing, yet until now fitting has been "an empirical process, in which neither the orthotist nor the physician, in many cases, is able to justify his reason for prescribing a particular brace. Here, in the new course, reasons have to be given."

The faculty member who coordinated the course, Clauson England, said, "Viewing the course from a teaching standpoint, I was pleased by the students' acceptance of the rationale and the techniques presented." He also expressed gratification at "the feedback from the students. They felt the course offered useful and workable advances in the field of spinal orthotics, and was a valuable contribution to all concerned in the treatment of spinal problems." In addition, Mr. England pointed out, "All the students liked the basic terminology and the concept of relating braces to functions."

The ten orthotists who attended the first course came from eight cities in the United States and one in South Australia. Their comments at the close of the two-week curriculum clearly supported the views of the faculty. George Estrin, of the Veterans Administration Hospital in the Bronx, New York, approved of the fact that there was "no egghead theory in the course." Instead, he said, he'd found it extremely practical. "Everything taught can be put into immediate use as needed, and none of the new concepts or techniques require new equipment or materials." He also said the anatomy lectures were clearer than any he'd had before, but he was pleased that actual brace-making, not anatomy, received the major emphasis.

Michael Di Pompo, an orthotist with the Veterans Administration Prosthetic Center in New York City, said that he planned to turn the written materials from the course over to his facility, where they would be incorporated into their own training program.

John A. Roberts, a Philadelphia orthotist, expressed appreciation for the fact that the course emphasized how to *fit* orthoses, rather than how to prescribe them, which can lead to needless disagreements with the prescribing physician.

The orthotist from South Australia, Frank Simson, who is in New York on a Winston Churchill Fellowship, applauded the logical approach of the course. "For the first time," he said, "names are not emphasized, but instead we concentrate on the function of a particular brace."

Harold W. Smith, of Children's Hospital in Boston, agreed with this viewpoint. "Why call a brace by a proper name," he asked, "rather than

by a specific function?" He felt the course instruction had been helpful not only in introducing new principles, but in serving as a refresher course as well.

Future Plans

As a result of the unqualified success of the first offering, New York University will continue to offer spinal orthotics for orthotists on a regularly scheduled basis. In addition, work is being completed on a corresponding course for physicians and surgeons to be inaugurated in the Fall of 1968. This will result in comprehensive instruction in this field being available to the two groups most intimately concerned — physicians-surgeons and orthotists.

As a result of the experience of developing and teaching this course, it appears abundantly clear that the great majority of individuals engaged in spinal orthotics will experience direct, tangible improvement in their fitting activities through attendance in these courses.

Course No. 756A: Spinal Orthotics for Orthotists
First Week

Date	Hour	Subject	Instructor
Monday	8:30- 9:00	Registration and Orientation	Mr. England
	9:00-12:00	Anatomy: Skeletal and Surface	Mrs. Edelstein
	1:00- 2:00	Functions of Spinal Orthoses	Mr. Springer
	2:00- 3:00	Basic Components of Spinal Orthoses	Mr. England
	3:00- 4:30	Lumbosacral Corsets	Mr. Fannin
Tuesday	9:00-11:00	Anatomy: Joints and Their Functions	Mrs. Edelstein
	11:00-12:00	Measurements and Tracings for the Lumbosacral A-P and M-L Control Brace	Mr. England
	1:00- 2:15	Measurements and Tracings for the Lumbosacral A-P and M-L Control Brace (lab-each student measures and traces two patients)	Faculty
	2:15- 3:00	Measurement and Tracing Critique	Faculty
	3:00- 5:00	Fabrication of the Lumbosacral A-P Control Brace with Full Front Abdominal Support (lec and lab)	Mr. England & Faculty

Date	Hour	Subject	Instructor
Wednesday	9:00-11:00	Fabrication of the Lumbosacral A-P Control Brace with Full Front Abdominal Support (lec and lab, continued)	Mr. England & Faculty
	11:00-12:30	Critique	Faculty
	1:30- 4:00	Correction of A-P Control Brace and Conversion to A-P and M-L Control Brace with Corset Front (lec and lab)	Mr. Fillauer & Faculty
	4:00- 5:00	Critique	Faculty
Thursday	9:00-11:00	Anatomy: Muscles and Nerves	Mrs. Edelstein
	11:00-12:00	Measurements and Tracings for the Lumbosacral P and M-L Control Brace	Mr. Fannin
	1:00- 2:00	Measurements and Tracings for the Lumbosacral P and M-L Control Brace (lab)	Faculty
	2:00- 3:00	Preparation of Pelvic and Thoracic Bands and Lateral Bars (lab)	Faculty
	3:00- 4:30	Completion of P and M-L Control Brace	Mr. England
Friday	9:00-11:00	Completion of P and M-L Control Brace (lab)	Faculty
	11:00-11:30	Fitting of P and M-L Control Brace	Mr. Fannin
	11:30-12:30	Fitting of P and M-L Control Brace (lab)	Faculty
	1:30- 3:00	Critique	Faculty
	3:00- 4:00	Thoracolumbar Corsets	Mr. Fannin
Second Week			
Monday	9:00-11:00	Pathologies of the Trunk Requiring Bracing	Mrs. Edelstein
	11:00-12:00	Measurements and Tracings for the Thoracolumbar A-P Control Brace	Mr. England
	1:00- 2:00	Measurements and Tracings for the Thoracolumbar A-P Control Brace (lab)	Faculty

Date	Hour	Subject	Instructor
	2:00- 2:30	Fabrication of the Thoraco-lumbar A-P Control Brace	Mr. England
	2:30- 4:30	Fabrication of the Thoraco-lumbar A-P Control Brace (lab)	Faculty
	4:30- 5:00	Fitting of the Thoracolumbar A-P Control Brace	Mr. England
Tuesday	9:00-10:00	Completion and Fitting of A-P Control Brace (lab)	Faculty
	10:00-11:30	Critique	Faculty
	11:30-12:30	Modifications of Thoracolum-bar A-P Control Brace: Sternal Plate, Thoracic Band, Lateral Uprights	Mr. Fillauer
	1:30- 2:00	The Thoracolumbar A-P, M-L and Rotary Control Brace: Patterns for Sub-Clavicular Extensions	Mr. England
	2:00- 2:30	The Thoracolumbar A-P, M-L and Rotary Control Brace: Patterns for Sub-Clavicular Extensions (lab)	Faculty
	2:30- 6:00	Fabrication and Assembly of the A-P, M-L, and Rotary Control Brace (lec and lab)	Mr. Fillauer
Wednesday	9:00- 9:30	Fitting of A-P, M-L, and Rotary Control Brace	Faculty
	9:30-10:30	Critique	Faculty
	10:30-11:00	Measurements for Anterior Hyperextension Brace	Mr. Glancy
	11:00-11:30	Measurements for Anterior Hyperextension Brace (lab)	Faculty
	11:30-12:00	Select and Adjust Brace Ac-cording to Measurements	Mr. Glancy
	1:00- 2:00	Select and Adjust Brace Ac-cording to Measurements (lab)	Faculty
	2:00- 2:30	Fitting the Anterior Hyper-extension Brace	Mr. Glancy
	2:30- 3:30	Fitting the Anterior Hyper-extension Brace (lab)	Faculty

Date	Hour	Subject	Instructor
	3:30- 5:00	Critique	Faculty
Thursday	9:00-10:00	Functions and Fitting of Stock Collars	Mr. Glancy
	10:00-10:30	Patterns for Custom Collars	Mr. Glancy
	10:30-11:30	Patterns for Custom Collars (lab)	Faculty
	11:30-12:00	Fabrication of Custom Collars	Mr. Fillauer
	1:00- 2:00	Functions and Fitting of Poster Cervical Appliances	Mr. Fillauer
	2:00- 3:30	Functions and Fitting of Poster Cervical Appliances (lab)	Faculty
	3:30- 4:30	Critique	Faculty
Friday	9:00-10:30	Orthotic Management of Spinal Pathology	Dr. McCauley
	10:30-12:00	Introduction to Scoliosis	Dr. McCauley
	1:00- 3:30	Introduction to the Milwaukee Brace	Faculty
	3:30- 4:30	Critique and Final Exam	Mr. England

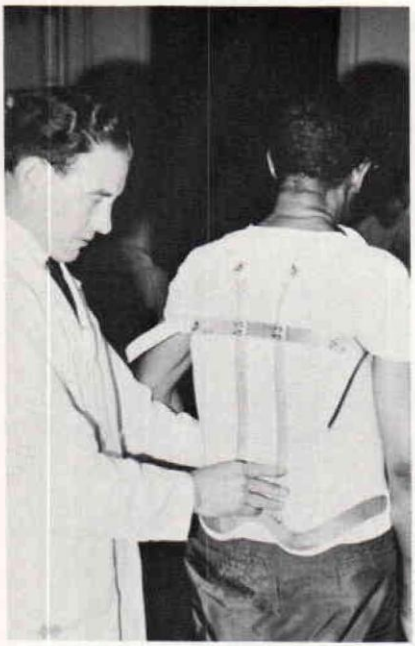


FIGURE 1

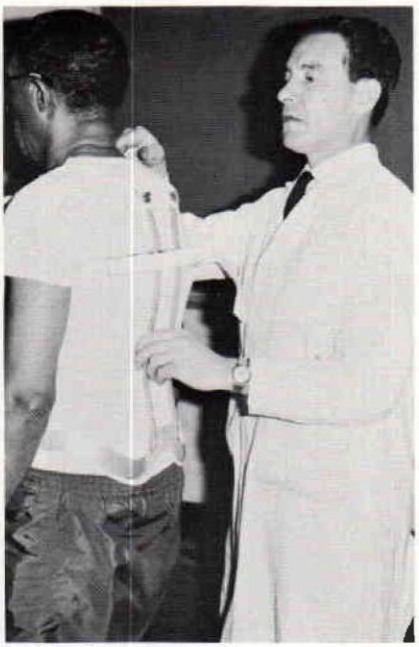


FIGURE 2

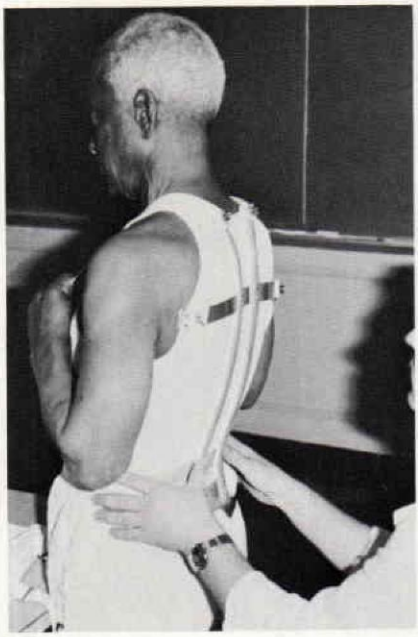


FIGURE 3
FIGURE 1-3—Fitting Thoracolumbar Anteroposterior Frame

FIGURE 4—Bench Alignment of Thoraeolumbar Anterposterior Frame

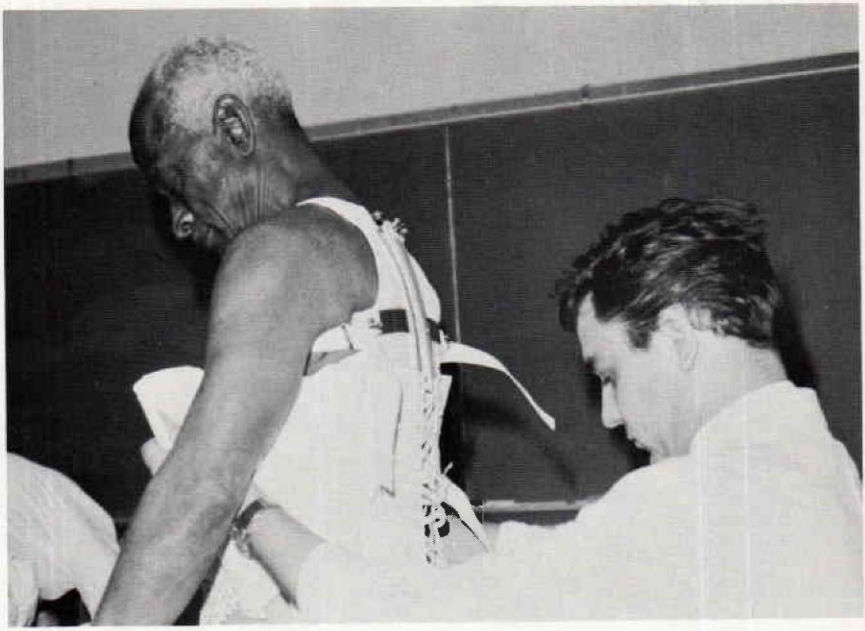


FIGURE 5—Fitting Full Lumbosacral Corset over Thoracolumbar Frame.

FIGURE 6

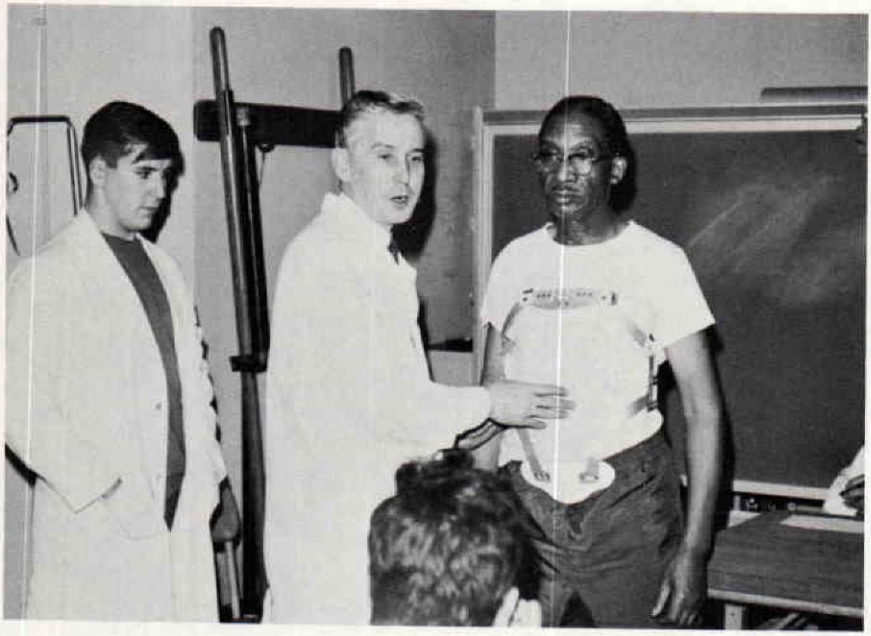


FIGURE 7
FIGURE 6-7—Critique of Student Fittings of Thoracolumbar Anterior Control Brace.

Management and Construction Procedure of Bilateral Split-Bucket Type Hip Disarticulation Prosthesis

By Peter A. Ockenfels, C.P.
Columbus Orthopedic Appliance Co.,
Columbus, Ohio

The patient, a 37-year old white male, received traumatic injuries while involved in an auto-truck accident in October, 1965. Both limbs were severely crushed, and very high amputations were necessary. The physical appearance of the patient resembled that of a bilateral hip disarticulation amputee; however, closer examination of the patient revealed that a femoral neck and head were present. Ths skeletal remaining structure of the femur can be measured at approx. 3″ on the left and 4″ on the right side. (*Figure 0*)

It was felt that this patient would represent a difficult problem regarding a prosthetic fitting. (At this point I would like to quote a sentence from an article which appeared in this Journal previously as follows, "it should be pointed out that there is no longer any need to attempt to leave an inch or two of femur at hip level because of advances in the prosthetic art.")

The patient was first hospitalized at the Allentown Hospital in Pennsylvania, and then became a patient at the St. Vincent's Rehabilitation Center in Erie, Pa. There he received initial rehabilitation training and became ADL independent.

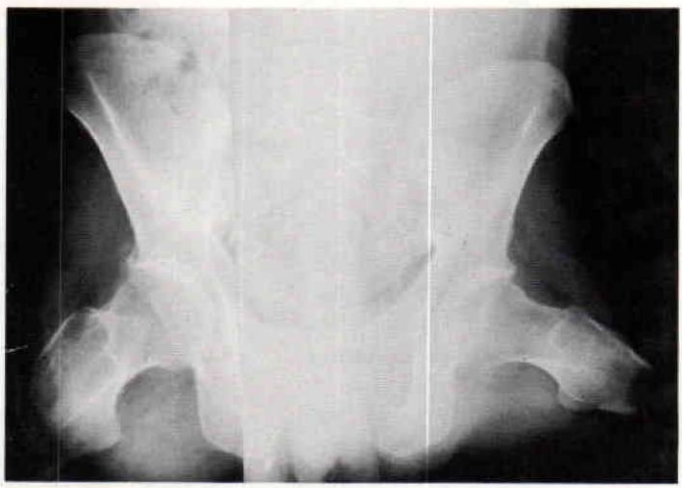
He was fitted with a walking device consisting primarily of a pair of control braces with a pelvic band and an ischial seat bar attached to both sides of the control braces hip joint area.

He was presented at the Ohio State University Hospital Rehabilitation Center Prosthetic Conference on September 29, 1967, and a prosthetic prescription for a definitive prosthetic unit was written.

The Clinic Team then discussed the components for this prosthetic unit, and under careful consideration the following prescription was worked out and written by the Clinic Team:

"Modified bilateral hip disarticulation prosthesis with modified plastic split hip disarticulation buckets for bilateral use, North Western stride control hip joints, single axis knee units with positive locks and SACH feet."

The split bilateral hip disarticulation bucket was prescribed with the hope that the patient would be able to accelerate one foot after the other and, consequently, would walk with a semi-normal gait (taking full advantage of the remaining femoral skeletal structures bilaterally). The stride control with hip locks and positive knee locks would give him stability during walking and stance.



Taking of the Cast

The negative mold of the patient's body was obtained by utilizing the North Western Type Four Point Suspension Technique. A double layer of 10″ wide nylon stockinette was tailored to the patient's body. The proximal portion of this stockinette was doubled, and two 2″ by 2″ webbing patches were sewn anteriorly and posteriorly to the brim of this tailored body stocking. A ⅜″ hole was punched into each of the patches, through which the ⅜″ Manila rope of the Four Point Suspension System was tied. The patient was freely suspended approx. 3 feet off the floor, and the body stocking conformed snugly to the patient's body. (*Figure 1*)

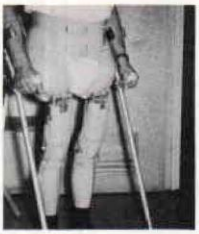


FIGURE 0

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

The outlines of the prosthetic socket to be and all bony protuberances, such as the remaining femural bony structures, the anterior superior iliac spines, the iliac crests, and the ischial tuberosites, were carefully marked with indelible pencil. These markings would later transfer to the male mold. (*Figure 2*)

Four inch fast setting Plaster of Paris bandages were used for the wrapping. A roping of Plaster of Paris bandage was pulled in deeply bilaterally behind the iliac crest, or iliac crest concavity. This would later supply the major suspension of the bucket on the patient's body. The wrapping of the entire cast was applied firmly. (*Figure 3*)

After the wrapping was completed, the patient was lowered to a platform on a stool until the ischial tuberosities would touch moderately and the patient stabilized. A plumb line anteriorly and posteriorly was defined, and the cast was then quartered and posterior as well as anterior and lateral reference lines were established. (*Figure 4*)

Now the cast was split anteriorly and posteriorly and removed from the patient's body. (*Figure 5*)

Filling of the Negative

The anterior and posterior opening cuts were sealed with two strips of Plaster of Paris bandages, and the negative was positioned on a table with all four vertical reference lines exactly aligned with a level. A mandrel, or ¾″ iron pipe, was positioned and aligned with the four reference lines by using a special holding device. A 16 oz. paper cup was attached to the pipe and inserted just to the brim of the negative to obtain a vacuum chamber needed for lamination. The filling of the negative proceeded in the usual manner. (*Figure 6*)

After hardening of the plaster, the reference lines were punctured with an awl and marked on the top surface of the cast. The lateral reference lines were used to establish a fictitious trochanter bilaterally.

These trochanters were located 1½″ proximal from the end of the cast. With a 45° angularly cut 1″ thick plywood the positioning lines for the placing of the hip joints were marked by positioning the plywood exactly

FIGURE 5

FIGURE 6

FIGURE 7

FIGURE 8

FIGURE 9

on the point previously marked for the trochanters, with the lower point anteriorly.

The wast was then peeled until only the male mold remained.

Modification of the Male Mold

All reference lines punched with the awl were connected and retained. All marked bony protuberances were elevated with Plaster of Paris to approx. ⅜″ to ½″. This included the ridges of the iliac crest, the anterior superior iliac spines, the ischial tuberosities, and the very short distals of the remaining femoral structures bilaterally. Outlines for the definitive bucket were reinforced. These outlines consisted of a proximal brim approx. ¾″ below the rib cage and anterior and posterior teardrop openings, 4″ by 5″, connected with each other (width: 1 inch). The cast was then smoothed and the markings bordered with ⅜″ Plaster of Paris roping, which was then filled with Plaster of Paris and molded to a flare of an approx. ¾″ radius. This would give the patient comfort in the prosthetic bucket. (*Figure 7*)

The mold, modified and smoothened, was then allowed to dry in an oven for 24 hrs. at a temperature of 115° F. Then the cast was positioned in the vice exactly at 45°, using a specially milled 45° steel positioning block. The mold was rotated and the trochanter reference lines positioned vertically with the aid of a plumb line. These lines, clearly established, would serve as the exact positioning for the hip joints.

Two cardboard cylinders, 4″ in circumference and 3″ high, were taped to the cast, keeping the hip joint reference lines exactly centered. Both cylinders were covered on top, and only a hole in the size of a Quarter coin was left open on each cylinder through which the liquid styrofoam was poured for the styrofoam hip joint mounting blocks. (*Figure 8*)

Hip Joint Mounting

The top of each block was cut level and level to the ground and as closely to the cast as possible. The hip joint mounting reference lines were marked on the styrofoam, and both hip joints positioned. (*Figure 9*)

FIGURE 10

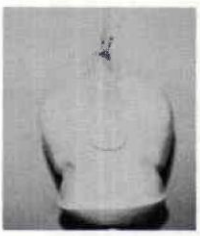


FIGURE 11

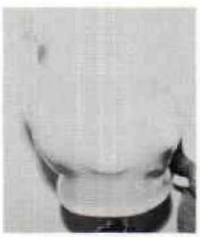


FIGURE 12

FIGURE 13

FIGURE 14

The base plates of the hip joints were marked, and the styrofoam block was shaped to blend in with the entire cast. The base plates were attached with Plaster of Paris, and the entrie styrofoam build-ups sealed with Plaster of Paris.

An extra build-up of Plaster of Paris of approx. ¾" thickness was provided over the entire seat area, which would later give space for a comfortable foam rubber (silastic) seat pad. The cast was now air dried rather than treated in the oven to avoid expansion and contraction of the styrofoam. (*Figure 10*)

Preparing of the Cast for Lamination

A 12" long ¼" drill was used to drill suction channels to provide for maximum vacuum during lamination. A channel was drilled in each deep concavity leading to the provided air chamber at the opposite side of the cast. The entire model was smoothened and lacquered with a high gloss lacquer. A PVA sleeve was tailored and, by using a lubricant, tightly and smoothly pulled over the entire cast. The vacuum was attached, and the cast was ready for lamination. (*Figure 11*)

Lamination of the Split Bucket

The first lamination consisted of four layer 8" wide nylon stockinette. After this lamination was completed, the PVA pressure sleeve was removed and the entire laminated area was roughened with very coarse sand paper. Nine feathered layers of fiber glass cloth were laminated with epoxy (C-8 Resin) over each hip joint mounting area for reinforcement. Three more 8" wide nylon stockinette layers completed the lamination lay-up of the split bucket (a 90-10 laminac mixture was used for the lamination, 90% 4110 — 10% 4134). (*Figure 12*)

The completed laminated bucket was split in the center and removed from the cast. The two half buckets were trimmed to the trim lines, sanded, and smoothened with a felt cone. (*Figures 13, 14, 15*)

Removal and Restoring of Cast

The styrofoam blocks and ¾" Plaster of Paris build-ups for the seat areas were carefully removed, and the

FIGURE 15

FIGURE 16

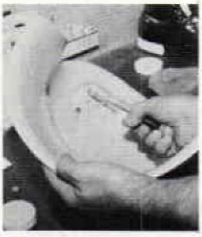


FIGURE 17

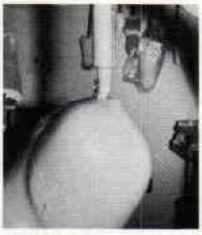


FIGURE 18

FIGURE 19

entire cast smoothened and lacquered with a high gloss lacquer and restored as in Picture #6. The entire area then received a fine Vaseline coating. (*Figure 16*)

The interior hip joint mounting plates were positioned and attached with two screws, leaving one screw hole and a ⅜″ center hole in the mounting plate open for injection of the silastic. (*Figure 17*)

The two half buckets were repositioned on the male mold and the silastic, consisting of a 25% 385 silastic and 75% 386 silastic mixture, was injected into each hip joint and seat area. (*Figure 18*)

After curing of the silastic the half buckets were removed, containing smooth seat pads. (*Figure 19*)

The hip joints as well as the finished stride control unit blocks were then installed. (*Figure 20*)

Dynamic Alignment of the Prosthetic Unit

The prosthetic foot was set up in a special way in relationship to the hip joint, so that from the lateral view a reference line from the hip joint anteriorly through the knee bolt would fall 2½″ posterior of the heel of the shoe. This would give the patient maximum stability and stance phase. (*Figure 21*)

Since no adjustable knee units were used during the alignment procedure, surplus wood was kept on the ankle blocks as well as the knee blocks. (*Figure 22*)

During the dynamic alignment the stance phase reference line (hip joint, knee joint, posterior of heel) needed to be increased 3 inches posterior of the heel of the shoe.

Suspension of Prosthetic Bucket

A prelaminated flexible plastic tongue (as shown in picture #10) provided a closure of the anterior opening of the bucket. Buckles and Dacron reinforced leather straps were used to hold the closure secure. In this case leather straps with holes have a more accurate closing point each time the prosthesis is used. A Velcro closing would be too inconsistent. (*Figure 23*)

The posterior opening of the bucket was provided with a 4″ by 6″ by ⅛″ Ortholene flexible hinge. This hinge would allow the patient to operate the prosthesis with the very short stumps, using his semi-normal gait. (*Figure 24*)

FIGURE 20

The height of the prosthetic unit was determined by using a proper knee flexion height of the knee unit, so that the patient would be able to sit down comfortably in a normal chair with both feet flat on the floor. (*Figure 25, 26*)

Two cork seat blocks had to be added to the seat areas of the bucket, thus bringing the patient up to a normal and level sitting position.

FIGURE 21

Knee Locks

Cable extensions, complete with housing and retainers bilaterally, were brought up laterally within easy reach of the patient's hands, and, for unlocking, hooked into a small stainless steel hook. Unlocking of the knee units would only be used for sitting, and both knees were locked during ambulation. (*Figure 27*)

The stride control hip locks would lock automatically when the patient would rise to a standing position. (*Figure 28*)

FIGURE 22

The patient indeed is able to ambulate, using one foot after the other consecutively. (*Figure 29*)

Ascending and descending stairs was accomplished by the patient by hoisting himself, using bannisters. (*Figure 30, 31*)

After the patient became more skilled in ambulating with his prosthetic unit, and due to the extreme stability (see hip joint, knee joint, posterior of heel reference line), the hip stride control lock could be removed, giving the patient a somewhat larger step. (*Figure 32, 33*)

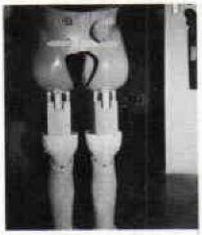


FIGURE 23

The stride control straps were attached three inches distal and 1″ anterior of the knee center medially and laterally on each leg, brought up posteriorly to the plastic bucket and retained with a D-ring in the area slightly anterior of the ischial tuberosity. (*Figure 34, 35*)

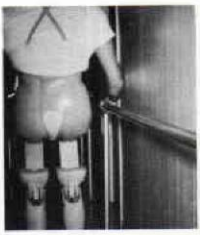


FIGURE 24

FIGURE 25

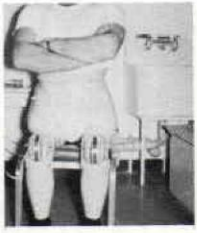


FIGURE 26

FIGURE 27

FIGURE 28

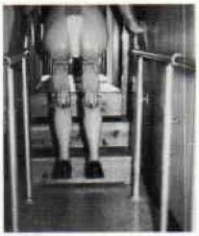


FIGURE 31

FIGURE 34

FIGURE 29

FIGURE 32

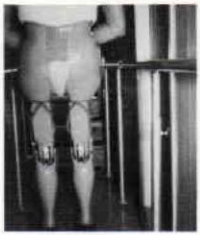


FIGURE 35

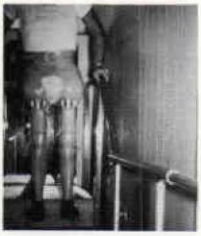


FIGURE 30

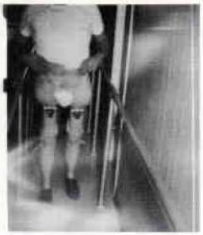


FIGURE 33

FIGURE 36

Follow-Up Rehabilitation Services

By Marvin H. Spiegel, M.D.
Director, Rehabilitation Center, Ohio State University

The patient was admitted to the Rehabilitation Service, Dodd Hall, Ohio State University Hospitals on September 27, 1967. Shortly thereafter the patient was started on the program of physical treatment which consisted of strengthening exercises for the upper extremities and the lower extremity stumps. Ambulation training was carried out using the patient's own temporary devices which consisted of bilateral long-leg braces which had been attached together with a metal band and to which had been affixed wooden bases at the distal end to serve as feet. Using these devices with Lofstrand crutches the patient was able to perform a very satisfactory drag-to gait.

On December 6, 1967 the patient received his bilateral hip disatriculation prosthesis and training was instituted in the use of this prosthesis. From the outset the patient did exceedingly well with his prosthesis and exhibited excellent balance and versatility in the types of ambulation he was able to perform which included drag-to, swing-to and the alternate-four-point gait. He was able to ambulate approximately 150 yards before tiring. The patient's initial tolerance for wearing the prosthesis was approximately one hour but by December 27, 1967 the patient was able to wear the prosthesis approximately six hours continuously and was successful in performing a swing-through gait although he preferred the four-point and drag-to gaits. The patient was able to successfully ascend and descend stairs and ramps and ambulate on uneven surfaces such as grass, gravel and cement. During the periods when the patient was not receiving his gait training he wore his prosthesis while sitting in an amputee-type wheelchair.

During his hospitalization the patient underwent a pre-vocational and vocational evaluation. As part of this evaluation the patient spent considerable time in the Department of Occupational Therapy where he was found to have superior manual manipulative skills and excellent work habits.

These activities were largely performed from the sitting position in the wheelchair wearing his prosthesis. The patient did experience a problem with managing toilet activities while wearing the prosthesis. Attempts to solve these problems were not successful and it was felt it would be necessary for the patient to attempt to regulate his daily toilet activities prior to donning his prosthesis. The patient was able to independently put on and remove his prosthesis. Entrance into the prosthesis was done by placing the prosthesis in a supine position and having the patient slide into the plastic bucket. Removal was accomplished in much the same way although the patient was also able to remove it from the sitting position. The patient was able to wear his prosthesis while driving a hand-control equipped automobile. At the time of discharge the patient was felt to have surpassed expectations in the use of his prosthesis and had tentative plans to return to work. (*Figure 36*)

Supracondylar Wedge Suspension of The P.T.B. Prosthesis

By Carlton Fillauer, C.P.O.

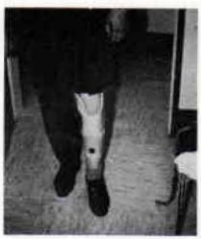


FIGURE 1

Background

The relatively brief history of the P.T.B. Prosthesis has been one of dramatic success and perhaps as no other U.S. development, influenced prosthetic practice throughout the world.

There is no single feature of the P.T.B. that has made this possible. So much information was introduced by this new technique that only a detailed study of it would reveal the full scope of its innovations. Then one can appreciate that this was the product of a comprehensive biomechanical study (1) of all aspects of the BK amputee and the prosthesis and not just a novel socket design.

During recent years a variety of modifications have appeared here and in Europe. Some disappeared rapidly while others (2) and (3) persist for they have merit in specific applications. It is noteworthy and a credit to the investigators at U.C.B.L. that the basic principles not only stand today but they have been reinforced.

FIGURE 2

If there has been a persistent need for a change it lies in the method of suspension. The original cuff suspension strap as described provides adequate retention for a good percentage of patients. Properly fitted the "holding on" effect is obtained over the patella and not circumferencially around the distal thigh. Some

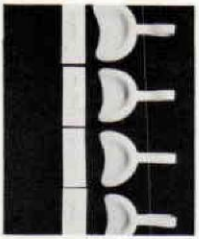


FIGURE 3

difficulties have developed which relate to restricted circulation, piston action and to lateral instability with short stumps. In these areas the P.T.S. technique offered substantial improvement over the cuff suspension.

Last fall while visiting the Orthopedic University Clinic in Muenster, I had the opportunity to become acquainted with a new approach. This involved the use of a *rigid* wedge inserted inside the socket over the medial femoral condyle, after the prosthesis is donned. (*Figure 1*) It was not considered an experimental item since they were employing it routinely on all BK amputees including their immediate post operative plaster sockets. My interest was so aroused that I remained in the area another day for a closer look.

FIGURE 4

Of particular interest was their rather complicated procedure for obtaining a plaster wrap under pressure. It involved a three step operation of partially covering the stump with a few layers of plaster bandage then applying a negative pressure bag. First the area of the knee was cast, followed by the proximal half of the stump and then finally the remaining distal segment.

Prior to the application of the plaster bandages the height of the medial flair of the socket was measured and marked off on the stump (*Figure 2*) so that it would transfer to the plaster wrap. The determinant factor was the top of the knee when flexed to 90°. The location of the wedge would be determined by the marks and the impression of the condyle in the plaster model.

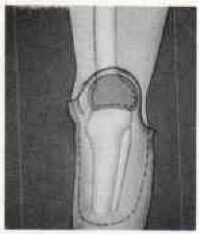


FIGURE 5

Immediately upon my return to Chattanooga we proceeded to fit our next BK with a supracondylar wedge for suspension. You can be sure that this was preceeded by a considerable amount of planning, more mental than physical. Good success with this first patient spurred us on to more fittings.

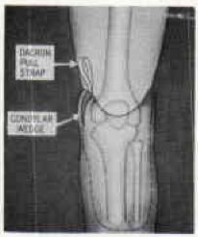


FIGURE 6

Our initial experience was with a tapered wedge similar to that seen at Muenster, first of neoprene crepe then of hard felt. We tried several measuring techniques to give us accurate wedge location, as this is very critical. Soon after completing a few fittings we began casting the stump with a *flexible* wedge held in its proper location by masking tape. This we feel has proven best since it was more reliable and it provided, by the pressure of the elastic plaster bandage on the wedge, adequate depth of the impression into the thigh.

FIGURE 7

FIGURE 8

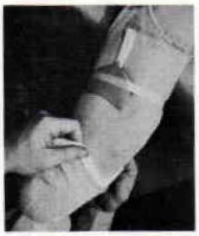


FIGURE 9

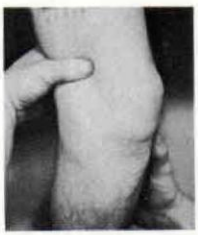


FIGURE 10

The Wedge, now made of plastisol, does not present a sizing problem. Three sizes* have been standardized with the medium size in two thicknesses (*Figure 3*). We have found that most adults can be fitted with the medium size (*Figure 4*). It covers the medial area of the knee from just posterior to the patella to and including the posterior medial face of the femoral condyle (*Figure 5*). Its centerline cross section is comma shaped and as fitted the thick lip area is placed just proximal to the medial condyle (*Figure 6*). When held in place by a *rigid* socket wall it effectively prevents distal displacement of the prosthesis.

The proximal brim of the medial wall has a medially projecting lip which retains the wedge in position (*Figure 7*). A loop of ½″ dacron webbing, extending from the proximal margin of the wedge and impregnated into the plastisol, provides a "handle" which facilitates removal from the socket.

When used as described below it will be seen how its shape is individualized. The plastisol selected is of approximately 40°-50° shore durometer. This does not permit much compressibility yet it is friendly to the stump and provides a feel of security to the patient. At the same time its flexibility is quite adequate to permit it to adapt in the plaster wrap to the slight variations in knee shapes.

Procedure

These steps cover only those that we consider departures from the routine in the standard P.T.B. sequence of measuring, stump marking, and hand modeling of the plaster wrap.

(1) If the wedge and the tape is located over the first layer of tube gauze** it will not interfere later with removal of the plaster wrap (*Figure 8 & 9*). Care must be taken that the lip of the wedge is actually above the condyle (as in *Figure 6 & 10*) and of sufficient width to encompass the A.P. dimension of the condyle (as in *Figure 5*). Adults with a large bony structure will require use of the large wedge.

* The four wedges are commercially available from Fillauer Surgical Supplies.

** Tube gauze is superior to a cast sock because it impregnates well with the plaster bandage. Size #78 (3⅝″ width) is suitable for most below knee stumps but for smaller circumferences we recommend size #5 (2″ width).

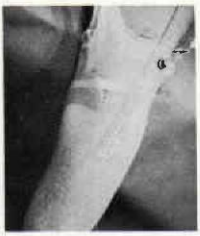


FIGURE 11

(2) Since the wedge remains a part of the wrap until it is filled with plaster, the wrap cannot be removed from the stump unless it is cut open to the level of the tibial tubercle.

With the elastic webbing inserted as shown (*Figure 11*) running from laterally above the patella down medially to the tibial tubercle a short diagonal cut (*Figure 12*) over the strap will permit opening of the proximal aspect of the wrap sufficiently to allow removal. If the wrap can be removed without cutting, something is wrong and a new wrap and recheck on wedge size and thickness is in order.

FIGURE 12

(3) Wrap stump with 2 to 4 elastic plaster bandages (8-10 cm width) beginning proximally above the wedge (a small dab of plaster mix rubbed in above and below the wedge helps lock the wedge to the wrap). In the area of the condyles it is important that the bandage be wrapped *tightly* to pull the wedge firmly against the condyle (*Figure 13*) and in this area it should be 3-4 layers heavier than usual. Continue wrapping distally in the standard procedure.

FIGURE 13

(4) When the model is stripped of the wrap the outline of the wedge should be clearly defined (*Figure 14 & 15*). No modification in this area is necessary except to remove plaster from above the wedge area so that a medial lip will form over the proximal edge of the wedge during the plastic lamination (*Figure 16*). Preparation of the model is routine below the level of the wedge. The lateral proximal extension area should be brought medial by removal of ¼″ to ½″ plaster to assure close contact and counter support to the wedge. The proximal edge of the lateral wall should be at approximately the same height as the medial side and be flaired away from the thigh (*Figure 17*) so as not to leave a sharp edge which would increase the difficulty in donning. The usual preparations for lamination should be followed though the use of double vacuum is superior in holding the lamination close to the wedge and around its margins. Extra thickness of the laminate in the area above the mid patella tendon is desirable to increase the rigidity of the extensions. For the average size (13″ circumference at M.T.P.) the following lay up is recommended: 2 dacron, 3-4 nylon stockinettes overall with extra dacron filler around the M.T.P. and

FIGURE 14

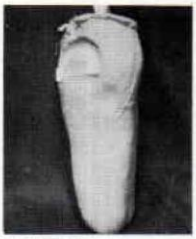


FIGURE 15

popliteal area and an additional 2-3 layers of nylon above M.T.P. level. The usual 80-20 rigid to flexible resin mixture is recommended. When the resin has gelled sufficiently to permit cutting the laminate without fraying, the area above the trim line should be cut away. Lift the medial extension with screw driver and remove wedge. The socket can then be pulled off the model.

Fitting Suggestions

The proximal opening (M-L) should be just wide enough to permit entrance of stump (*Figure 18*). Only a narrow $\frac{1}{8}$-$\frac{3}{16}$ lip is required to retain the wedge in the socket. After the stump is *well seated* in the socket check for correct height of wedge, if too low (distal) pressure on condyle may be excessive, constant and soon painful. When atrophy makes the stump loose in the proximal area, a thicker wedge may be needed.

FIGURE 16

Advantages

Once familarity with this technique has been acquired, few extra steps and little extra time, or expense is consumed.

(1) Shorter stumps can be fitted than with the conventional cuff suspension.

(2) Short stumps are much more secure with regard to medial-lateral stability.

(3) The wedge can be used on practically all fittings without a soft liner, though a soft liner may be used.

(4) Suspension is usually excellent, better than with any strap combination.

(5) There is less constriction in knee flexion, especially in comparison when the cuff circumferential strap is worn tightly.

(6) The stump sock does not tend to wrinkle around patella as with the suspension cuff.

(7) Donning prosthesis is accomplished easily without pull on socks, etc.

(8) Unlike the P.T.S., suspension is as good in flexion as in extension. For those prosthetists who are routinely fitting P.T.B.s with success and want to change over to the wedge method of suspension they do not have to learn a new technique of socket making. The standard U.C.B.L. methods have proved adequate with

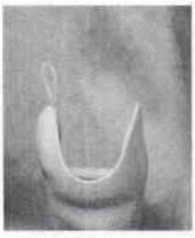


FIGURE 17

FIGURE 18

FIGURE 19

minor changes. One need only adopt a few steps to incorporate the higher medial and lateral flanges and casting in the condylar wedge. Many of the above "claimed" advantages are duplications of the claims for the P.T.S. From our experience and in the experience of the group in Muenster, the crux of the matter is that the wedge accomplishes these in a less complicated technique, more effectively.

Summary

We have learned that much can be benefited from the higher medial and lateral extensions not only in terms of suspension but in medial-lateral stability so important for the short stump.

Cosmesis cannot be overlooked and this innovation does not create a new problem (*Figure 19 & 20*). Nor has fitting been appreciably complicated, except that this system does require intimate fitting of the medial-lateral aspects of the socket. New and serious attention must be directed to the areas above the M.T.P. level as essential parts of the socket. Use of the supracondylar wedge will provide a new tool to the prosthetist. It should enable him to improve suspension to the majority of BK amputees and as a result further established the P.T.B. as the standard in modern prosthetics. This new system might be known by the designation S.T.P., Supracondylar Tibial Prosthesis.

FIGURE 20

References

1. University of California, San Francisco, Biomechanics Laboratory, "Manual of Below-Knee Prosthetics," November 1959.
2. Air Cushion Socket, U.C.B.L.
3. The P.T.S. Prosthesis (Complete enclosure of patella and femoral condyles in below knee fittings), Kurt Marshall, C.P. and Robert Nitschke, C.P., June 1966.

The Geriatric Amputee

By Jack Sokolow, M.D.

The problem of the older person was not really a "problem" until our life-span began to increase significantly at the turn of the century. The combination of technical improvements in housing and production, increased knowledge of nutrition and advances in medicine and surgery produced an outstanding addition to our years. Along with it, a whole host of new dilemmas arose and new areas of concern for medicine and society in general began to develop.

The special field of the amputee and prosthetics was slow to react and for many years prior to W.W. II all amputees suffered from the absence of any concerted attempt at improvement of prostheses. After the war it was the large number of amputee veterans that provoked a spurt in development in prosthetics and concomitantly, consideration was extended to the particular problems of geriatric amputees.

Up to that time prostheses and suspension mechanisms were relatively simple and largely unsatisfactory in many ways. For the younger amputee (often traumatic) in whom circulation was comparatively good, the problems of weight-bearing, strength, stability, etc., loomed less large. In the older person these problems were often devastating, especially when combined with the excessive energy requirements involved in using the limbs then available. For the geriatric amputee has, in addition, many medical and psychosocial complications which add an infinite complexity to the overall problem.

The general medical picture may present cardiac disease, diabetes, generalized arteriosclerosis, peripheral vascular disease, renal disease, hypertension, or chronic pulmonary disease. Any of these can reduce the physical capability of the patient to a point where use of a limb is precluded or made extremely difficult. In addition, there may be neurological problems which result in weakness or marked instability. Learning ability is frequently impaired.

Concomitantly, the social picture is not infrequently bleak. Faced with no place to live or the prospect of living alone, the patient's interest in a limb is certainly not improved. Financial worries often overshadow all

else and the psychological aspects of loneliness, rejection, financial insecurity, etc., depress a frequently already low level of motivation.

While the overall approach to pre-prosthetic and prosthetic management applies to both young and old, certain aspects are of much greater importance to the older amputee if successful prosthetic care is to be attained.

Pre-surgical physcial and psychological conditioning are important and the choice of amputation site (where a choice exists), i.e., above or below the knee, can mean success or failure in ability to use a limb. Post-surgical conditioning and training for the prosthesis should be started at once. The goals must be feasible. The staff must make every attempt to avoid "wishful thinking" in reaching a decision. When immediate post-surgical fitting is possible, this is today considered by many the method of choice. The benefits of rapid mobilization and the elimination of edema and contractures as complications have a salutary effect on the older patient. Confidence and security, comfort and stability are improved by early ambulation, not to mention the enormous benefit of early discharge and even return to work on occasion.

The considerations for the older amputee as described above are at present not being adequately met. Generally speaking, in the above-knee amputee, more especially in women, the stump is fleshy and does not show well-defined muscle groups. Therefore, a quadrilateral socket does not serve the geriatric amputee's purpose and its advantages are frequently lost with this type of patient. The plug-fit socket is not ideal either, in view of the poor distribution of weight-bearing areas, and the frequently thin, ill-nourished skin of the stump. A combination of the two types of socket appears to serve the purpose better than either. The total contact socket properly shaped for the best distribution of weight is an improvement in some cases. Suspension by means of a pelvic band and hip joint lends the most control and stability. Suction, on the other hand,

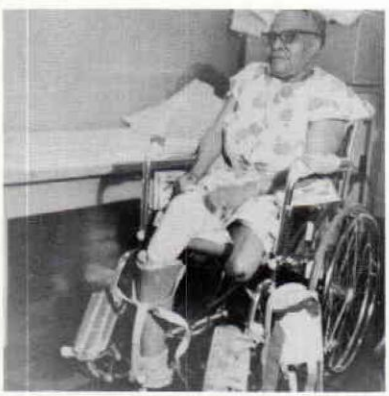


FIGURE 1—Geriatric amputee with temporary and permanent prosthesis.

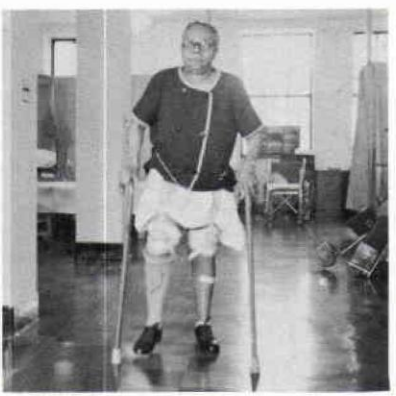


FIGURE 2—Patient after successful gait training.

FIGURE 3—Evaluation team consisting of Chief, Residents, Prosthetists, Therapists and patient in action

requires more ability for control than the geriatric amputee has in most cases.

The single axis or a friciton-lock knee is most frequently used, especially when the hip extensors are weak. This may be indicated even though the friction-lock knee may be somewhat heavier.

The foot usually used is an articulated one or a S.A.C.H. foot. Plantar flexion must be readily and easily carried out to give the geriatric amputee the confidence of a foot flat on the ground, most especially in the earlier stages. The heel bumper or heel wedge must be soft to begin with and can be adjusted later.

Not infrequently the older amputee, even under the best conditions, may require an ambulation aid ranging from a cane to crutches. It is obvious that even with two axillary crutches, ambulation is preferable to a wheelchair existence. Many patients can be quite independent in this manner, but if the cardiac reserve is inadequate and the energy cost too high, a wheelchair may be the only possibility.

In the management of the geriatric amputee the use of either a pylon or temporary prosthesis plays a large part. This latter has a fairly well-fitted socket, knee, and foot, and good alignment, whereas the pylon has a socket (sometimes only a cast) that can be replaced as necessary, and a rigid extension to the ground.

Both permit early mobilization of the geriatric amputee. This prevents loss of confidence and security in the erect position that is a frequent result of prolonged immobilization. Other benefits of early standing are quicker and more efficient stump shrinkage, enhanced motivation, and a chance to assess the patient's potential for a prosthesis.

In view of the medical and psychosocial complications which add to the difficulty of management of the older amputee, prescription of a prosthesis must be given careful consideration.

There are few definitive contra-indications to a prosthesis: imminent loss of the remaining leg, cardiac disease classified IV E, cancer with poor prognosis, or marked instability can be definite reasons for denying a limb to a patient.

The level of a patient's capability is extremely difficult to judge accurately. However, guidelines such as stability, independence in ADL, crutch ambulation, etc., are useful. Assessment with a pylon or temporary pros-

thesis based on these guidelines is fairly indicative of what to expect from the amputee with a definitive prosthesis. It is also essential to bear in mind that energy costs of ambulation with or without a prosthesis may preclude anything other than wheelchair mobilization in older amputees.

With all these special problems in the medical and psychosocial spheres, it is obvious that special prostheses must be fabricated for the geriatric amputee. Why should we expect the young and old amputee to be able to function equally well with the same prostheses?

Whereas the younger amputee requires mobility and control above all, comfort, security and ease of use are paramount for the older person.

The geriatric amputee must develop confidence in his ability to control and use the limb. He must develop a sense of security when using it. These attributes can be developed by assuring the amputee of stability in the prosthesis.

Another aspect of this whole question of tailoring the prosthesis to the individual's needs is concerned with the ease of putting on and removing the limb. That this should be as simple as possible is self-evident. But, in addition, the limb should be so constructed that it can be put on in only one way (i.e., no possibility of applying it in external or internal rotation on the stump) to prevent ambulation with the limb on the stump in poor alignment.

New prostheses must be designed with imagination. Sensory feedback to the maximum degree possible would be an enormous boon to the amputee. His safety and security could be greatly enhanced by designs that would permit proprioceptive mechanisms to operate. A knee with automatic safety locking at a given point of flexion, as in stumbling, would be extremely important to the geriatric amputee. A socket that could vary according to stump volume changes and yet fit properly, permitting a wide distribution of weight-bearing pressure, would be a great step forward. The suspension should be efficient and comfortable, and yet, cause no interference with his mobility. The foot should duplicate normal plantar flexion and permit some degree of dorsiflexion (about 10°).

Clearly, lightness of material and components coupled with strength and durability are highly desirable. Furthermore, good cosmesis is a factor which must not be overlooked. While it is of small import to some older amputees, more particularly men, it is certainly essential to women.

Naturally, since age is not the sole definition of the geriatric amputee, but rather the aggregate of physiological decline, the requirements of geriatric amputees will differ in a rather wide range. An elderly man who goes out infrequently needs less mobility in his prosthesis than one who is still working. While requirements for mobility and degree of stability will therefore vary, the need for lightness, safety, comfort and ease of application is constant. It is with this in mind that the prosthesis for the geriatric amputee must be designed.

Trilateral Socket Hip Abduction Orthosis For The Treatment of Legg-Perthes' Disease

By
Mihran A. Tachdjian, M.D.*
and
Loren D. Jouett, C.P.O.*

Legg-Perthes' disease or coxa plana is a self-limited disease of the hip in which the ossific center of the head of the femur first becomes necrotic and then is absorbed and replaced by live bone. It is quite common, occurring in children between the ages of three to ten years, predominantly in boys. The etiology remains obscure, but the process is produced by avascularity of the femoral head.

The stages of the disease are shown in *Figures 1* through *4*. *Figure 1* shows the synovitis (incipient) stage with swelling of capsular shadows, soft tissue thickening and widening of articular cartilage space. The time interval is one to three weeks. *Figure 2* shows the aseptic necrosis stage with increase radio-opacity of the entire femoral head. The time interval is two to twelve months.

The regenerative stage is illustrated in *Figure 3*. The radiolucent areas and fragmentation of condensed bony epiphysis are well known. Revitalization of femoral head is taking place by creeping substitution. The time interval is one to three years. *Figure 4* is the residual coxa magna stage with flattening and mushrooming of the femoral head and broadening of the neck.

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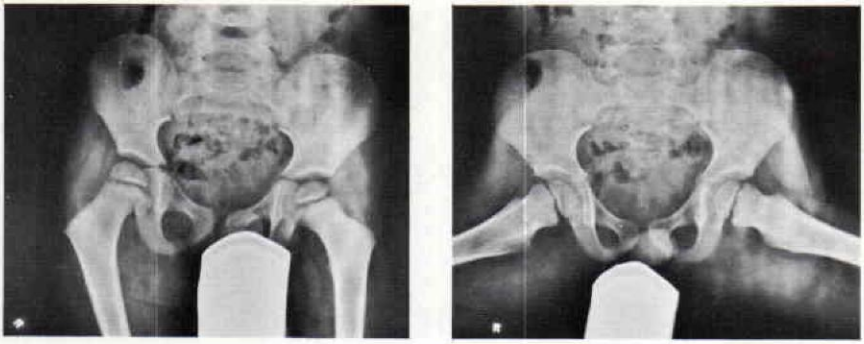

FIGURE 1 A-B—Synovitis of incipient stage of Legg-Perthes' disease. Note the swelling of capsular shadows, soft tissue thickening and widening of articular cartilage space.

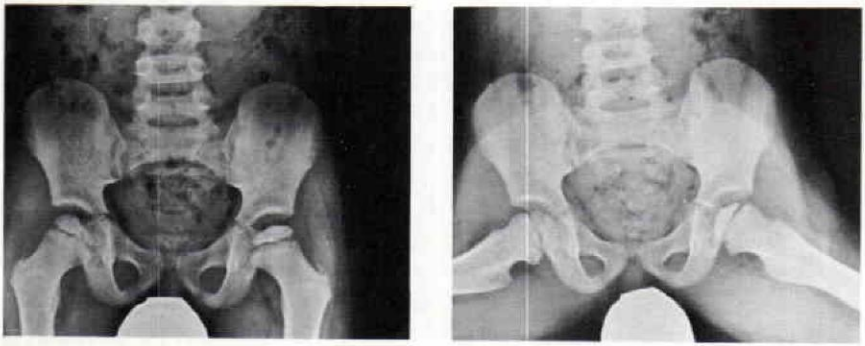

FIGURE 2 A-B—Aseptic necrotic stage of Legg-Perthes' disease. Note increased radio-opacity of the entire femoral head.

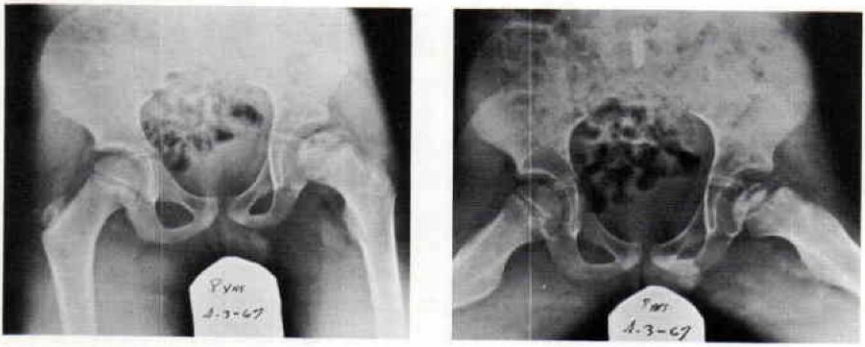

FIGURE 3 A-B—Regenerative stage of Legg-Perthes' disease. Note presence of radiolucent areas and fragmentation of condensed epiphysis. Revitalization of femoral head is taking place by creeping substitution.

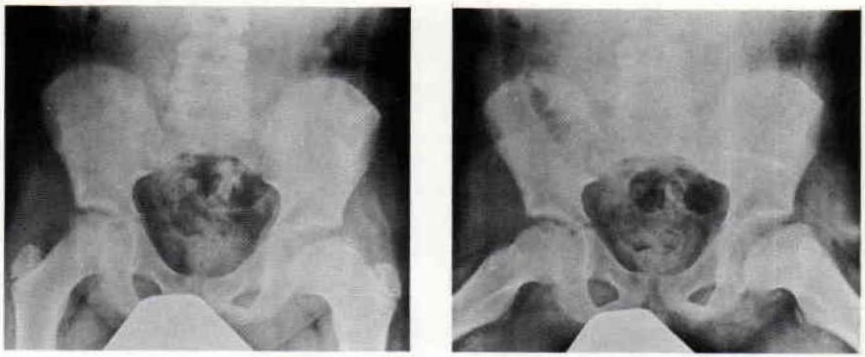

FIGURE 4 A-B—Residual or coxa magna stage. Note flattening and mushrooming of epiphysis and broadening of neck of femur.

The objectives of treatment of Legg-Perthes' are: 1) to preserve a normal femoral head outline and acetabular-head congruity and maintain a normal range of motion of the hip, 2) to give the patient a painless and useful weight-bearing joint in the years ahead and, 3) to achieve the above results without confining him for years in bed, in an institution or at home, by allowing him to be ambulatory, performing activities of daily living as near normal as possible and with the least discomfort.

The factors which determine the final outcome are:

1. The age of the patient. The earlier the onset, the better the prognosis, because
   a) in the young child the greater portion of the femoral head is cartilaginous; whereas, in the older child the larger proportion of the femoral head is osseous, hence the greater the opportunity for deformity.
   b) the younger the patient, the more the growth and the potential of remodeling.
2. Types of involvement—partial or total:
   In the partial type *(Figure 5A and B),* the prognosis is good, however, it is important to follow the patient for a period of four to six months to be sure that it is not going to progress to greater or total involvement. In the partial involvement almost always it is the anterior half or two-thirds of the epiphysis which is affected where weight-bearing stresses are much less in the erect posture. In total type *(Figure 6A and B),* the prognosis is much worse.
3. Stage in the course of the disease and the condition of the hip when the patient is first seen and treated.
4. Type and adequacy of treatment.

All the evidence indicates the most important factors in treatment to obtain a normal hip are:

1. Dynamic maintenance of the femoral head in the acetabulum with the hip in moderate abduction and some internal rotation.

2. Elimination of stresses of body weight from the avascular femoral head, as much as it is feasible.

The purpose of this paper is to describe an orthosis which satisfies the above requirements.

The Components of the Orthosis *(Figure 7A-C)*:

They consist of 1) the trilateral socket, 2) a medial upright with lengthening adjustment for growth, both above and below the knee joint, 3) slide guide extension, 4) shoe attachment slide stirrup, 5) distal control spring, and 6) walking heel extension unit.

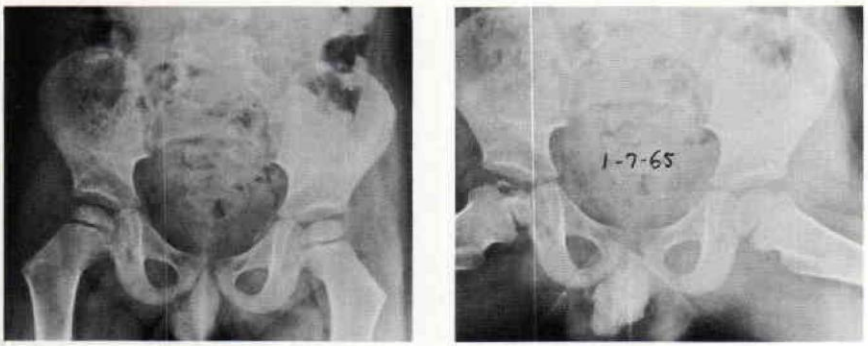

FIGURE 5 A-B—Partial type of involvement. Note in partial involvement almost always it is anterior half or two-thirds of the epiphysis which is affected where weight-bearing stresses are much less in the erect posture.

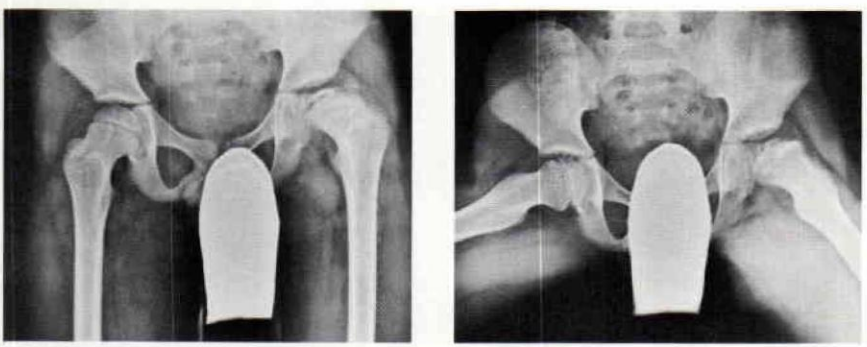

FIGURE 6 A-B—Total type of involvement.

Measurements and Tracings

With the patient in prone position a medial-lateral tracing of the extremity in the desired degree of abduction is made with the ankle and foot in neutral position and with the knee in extension *(Figure 8)*. One should make careful measurements of the widths and circumferences of the limb; floor to knee to ischium lengths; anterior-posterior (A-P) and medial-lateral (M-L) dimensions at ischial level. The measurement from the superior border of the greater trochanter to the inferior border of the iliac crest with the extremity in at least thirty degrees of abduction is important.

FIGURE 7-A

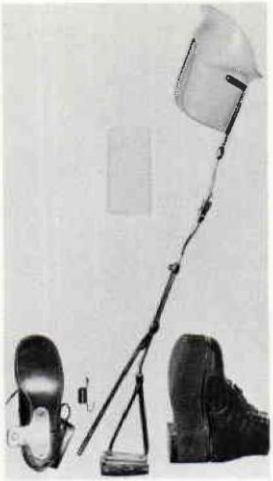

FIGURE 7-B

FIGURE 7-C

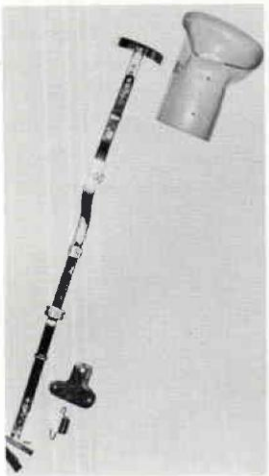

FIGURE 7-D

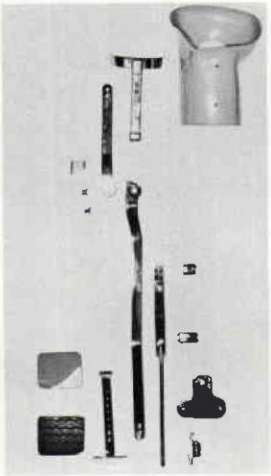

FIGURE 7-E

FIGURE 7-F

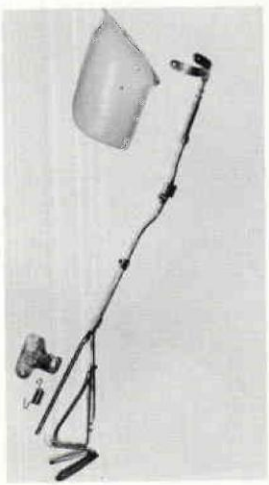

FIGURE 7-G

FIGURE 7 A-G—Components of the hip orthosis.
FIGURE 7 A—Postero-medial view.
FIGURE 7 B—Posterior view.
FIGURE 7 D-G—Detached components of the orthosis.

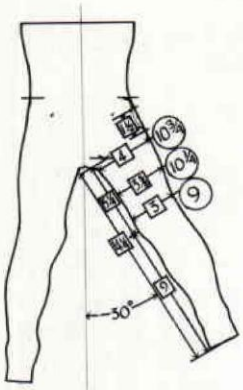

FIGURE 8 A—Measurements and tracings for the trilateral socket hip abduction orthosis. Outline of the lower extremely —anterior view.

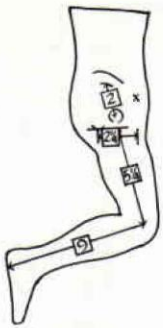

FIGURE 8 B—Outline of a lateral view of the lower extremity.

A lateral outline with the knee flexed to ninety degrees and the hip in neutral extension including the waist is also made. The gluteus maximus should be included to facilitate modification of the socket mold. The anteroposterior dimension from the ischial tuberosity to the apex of Scarpa's triangle is obtained by seating the patient on a firm table and measuring from the surface of the table to the top of the adductor longus, which is made prominent by the patient adducting the thigh against resistance *(Figure 9)*.

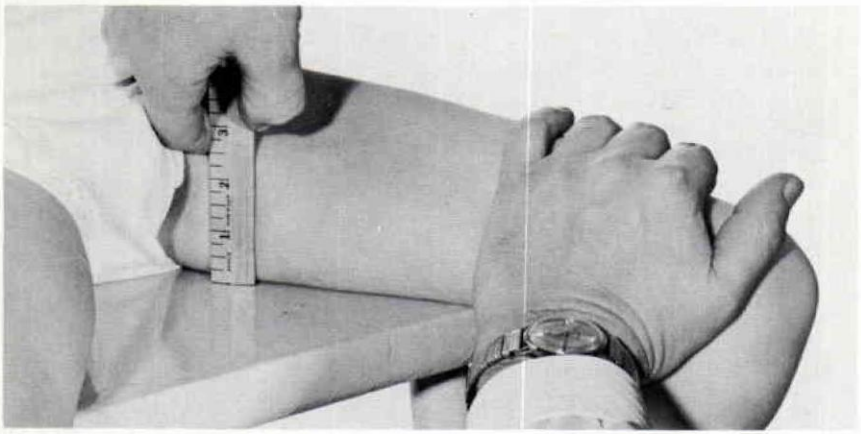

FIGURE 9—Method of A-P measurement from the ischial tuberosity to the apex of Scarpa's triangle. Note how the adductor longus is made prominent by asking the patient to adduct the thigh against resistance.

Cast Technique

The steps are as follows:

1. Apply talcum powder or silicone spray to the patient from the waist to the femoral condyles on the affected side.

2. Pull a piece of snugly fitting stockinette of sufficient length to cover the area from the knee to include the iliac crest.

3. Split the stockinette to contour to the perineum and the area of the gluteus maximus.

4. Hold the stockinette in position over the iliac crest with a piece of webbing and yates clamps.

5. With patient standing on his sound extremity, with the pelvis level and supported by parallel bars or other appropriate means, abduct the involved extremity thirty degrees or more with ten to twenty degrees of rotation. Elevate the foot on a box or some type of support to maintain this position *(Figure 10).*

6. Mark with indelible pencil the points of measurement previously recorded, namely, widths and circumferences at supracondylar, mid-thigh and ischial seat level. Outline the gluteus medius area between the greater trochanter and the iliac crest.

7. A plaster of Paris bandage is applied firmly from mid-thigh to include the crest of the ilium, the gluteus maximus, the pubic ramus and the femoral triangle. The proximal contours of the cast are formed by using one hand to form the medial wall parallel to the sagittal plane—line of progression. The thumb of the same hand is used to form a depression over Scarpa's triangle. The other hand forms the posterior wall *with the ischial seat level* at approximately right angles to the medial wall. A relief channel is molded for the adductor longus tendon by inserting a finger in the plaster wrap.

8. Cut the cast on the lateral side from the distal end to the trochanter to facilitate removal. Seal the lateral wall and the distal end of the cast with plaster bandage. Apply a separator and pour the positive mold. Insert a mandril with some accommodation for vacuum laminating.

FIGURE 10—Positioning of patient for application of plaster of Paris cast.

FIGURE 11—Note weight is transmitted through the applicance and not through the thigh when the patient kneels.

Modification of the Positive Mold

The modifications necessary are similar to those advocated for a quadrilateral socket. The A-P of the positive mold is reduced ¼" to ½" less than the A-P measurement obtained from the patient dependent on the musculature.

The ischial shelf is formed to be horizontal when the hip is maintained in the desired degree of abduction which usually is thirty degrees. The M-L width of the mold at ischial level should not exceed circumference measurements of the thigh at ischial level divided by three minus one-fourth inches.

The circumference of the mold at ischial level is reduced one-half to one inch depending upon the size of the patient and firmness of thigh musculature.

The medial brim is flared and should be high enough to impinge on the pubic ramus when the extremity is positioned in less than twenty-five degrees abduction. The medial wall must be parallel to line of progression.

The Scarpa's bulge is contoured smoothly and adequate relief is provided for the adductor longus tendon. A generous flare at the proximal edge over the Scarpa's bulge will ensure comfort for sitting. The anterior lateral border of the cast is kept high, but care must be exercised that the anterior superior spine of the ilium will not be impinged upon during hip flexion.

Lamination

The trilateral socket is fabricated by the standard polyester laminating technique. The best results are obtained when a vacuum laminating procedure is employed. A polyester resin mix of seventy per cent rigid and thirty per cent flexible is used. The layup for the socket requires one layer of one-half ounce dacron felt, and two layers of nylon stockinette. Additional strips of dacron felt are added to the proximal posterior and medial flares for reinforcement. One complete piece of fiberglass is added around the periphery of the layup within one-half inch of the final trim lines for additional strength. The layup is completed with two more layers of nylon stockinette.

All the layers of stockinette are spiraled except the last which is pulled straight down for cosmetic reasons. Remove the cured lamination from the mold. Trim and smooth the edges ready for assembly and fitting.

Medial Upright

Commercially available brace uprights of adequate strength with a knee lock are used for the medial upright *(Figure 7).* A clevis type drop ring lock knee joint has proven most satisfactory as the joint must be well fitted with minimal play in any direction when locked in full extension. Stainless steel is most desirable, however, plated carbon steel has proven

adequate. Aluminum uprights are not advised as the joint surfaces wear and become "sloppy" where they are in contact with joint races or bearings. The joint uprights must be of the solid, one-piece type as the assembled type will break at the weakened rivet hole where the upright bar is fastened to the joint-lock assembly.

A/K Lengthening

Adjustment above the knee is obtained by use of a looped lengthening segment of the same size material as the joint upright. The lengthening loop should be continuous (not split) and fitted to close tolerance. A one-half inch strip of nickel silver (one-eighth inch) can be formed and silver soldered if forging a loop is not practical. Two 8-32 screw holes, correctly aligned, are drilled and tapped at the proximal end of the upright for lengthening. Countersunk, oval-head 8-32 stainless steel screws are suggested.

Socket-Upright Attachment

The medial upright and socket are attached by riveting the socket front and back to a strong contoured yoke which has been securely brazed, welded or silver-soldered to the proximal end of the proximal upright segment. An additional rivet is then used to form a triangular attachment toward the distal end of the socket to the upright segment.

Knee Positioning

There will be some compromise necessary as to placement of the knee joint. A good starting point is at the level of the MTP (medial tibial plateau). Two factors are involved: 1) the patient's weight must be transmitted through the appliance and not through the thigh *(Figure 11)*. A

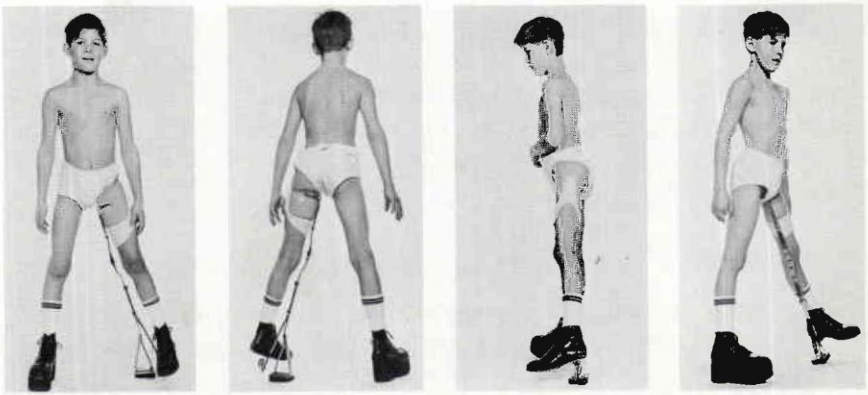

FIGURE 12-A FIGURE 12-B FIGURE 12-C FIGURE 12-D

FIGURE 12—Patient standing with the trilateral socket hip abduction orthosis. A—anterior; B—posterior; C—lateral and D—medial view.

properly fitted socket is necessary to maintain the functional A/K length. 2) projection of the knee joint should be minimal when the knee is in ninety degrees of flexion.

B/K Components

The below-knee portion of the upright should have no holes or irregularities that could weaken the appliance by stopping the transmission of forces to its distal end where there are two screw holes for the walking heel extension attachment. The upright is contoured medially for the knee, but must remain perfectly straight, thereafter, to a point just above the medial malleolus where the distal end is bent at an angle to accommodate the medial positioning of the walking heel. Before the bend is made, however, two sliding-locking rings are made and fitted to hold the slide guide extension *(Figure 7)*.

*Slide Guide Extension**

This is a round rod and flat bar brazed or silver-soldered together to provide for adjustable suspension and guidance control of the appliance. The flat bar is of stock of the same width as the upright and of an adequate thickness (no less than one-eighth inch). The length should be equivalent to the distance from the knee contour on the below-knee upright to approximately one and one-half inches distal to the bend in the upright. This adjustment bar is held firmly to the upright by two locking rings which are made of stainless steel. They must be made to close tolerance. The upper ring is drilled and tapped in the center of the lateral side for an oval-head countersunk 8-32 stainless steel adjusting screw. The lower ring is drilled and tapped for double 8-32 sharp point Allen screws on the anterior and posterior edges to lock the slide guide to the upright *(Figure 7)*.

At the squared proximal end of the adjustment bar a #18 hole is drilled to accept the adjusting screw of the upper ring. A slot of at least one-eighth inch wide by three-fourths inch long is milled at the rounded distal end of the extension rod to engage the control spring. The length of the extension rod should extend to approximately three inches distal to the bottom of the foot *(Figure 7)*.

Control Spring

The control spring is a closely spiraled nickel-plated 3/32″ steel spring *(Figure 7)*. It is wound with a three-fourths inch diameter by one and

* The slide guide extension was originally designed as a one piece flat bar with a rectangular cut-out in the stirrup. The round bar and hole has proven more satisfactory.

one-fourth inches length. A half-round top loop is formed for engaging in the posterior-medial part of the shoe attachment slide stirrup. The elongated bottom loop of the spring is positioned in the distal slot of the slide guide under slight tension. The overall length of this spring from top to bottom loop should be approximately two and one-half inches. This spring provides suspension and stabilizes the appliance on the patient. It prevents pumping action, excessive displacement between the extremity and the appliance and plantor flexion of the ankle.

Stirrup

The shoe attachment slide stirrup is fabricated from stainless steel and shaped for riveting to the heel, sole and shank of the shoe. It has a medial projection with a cut-out or hole which is shaped to slide up and down freely on the slide guide rod. The hole in the medial projection should be large enough and beveled to prevent "binding" or "locking." The medial edge can be bent slightly downward so inversion of the foot will not "bind" a close fitting hole. The hole should be close to the shoe so that the medial malleolus will contact the appliance preventing eversion. Positioning the hole posterior to the center line of the leg-ankle center tends to induce increased internal rotation. The control spring hole is drilled at the posterior medial aspect of the stirrup *(Figure 7)*.

Walking Heel Extension

The walking heel extension segment is made of steel bar stock of the same width as the upright bar. It is looped to close tolerance around the upright bar at its proximal end for length adjustment. It should be located just distal to the bend in the upright so there will be sufficient length adjustment for growth. Double 8-32 stainless steel oval-head, countersunk screws are threaded into it through the distal end of the upright bar for lengthening.

The length of stock used should measure from the looped proximal end down to the walking heel level which is approximately three inches below the sole of the heel, plus enough stock to bend horizontally two to three inches across the walking heel plate and returned to just below the loop to form a triangle. This is brazed or silver-soldered at this point *(Figure 7)*.

Walking Heel

The heel plate is at least two inches by two inches steel plate riveted and brazed to the horizontal bend. It is drilled at each corner to accept the riveting of a leather heel attachment sole. The most desirable finished heel is obtained by attaching a tread section of an automobile tire as a walking surface. It should be wedged in its posterior-lateral aspect to increase internal rotation forces *(Figure 7)*.

Medial placement of the walking heel reduces the horizontal distance from the floor reaction forces to the vertical weight line from the center of gravity of the body. If the walking heel is placed laterally, a greater effort is required for walking.

Compensatory Lift on Opposite Side

The shoe for the foot on the non-involved side requires a lift of adequate height to level the pelvis with the involved extremity abducted in the appliance.

A practical method is by using light weight sole crepe. The heel is removed from the shoe and layers of one-half or five-eighths inch crepe are laminated with a strong bonding cement until a total sole lift of two of two and one-half inches is applied. A heel is added to gain the additional one-half inch to balance the three inches extension on the involved side.

Most patients tend to wear the lateral border of the lift. To prevent this and to reduce weight and inversion wear, honey comb holes are drilled to soften the lift more on the medial side. Toe drag is reduced by grinding the toe to form a rocker. Both modifications are completed before the application of the final layer of the sole.

Fitting and Alignment

The patient with Legg-Perthes' disease is ready for fitting of the appliance when he has full range of motion of the affected hip and is free of pain and muscle spasm.

A thin cotton cast sock or cotton stockinette should be used to pull the patient into the socket. It should be worn at all times with the appliance to prevent friction between the skin and socket. No skin problems should occur if this sock is dry and is regularly cleaned and changed. The patient should be advised that if skin irritation develops at the site of the ischial tuberosity from the pressure, a wetted tea bag applied several times a day to the area will toughen the skin. The tannic acid is very effective and is absorbed quickly leaving no undesirable residue or greasiness. Rubbing alcohol is another means to achieve the same results.

The patient and parent must understand that the body weight forces are to be borne by the ischial tuberosity on the socket shelf of the orthosis. If anterior displacement of the ischial tuberosity occurs, additional smoothly folded layers of stockinette or open end wool stump socks should be worn to maintain socket fit. With atrophy of disuse reduction of the volume of proximal thigh is to be expected. If extreme volume loss is encountered, a new socket may have to be fabricated.

The appliance is applied by inserting the foot through the socket with the toe pointed down and out of the open lateral wall.

Seated, with the leg inserted and the knee joint unlocked, the patient can pull the appliance up enough to insert the slide guide extension through the shoe attachment slide stirrup and engage the control spring. The patient then stands on the sound foot, extends the involved knee, checks to be sure the drop lock is secure and shifts his weight from one side to the other.

Initially, most patients attempt to adduct the involved extremity and complain of pubic ramus pressure. The purpose of the high medial brim should be explained to him and he should be instructed to walk with the hip in abduction. It should be stressed that he also should walk in internal rotation. If the patient has difficulty in walking in internal rotation, an elastic strap may be attached to the toe of the shoe with its other end buckled around the medial walking heel extension bar.

Once the patient has standing balance, one should check the ischial shelf to be sure it is level and that the extremity is properly abducted and internally rotated *(Figure 12A - D)*. The wedged walking heel should be flat on the floor about mid-way or slightly lateral between a projected line of the extremity and a vertical line from the ischial tuberosity. During the stance phase on the affected lower extremity there is a negative Trendelenberg and further abduction of the involved hip *(Figure 13)*. If the patient has been in a bed rest split Russell's traction up to this time, he will more than likely display some weakness and imbalance.

The parents should encourage the child to pursue all normal activities as long as no weight is borne on the foot or outside forces applied to the involved extremity.

The patient should return to the prescribing physician after the fitting. The "check out" procedure should include: 1) roentgenograms, to ascertain if the head of the femur is properly positioned in the acetabulum, 2) gait training and active and passive exercises to maintain range of motion of the affected hip, 3) fit of the socket, 4) position of the foot,

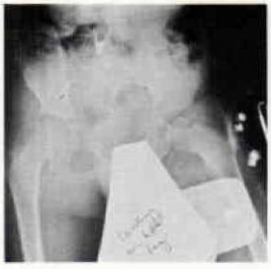

FIGURE 13-A

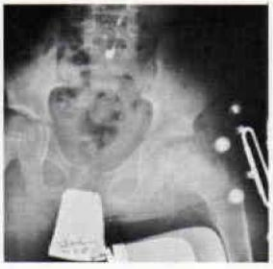

FIGURE 13-B

FIGURE 13-C

FIGURE 13—Roentgenogram of both hips in gait.

FIGURE 13 A—Roentgenogram of both hips standing on both lower extremities.

FIGURE 13 B—Roentogram of both hips in stance phase on left leg in gait. Note on weight-bearing of left lower extremity only, a negative Trendelenberg and shift of the trunk to the left and further abduction of the affected hip.

FIGURE 13 C—Roentgenogram of both hips in swing phase of gait on left leg standing on right leg.

5) correct abduction and alignment, 6) general comfort of appliance, and 7) follow-up instructions.

The patient should feel free to call on you should he have any problems or questions. He should be checked between two to four weeks after fitting to verify the fit and correct any faulty habits that may be developing. Follow-up is very important until the appliance is removed. It has been our experience that about two years should be expected.

The measurements, making of the cast, fabrication and fitting, without follow-up for this orthosis, will require an average of 32.5 hours.

Patients with bilateral involvement can be treated equally satisfactorily with this method *(Figure 14A - F).*

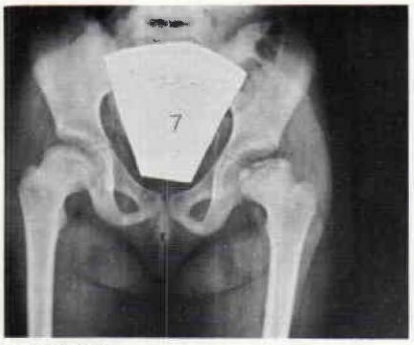

FIGURE 14-A

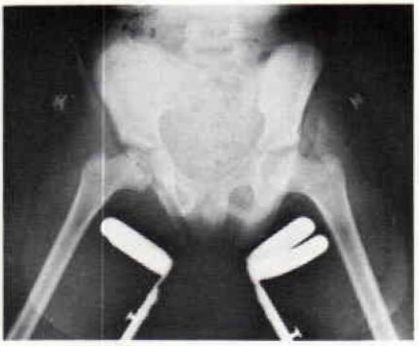

FIGURE 14-B

FIGURE 14-C

FIGURE 14-D

FIGURE 14-E

FIGURE 14 A-G—Bilateral Legg-Perthes' disease.

FIGURE 14 A—Standing without appliance. Note the lateral subluxation of the hips.

FIGURE 14 B—Standing with the orthosis. Note the anatomical placement and congruity of the femoral head in the acetabulum.

FIGURE 14 C-G—Photographs of the patient walking without assistance.

Prosthetic Management of Hemicorporectomy

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Trans-lumbar amputation is the most revolutionary of all surgical procedures, severing the body in the low lumbar spine while preserving vital life functions. The procedure has been referred to as a hemicorporectomy. It was first conceived in 1947 for a female patient with far advanced cancer[1], but because of the physiological and psychological implications of such a procedure, it was not performed.

The first paracorporectomy was done in 1960[1,2]. The patient expired

This project was supported in part by the Vocational Rehabilitation Administration Grant RT-3.

shortly thereafter from pulmonary complications. Since then ten other patients that have undergone this procedure have been reported in the literature [3-9]. Of these, four are presently living. All have been done for advanced cancer in a final life saving effort.

The surgical procedure is now very feasible. It can be done in two stages in a reasonable amount of time and with moderate hope of success. The amputation is usually between L4 and L5. The fecal stream is usually diverted to the abdomen through a colostomy, although an ileostomy has been used in one patient. The urine is diverted to an artificial bladder constructed from a section of a small bowel which opens on the abdomen. Collection devices must therefore be worn continuously.

The greatest remaining barrier has been rehabilitation so that the person whose life has been saved can return to meaningful living.

A most necessary part of this rehabilitation is a prosthesis that will allow mobility and provide functional support. A total lower body prosthesis presents major challenges to the prosthetic profession.

The ninth and eleventh reported cases of trans-lumbar amputation were done at the University of Washington Hospital on August 10, 1966 and November 14, 1966 respectively[9].

Easton, et al[10], from the University of Minnesota first described a prosthesis for patients with trans-lumbar amputation in 1964. This prosthesis was essentially open over the abdomen to allow access to the colostomy and ileal bladder collection devices. They demonstrated that a patient could be suspended in a prosthesis in an upright position with enough stability to allow wheelchair ambulation.

New York University has reported in a USPH Service film[11] results of two patients who were successively fitted with a prosthesis. Large openings were made in the plastic laminated socket to provide ventilation, reduce weight, and permit changing of ileal bladder and colostomy bags. A foam rubber lining one-half inch thick was used in the plastic socket to help distribute weight and avoid pressure necrosis. One patient was fitted with a total lower body prosthesis that enabled him to ambulate with a swing-through gait using Lofstrand crutches. He later progressed to stairs and curbs. This patient subsequently qualified himself to drive an automobile wtih hand controls.

In making prostheses for our two patients, no attempt was made to copy the prostheses made at Minnesota or New York University, other than to be aware of the general concepts they developed. The following criteria have been established in our laboratory for paracorporectomy prostheses:

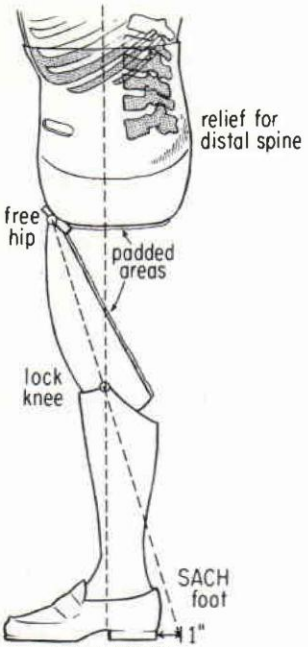
1. Independent transfer in and out of the socket.
2. Maintenance of an upright position with sufficient stability to allow free use of upper extremities and wheelchair mobility.
3. A minimum eight-hour socket tolerance per day to be divided into two four-hour periods.

4. Sufficient distribution of weight bearing surfaces to prevent pressure necrosis.
5. Allowance for adequate respiratory exchange.
6. Prevention of abdominal pain and nausea from continued pressure on abdominal contents.
7. Prevention of eversion of colostomy and ileal bladder stoma.
8. Easy access to colostomy and ileal bladder drainage bags.
9. Relief of pain and pressure over sternum and distal lumbar spine caused by leaning forward or backward in the socket.
10. Cosmetic appearance in both platform and walking prostheses.
11. Ease in cleaning areas of socket in body contact.

Fabrication of the prosthesis is accomplished by obtaining a plaster of Paris impression of the patient's trunk. A stockinette tube is sewn closed on one end, pulled onto the trunk and held in place under tension by use of elastic straps over the patient's shoulders. Patients can elevate the distal portion of the trunk while in the supine position. This allows adequate work area for applying the plaster of Paris bandages. Elastic plaster of Paris bandages are used to wrap the proximal portion of the trunk. The wrap begins at the level of the fourth intercostal space. It is continued distally in a figure of eight pattern. Considerable tension is applied to form the bandages well under the tenth costal cartilage as far posterior as possible *(Figure 1)*. This proximal wrap tends to cause some distension of the abdominal area. Therefore, non-elastic plaster of Paris splints are applied distally to support the soft tissue. This prevents the complications of abdominal compression in the finished prosthesis, i.e., abdominal pain, nausea, decreased vital capacity, and eversion of colostomy and ileal bladder stoma.

FIGURE A

FIGURE 1



2. A-P ALIGNMENT

FIGURE 2

3. SOCKET AND PLATFORM FOR WHEELCHAIR AMBULATION

FIGURE 5

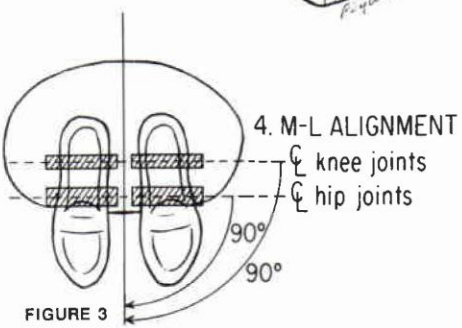


FIGURE 3

FIGURE 4

The negative impression is filled with plaster of Paris and a mandrel provided for holding. The plaster of Paris positive is modified by building up with additional plaster at the end of the stump and paravertebrally to provide pressure relief at the distal end of the vertebral column and along the spines. Plastic lamination is accomplished using dacron felt, nylon stockinette and polyester resin. Best results were obtained by using an inner PVA bag and vacuum.

Our patients were provided with two prosthetic devices. A full prosthesis with free swinging hip joints, locked knee joints, and SACH FEET is used for forearm crutch ambulation. The anterior-posterior alignment is as described by F. Hampton[12]. Medial-lateral alignment is accomplished

by placing hip joints on exactly the same plane and at 90° to the line of progression *(Figure 4)*. The second prosthesis consists of a socket mounted on a platform in such a way as to allow the socket to rotate and in a position that provides for patient balance in both planes *(Figure 3)*. Both of these prostheses are suspended by a shoulder harness.

One of our patients presented a unique problem with fecal drainage inasmuch as he had an ileostomy, rather than a colostomy, therefore a stoma was not present. The colon is normally evacuated only once per day so that an early morning enema can be given to a patient with a colostomy and no further drainage need occur until the following day. Because fecal contents in the small intestine are liquid in nature, continuous drainage is necessary to prevent intestinal obstruction. A direct opening over the stomal site provided access to the bag, but eversion of the bowel was found to occur with strenuous activities. To prevent eversion of the stoma and still allow free drainage of the fecal stream, a "mail slot" opening was developed in which the stoma was covered by the socket wall, thus preventing eversion of the bowel *(Figure 5)*. A form-fitting slot was made two inches below the stomal site through which the bag could emerge from the socket, thus allowing easy access for drainage. Care must be taken to assure proper position of the slot so that the body weight does not occlude the bag. If the bag is occluded, a back pressure develops which can result in leakage around the point of attachment to the skin.

An adequate dry urine collection system is not only socially desirable, but an absolute medical necessity while in the socket to prevent maceration of the skin. A Lapides vesicotomy bag was originally used for urine collection from the ileal bladder. Because of the extreme flexible nature of this particular collecting device it was continually kinking, causing the glue seal to leak. An ileostomy bag was used for urine collection with a similar "mail slot" which proved very much superior to the Lapides collection device.

A semicircular notch was put in the front of the wheelchair platform to allow the patient to move forward on the chair and drain his collection bags into a toilet *(Figure 3)*. This did not affect the stability of the platform.

Both patients have returned to their former employment. One is in the insurance field and the other in electronics repair. Our first patient has a remarkable socket tolerance *(Figure A)*. Although advised to stay in the socket for only four hours at a time, he has on occasion been in the socket up to 12 hours a day with only a half hour break at lunch. By doing push-ups while in the socket at least every 15 minutes, potential pressure necrosis problems have been avoided.

Our second patient has a limited respiratory capacity from chronic lung obstructive disease. His maximum socket tolerance has been 3 hours at a time with 1 hour break during noontime, thus normally spending a 6-hour working day in his prostheses.

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A Light Weight Model of the Becker "Boomerang" (A Self-Help Device To Facilitate Locking and Unlocking of Long-Leg Braces)

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Introduction

It is extremely difficult for a patient wearing long-leg braces to comfortably extend the braces to the lock-knee position while seated. This difficulty is even greater where there is any degree of spasticity in flexion such as may be seen in paraplegia and hemiplegia. Bending forward at the hips in any effort to extend the knees greatly increases the difficulty by putting mechanical stress on the hamstring muscles.

The Becker "Boomerang"[1] leg-brace extension device employs a principle which enables a patient to lock and unlock his long-leg braces with ease and without assistance from others. Using the "Boomerang" in any case where the knee is mechanically capable of full extension, knee lock-

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ing in extension can be readily accomplished by patients in whom this act is normally very difficult without assistance from another person, or without sitting precariously on the edge of the wheelchair or bed with the heel resting on a point of counterpressure such as the floor. It is possible with this device to produce knee extension while also extending the hip rather than bending forward to support the leg or to apply downward pressure. The savings in man hours made possible by the "Boomerang" amounts to at least one-half man hour daily per patient. This device has a secondary use in permitting patients with short and long leg braces to perform active assistive exercises of a weak lower extremity.

The original model of the Becker "Boomerang" has been in general use since 1955. This report presents the newer, lightweight model that has been tested with success over a three-year period in our rehabilitation cen-

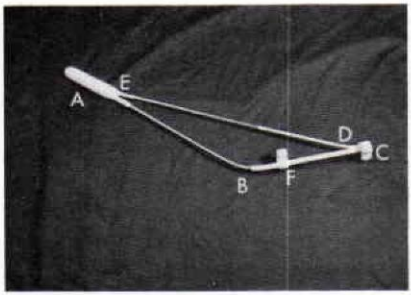


FIGURE 1

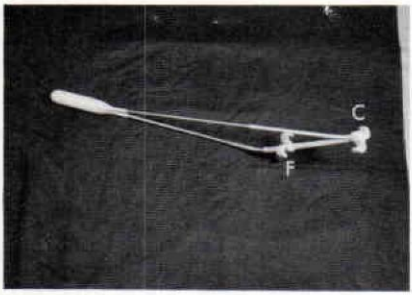


FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

ter. Stainless steel tubing has been used because it is lightweight, strong, rust free and cosmetically acceptable.

Specifications

The main bar of the "Boomerang" leg extension device is made of ⅜ inch (outside diameter) stainless steel tubing, 27 inches in length. The proximal arm, A-B, is 17 inches in length, including the grip. The distal arm of the "Boomerang," B-C, is 10 inches in length. To this arm, double hooks formed from ⅛ inch x ⅝ inch x 5 inches stainless steel are welded solidly to the "Boomerang" at points F and C. Distance from B to F is 2 inches. Double hook at C is flush with the end of the "Boomerang." All hook gaps must be ½ inch in width. The sides of the hook are ¾ inch deep on the inside and ½ inch deep on the outside. The strut to support the "Boomerang" angle against spreading is of 3/16 inch stainless steel rod 20 inches in length and firmly welded at points E and D. Hooks at F have the gaps facing down; those at C have the gaps facing upward. The device can be applied to any side of either leg brace, which is most helpful where some degree of upper extremity disability may be present.

The handpiece or grip has an additional piece of stainless steel tubing or aluminum ½ inch (outside diameter) x 5 inches in length slipped over the end, A-E, to increase the diameter of the grip. The handgrip is then dipped several times in Plastisol to build up a thick protective and comfortable covering. The hook end, B-C, is dipped enough to allow minimal coating which eliminates scratching of the brace uprights. Plastisol is used because it has the advantages of 1) a comfortable grip, 2) an easily cleaned surface, and 3) its durability against long and continued use. The weight and cost of the "Boomerang" have been kept at a minimum by using lightweight materials (approximately 1½ pounds) that should not exceed ten dollars.

A leather case (holster) or straps can be attached to the wheel-chair to hold the device for convenience at hand.

Discussion

Figure 3 illustrates the starting position for obtaining knee extension. Note that the "Boomerang" feature of this device permits the greatest component of pull in the long axis of the femur practically throughout the entire extension phase. Figure 4 shows the leg not quite fully extended. It is within these last few degrees of full extension that devices heretofore proposed have fallen short in that there has not been sufficient offset provided for pull rather than downward push. The angle at B should be 130 to 140 degrees for optimum mechanical advantage. Figure 5 shows the leg brace fully extended and locked. It can be seen that while comfortably and safely seated the patient still has plenty of room. Without the "Boom-

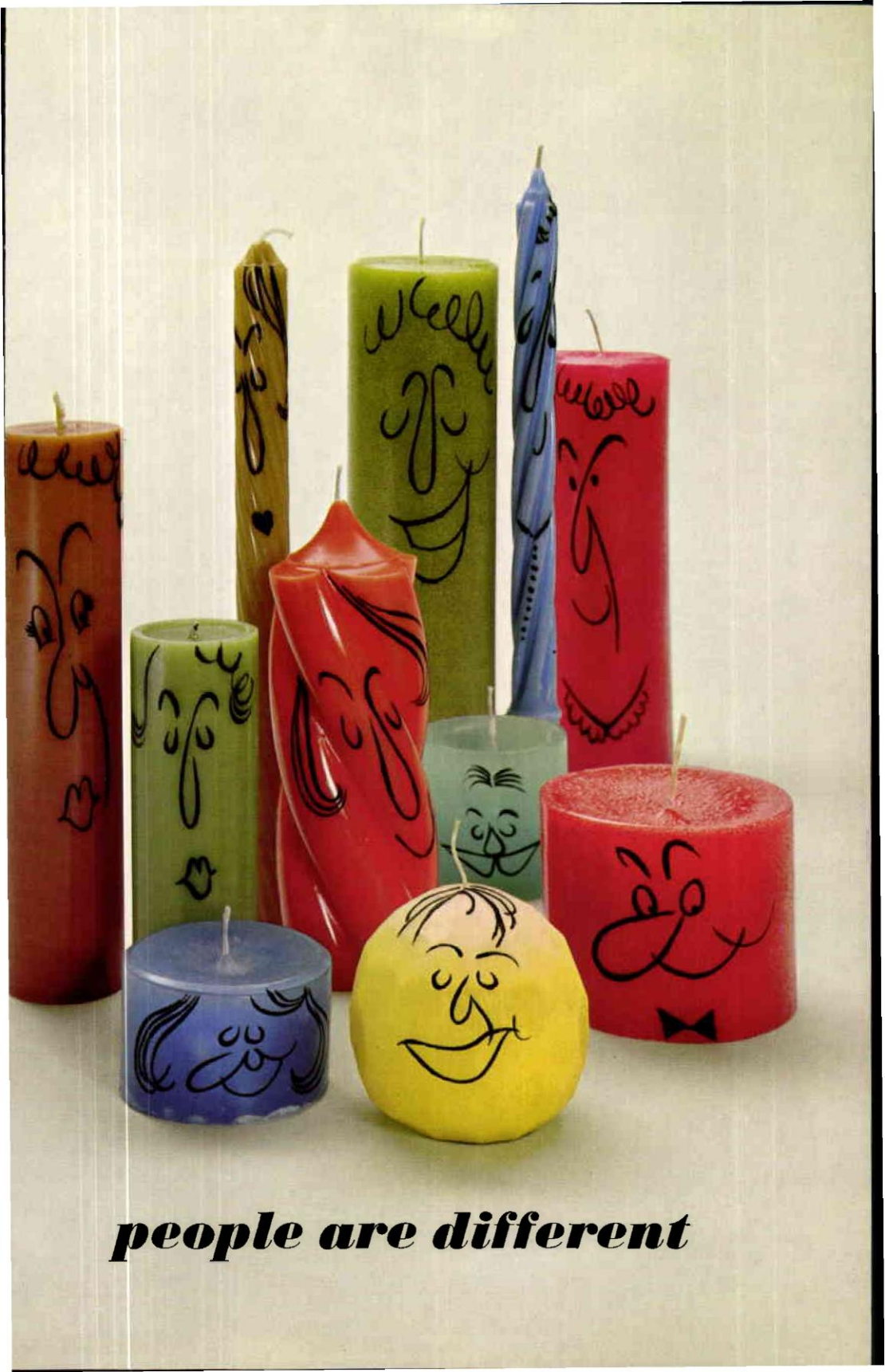
erang" feature (e.g., straight bar) the patient would have to move forward in the seat and would have to apply all pressure in a downward direction, or push, at this phase of the procedure. Torque, spring, and tissue yield, would add to the difficulty where a straight lever is employed in the last few degrees of extension. Torque is a negligible factor in the use of this device.

Conclusion

The Becker "Boomerang" has proven itself not only as a time saver, but as a device that has made possible a patient being able to extend his long-leg braces to the knee-lock position without human aid. This lightweight model is relatively new and has been tested only at the Spain Rehabilitation Center. These tests, however, have proven its advantages already mentioned — it is lightweight, rust-free, strong, cosmetically acceptable, has a comfortable grip, and the easily cleaned Plastisol surfaces are durable even with continued use.

Since the modified device weighs less than 1½ pounds and is quite easily handled by the average patient having paralyzed or weakened lower extremities, the weight-strength relationship need not be changed to accommodate individual patients. Lighter materials such as tempered aluminum and magnesium may be used providing this results in no significant reduction in strength. The "Boomerang," as described, is extremely rugged and repairs are seldom necessary even after years of continuous use.

This project has been supported, in part, by the Social and Rehabilitation Services grant, Rehabilitation Research and Training Center, Medical, RT-19, University of Alabama.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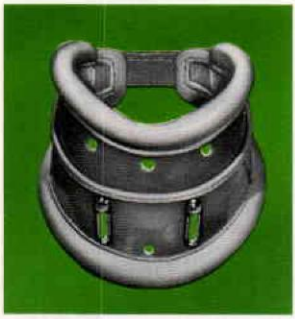

Cervical collar

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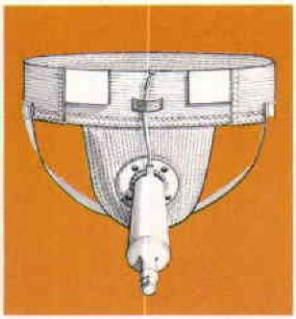

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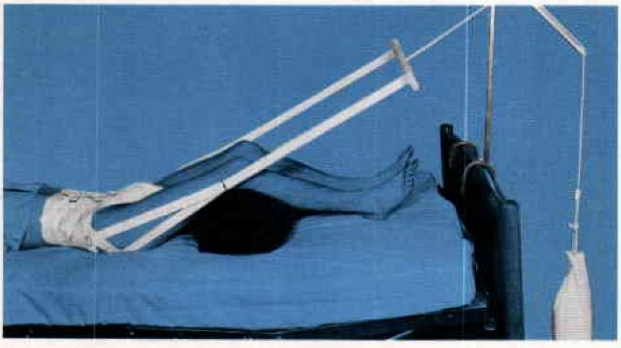

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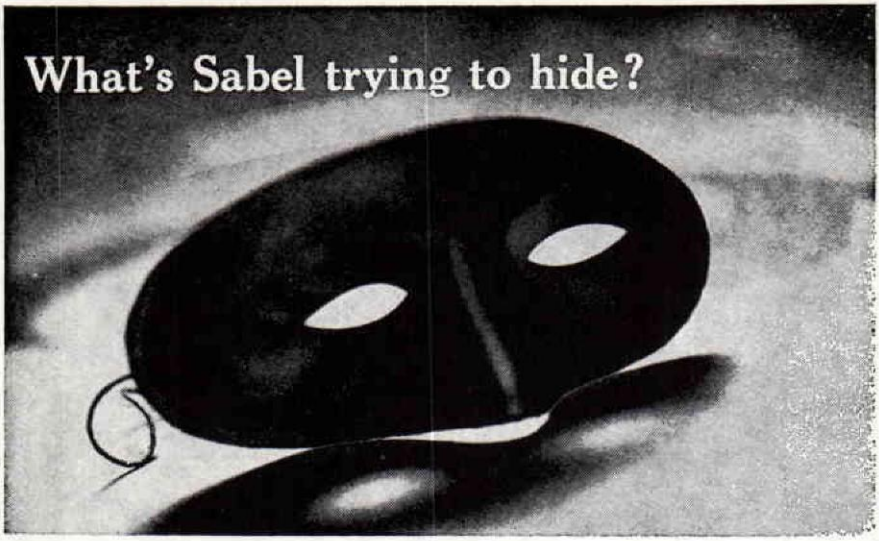

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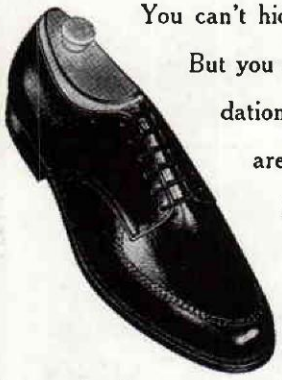

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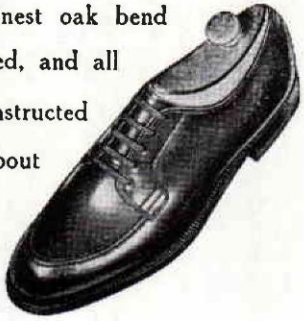

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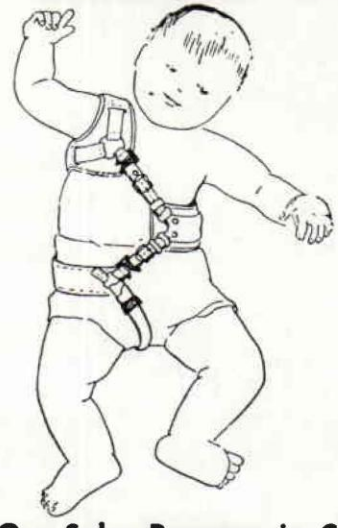

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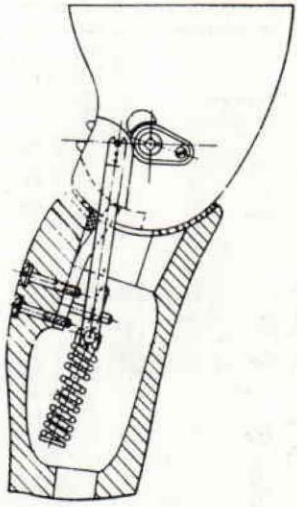

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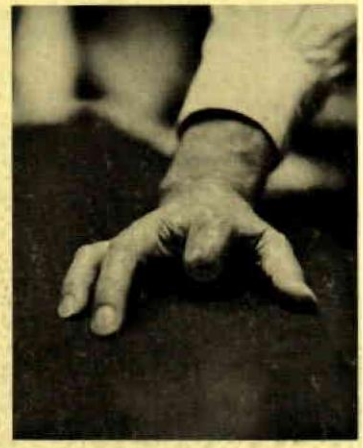

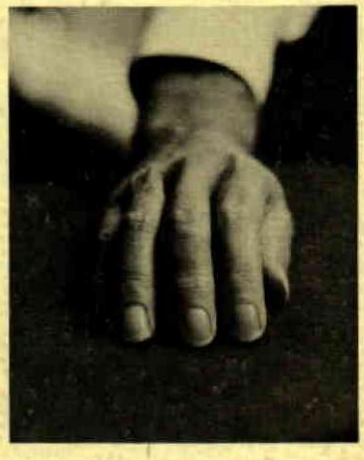

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