Toronto Orthosis for Legg-Perthes Disease

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The treatment of Legg-Perthes disease has been given considerable attention at the Hospital for Sick Children in Toronto during the last few years. It is now known that certain types of Legg-Perthes disease have a good prognosis regardless of the type of treatment used, whereas other types tend to have a poor prognosis. Proper prescription of treatment must, therefore, recognize this difference in prognosis.

Attempts have been made to assess the outcome of the disease on the basis of age at onset and the degree of involvement of the ossific nucleus of the femoral head.

In children who develop Legg-Perthes disease prior to the age of five years, the prognosis tends to be better than in a child who develops the condition at an older age. This difference is probably related to the total mass of bone that has to be re-ossified, since it has been noted that in a smaller femoral head the time for re-ossification is often shorter, being in the vicinity of 12 to 18 months compared to several years for an older child.

The degree of involvement also plays a most important part, and attempts have been made here to differentiate between cases where the entire femoral head is involved, with avascular necrosis of the entire ossific nucleus, and those where merely a portion is involved. The partial-head-type of Legg-Perthes disease carries a much better prognosis and is less liable to deformity, since a part of the femoral head remains uninvolved.

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If there is any tendency towards the formation of a metaphyseal cyst, the possibility of a poor long-term result is increased.

The stage at which the patient is first seen is of the utmost importance. If the child is seen early in the course of the disease, before joint deformity has occurred, proper management, if instituted quickly, can often result in a congruous joint. If, however, there is already considerable flattening and subluxation when the child is first seen, then the result, of course, cannot be as good. If the entire process of re-ossification has already occurred by the time the child is first seen, the golden opportunity has passed, and at this stage only secondary reconstructive procedures can be carried out, with even less satisfactory results.

Certain selected cases are suitable for innominate osteotomy, in which the femoral head is covered and seated just as if the hip were held in abduction and internal rotation. At present, innominate osteotomy is restricted to the child who carries an unusually bad prognosis; that is, a child over the age of six years with total involvement of the femoral head. In addition, an arthrogram must be made to be certain that a significant joint deformity is not already present. If a deformity is present, innominate osteotomy is contraindicated. In addition, prior to the use of an innominate osteotomy, full joint movement must be obtained, which sometimes will require traction or soft tissue release of contracted structures, such as the psoas tendon.

In the very young child with only a part of the head of the femur involved, often no treatment is indicated, provided that no soft tissue contractures have occurred. If soft tissue contractures are present, then soft tissue release may suffice, with or without a short period of traction.

This leaves a small group of children for whom bracing may be used to advantage. These children would typically be in the under-six age group, with partial or total head involvement and with free joint movement, before deformity has set in.

In the past, ischial weight-bearing braces have been used in the treatment of Legg-Perthes disease with little regard for the various forms and severity of the disease process. Cineradiography has revealed that as the patient walks with an ischial-bearing brace the involved hip tends to move medially and laterally, a condition which may contribute to subluxation and further flattening in the form of a coxa plana; therefore, use of such braces has been discontinued at the Hospital for Sick Children.

In 1957, Dr. William Craig[2] of Los Angeles first reported *(1)* the use of the abduction and internal rotation method of treatment of Legg-Perthes disease, a procedure which has been modified by Dr. Gordon Petrie[3] of Montreal (2). When a child was allowed to bear weight on the legs in the abducted cast, it was found that a remodeled femoral head would, in fact, develop in a spherical fashion in its round and uninvolved acetabulum. This method has proved satisfactory in many instances, but there are certain disadvantages. Because the child's legs must be kept in abduction for a period of several years, cast changes must be made at 8- to 12-week intervals. Considerable stiffness develops about the knees and ankles and, in some instances, there has been a suggestion of flattening of the femoral condyles because of the continuous pressure that is applied to the knee as it is held in one position over a prolonged period of time. In addition, prolonged plaster immobilization encourages the development of osteoporosis, atrophy of muscle, pressure sores, and other problems.

To eliminate some of the problems encountered with the use of abduction casts, a new type of articulated experimental brace has been designed. Known as the "Toronto Legg-Perthes Brace," it provides for 90-deg. abduction and slight internal rotation, yet allows hip and knee movements so that the child may ambulate and sit (Figs. 1 and 2). With the brace, the child is encouraged to walk as much as possible, for it is the weight-bearing movement with the hips centered in a safe position that encourages successful remodeling of the femoral head during growth. The brace is removed easily, but the child, of course, must not be allowed to walk without the brace. It is emphasized that at present (1968) this brace has been used on an experimental basis for the past 18 months, and we do not yet have any indications as to whether any problems will develop, such as those that were produced by ischial weight-bearing braces which, in fact, produced a coxa plana and probably did more harm than good. Cineradiography on one patient has indicated that the femoral head does stay within the acetabulum during loading and unloading of the joint.

Sixteen patients are presently using the Toronto brace and, in our present state of knowledge, this new type of brace appears to fulfill all the criteria set forth.

BIOMECHANICS

The Toronto brace holds the legs in 90-deg. abduction with respect to each other, with the feet rotated internally. The body weight, when the patient stands erect, is distributed axially through each leg to each foot. The shoes are fastened to blocks of wood with the plantar surface

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[3] Dr. James A. Petrie, Orthopaedic Surgeon, Royal Victoria Hospital, Montreal, P.Q., Canada.

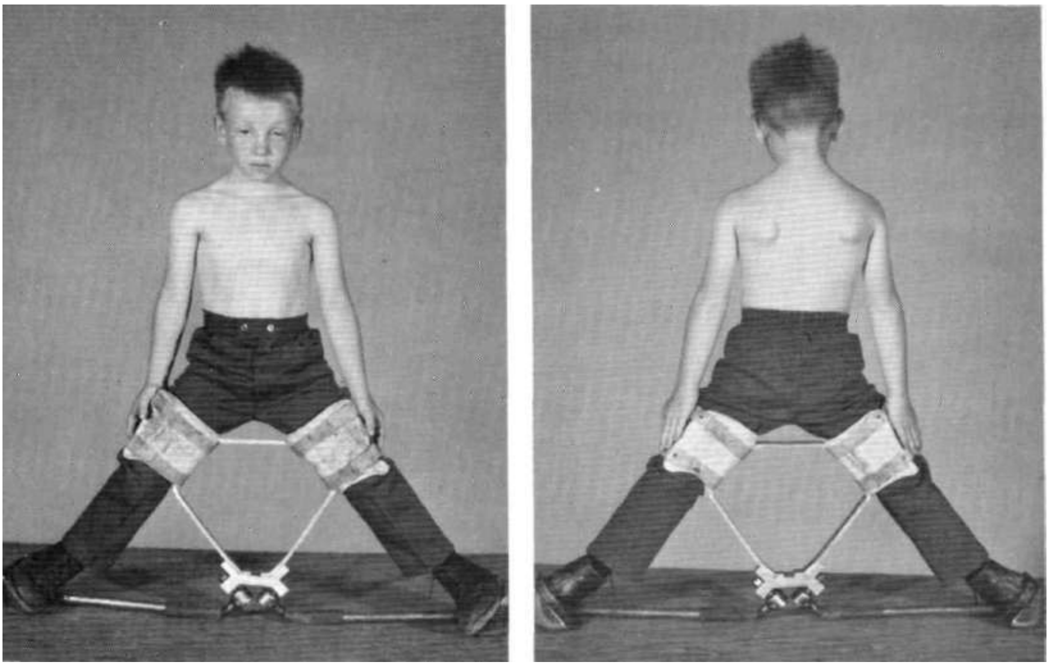

Fig. 1. Front and rear views of the Toronto brace for Legg-Perthes disease.

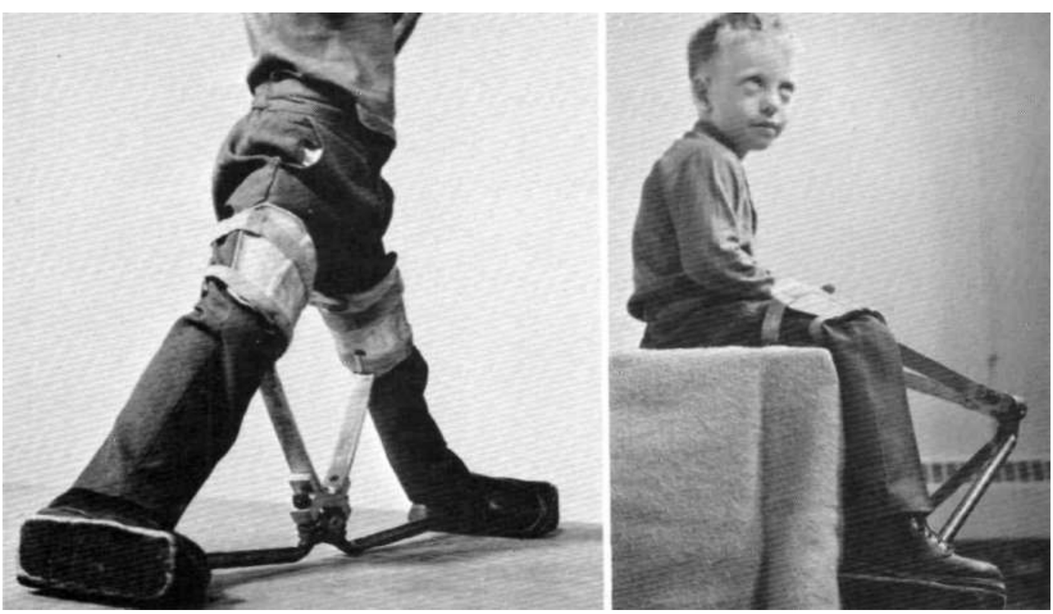

Fig. 2. The Toronto brace for Legg-Perthes disease in use. *Left,* Three-quarter view in the standing position; *Right,* side view in the sitting position. Note that the thighs are maintained in the abducted position at all times.

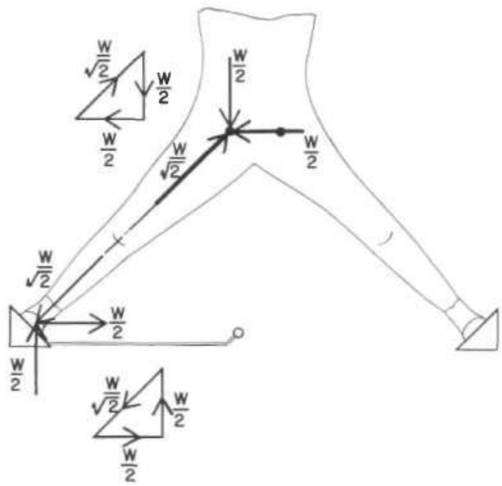

Fig. 3. Resolution of forces being applied to patient using the Toronto brace for Legg-Perthes disease.

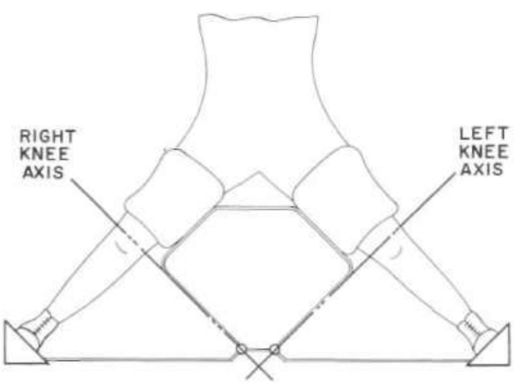

Fig. 4. Schematic view from the front of the Toronto brace for Legg-Perthes disease to show the geometry of the system.

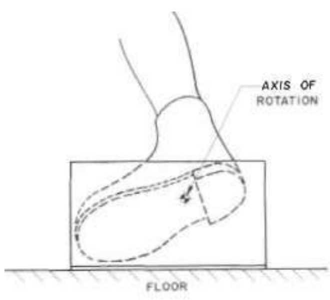

Fig. 5. Location of the shoe with respect to the foot block.

at an angle of 45 deg. to the floor. The foot blocks are tied together by rods which are rigidly attached to the blocks but articulated at the sagittal plane. The force diagram is shown in Figure 3.

Each tie rod is connected by a ball joint to a rigid frame that supports the two thigh cuffs. The thigh cuffs take no load when the patient stands with knees extended, yet the hips are held in abduction as the knees are flexed. The geometry permits each knee to flex independently of the other (Fig. 4) and, because ball joints are used, accurate alignment is not necessary. The ball joints also allow dorsiplantar flexion of the foot block (Fig. 5). Because the plantar surface of the shoe and foot is at 45 deg. to the floor, plantar flexion of the foot itself is accompanied by toe-in and dorsiflexion of the foot is accompanied by toe-out. Otherwise, toe-in and toe-out are securely held to the appropriate angle (Fig. 6).

FITTING AND FABRICATION

The first step in fitting and fabrication of the Toronto orthosis is to make a tracing of the patient's legs and pelvis when he is supine with each leg abducted 45 deg. from

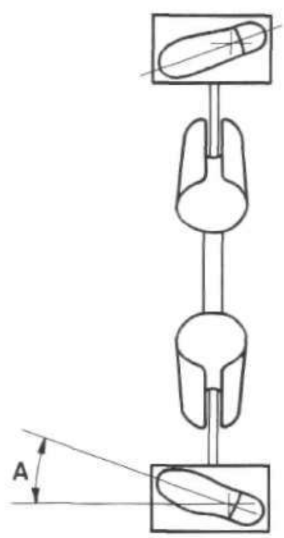

Fig. 6. Schematic view from the top of the Toronto brace, showing angular position of the sole of the shoe.

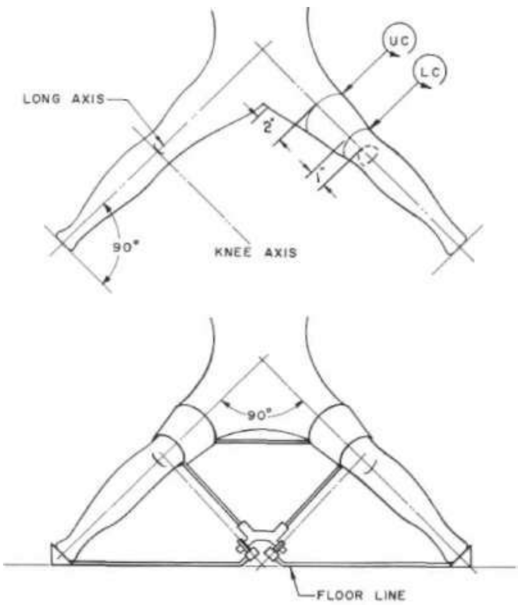

Fig. 7. Typical tracing needed for fabrication of the Toronto brace for Legg-Perthes disease.

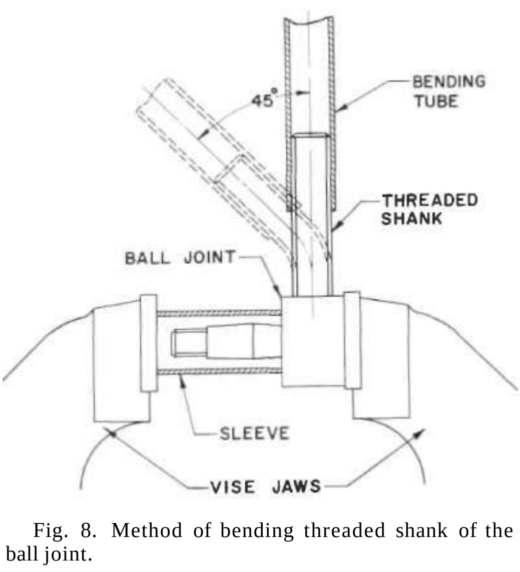

Fig. 8. Method of bending threaded shank of the ball joint.

the center line of the body. (If this cannot be accomplished, traction or soft tissue release is indicated before fitting can proceed.) The shoes are put on the patient's feet so that the edge of the sole is traced rather than the edge of the foot itself, because the shoes are a part of the total structure. The following information should be indicated on the tracing (Fig. 7):

1. The position of the thigh cuffs, which should be 1 in. above the patella and 2 in. below the groin.
2. The position of the shoe, when the sole of the shoe is placed at a 90-deg. angle to the long axis of the leg.
3. The position of the knee axis.
4. Measurements of the lower (LC) and upper (UC) circumferences of the thigh cuffs.

The frame, joint block, tie rods, foot blocks, and thigh cuffs are outlined on the tracing to facilitate fabrication.

FRAME

The frame, which supports the thigh cuffs and joint block, is made from 1 in. X 1/4 in. 24ST-4 aluminum bar, bent cold into a more or less diamond shape to conform to the tracing, and attached to the upper sides. The joint block is attached to the lower apex.

JOINT BLOCK

The purpose of the joint block is to provide a firm mounting for the ball joints to which the tie rods are attached. The block is assembled from five sections cut from 3 in. X 3 in. X 1/2 in. 65 ST (or equivalent) aluminum angle. Two automotive-type tie rods and joints are used for the ball joints,[4] which are located in the block so that they are in line with the knee axis. The threaded shank of the socket is bent to a 45-deg. angle before being brazed to the tie rod (Fig. 8). The tapered shank (Morse taper no. 1) on the ball of the joint is fitted to a hole in the joint block when the Chevy II part is used.

TIE RODS

The tie rods which connect the joint block with the foot blocks are made from chrome molybdenum tubing, 3/4 in. O.D. X .056 in. wall thickness. Tubing of this strength is required to resist damage that may be encountered with curbs, steps, etc. One end of the tie rod is brazed to

[4] Joints from a 1965 Chevy II have been used satisfactorily.

a foot-block plate and the other end to the threaded shank of the joint.

FOOT BLOCKS

The foot blocks are used to secure the shoes to the rods and support the shoes at the correct angle. Each foot block consists of a metal plate and a triangular block of wood. The metal plate is brazed to the distal end of the tie rod, and the wooden block is fastened to the plate with epoxy resin and wood screws. The shoes are fastened to the sloping surface of the wood block with rubber cement and wood screws. Note that the shoes are aligned on the block with approximately 15 deg. to 20 deg. internal rotation, as shown in Figure 6. The bottom surface of the blocks should be covered with a tough soling material. A section of automobile tire is very serviceable, but tends to mark floors. It can be fastened on with rubber cement and wood screws. Frequent replacement is usually necessary.

THIGH CUFFS

The thigh cuffs should fit from 2 in. below the groin to 1 in. above the proximal border of the patella. The distal posterior edge should be flared to minimize discomfort in the popliteal area when the knees are flexed. The cuffs should be made to fit (not too tightly) over the trousers. They should be made from a semi-flexible material with a lateral opening so that the brace can be put on and taken off readily. Velcro straps provide a convenient method of adjustment. Cuffs made at the Centre were formed from a thermoplastic material from Smith and Nephew called "San Splint." A similar material, "Orthoplast," is marketed by Johnson and Johnson. The thigh cuffs and Velcro straps have required frequent replacement in active patients.

GAIT TRAINING

Usually about three days of intensive training by a physiotherapist are required for the child to learn to walk in the brace. Two crutches are used. They are usually held in front of the body, although the occasional child keeps one crutch behind. Stairs and curbs can be negotiated with little difficulty, and some patients learn to walk without crutches for short distances.

The braces are removed for bathing, swimming, and sleeping, but the child must never be allowed to stand, kneel, crawl, or walk without the brace.

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