Bracing in Cerebral Palsy*

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In cerebral palsy, bracing may be made very simple or it may be very complicated. Overbracing can be as disadvantageous as inadequate bracing.

Definition of Cerebral Palsy

Cerebral palsy is a group of syndromes characterized by a permanent motor abnormality which is caused by involvement of the motor control center of the brain. Since no active disease exists, this definition excludes children with brain tumors, active encephalitis, and muscular dystrophy. It also excludes mental retardation. The diagnosis is not limited by age; but by common usage cerebral palsy is divided into two groups, infantile and juvenile. The upper age limit for onset of the original lesion in the juvenile form is eight years.

Incidence

The incidence of cerebral palsy at the present time is said to be 7.5 children per 1,000 live births. Pearlstein estimates that there are 750,000 young people in the United States who have cerebral palsy. This estimate does not include adults. At present in a study underwritten by the National Institutes of Health, fathers and mothers are interviewed as soon as pregnancy is recognized. The information obtained is being tabulated on I.B.M. cards, and it is hoped that ultimately the true incidence of cerebral palsy, as well as the influence of the environmental factors responsible for it, will be found. Physicians of the Crippled Children Service saw 28,411 children with cerebral palsy in their clinics during 1959 (8 per cent of the total number of children seen).

Classification of Cerebral Palsy

The classification used most frequently has been that of Phelps (1950) which is as follows: (1) flaccid paralysis, (2) spasticity, (3) rigidity, (4) tremor, (5) athetosis, and (6) ataxia.

There are many classifications, but for the purpose of this discussion, two major divisions (pyramidal and extrapyramidal) and one mixed group will be used. The classification pyramidal (spasticity) accounts for 60 per cent; extrapyramidal accounts for 25 per cent (athetosis, 15 per cent; ataxia, 5 per cent; rigidity, 5 per cent); and the mixed classification includes 15 per cent. How strictly one adheres to the following definitions depends on how many patients fall into the mixed category.

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Spasticity

This is the so-called pyramidal-tract lesion characterized by a positive Babinski sign, ankle and patellar clonus, hyperreflexia, the exaggerated stretch reflex, the clasp-knife phenomenon, and a tendency for contractures to develop. In a group followed at the Boston Children's Hospital [1], 60 per cent of all spastic children had hemiplegia, and spastic children constituted 64.6 per cent of all those with cerebral palsy.

Extrapyramidal

Since the American Academy for Cerebral Palsy established a brain registry, a great deal of overlap has been found between clinical and pathological findings. Nonetheless, it is convenient to lump athetosis, chorea, ataxia, and rigidity into this second major category. They have in common hypoactivity of the deep tendon reflexes, absence of clonus and positive Babinski sign, frequent failure of contractures to develop, at least early in life, and a difference in the muscle tone. The stretch reflex and the clasp-knife phenomenon are not present.

In actual practice, the extrapyramidal group can be subdivided quite easily:

Athetosis: This is characterized by a series of involuntary muscle contractions resulting in unpredictable motions which may be rapid or slow and which are aggravated by stress or tension. It frequently is associated with either the Rh problem, ABO incompatibility, or anoxia which is bloodborne and not a result of trauma. Braces are used in athetosis primarily for training and not for the prevention of contractures.

Ataxia or incoordination: Strictly speaking, this condition is seen in most patients with cerebral palsy. It affects gait by causing poor balance. Usually the lesion is considered to be localized in the cerebellum. Because the problem is one of balance, braces are not of much value. Skis, weighted shoes, square heels, and so forth, give the child a wide base, and thus they may help him to walk earlier.

Rigidity: This is a sustained involuntary condition which gives the impression of pipe-stem rigidity whenever an affected joint is flexed or extended. Classically, the condition in children with extrapyramidal lesions can be relaxed by shaking the extremity involved (athetosis and rigidity); but in children with pyramidal-type lesions (spastic), the stretch reflex will not shake out and the extremity will remain stiff. Actually, rigidity is very similar to spastic tetraplegia, and only by careful examination can the two be differentiated. Braces may be of little value in rigidity but troublesome contractures should not be allowed to develop. Unfortunately, this condition usually is associated with widespread brain damage.

Mixed type: This is a combination of spasticity and athetosis. The series studied at the Boston Children's Hospital [1] revealed 13.1 per cent of the mixed type, while Pearlstein found that 17 per cent of the 5,000 cases he recently reviewed fell into the mixed type [2].

I shall discuss primarily the braces used in the spastic type of cerebral palsy. In spasticity, the deforming factors are the strong or spastic muscles rather than paralyzed muscles, as is the case in poliomyelitis. The result may be the same so far as the deformity is concerned, but the management of the deformity may be difficult because the spastic muscle is difficult to assess accurately.

Regardless of the difficulty, it is very important to fill out a muscle chart in cerebral palsy, the same as is done in poliomyelitis. It may be necessary to do a local nerve block to paralyze the spastic muscle in order to determine accurately the strength of the opposing muscles. For example, if the tight hip adductors are sectioned and the obturator nerve is excised, weakening of the spastic hip adductors will result. If this happens and the abductors are weak, the child may be unable to walk as well as he did prior to the operation.

In general, it is no problem to get the patient to wear a brace, but it is a problem to get the physician to order and to maintain the brace over a long period of time. I have been guilty of removing a brace too soon, only to see the deformity recur. Yet, we know that spastic muscles and tendons do not keep pace with bone growth.

There are two major types of braces: (1) permanent braces, such as those for poliomyelitis or other neurological conditions that are primarily associated with muscle weakness and (2) temporary braces, applied for a specific purpose, such as the prevention of contracture, as used in angulation deformities, for instance, genu varum or genu valgum. Once the child has reached adolescence, the brace frequently can be discontinued.

A brace is expected to prevent deformities by preventing contractures, correct existing deformities, assist in training and directing a specific motion, determine the possible effect of operation, and protect tendon and soft tissue after operation.

Fig. 1—Goodyear floor matting cut to fit the sole and heel of the shoe. This is a cheap but effective way to add a non-skid surface.

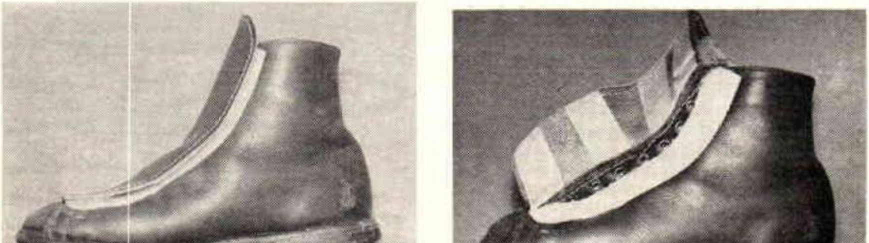


Fig. 2—Velcro has been sewn to the tongue of the shoe and along the margin of the eyelets. This non-skid material actually holds the shoe tighter than shoestrings.

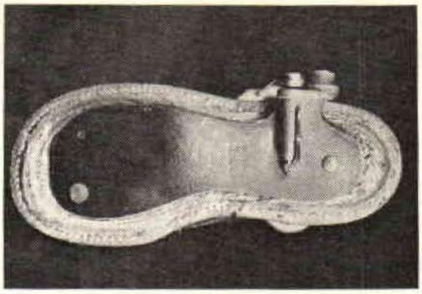


Fig. 3-A Fig. 3-B

Fig. 3-A—The sole shows the effect of a tight heel cord on a shoe that does not have a shoe plate. The equinus deformity of the heel persisted despite the short brace and the high-top shoe. T strap shown is one used most commonly at the Shriners' Hospital.

Fig. 3-B—Shoe plate placed between the inner and outer sole must extend to near the end of the shoe and definitely must extend beyond the metatarsophalangeal joints. This is one of the Pope short braces and demonstrates the spring which keeps the brace in place.

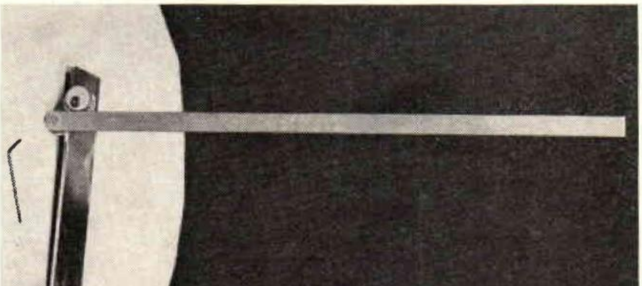


Fig. 3-C—Pope short brace in the rough before the sole plate was altered to fit specific sole size.

Lower-Extremity Braces

Most braces are effective only when they are properly anchored to the extremity and thus a good snug-fitting, high-top shoe is required. The problem encountered most frequently is the equinus deformity secondary to spasticity of the triceps surae muscle group. In spastic hemiplegia the shoe size of the involved foot may be from one-half to a full size smaller than that of the normal foot. In addition to this over-all atrophy of the foot the heel itself may be narrower. The involved leg will be shorter, and the bone age, calculated with the normal extremity, will be retarded. Thus, it may be necessary to obtain mismated shoes to get a good fit. I recommend high-top shoes for all children who have tight heel cords and who require some type of brace. This shoe fits the heel snugly and gives a better purchase for the T strap if one is indicated.

I have not used shoes that lace in the back to enable observation of the heel. The shoe may be fitted with an extra strap over the dorsum of the foot to hold the forepart of the foot down in the shoe and thus prevent the heel from sliding up. Another simple check is to lace the shoes in the reverse direction with the bow at the base of the tongue.

A rubber traction grip made from floor matting may be applied to the sole of the shoe (Fig. 1). Pearlstein obtains these mats in sheets. Then he applies the mat to the shoes with the grain of the mat running in different directions and observes the child to see which position of the mat affords the child the most traction. In many of our public buildings, hospitals, and schools, the floors are kept highly polished. On such slippery floors, this device may be a very simple method of offering the child a little more security.

No brace will hold the ankle if the shoe does not first hold the foot. Some of the shoes have velcro applied to obviate tying the shoestrings (Fig. 2). This adds to the child's independence and may be especially helpful to the child with quadriplegia. If low quarter shoes can be used, the type that has a flip tongue eliminates the tedious job of tying shoestrings.

Figures 3-A and 3-B show what may happen if a sole plate is not inserted in the shoe. I am sure the physician in this case thought that he was correcting the equinus deformity with a short brace and a shoe, but the shoe broke in the shank so that the heel was still in equinus. If this condition were left unchecked, it would contribute to a rocker-bottom deformity which is frequently seen in the child with spastic hemiplegia or paraplegia. Foot plates should be inserted into the sole of the shoe so that as the leather softens this situation does not develop. The plates come in three sizes and must extend nearly to the end of the sole of the shoe. Extension to just the metatarsophalangeal joint is not sufficient. The child with a mild equinus deformity, whose foot can be stretched passively to 80 degrees and who can get his heels on the floor when standing, does not require a shoe plate.

The T strap is required when valgus or varus cannot be controlled with the brace. As a rule, the simple T strap that is demonstrated in Figure 3-A is used. In more severe cases it may be necessary to attach the strap along a more extensive origin (Fig. 4).

Fig. 4

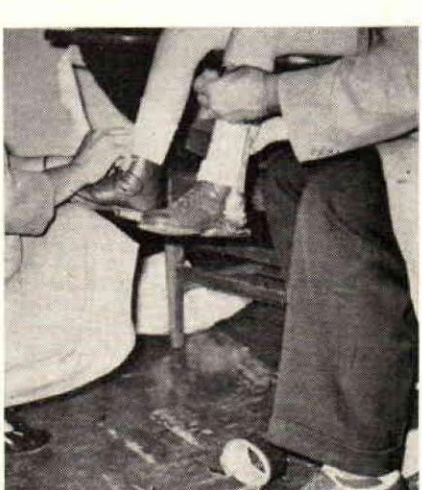
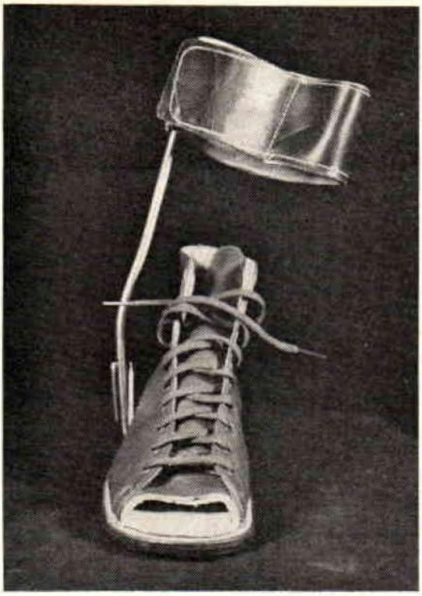


Fig. 5

Fig. 4—Other type of T strap frequently advocated for correction of varus or valgus deformity. It allows a more extensive origin of the T strap.

Fig. 5—Shoe is placed on the foot first. After the heel has been secured, the short brace is attached to the shoe.



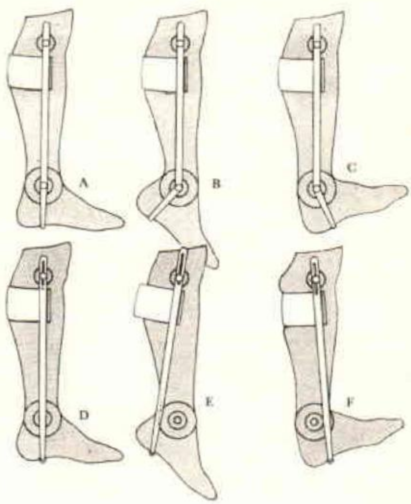


Fig. 6 Fig. 7

Fig. 6—With a single upright brace, it is relatively easy to accommodate for valgus or varus deformity. If the round caliper is used, flexion or extension can be managed in the same manner.

Fig. 7—Comparison of the anatomical ankle joint with ankle-heel caliper. With unlimited ankle motion it is possible to get undue calf pressure in extreme dorsiflexion, but this problem seldom exists in cerebral palsy. (Reproduced with permission from Orthopaedic Appliances Atlas, Vol. 1, p. 372.)

Short Brace

A short brace is used for control and not for support in the child with spastic hemiplegia or paraplegia. The same brace that is used in poliomyelitis may be used in cerebral palsy. Whether one uses a short brace of the double upright type or a single upright brace makes very little difference, except that there are a few specific advantages to the short brace with a single upright and round caliper fitting into the stirrup. Figure 5 demonstrates how the shoe can be applied first and then the brace fitted into the shoe. If this is done one can be more confident that the heel is fitting snugly into the shoe at the time of application of the brace. Figure 6 shows that the caliper may be bent to allow for either a valgus or a varus deformity without harming the alignment of the ankle joint. In a double upright brace, such bending of the upright would alter the alignment of the ankle joint so that it would have a tendency to bind. This is especially true with a long lower-extremity brace.

The Phelps brace comes in different sizes so that an orthotist should be able to apply the brace quickly and inexpensively. One may use a brace with either an inside or an outside upright depending on the need for a T strap. The arguments against the brace with the ankle joint located in the heel stem from the fact that the joint is not at the level of the anatomical ankle joint. From a practical standpoint, this does not seem to make much difference because children with cerebral palsy have a limited range of motion in the ankle. A child with a full range of ankle motion conceivably could have undue pressure from the calf band on the gastrocnemius when the foot is put into maximum extension (Fig. 7).

The offset ankle joint, manufactured by the Pope Manufacturing Company, Kankakee, Illinois, has a specific advantage (Fig. 3-C). With a fixed equinus deformity, correction can be obtained gradually by turning the offset with an Allen wrench. This allows the braceman a little more leeway when the apparatus is applied; in addition, it can be adjusted as the equinus deformity is stretched out. We have had some difficulty in small children with the brace breaking at the attachment of the caliper. In older children the caliper is larger and we have not had this problem.

We have not had enough experience to say that the klenzak ankle joint should never be used. It has been the impression of other authors that the spring action of the klenzak ankle gives constant passive resistive exercise to the gastrocnemius group of muscles and thus aggravates the equinus deformity rather than correcting it. Duncan, from Seattle, stated that he has used this type of ankle joint without any apparent difficulty. It would not seem to me that the amount of tension ordinarily found in the klenzak ankle joint would be enough to give harmful passive resistive exercises to the triceps muscle and thus contribute significantly to further shortening. On the other hand, if the triceps surae is structurally short, the tension within the klenzak ankle joint would not be enough to correct the deformity. In other words, I suspect that much of the difficulty with the klenzak ankle joint with a spastic triceps surae has been overemphasized.

The short brace used most frequently at the Shriners' Hospital in St. Louis is the double upright with limited ankle motion as shown in Figure 3-A. The caliper is fixed to the shoe, and the ankle joint is maintained essentially in the anatomical position. Velcro has replaced the buckles on our new braces.

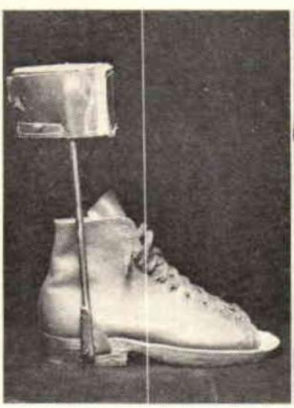


Fig 8

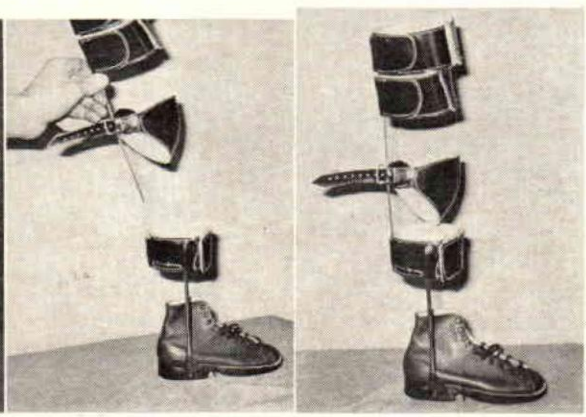


Fig. 9

Fig. 8—Phelps brace used as a night brace. The shoe can be applied to the foot and the brace attached later. Dorsiflexion can be altered by bending the round caliper. Note velcro replacing buckles and straps.

Fig. 9—Short brace can be converted to a long night brace by the addition of an insert in the calf band. This is useful in simple knee-flexion contractures.

Night Splints

Before discussing the long brace for the lower limb, I would like to mention the indications for night splints and the type that I use. I frequently see children who walk on their toes when they first arise in the morning, and then, as the day passes, they are able to get their heels on the floor. These children definitely should have a night brace to hold the foot to a right angle. This can be accomplished by using an old brace (Fig. 8). The toe may be cut out if the shoe is too short, and a large woolen sock may be pulled over the shoe so that the bedclothes are not soiled. The same result can be obtained with a plaster mold. For a child who has an associated contracture of the hamstring muscles, a simple attachment may be added to the night brace to help control the contracture of the hamstrings (Fig. 9). Many children who have undergone lengthening of the heel cord perhaps could have been saved this procedure by the use of the night brace. It is important to explain to parents early in the course of treatment that a child may require some type of night brace until he has completed his growth. If this is understood and the other children in the clinic are also using night braces, very little resistance will be encountered.

Long Braces for the Lower Extremity

There is disagreement about the merits of the double upright versus the single upright long brace. Until a few years ago, we rarely used anything at the Shriners' Hospital but a double upright brace. The double upright brace is the most efficient, but if we remember that, for the most part, we are bracing to control deformity and not for support, I think that we will

Fig. 10

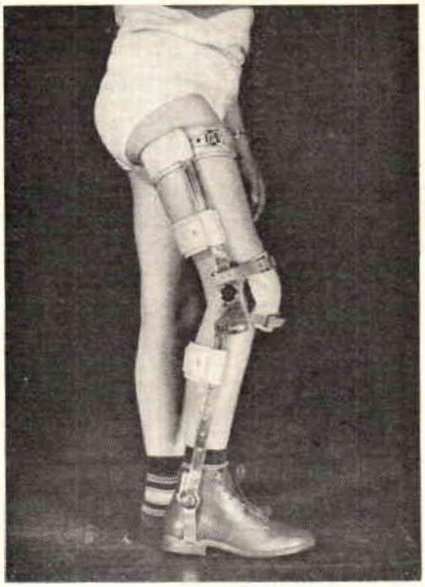


Fig. 11

Fig. 10—A single upright long brace does not control or correct knee-flexion contracture. A double upright brace with a knee pad should have been prescribed for this girl. An Eggers procedure could make bracing easier or, perhaps, unnecessary.

Fig. 11—Knee-flexion contracture being reduced by means of a long brace with a dial lock at the knee. As the contracture is reduced, tension can easily be altered by changing the position of the bolt in the dial lock.

Fig. 12-A

Fig. 12-B

Simple type of bale lock that does not incorporate a spring or multiple moving parts. In Fig. 12-A, the knee is locked and the elastic strap keeps the lock tight. In Fig. 12-B, upward pressure on the half ring forced the lock to unhook.

often find that the single upright brace will accomplish the same objective. If one is trying to correct deformity, not just to maintain the present status, a bilateral upright brace should be ordered in nearly all cases. For the last several years I have used many single upright long braces. One of their main advantages is that allowance for flexion deformities and angulation deformities at the knee and ankle is easier to make with the single upright, and it frequently is easier to make the single upright brace fit. Also, when it becomes necessary to lengthen the brace only a single upright must be changed. Although it is slightly cheaper and slightly lighter, these considerations alone are not sufficient for choosing the single upright brace.

I believe there are fewer indications for the single upright long brace than there are for the single upright short brace. The leather cuffs support the leg very nicely in the brace; and if an inside T strap is required and one prefers not to use an inside bar, a short inside caliper may be added for attachment of the T strap. For the control of knee flexion, it is necessary to use the double upright brace with a knee pad. The inadequacy of a single upright long brace and a pelvic band in flexion contracture of the knee is shown in Figure 10.

In children with flexion deformities of the knee, the dial lock (Fig. 11) may be used; and, after the contracture has been straightened, the knee joint of the brace can be altered to a movable joint. During the stretching of the hamstring muscles, I keep the knee joint locked. In our clinic, we have not had enough experience with the dial lock to be certain that it is advantageous; however, Pearlstein seems to be very pleased with it. If one wants to stretch out hamstring muscles with a dial lock, the calf band or cuff should be posterior to the calf and should not press on the tibia anteriorly, since this may lead to subluxation of the tibia on the femur.

Knee Joints, Locks and Pads

For years I have used the regular drop-lock at the knee. On children with adequate manual dexterity this lock is perfectly satisfactory. However, it seems to me that it would be much better to give some of these children a bale lock (Figs. 12-A and 12-B). The bale lock allows automatic release of the knee joint and adds to the wearer's independence. The main objection is that the lock may be released inadvertently, but this has not been a major problem. The upkeep is no more than in the simpler mechanical devices.

In some cases it might be better to use the Warm Springs type of knee lock, which can be released at the level of the hip joint by pulling on the control lever (Fig. 13). On patients with a spastic or an athetoid condition, the lock will have to withstand a great deal of stress. In athetosis, I recommend a double upright long brace because of the torque applied to the knee joint and to the uprights of the brace. A single upright brace manufactured

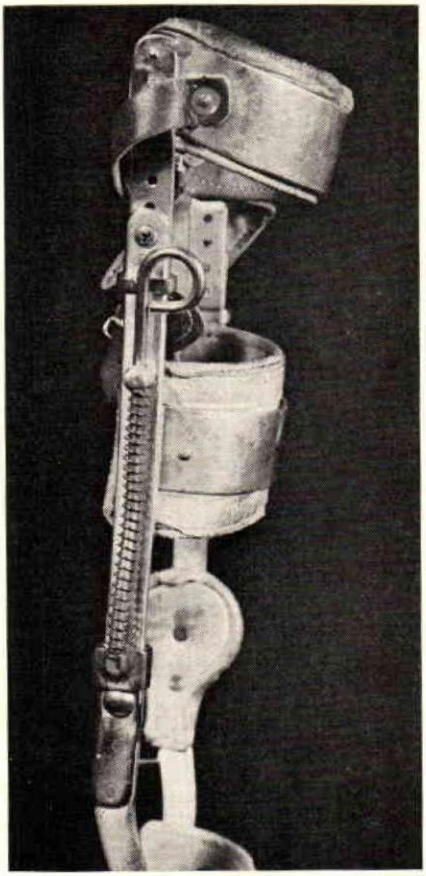


Fig. 13

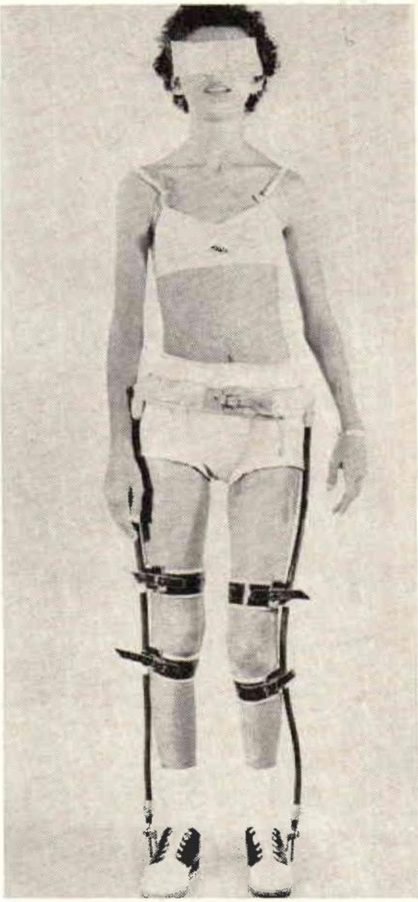


Fig. 14-A

Fig. 13—Close-up of the drop lock at the knee. A cord can be attached to the ring, making it easier for the child to release the lock.

Fig. 14-A—This patient walked with severe medial femoral torsion, with associated scissoring. Injection with 1 per cent xylocaine gave a good preoperative estimate of anticipated results. She was followed in an alemite twister made from grease-gun cable.

Fig. 14-B—Twister may be attached directly to the shoe or brace; torsion is adjusted by loosening the socket with an Allen wrench, applying desired twist, and then tightening the socket.

by the Pope Foundation has a reinforced joint with roller bearings designed to withstand the torque. It comes in several sizes and can be assembled by a competent orthotist in a relatively short time.

On children with a tendency to genu valgum, one can use either a strap to prevent knock knees or a leather button on the medial upright to apply pressure over the medial femoral condyle. Genu varum is very rare in the child with cerebral palsy. I prefer the button since the pressure is more or less constant whether the child is standing or sitting. The position of this button must be checked frequently, because unless it is accurately placed, it moves anterior to the knee joint when the child sits and does not give the desired pressure. In addition to this, normal growth of the child will alter the position of the button so that it may be ineffective. Perhaps the button should be in the shape of a c rather than a round circular pressure pad. If both knee flexion and genu valgus are present and moderately severe, the knee pad will be more effective.

Medial Femoral Torsion

If the medial femoral torsion is a severe problem, one may add some type of rotator device to the brace. The girl shown in Figure 14-A was able to walk without braces, but she had severe medial femoral torsion. After injection of 1 per cent xylocaine into the obturator nerve on the left, the scissoring and internal rotation were much reduced. Several days after injection the obturator nerve was surgically sectioned on the left, and tenotomy was performed on the adductor longus muscle. A b lateral long cast in mild abduction was used for four weeks and then followed with bilateral twisters. Presently, I am using the grease-gun cable (alemite) as the twisting device. This is anchored to a pelvic band, and the distal end may be attached either to the proximal portion of the short brace or to the shoe if the child does not require a brace. We hope we can correct medial or lateral torsion by this means. Rotation can be increased or decreased by adjustment of the torque at the insertion of the cable. The twisters may be changed from one pair of shoes to another by using a skate type of attachment for the insertion of the alemite cable. Although we have not used the rotators as a night splint, they certainly could be so used.

In dealing with medial femoral torsion with a mild amount of lateral tibial torsion, it may be that the cables could be attached to a form-fitting femoral cuff. In our institution elastic twisters have not been very satisfactory. A child I saw in Chicago recently who was using the elastic twisters is shown in Figure 15. The corset should be applied with the child lying

Fig. 15

Fig. 16-A

Fig. 16-B

Fig. 15—Elastic twisters have the advantage of being light but have the disadvantage of requiring a corset. Also the elastic bands lose their elasticity and must be replaced.

Fig. 16-A—The Miller twister is a tightly coiled spring which is effective in controlling rotation. A plastic cover has been placed over the spring to reduce wear and tear.

Fig. 16-B—The twister has been attached directly to the short brace.

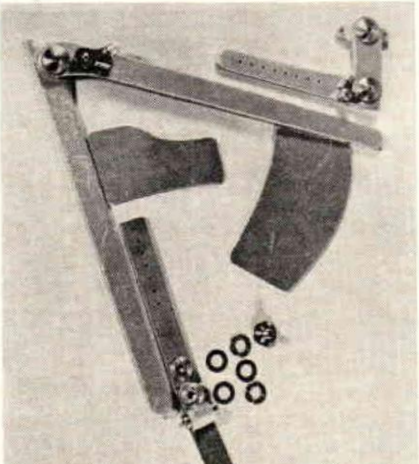


Fig. 17-A

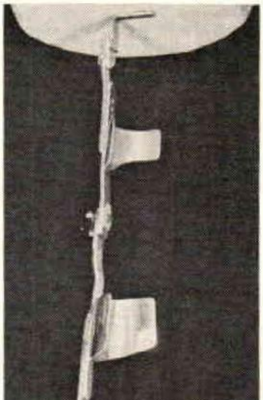


Fig. 17-B

Fig. 17-A—The Newington brace before fitting and assembly. The ankle joint has been disassembled to show the component parts.

Fig. 17-B—The assembled Newington brace. The pelvic band has been cut in half for demonstration and the sole plate has not been applied.

down, and it should fit snugly and hug the iliac crest. The device may be quite annoying, particularly in hot weather, as the twisters tend to chafe the legs when the child walks. Another type of twister consists of a spring attached to the pelvic band and to the shoe in a way similar to the alemite cable (Figs. 16-A and 16-B).

The spring is covered with a plastic tubing. This apparatus is rather expensive since the spring breaks frequently.

Fig. 18-A

Fig. 18-B

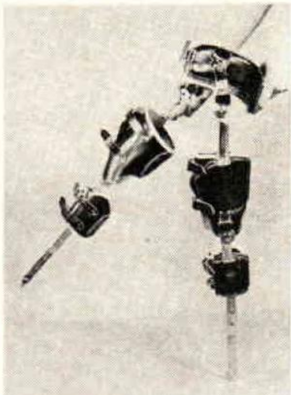


Fig. 18-C

Fig. 18-A—Patient with poliomyelitis demonstrating the straight pelvic band. With a mild hip-flexion contracture the buttocks would slide under the band, giving the child very little support.

Fig. 18-B—The pelvic band with the inferior portion being curved to fit the proximal portion of the sacrum. Also demonstrated is the joint located at the pelvic band.

Fig. 18-C—Demonstration of the amount of motion possible at pelvic-band joint when the hip joints are locked.

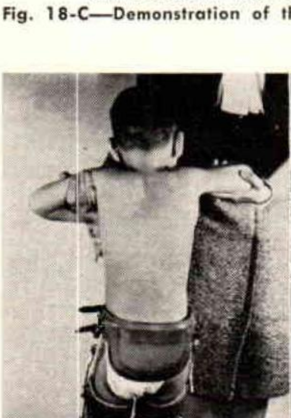


Fig. 18-D

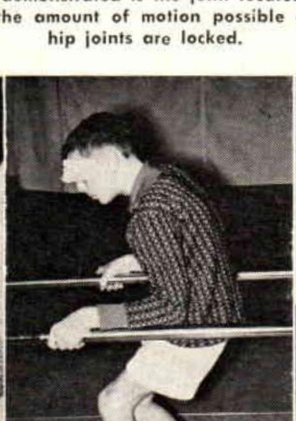


Fig. 18-E

Fig. 18-F

Fig. 18-D—Extreme extension of the pelvic band to hold the buttocks forward.

Fig. 18-E—This child is able to walk with difficulty between parallel bars.

Fig. 18-F—With proper bracing, including double upright long braces and pelvic band, the child is able to walk without support. Properly selected surgical procedures might give him greater or total relief from braces.

Long Braces with a Pelvic Band

I believe that we frequently can eliminate the double upright brace if we attach the brace to the pelvic band. Leather cuffs can be made to hold the legs very securely. The weight and bulkiness of a double upright brace with a pelivc band can be a real problem to both parents and child. Certainly the long brace with a pelvic band may be very useful. On the other hand, it is a very cumbersome piece of equipment and should be recommended only after due consideration.

It is important that the brace be strong and the hip locks arranged so that they can be locked and unlocked. The pelvic band must be so constructed that it will give support over the sacrum. Otherwise, the band will slip and much of the support will be lost. If the band is constructed like a poliomyelitis brace, the same problem is present. The difficulty can be avoided by curving the band so that some pressure will be applied to the sacrum or by use of butterflies, which are extensions from the pelvic band.

The Newington Home brace is prefabricated and it may be ordered and assembled by the orthotist. Figure 17-A shows the Newington brace unassembled, and Figure 17-B shows it assembled but without any of the leather work. It is important that long braces with a pelvic band be well balanced, and one simple test is to see if the brace can stand by itself. The pelvic band should be removed as soon as possible since it leads to further weakness of the gluteus medius muscle. A simple friction joint with a drop lock is used at the Shriners' Hospital. If free motion is required, the lock can be taped or a simple latch can be attached to hold it up. Recently following a suggestion by the Pope Foundation, I have allowed 20 to 30 degrees of motion at the pelvic band so that the hip joint is still partly locked, giving the child sufficient support (Figs. 18-A through 18-F). If scissoring is a

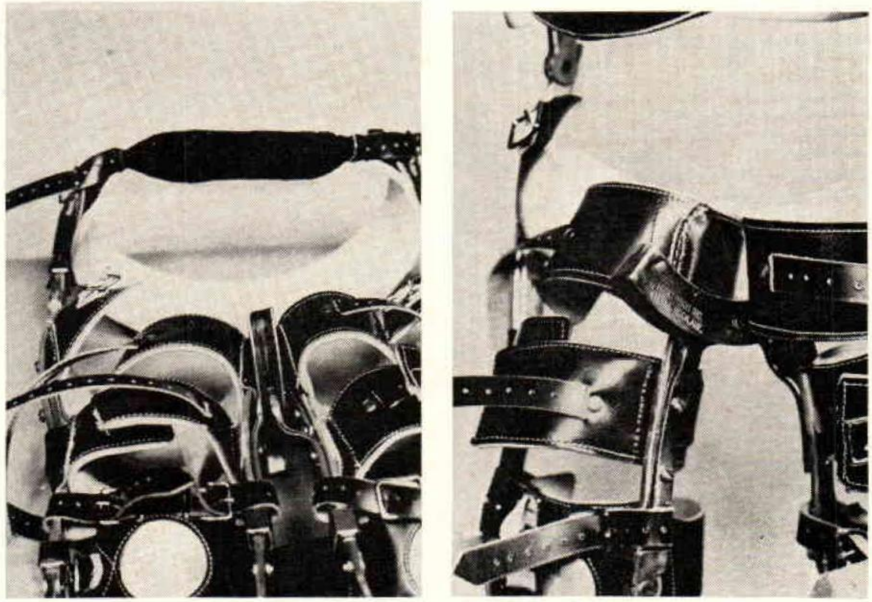


Fig. 19—Trolley may be added to the brace to control scissoring. A long brace with a pelvic band should be attempted first and, if scissoring persists, the trolley can easily be attached.

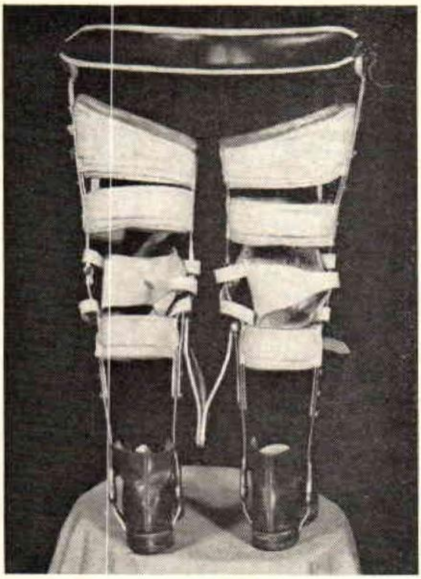


Fig. 20-A

Fig. 20-B

Fig. 20-A—A simple antiscissoring device consists of two pieces of steel with a simple axis joint.

Fig. 20-B—Trochanteric extensions added to long braces; a leather strap between these extensions can be tightened to aid in correcting medial or lateral torsion, depending on whether the strap is posterior or anterior.

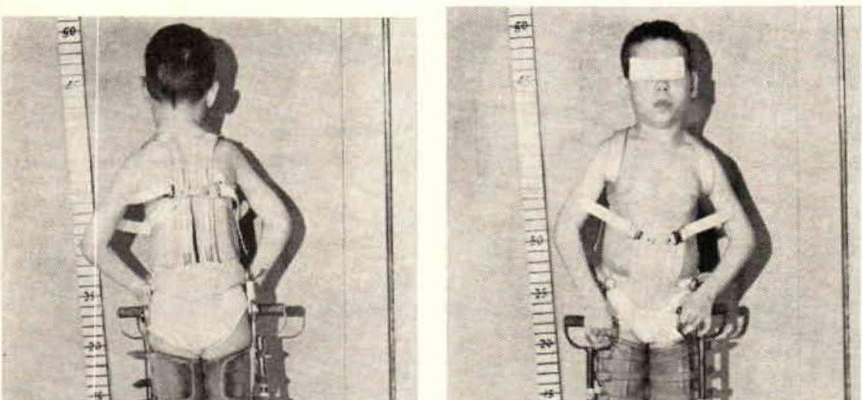


Fig. 21—This boy is able to walk slowly with extensive bracing and quadriped canes. So much energy is needed to walk short distances that he is somewhat reluctant to walk.

major problem, an antiscissoring device may be applied to the long brace with a pelvic band. One such device is the trolley (Fig. 19) manufactured by the Hickerson Company of Little Rock, Arkansas, as the result of work done by Dr. S. B. Thompson. Unfortunately there is considerable friction in this particular joint. A small child of four or five years of age would have some difficulty with bilateral long braces with a pelvic band and the trolley.

Another antiscissoring device consists of two metal rods with movable joints at the middle and at both ends (Figs. 20-A and 20-B). If long braces are sufficient, but there is some rotational deformity as a result of medial femoral torsion, a trochanteric extension may be added to the brace with a leather strap around the buttocks to help control internal rotation. An anterior strap can be used to control external rotation. The trochanteric extension and the trolley arrangement might be used to eliminate the pelvic band, but I have not tried this.

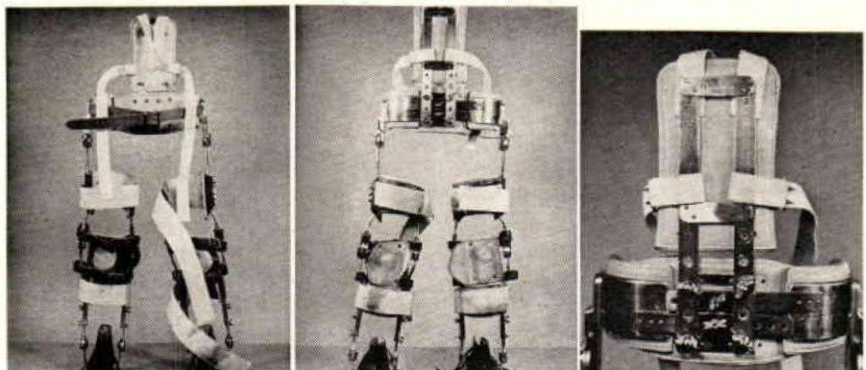


Fig. 22—Anterior view, posterior view, and close-up of training brace. It may be lengthened and the pelvic band may be widened with minimum effort. The shoes can be removed and the suitable size attached. The back support can be raised, lowered, or removed. It should be emphasized that this is a training brace and not a permanent one.

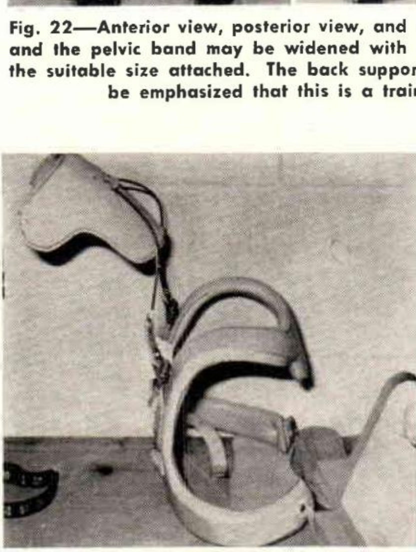


Fig. 23

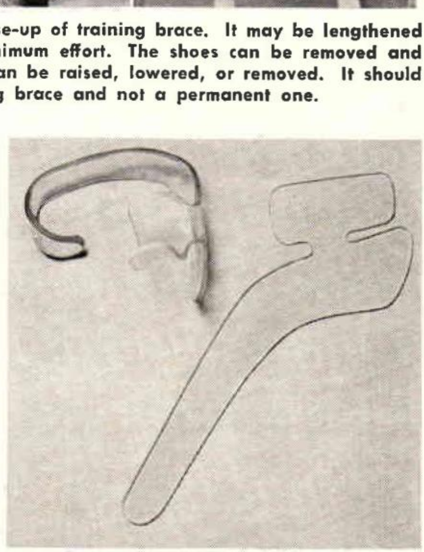


Fig. 24

Fig. 23—Head control brace used by Dr. Pearlstein.

Fig. 24—Opponens splint. With only slight modification of the C bar, this splint can control adductor contracture of the thumb. It can be made of plastic or precut metal.

Control Brace

The full control brace includes a back support added to the pelvic band and long braces (Fig. 21). Occasionally it is necessary to resort to such heavy bracing to initiate standing and walking. An adjustable brace which will allow training of a child was devised by Dr. Machek, a physiatrist in St. Louis. It is being used at the Alhambra Grotto Cerebral Palsy Center (Fig. 22). If it appears that such a brace is worth while, it can be designed to the exact measurements of the patient. A brace of this type might be appropriate for a number of children, but frequently it is rejected because of the expense and the possibility that it will not be satisfactory. I believe that this device has merit, and Dr. Machek and the B & H Orthopedic Company in St. Louis are trying to correct some of the mechanical flaws in order to make the brace more effective.

The full control brace may be required for the child with athetosis, and in some cases it may also include a head control device, which either is attached to the brace or, as Pearlstein demonstrated, may be used independently. I have experimented only recently with the head control brace (Fig. 23). Thus, I can only refer you to Dr. Pearlstein or to Dr. Phelps.

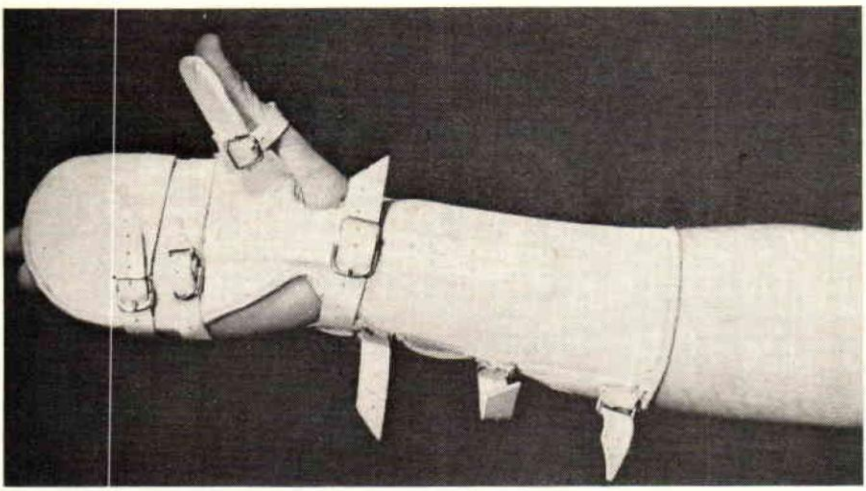


Fig. 25-A

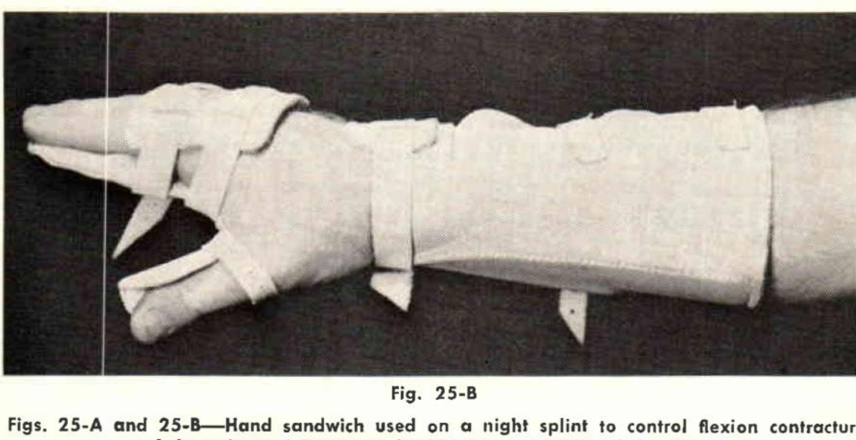


Fig. 25-B

Figs. 25-A and 25-B—Hand sandwich used on a night splint to control flexion contracture of the wrist and fingers and adductor contracture of the thumb.

The full control brace for children with athetosis has not been used at the Shriners' Hospital in St. Louis to my knowledge. I do not mean to imply that we do not prescribe braces for children with athetosis because we do. However, results are much less gratifying in athetoid patients than in spastic patients.

Bracing of the Upper Extremity

I have not braced the upper extremities to the extent that I have braced the lower extremities. I believe that we have neglected the upper extremities. Results with braces and with surgical treatment for the upper extremity have been disappointing. I think we have expected too much. If we recognize that minimum improvement may help the child a great deal, perhaps we will be more easily satisfied. Except for brachial palsy, I have not used shoulder braces for abduction or adduction deformities. The elbow brace may be of value in controlling flexion contracture of the elbow and in preventing pronation deformity of the forearm. A plaster cast can be made for this purpose and changed as the child grows. Correction may be obtained by a series of casts. The last one is used as a night splint. If the deformity cannot be controlled, the tendon of the pronator teres muscle may be sectioned and transplanted to act as a supinator, or on some occasions the entire origin of the muscle can be recessed from the medial humeral condyle distally. It is certainly wise to brace after operation in both the upper and the lower extremity until the child regains active control.

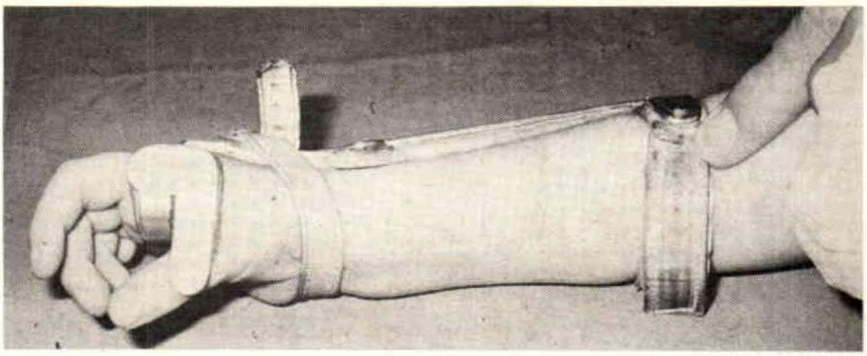


Fig. 26-A

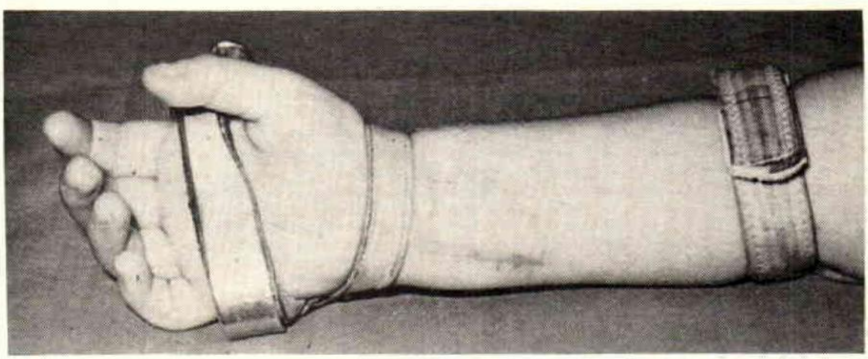


Fig. 26-B

Figs. 26-A and 26-B—Cock-up splint to control wrist flexion contracture. This child has had transplantation of the flexor carpi ulnaris to the wrist extensors. The splint is being used to protect the tendon transplant.

Three braces should be mentioned specifically:

1. *The opponens splint to prevent adduction contracture of the thumb (Fig. 24):* This splint should be applied very early since it is difficult to tell which children will be candidates for operation and which will not. Perhaps, if adduction contracture could be prevented, tendon surgery would be indicated when the child is four or five years of age. The result would be better functioning hands. In general operation has been withheld until the children were older than four or five years. The plastic opponens splint is easily made by the orthotist and may be changed as indicated.

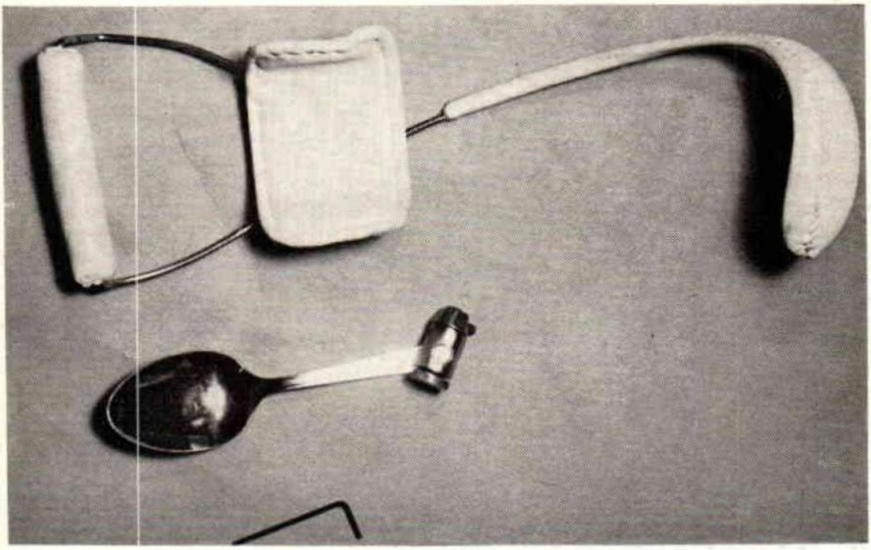


Fig. 27-A

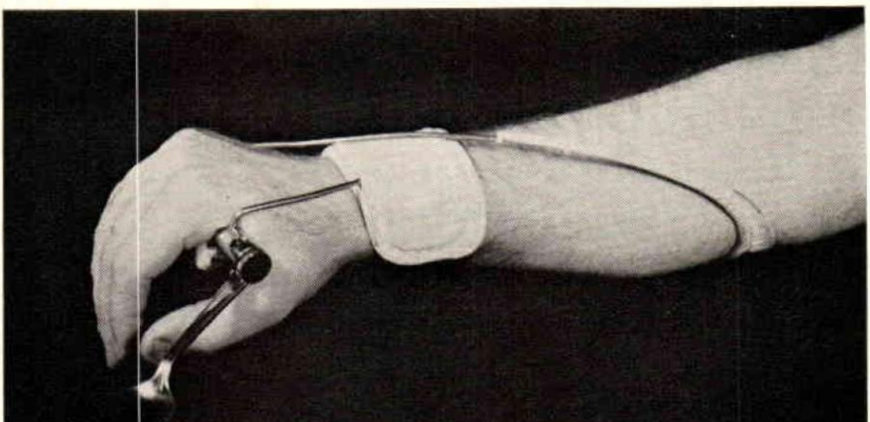


Fig. 27-B

Figs. 27-A and 27-B—Front and dorsal applied views of the Australian splint—a simple cock-up which requires no straps to hold it in place. The amount of wrist extension can be controlled by bending the dorsal wire. In larger children, it may be necessary to run additional wire to control wrist flexion. The spoon can be removed and the hole will accommodate a wooden lead pencil.

2. *The hand sandwich (Figs. 25-A and 25-B):* This is used as a night splint. I regret that we have not used this splint as much as we might have. Swanson states that it is used very frequently in the Cerebral Palsy Center at the Mary Free Bed Hospital, Grand Rapids, Michigan. The hand sandwich can correct as well as prevent deformity since it limits flexion contractures of the wrist and fingers. Thus, when operation is indicated it should be more successful. Instead, we have used the cock-up splint with an opponens bar for many of our children (Figs. 26-A and 26-B). We may not have paid as much attention as we should have to flexion deformities of the fingers.

3. *The Australian splint (Figs. 27-A and 27-B):* This splint was made for me by Mr. Jouett of Dreher-Jouett Brace Shop in Chicago. I believe that Dr. Pearlstein saw it when he was on his trip to Australia a year or two ago. It is merely a single rod which has no hooks or straps. Thus it leaves the flexor surface of the forearm free, an important consideration in all upper-extremity braces. This principle is true for children with poliomyelitis as well as with cerebral palsy. One can add the opponens bar or fork and spoon adapter which also will accommodate a pencil. Some flexibility in the brace is a definite advantage. As the flexion contracture is corrected, the splint can be bent to allow for this correction.

At present, we are experimenting with different types of hinge splints such as those used at Rancho Los Amigos in Los Angeles, Warm Springs in Georgia, and the splints manufactured by the Pope Foundation. However, I have no idea how much one can train a spastic muscle. Individual aluminum splints can be taped to the fingers, as suggested by Swanson, to get some idea of the benefit of the operation in swan-neck deformity of fingers.

Conclusion

Bracing is a very important adjunct in the care of the child with cerebral palsy. Contractures can be prevented in many instances by the judicious use of physical therapy combined with adequate bracing and night splinting. I do not mean to imply that we try to keep all of our children in cumbersome, clanking braces. We attempt to rid them of their braces by specific surgical procedures when these are feasible. Recurrent deformities have frequently resulted from inadequate bracing or splinting in the post-operative period.

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