

A HIP-ABDUCTION ORTHOSIS FOR LEGG-PERTHES DISEASE

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There is general agreement that the soft femoral head should be contained within the acetabulum during the fragmentation and reparative stages of Legg-Perthes disease. Deformation of the femoral head occurs because of lateral subluxation and the effects of the resultant abnormal compressive forces upon the biologically soft capital femoral epiphysis. Many attempts have been made to reduce the weight-bearing stresses across the affected hip joint. Strict bed-rest is one of the procedures tried but this is detrimental to the psychological well-being of the child since it removes him from his natural surroundings. Moreover, it does not prevent lateral subluxation and resultant head deformity. Bed-rest in abduction splints gives better results, but still has the inherent problems just mentioned. It has been felt by some that the child should be allowed to ambulate so that he could participate in school and other social activities. During this ambulation, however, the resultant deforming pressures on the femoral head should be relieved. Various methods and devices have been promoted to achieve this goal.

EARLIER WORK

The paten-bottom ischial weight-bearing orthosis was used for years in the Legg-Perthes Clinic at the Children's Orthopedic Hospital in Seattle. However, Salter (13) showed with cineradiography that, in a paten-bottom orthosis with an extension which included the chest, the affected hip subluxed laterally in the stance phase of gait. Petrie (10) reported excellent results with the use of bilateral abduction weight-bearing long-leg casts. From his work evolved the Toronto (4) Legg-Perthes Orthosis, which was much easier to use and more acceptable to the patient and parents. The Newington (5) Orthosis is similar to

the Toronto Orthosis but without knee motion. Tachdjian (15) designed an ischial weight-bearing, abduction orthosis which is worn only on the involved side. Glimcher (6) described a pogo-stick ischial weight-bearing orthosis with a different principle. A quadrilateral socket is used, which supports the pelvis, and as a result the abductors become inactive, because they are no longer necessary to keep the pelvis level. This factor decreases the forces acting on the femoral head.

We have felt that the most important aspect of all these devices is the provision for abduction and internal rotation in order to obtain complete containment of the soft femoral head within the acetabulum. Because of this belief we have modified some of the orthoses previously mentioned, and, over the past six years, have used a quadrilateral ischial weight-bearing hip-abduction orthosis which allows adequate abduction, excellent femoral head coverage (Fig. 1), and easy mobility without crutches, while causing the child very little hindrance. The foot is held in internal rotation to increase the coverage of the femoral head. The tubular support portion of the orthosis must



Fig. 1. X-ray of patient standing in orthosis, showing amount of coverage of the femoral head.

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be lengthened as the child grows, because the amount of abduction is decreased as the legs lengthen. For bilateral Legg-Perthes disease, the Toronto or Newington orthosis is still used in our clinic. It must be stressed that, prior to prescribing the orthosis, there has to be a normal range of motion in the involved hip, and to obtain this range, hospitalization, traction and an adductor tenotomy with or without an arthrogram may be required.

FABRICATING AND FITTING THE ORTHOSIS

GENERAL CONSIDERATIONS

The orthosis should be fitted and aligned to completely eliminate weight-bearing through the affected hip joint by providing ischial weight-bearing. Hip abduction of 35-40 deg., internal rotation of 20 deg., and knee flexion of 10 deg., are

considered to be optimum. Socket suspension is provided by a shoulder strap and occasionally a Silesian bandage to minimize pistoning of the orthosis on the leg and to provide rotational stability (Fig. 2). An appropriate shoe buildup of 2 1/2 to 3 1/2 in. is provided on the sound side (Fig. 3). The orthosis must be rugged enough to withstand the activities of children's play and its fabrication cost must be reasonable. By minimizing moving parts in the orthotic design, service requirements are reduced. Design characteristics should also accommodate growth of the child without having to provide a new orthosis periodically.

MEASUREMENTS AND TRACINGS

- With the patient in a supine position, a tracing of the extremity in the desired degree of abduction, internal rotation, and knee flexion, is obtained.



Fig. 2. Front view of the orthosis with shoulder strap and Silesian-bandage waist strap. Note the blocks under the vertical support bar made necessary because of growth.

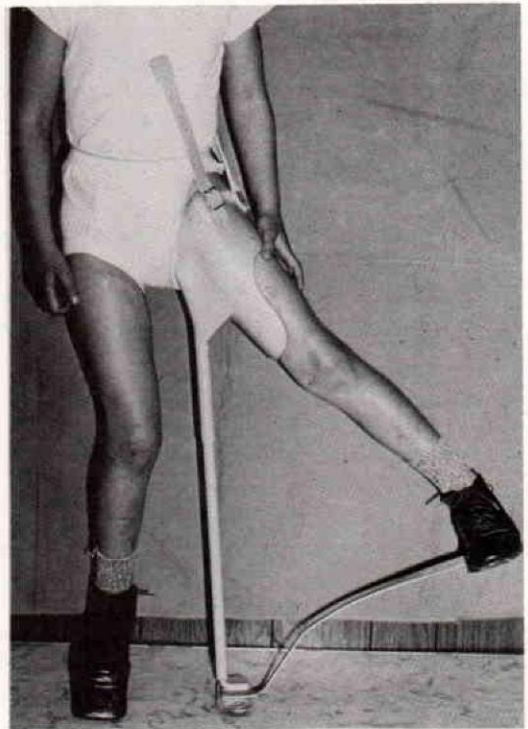


Fig. 3. Front view showing the built-up shoe on the uninvolved side to prevent weight-bearing on the affected side.

- Precise circumferential measurements from ischial tuberosity distally to the proximal border of the patella are secured at two-in. intervals.

- A-P and M-L dimensions at ischial level, including the measurement between the iliac crest and greater trochanter, are obtained.

- The length of the vertical support bar extending from the ischial tuberosity to the rocker base plus the height of the shoe extension, (2 1/2 in.-3 1/2 in.) is determined.

- The measurement for the shoulder-strap suspension is taken from the apex of Scarpa's triangle over the opposite shoulder to the greater trochanter.

- The measurement for the Silesian bandage is taken from the greater trochanter, over the opposite iliac crest, to the midline anteriorly.

- A pair of good quality high-top laced shoes, preferably with leather soles and an internal reinforcement steel shank, are obtained.

CASTING

The thigh shell is cast with the limb in 10 deg. of hip flexion and 35-40 deg. of hip abduction, the precise degree being determined by the prescribing physician. Either hand molding or a prefabricated cast molding brim can be utilized to achieve a quadrilateral-shaped ischial-weight-bearing thigh shell. The proximal trimline of the thigh shelf must be horizontal medially and posteriorly when the extremity is abducted. The anterior trimline of the shell extends 1 1/2-2 in. proximal to the posterior and medial borders; and laterally includes the iliac crest.

- Cotton stockinette or a casting sock is applied over the thigh, buttock, and hip of the limb to be cast and is secured with a 1-in. elastic-webbing strap over the opposite shoulder.

- The use of elastic plaster-of-Paris bandage is recommended for a smooth and accurate replica of the limb. The initial plaster wrap is reinforced with two layers of conventional plaster bandage.

- The wet plaster wrap is molded into a quadrilateral shape as described previously.

- For removal the cast is split laterally with a cast cutter or equivalent after it has dried sufficiently.

- The negative cast is sealed and filled in the usual manner, and a holding pipe inserted, to provide a positive model.

CAST MODIFICATIONS

The positive cast or model is modified in the usual manner to establish relative tension of the resulting laminated thigh shell on the extremity and to assure proper fit, stability, and rotational control. This requires, usually, removal of small amounts of plaster from the plaster mold, similar to the procedures advocated for a quadrilateral above-knee socket (1).

To prolong the active use of the orthosis, especially in a growing child, it is permissible to fit the thigh shell initially over the trousers. Obviously this must be calculated and taken into consideration during cast modification, similar to fabrication of a quadrilateral socket fitted with a stump sock.

As the child grows and the thigh shell subsequently becomes tighter, the medial seam of the trousers can be split proximally and a zipper or Velcro closure installed to allow the trousers to be worn over the orthosis, thus providing additional room in the thigh shell itself to accommodate for the growth that has taken place.

- A-P, M-L and circumferential dimensions are established on the positive cast according to accepted fitting practices, i.e., similar to the procedures advocated for a quadrilateral socket (1).

- The mold is smoothed and prepared for vacuum lamination.

LAMINATION

- The thigh-shell lay-up requires a minimum of two layers of 1/2 oz. Dacron felt, plus four layers of nylon stockinette for a small thigh shell with a circumference of 12 in. or less.

- Additional reinforcement with fiberglass is advisable for larger sizes.

- The shell is laminated in the usual fashion with a 90-percent-rigid, 10-percent-flexible resin mixture, using the vacuum method.

ORTHOTIC COMPONENTS

- 1 ea. laminated thigh shell.
- 1 ea. steel tube 5/8 in. outside diameter, 1/16 in. wall thickness, 1/2 in. inside diameter. Approximate length as measured, ischial tuberosity to floor, plus 2 1/2-3 in.
- 2 ea. wood blocks, approximately 6 in. x 5 in.

- 1 ea. steel rod 1/2 in. \times 7 in. (baseplate attachment rod).
- 1 ea. steel plate 3/16 in. \times 5 in. (baseplate).
- 1 ea. steel shoe plate approximately 1/8 in. \times 1 1/2 in. \times 6 in. (depending on actual shoe size).
- 1 ea. steel abduction bar 1/8 in. \times 1 1/4 in. \times 25 in. (approximately), depending on size of child and degree of abduction.
- A rubber walking heel: small, medium or large as indicated.
- An assortment of rivets and machine screws.

ASSEMBLING THE ORTHOSIS

Preparatory to fitting the hip abduction orthosis, the thigh shell is trimmed as follows:

- Distally the medial shell wall is terminated 1 1/2 in. proximal to the adductor tubercle.
- A cutout is made in the lateral wall extending from the level of the greater trochanter distally.
- The remaining portion of the lateral shell extends proximally from the greater trochanter to the iliac crest.
- The posterior and medial proximal trimlines are horizontal when the extremity is in the desired abduction position (35 deg.-45 deg.).
- The anterior proximal trimline extends 1 1/2 in. to 2 in. proximal to the medial and posterior walls and provides compression in Scarpa's triangle, and a bulge for the quadriceps, respectively.
- All edges are well-rounded and smooth.
- The steel tube extension is prepared by flattening one end for a distance of 1 in.
- The flattened portion of the steel tube extension is bent to an angle equivalent to that of the medial proximal thigh shell. This bend will cause the posterior and medial socket trimlines to be horizontal and the tube extension to be vertical.
- A number-9 hole is drilled through the flattened portion of the steel tube and centrally on the medial thigh shell approximately 1 in. inferior to the proximal trimline. The inside of the hole in the thigh shell is countersunk and the tubing fastened to the shell with a 10/32-in. screw and nut.
- A 5/8-in. hole is drilled through the wood block lengthwise and the block is cut on the band-saw to conform to the abduction angle of the exterior medial wall of the thigh shell.
- The medial portion is contoured on the router to a precise fit and, with a mixture of Solka floc and resin, the wood block is fastened to the me-

dial aspect of the thigh shell and steel tubing.

- The outer contour of the wood block is tapered and rounded towards the steel tube and re-finished with several coats of resin.
- An appropriate size rubber walking heel is selected. The baseplate is cut and shaped to the upper dimensions of the rubber walking heel.
- One and one-half inches at one end of the 1/2 in. \times 7 in. steel rod is heated and bent to a 90-deg. angle. This 1 1/2-in. portion is then welded to the center of the steel baseplate prepared in the step above (Fig. 4).
- The abduction bar is attached to the anterior portion of the steel baseplate with one 10/32-in. screw and nut.

ANTERIOR VIEW OF LEFT ABDUCTION ORTHOSIS

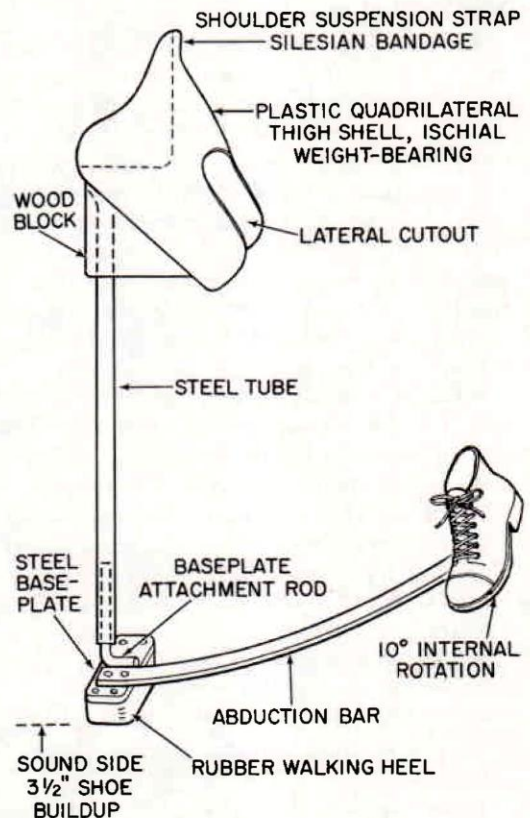


Fig. 4. Anterior view of left abduction orthosis.

- The rubber walking heel is attached to the steel baseplate with 6/32-in. screws and nuts applied at all four corners.

- The steel tube is cut to proper length and the steel rod, baseplate, rubber walking-heel assembly is inserted but not fastened.

- A wood buildup of 2 1/2 in. for a small child or 3 1/2 in. for a larger one is prepared and attached to the shoe on the sound side. A rocker contour is provided on the sole portion and the sole and rubber heel are attached to the buildup. (A Neoprene rubber buildup can also be used.)

- The other shoe is prepared for attachment to the abduction bar by removal of the heel from the boot. The steel shoe plate is shaped so that it fits to the outer contours of the shoe sole. The shoe plate should extend from the metatarsal heads to the center of the heel. The shoe plate is riveted to the shoe. (The shoe is not fastened to the abduction bar at this time.)

- The shoulder-suspension webbing strap and fasteners are prepared and attached to the orthosis.

The entire hip-abduction orthosis is now ready for fitting.

FITTING AND ALIGNMENT

- With the patient supine on a fitting table the leg with the foot in plantar flexion is slipped through the thigh shell.

- The shoulder-suspension strap is fastened.

- Both shoes are applied.

- The length of the orthosis is checked and adjusted as necessary. The pelvis on the affected side will appear slightly higher than the other due to abduction of the extremity. The orthosis should not be shortened excessively at this time but should be double-checked statically with the patient standing.

- With the patient standing between walking rails, the fit of the orthosis is rechecked.

- The ischial tuberosity is checked to be sure that it is properly located on the shelf portion of the posterior thigh shell.

- The pubic ramus and adductor longus are checked to be sure that adequate relief has been provided and adjustments are made if indicated.

- The orthosis should be considered to be too short if the patient flexes the sound extremity excessively during weight-bearing or mid-stance.

- The abduction bar is adjusted with bending

irons to an appropriate angle so that the shoe of the suspended extremity just touches the bar but without weight bearing. The foot is rotated internally 20 deg. on the abduction bar and the position on the shoe is marked.

- With the abduction bar internally rotated between 7-10 deg. on the steel baseplate, the position is marked by scribing through the second attachment hole with an awl.

- The baseplate and rubber walking heel are checked to be sure that they follow the line of progression. A mark is made on the steel tube to indicate the precise positioning.

- Any complaints of discomfort should be noted and investigated.

- The patient is placed back on the fitting table and the shoe and orthosis are removed.

FINISHING AND DELIVERY

All components previously held temporarily by screws should now be securely riveted in their marked positions, viz:

- the abduction bar to the baseplate.

- the rubber walking heel to the baseplate.

- the abduction bar (with excess material removed) to the shoe.

Two #13 holes, two in. apart, are drilled through the steel tubing and the rocker-assembly steel rod, and the parts securely fastened with two 3/16-in. steel rivets.

The orthosis is reapplied to the patient.

PATIENT INSTRUCTIONS AND GAIT TRAINING

At final checkout it may become necessary occasionally to add a Silesian bandage to counteract rotational instability and/or to maintain the orthosis in good contact at the lateral proximal thigh-shell extension. In most instances the need for this addition is the result of a loosely fitted socket. A temporary felt or leather liner in the thigh shell may eliminate this problem also. The general guideline here is an adequate fit which is nevertheless loose enough to accommodate future growth, since the orthosis might be worn for a period of up to two years and perhaps even longer. In our experience it has seldom been necessary to replace a socket to accommodate growth.

We initially fitted the trouser leg into the thigh shell in the case of a boy; added considerable pad-

ding inside the well-padded thigh shell in the case of a girl. The padding is gradually removed as growth occurs. Boys eventually may wear their trousers over the orthosis by splitting the seam medially to allow the orthosis to pass through. Velcro or zipper closure is provided.

Optimum alignment and positioning of the femoral head, in conjunction with an economical and rugged orthosis, are the basic considerations in the design of this orthosis which contains no moving mechanical parts.

Maintenance of the orthosis requires occasional replacement of the rubber walking heel, shoulder-suspension strap, or Silesian bandage, plus the unavoidable shoe changes and lengthening repairs. Otherwise, the maintenance costs are rather minimal considering the activity level and abuse to which the orthosis will be subjected. Instances have been recorded where children ride bicycles, climb trees and play baseball while wearing the hip-abduction orthosis.

It has been mentioned repeatedly by some prescribing physicians that the shoe buildup on the sound side is unnecessary. Indeed, we have fitted a small number of children who have done well without the customary shoe buildup on the sound side because it enhances the chances for "cheating."

Without the buildup, the child can place the involved leg, including the orthosis, into adduction. The knee on the sound side is flexed slightly, thus allowing weight-bearing through the abduction bar and the involved limb.

With the buildup in place, the flexion required about the sound knee obviously would have to be so great that it could not be retained comfortably for any significant period.

Of course, proper parental supervision, guidance, and strict discipline will help in controlling these abuses, but since children should not be taken for granted, every effort should be made to assure success even though it means adding the bulk and weight of the buildup to the system.

The patient and his parents are instructed concerning the importance of carrying weight-bearing forces through the ischial tuberosity on the posterior thigh shell (Fig. 5). No compromise is acceptable since violation of this requirement renders the orthosis ineffective. The patient has to be instructed to lean over the orthosis while bearing weight on the involved side so as to increase the amount of hip abduction. Initially,



Fig. 5. Posterior view of the orthosis showing the ischial weight-bearing seat.

walking attempts tend to bring the orthosis into abduction, and of course tripping results. Gait training by a qualified physical therapist is essential to good management of the patient. The child should be encouraged to pursue all normal activities so long as weight-bearing through the ischial tuberosity is maintained. In a matter of days the child should be able to balance and walk with one crutch and within two weeks should walk about freely without assistive devices.

Upon delivery of the hip-abduction orthosis, the patient is requested to return to the prescribing physician for a general checkout that should include a standing weight-bearing pelvic x-ray to ascertain good femoral head positioning and alignment in relation to the acetabulum (Fig. 1).

In follow-up clinic visits all x-rays should include the entire pelvis so as not to miss any bilateral hip involvement.

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