

# Fabrication and Fitting Instructions: Trilateral Perthes Orthosis

(Developed by M.A. Tachdjian, M.D.  
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Legg-Perthes' disease, osteochondrosis of the femoral head, is a condition that affects the femoral head of pre-adolescents, primarily boys of three to ten years of age. For some unknown reason, the femoral head suffers an episode of avascular necrosis followed by spontaneous regeneration of the bone. During the process, the head is malleable, and, if subjected to deforming forces, will adopt a flattened aspect that can eventually cause pain and arthritis.

To preclude this possibility, a number of treatment schemes have been developed over the years. Many of them rely on the so-called containment theory. This holds that, if the femoral head is held inside the acetabulum as the bone regenerates, it will adopt a normal congruent aspect. To achieve the position of containment, the femur is abducted and internally rotated. In addition to these criteria, the Trilateral Perthes Orthosis<sup>1</sup> endeavors to unweight the femur with ischial-gluteal weight-bearing. In contrast, the Toronto Orthosis<sup>2</sup> relies on bilateral abduction and internal rotation and dispenses with the weight-bearing component, and the Scottish Rite Orthosis<sup>3</sup> relies solely on bilateral abduction.

The orthosis described in this article is essentially the same as was originally described by Mihran A. Tachdjian, M.D. and

Loren D. Jouett, C.P.O. in their article of 1968. That orthosis (Figure 1) included a medial upright with knee joint and drop lock and a patten bottom. An ischial-gluteal brim unweighted the affected hip. The medial edge of the brim was purposely fit

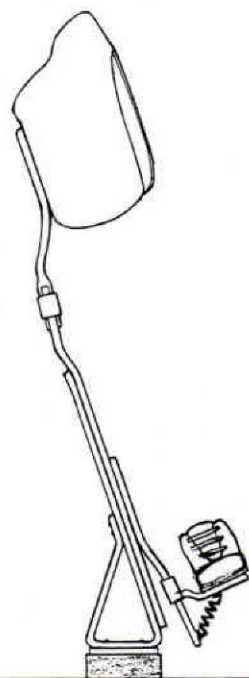


Figure 1: Trilateral orthosis as originally described by Tachdjian and Jouett.

high enough to cause discomfort if the patient adducted to  $20^\circ$  or less. This, in combination with the lengthening of the distal components, encouraged abduction. The posterior portion of the socket, proximal of the ischial seat, was fit high to encompass the inferior portion of the buttock and to block external rotation. This, in combination with the strap on the shoe, encouraged internal rotation.

The combination of the three factors—unweighting of the limb, abduction, and internal rotation—strove to accomplish the goals of protecting the diseased hip and maintaining it in the proper position for healing. The stirrup was rivetted to the shoe and free to move up and down and rotate on the round slide guide extension bar. A spring running from the end of the slide guide extension to the stirrup provided suspension, and a  $2''-2\frac{1}{2}''$  compensatory lift on the contralateral shoe completed the orthotic design.

There have been, of course, other designs similar to the design of Tachdjian and Jouett. Writing in 1970, Glimcher, Radin, and Amrich<sup>4</sup> described an orthosis they referred to as the Pogo Stick Brace (Figure 2). Like the Trilateral Orthosis, this device incorporated provisions for ischial-gluteal weight-bearing, abduction, and internal rotation. Unlike the Trilateral Orthosis, it attempted to reduce forces on the hip to the absolute minimum by reducing the activity of the hip abductors. The authors correctly argued that the muscular forces acting on the hip were, in some phases of gait, many times the body weight and cited in support of this fact the work of Inman, Paul, and Rydell. Their decision to eliminate the abduction forces on the hip is, of course, a logical extension of the decision to eliminate weight-bearing.

This objective of eliminating abduction forces was to be accomplished not just by putting the hip abductors in a relaxed position, but also by denying the lever arm (the leg in this case) any purchase. To this end, there was no rigid attachment to the patient's leg distally. An "ankle band retainer" consisting of spring steel, about 12 inches long, and bent in a "U" shape, was fastened to the weight-bearing pylon tube.

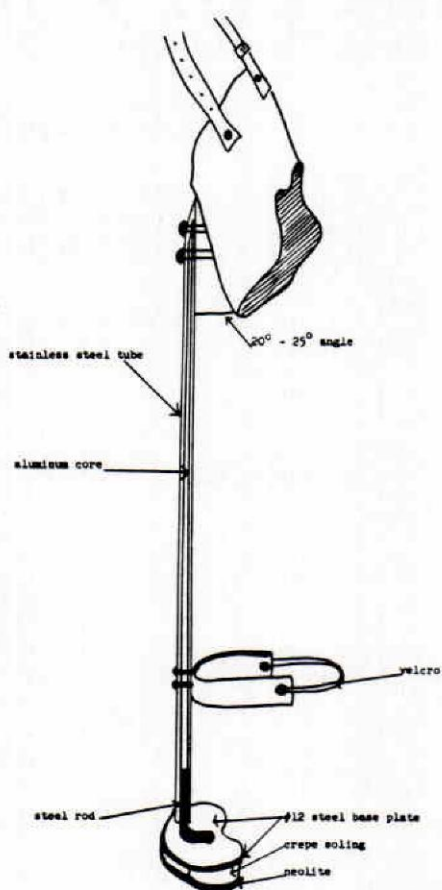


Figure 2: Pogo stick brace as described by Glimcher, Radin, and Amrich. Illustration reprinted from the original article (4) and used with the permission of the editor and authors.

A loose Velcro<sup>®</sup> strap laterally completed the retainer. This retainer and its strap were loose enough that no mechanical purchase could be obtained by the leg. Indeed, the parents of the child being fitted were to modify his pants legs to very loose oversize bell bottoms so that no stabilization from that source could be obtained. A shoulder strap to suspend the orthosis was to be worn, as well as a spring wire dorsiflexion assist orthosis on the involved side. A  $3\frac{1}{2}''-4''$  buildup on the contralateral shoe completed the prescription. The authors stated that the first child had been fitted in March of 1964 and that at the time of writing, 24 children had been fitted.



## ANTERIOR VIEW OF LEFT ABDUCTION ORTHOSIS

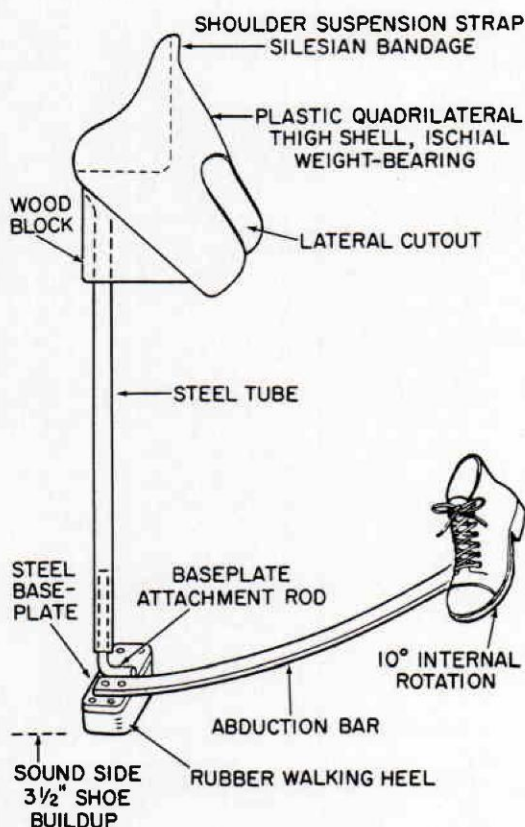


Figure 3: Abduction orthosis described by Birkeland and Zettl. Illustration reprinted from the original article (5) with the permission of the editor and authors.

In 1974, Birkeland and Zettl<sup>5</sup> described another variation on the same theme. This (Figure 3) consisted of the now familiar plastic trilateral socket, a medial weight-bearing pylon tube, and an abduction bar attached to the pattern bottom and to the patient's shoe to hold the leg in abduction and internal rotation. A shoulder strap and sometimes a Silesian band were used to suspend the orthosis, and, like the pogo design, no provision was made for knee flexion.

Birkeland and Zettl deliberately eliminated all moving parts from the orthosis and cited as the advantages of such a

move ruggedness of design and minimal maintenance. Apparently, little restriction of patient's activities were experienced, for they described instances of children climbing trees, riding bicycles, and playing baseball with the orthosis on. The authors stated that they had had six years experience with this design and that it was their prescription of choice for unilateral involvement. For instances of bilateral involvement they relied on the Newington and Toronto orthoses.

Birkeland and Zettl, as did the other authors cited, described the use of a shoe lift (approximately  $2\frac{1}{2}$ "– $3\frac{1}{2}$ ") on the opposite side. They felt that use of such a lift was necessary to prevent the child from bearing weight on the involved limb. Without the lift it would be possible to flex the knee of the sound side, adduct the hip of the involved leg, and bear weight through the abduction bar. The use of a lift on the sound side meant that so much flexion of the involved hip would be necessary that it would quickly become uncomfortable.

In contrast, the trilateral orthosis depends on the length of the medial support bar and patten bottom as well as the discomfort of the medial brim to hold the leg in abduction. This, of course, obviates the expense of obtaining and maintaining a lift on the opposite shoe.

It has also been argued that a shoe lift is necessary to protect the diseased hip should the patient adduct it. The theory is that if the child is not wearing a shoe lift, and if he adducts the involved limb, then a state of pelvic obliquity will result and an extreme amount of the femoral head will be exposed laterally. If he is wearing a shoe lift on the opposite side, and if he should adduct to the neutral position, at the very least, he will not be exposing an extreme proportion of the femoral head even if the position is undesirable.

The problem with this argument is that if the patient is fitted with a shoe lift, and if the pelvis is to be level, then the orthosis must be adjusted to establish a level pelvis. The result is the same relationship as without a shoe lift, only the child is 2"–3" taller. In contrast to this theory, the authors con-

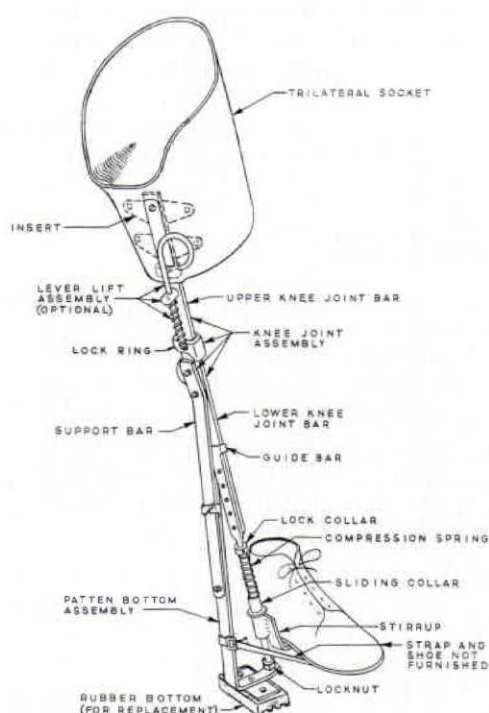


Figure 4: View of orthosis showing relationship of parts and proper nomenclature.

tend that the medial brim should be relied on to prevent adduction past a position of 20° abduction and should be deliberately modified so as to be uncomfortable in this position.

As originally described by Tachdjian and Jouett, the trilateral orthosis (Figure 1) was fabricated with a slide guide extension bar mounted on the lateral side of the distal knee joint upright and unsupported distally. Clinical experience in Chattanooga, Tennessee led to the conclusion that this arrangement was too weak, and Durr-Fillauer adopted the present design (Figure 4) in the version it now markets. Dates on the blueprints of parts for the prefabricated kits reveal that work began in the early part of 1969. The present day design has remained substantially unchanged since then.

Originally, when orthoses were centrally fabricated, it was specified that the ortho-

tist must furnish full measurements and a mold of the patient for the weight-bearing brim. However, as was often the case, orthotists neglected to secure an impression of the patient's leg before dismissing him from the office. As a convenience to orthotists in this predicament, we would endeavor whenever possible to furnish a laminated brim from one of the models on hand, selected on the basis of the measurements furnished by the orthotist. The resulting brims proved to be so suitable that some orthotists began ordering on the basis of measurements alone. Over a period of four years, from 1971-1975, a complete range of brim sizes accumulated. Today, prefabricated brims are available in a range of fourteen sizes, from 10½"-17", in one-half inch increments.

Indications for use of the Trilateral Perthes Orthosis include treatment of unilateral Legg-Perthes disease in pre-adolescents. While the orthosis may be used bilaterally, consideration should be given to orthoses intended for bilateral involvement, such as the Scottish Rite Orthosis.

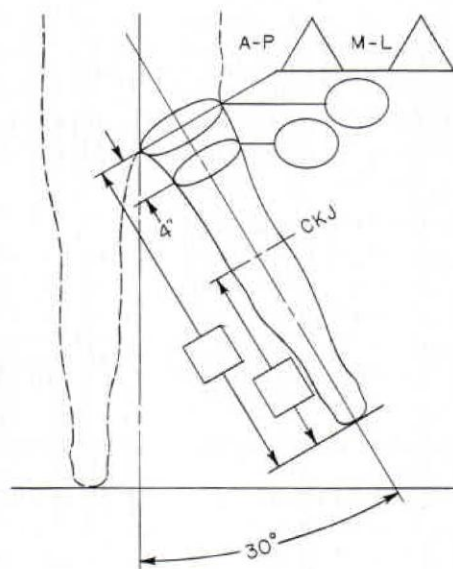


Figure 5: Tracing and measurements required. Solid line indicates the portion to be traced. Dotted line indicates patient's position.



Experience has shown that use of the trilateral orthosis bilaterally can be very uncomfortable in the perineum as well as difficult to walk on.

## OBJECTIVES OF THE TRILATERAL PERTHES ORTHOSIS

1. To hold the hip in a position of
  - a. 30 degrees abduction
  - b. 10-15 degrees internal rotation
2. The application of ischial-gluteal weight-bearing to unweight the hip
3. To permit ambulation

## FABRICATION

Measurements & Tracing: (Figure 5)

1. Patient position: A mid-sagittal line, longer than the patient, is drawn on a sheet of paper, and the patient is centered on the line:
  - a. supine and with spine aligned in a straight manner
  - b. sound limb parallel with mid-sagittal line
  - c. affected limb—30 degrees hip abduction, neutral rotation, knee extended, ankle neutral.
2. Trace the affected limb from perineum medially to above the iliac crest laterally.
3. Indicate on tracing:
  - a. plantar surface of the foot
  - b. knee joint center
  - c. perineum
  - d. proximal edge of greater trochanter of affected limb (in 30 degrees of abduction).
4. Measure and record on measurement sheet:
  - a. length from plantar surface of the affected foot to the perineum
  - b. length from plantar surface to center of knee
  - c. circumference at perineum
  - d. circumference 4" (10.2cm) distal of the perineum

- e. anatomical anterior-posterior diameter from the ischial tuberosity to the adductor longus tendon
- f. medial-lateral diameter at the perineum and perpendicular to the long axis of the leg.

## CASTING

1. Drape patient with appropriate sized cotton stockinette from the waist to the distal thigh on the affected side. Stockinette should be slit medially to fit about perineum and secured with an elastic strap and clamps. If the cast is not extended beyond mid-thigh, it can always be removed without cutting.
2. Position patient standing on the sound leg with pelvis level. The hand on the sound side is used to hold on to a table edge, chair back or some similar object for balance. A box of an appropriate size should be used to rest the foot, and hold the leg in proper position.
3. Use an indelible pencil to mark on the stockinette the following landmarks:
  - a. ischial tuberosity
  - b. adductor longus tendon
  - c. greater trochanter
  - d. superior edge of the iliac crest
  - e. perineum
  - f. mid-thigh
  - g. using points a, b, d, and e as a guide, draw a smooth flowing line to indicate proximal trim line of socket. Include the gluteus maximus posteriorly inside the trim line (Figure 7).
4. Wrap the leg from above the proximal trim line to the mid-thigh with the plaster of paris bandage. Before the bandage sets, use the hands to indent it and form the medial brim, Scarpa's triangle, and posterior seat. The ischial seat should be perpendicular to the floor and the medial brim should be parallel with the line of progression.

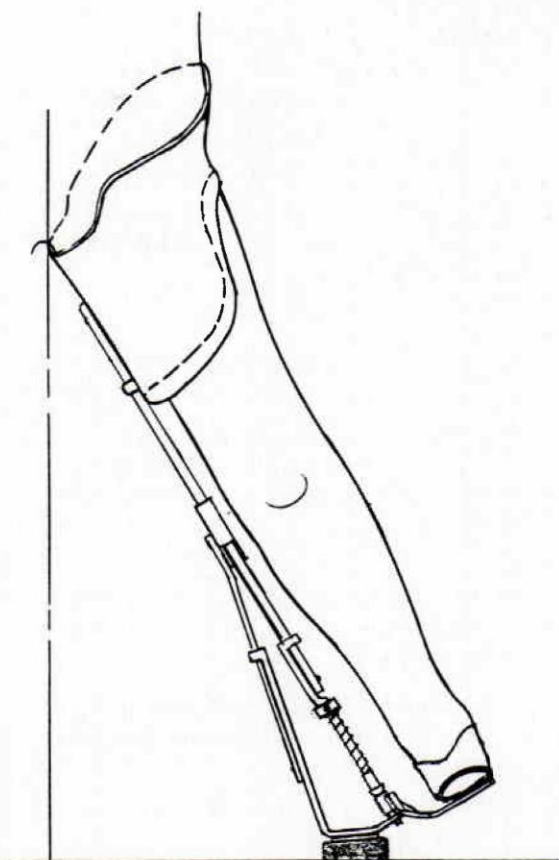


Figure 6: Assembled orthosis showing relationship to patient's leg and vertical and horizontal reference lines.

5. Remove the cast when it has set. The cast is sealed shut distally, the brims are extended proximally to the height of the lateral edge, and the negative model is poured with plaster of paris.

## MODIFICATION OF THE POSITIVE MODEL

The positive model is modified in a fashion similar to a quadrilateral socket:

1. The A-P diameter of the brim medially is  $\frac{1}{4}$ " (7mm)– $\frac{1}{2}$ " (13mm) less than the recorded anatomical diameter depending on size of the patient and musculature.

2. The ischial shelf is horizontal with the model in the desired position of 30 degrees abduction.
3. The M-L diameter of the socket is the same as the recorded anatomical diameter, or no greater than the proximal circumference divided by three.
4. The medial brim is parallel to the line of progression and flared. It should be high enough to impinge upon the pubic ramus in less than 20°–25° of hip abduction and  $\frac{1}{2}$ " (13mm)– $\frac{3}{4}$ " (20mm) wide.
5. The proximal circumference is reduced  $\frac{1}{2}$ " (13mm)–1" (25mm) less than the recorded circumference, depending on patient size and tissue firmness.
6. The distal circumference is reduced to anatomical measurement.
7. The posterior brim is  $\frac{3}{4}$ " (20mm) wide at the ischial tuberosity and tapers to nothing laterally.
8. Laterally the height of the brim is at the iliac crest and posteriorly it curves in a smooth flowing line to enclose the inferior portion of the gluteus maximus. Anteriorly over the Scarpas' triangle and laterally of it, the brim flares outward for comfort and is trimmed low enough to prevent impingement of the ASIS. Lateral of this point it rapidly turns proximal to a point on the lateral side just inferior of the iliac crest. The brim in this region exhibits an outwardly radiused edge to prevent pressure from a sharp edge when the leg is abducted.

## LAMINATION

1. The appropriate sized trilateral kit is selected from among those available (see Table 1).
2. The modified positive model is prepared for vacuum laminating in the usual fashion.



| Catalog Number | Description          | Knee Joint Bar Size                   | Guidelines                               |
|----------------|----------------------|---------------------------------------|--|
| 3176-XLK-LR    | X-LARGE, LONG, Right | $\frac{3}{16}'' \times \frac{3}{4}''$ | Perineum to floor greater than 30 inches |
| 3176-XLK-LL    | X-LARGE, LONG, LEFT  |                                       |  |
| 3174-XLK-SR    | X-LARGE, SHORT       | $\frac{5}{32}'' \times \frac{3}{4}''$ | Perineum to floor 26"–30", Obese         |
| 3174-XLK-SL    | X-LARGE, SHORT       |                                       |  |
| 3175-LK-LR     | LARGE, LONG, Right   | $\frac{5}{32}'' \times \frac{3}{4}''$ | Perineum to floor 26"–30", Normal size   |
| 3175-LK-LL     | LARGE, LONG, Left    |                                       |  |
| 3173-LK-SR     | LARGE, SHORT, Right  | $\frac{5}{32}'' \times \frac{5}{8}''$ | Perineum to floor 24"–26", Obese         |
| 3173-LK-SL     | LARGE, SHORT, Left   |                                       |  |
| 3172-MK-R      | MEDIUM, Right        | $\frac{5}{32}'' \times \frac{5}{8}''$ | Perineum to floor 20"–24", Normal        |
| 3172-MK-L      | MEDIUM, Left         |                                       |  |
| 3171-SK-R      | SMALL, Right         | $\frac{1}{8}'' \times \frac{5}{8}''$  | Perineum to floor less than 20 inches    |
| 3171-SK-L      | SMALL, Left          |                                       |  |

Table 1.

- One layer of one-half ounce dacron felt is applied to the model with additional strips about the brim. Two layers of nylon stockinette are applied (three for large sizes).
- The insert furnished with the trilateral kit (either #3137 or #3138 depending on size) is contoured to fit about the model so that the longitudinal portion of the insert lies along the mid-line of the medial wall of the model and parallel to the long axis. A piece of scrap stainless steel appropriately sized (as long as the insert and the same size as the knee joint upright) is selected, secured in place to the insert with a cap head screw proximally, and the adjustment clips of the insert are formed around it distally. This piece of stainless steel is a laminating dummy and will form a recessed channel in the lamination for the proximal upright.
- The screw holes of the insert are greased with vaseline and it is wrapped in fiberglass. It is sandwiched between four layers of fiberglass, and gauze is used to securely wrap it in place on the model. The fiberglass should extend just short of the trimlines.
- An additional two layers of nylon stockinette are applied (three for large sizes).
- The model is laminated with an 80/20 mix of rigid and flexible polyester resin.
- Once the lamination has reached its peak exotherm and while it is still pliable, a knife is used to trim the proximal and distal trim lines exposing the distal end of the insert and the laminating dummy. The knife is used to remove the lamination from over the laminating dummy while leaving the adjustment clips of the insert enclosed in plastic. The cap head screw is removed and the laminating dummy is driven out distally using a hammer and pin punch. The socket is removed from the model while still warm.
- The socket is trimmed as follows:
  - proximal—described under Modification of Positive Model.
  - distal—perpendicular to long axis and at level of distal end of insert.
  - lateral keyhole—proximally, the cutout is as high as the proximal edge of the greater trochanter and as wide in the anterior and post-

erior dimension, distally the cut-out meets the distal edge in smooth flowing curves.

- d. The screw holes (8-32 for small 3138, or 10-32 for large 3137) are drilled clear and retapped.
- e. All edges are finished and buffed.

## LAYOUT

(Figure 6)

1. Draw a line parallel with the longitudinal (parasagittal) axis of the leg and  $\frac{1}{4}$ " (7mm) medial of the medial condyle of the knee from the perineum to a point well distal of the foot. This becomes the medial longitudinal reference line and the orthosis will be laid out along it.
2. Transfer the heights of the knee joint center and of the perineum to the drawing measuring proximal from the sole of the foot.
3. Draw a line parallel and  $\frac{3}{4}$ " (20mm) distal of the anatomical knee joint

center. This will be the orthotic knee joint center. The orthotic knee joint is fit distal to the anatomical so that when the patient kneels, weight will be transferred through the orthosis and not through the leg.

4. Draw a line parallel and  $1\frac{3}{4}$ " (45mm) distal of the sole of the foot. This is clearance for the patten bottom.
5. Draw a line perpendicular with the midsagittal line such that it intersects the point defined by the patten bottom line (step 4 above) and the medial longitudinal reference line (step 1). This is the floor line and it, in conjunction with the two lines mentioned in steps 4 and 5, defines the position of the patten bottom.

## ASSEMBLY OF THE ORTHOSIS

(Figures 4, 7)

1. The knee joint assembly is laid out along the medial reference line and

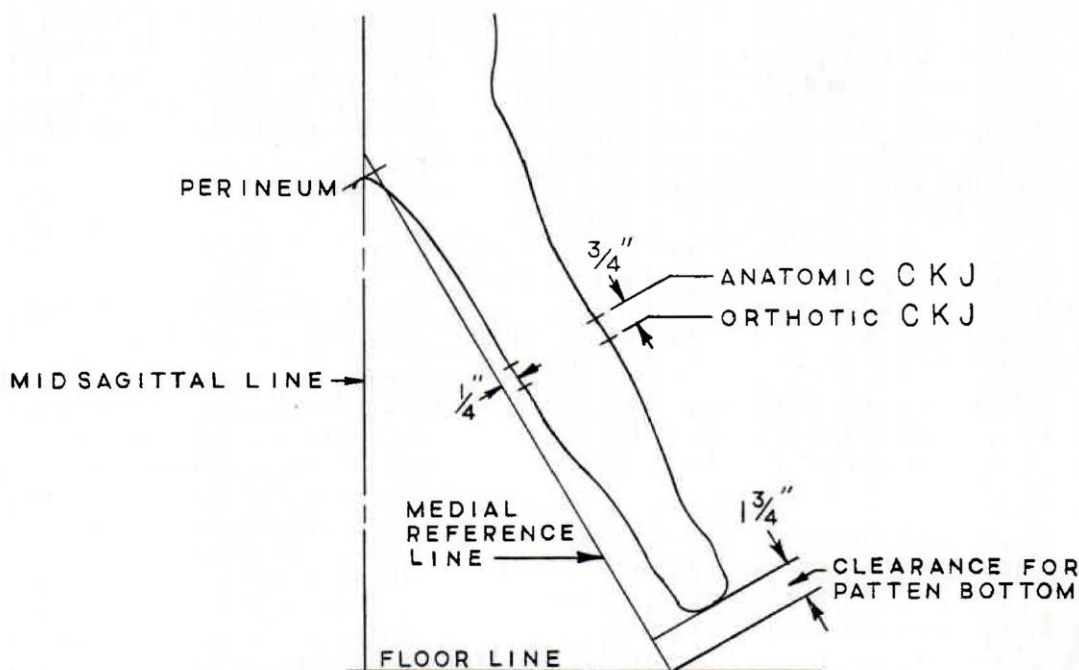


Figure 7: Layout of reference lines on the tracing for construction of the orthosis.



the knee support bar (#3111 or #3112) is contoured proximally so that the distal surface of the rubber bottom (#3118) of the patten bottom (#3114, #3115, #94 3116) lies parallel to, and on, the floor line.

2. Contour the adjustment clip of the patten bottom upright about the support bar and adjust the upright and support bar to the proper length.
3. To remove excess material from the support bar, cut it off  $\frac{1}{2}$ " (13mm) distal to the distal screw hole of the patten bottom plate upright.
4. Drill and countersink a hole (8-32 body drill) for the attachment screw at the distal screw hole of the patten bottom plate.
5. Assemble the upright guide bar (#3121, #3123, #3125, #3126, #3127, #3129, or #3131) and the patten bottom plate. In a fashion identical to steps 2, 3, & 4 above, the distal upright of the knee joint (#365, #366, #361, #362, #371, #372, #375, or #376) is cut to length and it and the upright guide bar are assembled together.
6. Excess material is removed from the proximal knee joint upright (#400, #402, #403, or #404) so that the medial brim coincides with the perineum. A screw hole (8-32 body drill #19) is drilled and countersunk in the upright for attachment to the proximal hole of the insert in the trilateral socket.
7. The orthosis is disassembled and all cut edges are smoothed and rounded and it is finished in the usual fashion.
8. The heel of the shoe is removed and a "D" ring on a leather chafe is sewn between the welt and the sole in the vicinity of the first metatarsal head.
9. The stirrup (#2001, #2002, or #20040) is riveted to the shoe in the usual fashion. If desired, a layer of

leather can be used to cover the area of the stirrup.

10. The lock collar (#3105LG or #3105SM), compression spring (#3107 or #3109), sliding collar (#3108 or #3106) with broad head down and stirrup are assembled on the upright guide bar in that order.
11. The guide bar is assembled on the patten bottom. The hex nut (#885145 or #885160) is tightened to lock the two together so as to prevent motion and wear.
12. The distal knee joint upright, support bar, guide bar, and upright of the patten bottom are assembled with the appropriate screws, lock-washers, and backing nuts.
13. The drop lock is put in place and the trilateral socket is assembled on the proximal upright with the appropriate screw.
14. A leather strap with the buckle on one end is passed through the "D" ring on the shoe, about the patten bottom upright, and is fastened to itself. This strap will internally rotate the leg while the pressure of the socket against the gluteus medius will prevent external rotation of the orthosis.

## FITTING

1. The orthosis is donned with a layer of stockinette on the thigh.
2. The patient is checked standing, in  $30^{\circ}$ – $40^{\circ}$  of abduction, for a level pelvis and proper ischial weight-bearing. If the patient complains of discomfort in the region of the pubic ramus, and if he is standing in abduction, check to be sure that the ischial tuberosity is on the ischial seat. If the ischial tuberosity is slipping into the socket a loose fit should be suspected and additional socks added. Only as a last resort should the medial brim be modi-

fied—and only then minimally—bearing in mind that the orthosis is intended to be uncomfortable in a position of adduction. The stirrup should be in about the middle portion of the upright guide bar. The toe strap should be adjusted to maintain the leg in internal rotation.

3. With the patient kneeling, check to be sure that weight is borne through the orthosis and not through the leg. If necessary, adjust the upright above and below the knee to provide kneeling weight-bearing through the orthosis and yet maintain the proper overall height.
4. With the patient walking, check for abduction and internal rotation. The stirrup should be checked to make sure it does not "bottom out" (contact the metal at the ends of the guide bar) proximally or distally. The lock collar should be adjusted so that compression of the spring provides suspension of the orthosis without undue pressure in the perineum which will cause discomfort. If necessary, the spring and/or the slide collar may be cut to reduce the pressure.
5. Recheck and tighten all screws. Locktite® may be used on the knee joint screw.

The patient and parents should be instructed in the principles of the orthosis and to expect discomfort—medially, if the

orthosis is adducted, and over the ischial tuberosity for the first few days. The patients should be encouraged to attempt internal rotation and abduction during ambulation. They should be instructed in care of the orthosis. The parents should be advised to supervise the patient's walking initially and to prevent such gait deviations as hopping or vaulting from becoming habits that cannot be undone.

Initial shrinkage may be expected during the first few weeks and may well necessitate additional socks to maintain proper fit. Eventually growth and increase in the patient's size should offset this decrease in circumference.

## NOTES

<sup>1</sup>Tachdjian, M.A. and Jouett, L.D., "Trilateral Socket Hip Abduction Orthosis For the Treatment of 'Legg-Perthes' Disease," *Orthotics and Prosthetics*, Vol. 22, No. 2, June, 1968, pp. 49-62.

<sup>2</sup>Bobechko, W.P., McLaurin, C.A., Matloch, W.M., "Toronto Orthosis For 'Legg-Perthes' Disease," *Artificial Limbs*, Vol. 12, No. 2, Autumn, 1968, pp. 34-41.

<sup>3</sup>Lovell, W.W., Hooper, W.C., and Purvis, J.M., "The Scottish Rite Hospital Orthosis for 'Legg-Perthes' Disease," Presented as a scientific exhibit at the Annual Meeting of the American Academy of Orthopaedic Surgeons in Dallas, Texas, February 23-28, 1978.

<sup>4</sup>Glimcher, M.J., Radin E.L., and Amrich, M.M., "The Design of a New Style Ischial Weight-Bearing Brace for Use in the Treatment of 'Legg-Perthes' Disease," *Orthotics and Prosthetics*, Vol. 24, No. 3, pp. 11-20, Sept., 1970.

<sup>5</sup>Birkeland, I.W., Zettl, J.H., "A Hip Abduction Orthosis for 'Legg-Perthes' Disease," *Orthotics and Prosthetics*, Vol. 28, No. 3, pp. 49-55, Sept., 1974.

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