

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

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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.

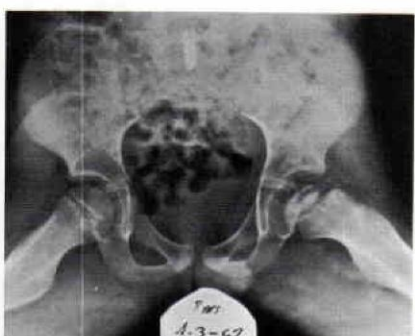


FIGURE 3 A-B—Regenerative stage of Legg-Perthes' disease. Note presence of radiolucent areas and fragmentation of condensed epiphysis. Revitalization of femoral head is taking place by creeping substitution.

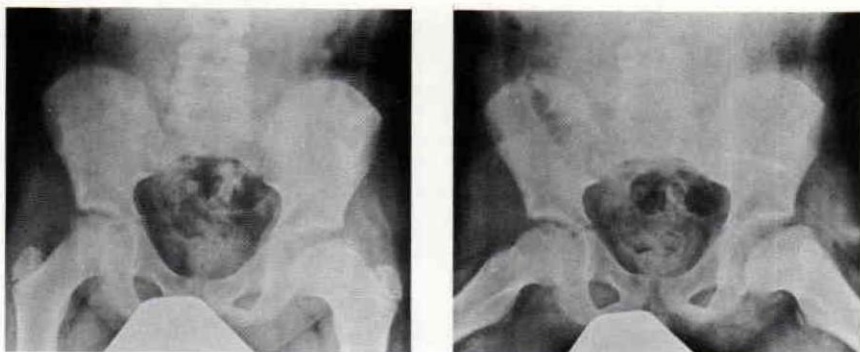


FIGURE 4 A-B—Residual or coxa magna stage. Note flattening and mushrooming of epiphysis and broadening of neck of femur.

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.

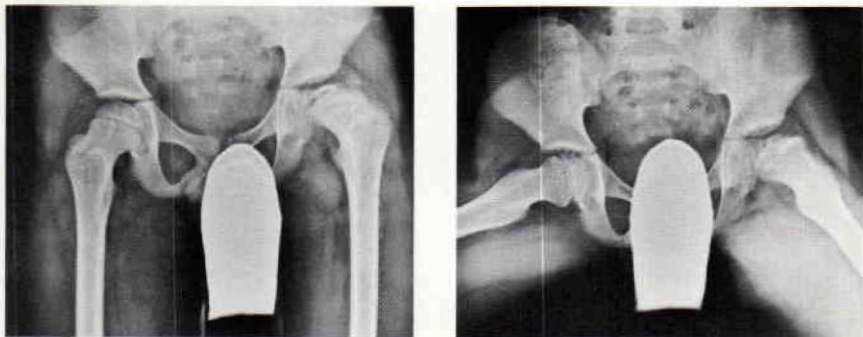


FIGURE 6 A-B—Total type of involvement.

### **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

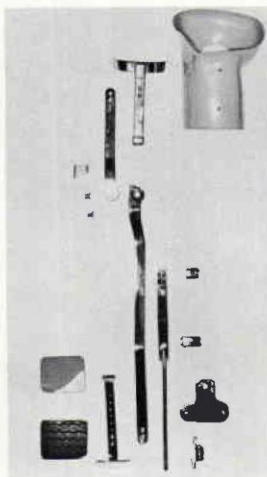


FIGURE 7-E



FIGURE 7-F

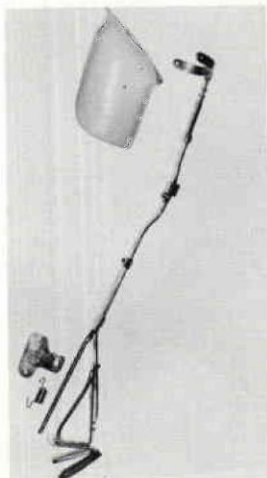


FIGURE 7-G

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.

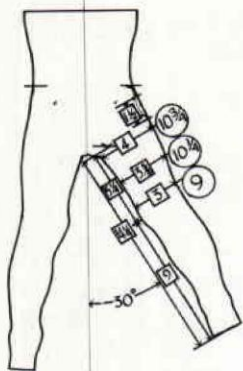


FIGURE 8 A—Measurements and tracings for the trilateral socket hip abduction orthosis. Outline of the lower extremity—anterior view.

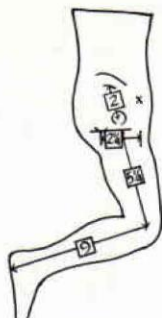


FIGURE 8 B—Outline of a lateral view of the lower extremity.

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).

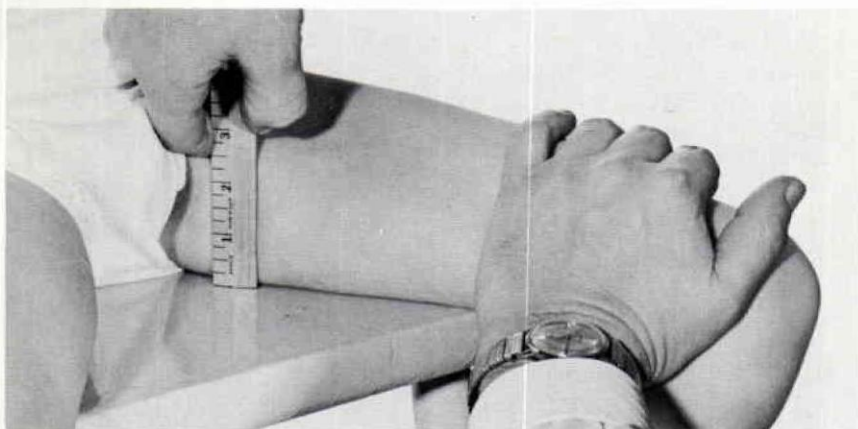


FIGURE 9—Method of A-P measurement from the ischial tuberosity to the apex of Scarpa's triangle. Note how the adductor longus is made prominent by asking the patient to adduct the thigh against resistance.

### 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  $\frac{1}{4}$ " to  $\frac{1}{2}$ " 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

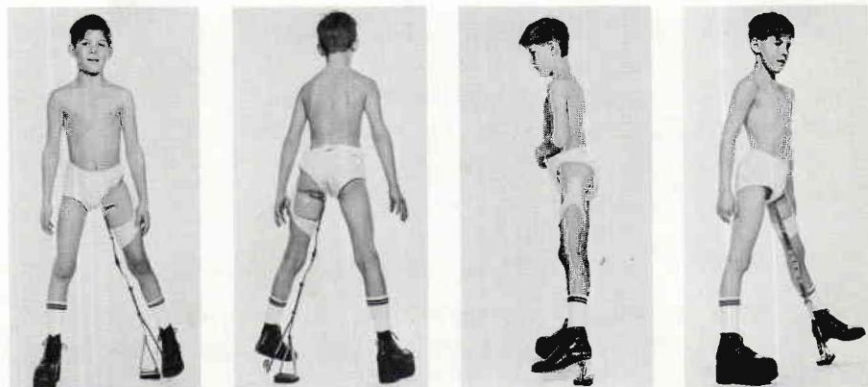


FIGURE 12-A

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 plantar 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—Roentgenogram 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.