CHAPTER 10

BRACING DEVICES FOR PEDIATRIC FOOT AND LEG DEFORMITIES

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The most common lower extremity pediatric deformities encountered by the podiatric physician are metatarsus adductus (MA), calcaneovalgus, and internal tibial torsion (ITT). Parents may bring their children for treatment at any age, but most commonly wait until they are 10-15 months of age, after walking has begun. Unfortunately, most of the deformities by this age have become rigid in nature and do not respond to conservative treatment as favorably as those treated earlier. There are significant differences regarding treatment recommendations among physicians caring for pediatric deformities.

Several authors (Staheli, Churgay) believe that these disorders will resolve spontaneously as part of normal ontogeny. They argue that pediatric lower extremity conditions are over-treated and result in unnecessary medical costs. Proponents of more aggressive treatment (Ganley, English) state that conservative measures should not be delayed since the deformities become more rigid with time. Furthermore, there is a significant financial burden and loss of function associated with the long-term sequelae, including compensatory changes of untreated lower extremity disorders. The authors believe that clinical evaluation is the primary indicator for treatment. If the deformity is not passively reducible, then early conservative treatment is indicated.

Current conservative treatment includes manual manipulation, and the application of casts or bracing devices to the child's deformed foot and/or leg to effect correction. The foundation of this treatment regimen is the deformation properties of bone (Wolff's Law) and the visco-elastic properties of soft tissue (Davis's Law).

A force applied to bone over time can change the direction of bone growth by affecting the growth plate and the bone itself. For example, tensile or compressive forces applied perpendicular to the growth plate (through the long axis of the bone) affects longitudinal bone growth. Torsional forces cause rotation at the physis, whereas forces parallel to the growth plate produce tilting of the physis.

Soft tissue elements of the musculo-skeletal system respond to chronic forces by elongating in the direction of the applied force. Consequently, correctly applied manipulative forces, serial casts, and bracing devices can reduce bony and soft tissue malalignments to a more functional and normal position.

CASTING VERSUS BRACING

Traditionally, bracing devices have been used to prevent the recurrence of certain deformities by maintaining position following cast correction. However, with the development of new devices and better patient selection, bracing can be used as the initial treatment to facilitate correction. The best results of treatment from the use of braces are attained by employing the following criteria:

1. Application of the brace at an early age, preferably before the child begins to ambulate.
2. Acceptance of the device by patient and parent.
3. Secure brace containment of the limb for several hours each day.
4. Flexible or semi-rigid deformities (typically, totally rigid and severe malalignments initially require casting).
5. Braces may be used as an alternative when parents refuse casting therapy for their children.

While cast treatment offers consistent results, there are distinct advantages to bracing. Effective bracing is potentially less expensive for the patient by decreasing the need for repeated cast changes. Furthermore, potential complications of casting (Table 1) can be avoided since the limb can be monitored daily. There are several bracing devices available with varying costs and indications for usage.

Table 1

COMPLICATIONS OF CASTING

—Loss of dermal integrity
—Circulatory compromise
—Creation of iatrogenic deformity
—Emotional distress of the child and parent

BRACING DEVICES

There are three basic configurations of bracing devices (Table 2). Each category allows different degrees of mobility for the child. Bars that link the feet afford minimal motion. Shoes or ankle-foot orthoses (AFOs) that do not connect the feet allow more mobility.

Table 2

CLASSIFICATION OF BRACES

BARS

Denis-Browne Bar
Fillauer Bar
Unibar
Ganley Splint

MOVABLE BAR

Counter Rotation System (C.R.S.) Splint

SHOES OR ANKLE FOOT ORTHOSES (AFO)

Ipos Anti-adductus Shoe
Bebax Shoe
Wheaton Brace (for MA) &
Bracing System (for MA & ITT)

In the senior author's experience, 90% of children tolerate these devices. However, a child who does not tolerate a particular brace will generally not accept an alternative brace. Moreover, children younger than 18 months are more accepting of brace immobilization, but become less so with time.

Frequently, positive reinforcement strategies by the parent, and proper presentation of the device will ease the child's anxiety to these devices. As the toddler's activity level increases each month, they become less accepting of restrictive devices particularly between 18 and 36 months of age, thereby decreasing the force application time. Consequently, appropriate, timely brace selection is paramount to therapeutic effectiveness. An introduction to the braces follows.

Bars

The Denis-Browne & Fillauer Bars. One of the first pediatric braces available was the Denis-Browne (D-B) bar (Fig. 1). Originally used to maintain correction following clubfoot surgery, the child's feet were taped to the device's foot-plates. The bar was then modified so that shoes could be screwed to the plates. The Fillauer modification (Fig. 2) uses clamps to attach the shoe to the plate.

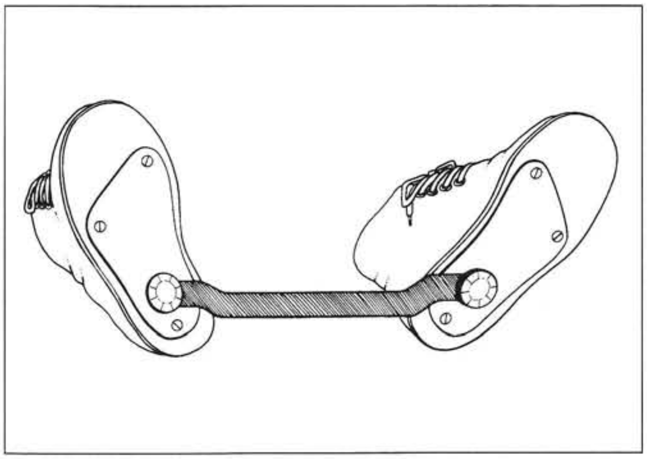

Figure 1. The Denis-Browne Bar

Figure 2. The Fillauer Bar

The D-B and Fillauer bars incorporate a rigid bar positioned between the child's feet to provide a transverse plane force against the leg when treating tibial torsion. The bar is available in either fixed widths of 4-16 inches or adjustable widths of 7-11 or 9-15 inches. Since these bars do not apply sagittal or frontal forces to the child's foot, they are not used in the treatment of metatarsus adductus or calcaneovalgus.

The advantages of these bars include low cost, sturdiness, availability, and ease of application to the child's shoe. A disadvantage of the Fillauer bar is the possibility of the child kicking off the bar's shoe clamps.

Care must be taken to avoid the development of an iatrogenic flat foot secondary to the transverse plane force upon the foot. The pronatory changes caused by such a force can be opposed by using regular last shoes (instead of straight or reverse last shoes), and by incorporating medial heel wedges and medial longitudinal pads into each shoe. Most importantly, a gentle corrective force should be applied in increments. Although difficult, another strategy involves bending the bar in the frontal plane to provide a varus force.

Considerations common to the use of bars is the width of the shoes relative to the hips. To avoid initiating an internal femoral position, the shoes should be set one to two inches wider than the distance between the anterior superior iliac spines. Furthermore, the treating physician should realize that as the child sleeps with these bars, the knees are usually straight, allowing some of the transverse force to be transmitted to the hip. Although these forces are not necessarily detrimental, treatment time is increased because not all forces are transmitted to the tibial growth plates.

The Unibar. The Unibar is a plastic polymer bar with a universal joint attached to shoe plates (Fig. 3). The bar is primarily used to treat internal tibial torsion, however, the universal joint's engraved degree settings can be adjusted to provide a triplane force on the rearfoot. Consequently, an anti-pronatory force may be accurately applied when setting the bar to treat internal tibial torsion. Sagittal plane adjustments are not as effective since the foot can plantarflex in the shoe.

The Unibar can be adjusted for length, whereas the D-B, Fillauer, and Counter Rotation System need to be ordered to fit each patient. Further advantages of the Unibar includes its light-

Figure 3. The Unibar

weight construction and ease of application to the child's shoe. The primary disadvantage is that the bar may be easily broken by toddlers.

The Ganley Splint. The Ganley splint consists of a pair of forefoot and rearfoot plates interconnected by malleable metal shank rods (Fig. 4). In addition, the right and left foot assemblies are connected by a malleable metal torque bar. This configuration enables forefoot to rearfoot corrective forces to reduce metatarsus adductus and calcaneovalgus deformities.

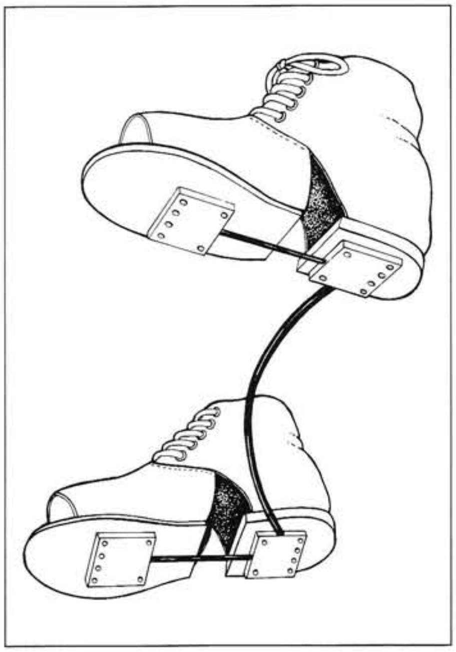

Figure 4. The Ganley Splint

Similarly, the malleable torque bar may be bent between the child's legs in the treatment of internal tibial torsion.

The Ganley splint is the most versatile bar currently available. This device is made of a lightweight, strong metal alloy able to resist breakage, but allow bending. It may be used to treat single or compound, unilateral or bilateral deformities. Furthermore, the splint can be adjusted as the child grows, whereas other non-adjustable pediatric devices may require purchasing a new splint.

A minor disadvantage of The Ganley splint is that mounting shoes to the foot plates is somewhat time-consuming. However, if the shoes are attached properly to the bar, they will virtually never become detached. Another potential disadvantage of the Ganley splint is its lack of availability. However, it currently remains available through some medical supply houses.

Movable Bars

The Counter Rotation System (C.R.S.). The Counter Rotation System consists of two foot plates connected by a multi-hinged bar (Fig. 5). This device allows the child mobility while providing a transverse plane force on the child's leg when treating tibial torsion. The C.R.S. foot plates may be adjusted to provide forefoot and midfoot frontal plane support when the shoe is cut.

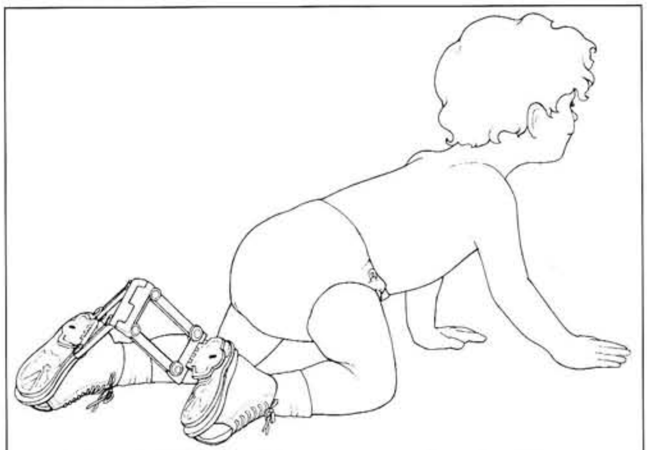

Figure 5. The Counter Rotation System

Advantages of this device include increased mobility for the child and ease of applying shoes to the foot plates. Furthermore, the motion this brace allows has been reported to enhance correction by improving parental and patient acceptance, therefore resulting in increased compliance.

The primary disadvantage of the C.R.S. is its cost. It is a relatively expensive device offering greater motion to the child, but providing no greater corrective force than other bars. Moreover, the shoes are less securely held to the plates (using glue alone) than other bars incorporating glue and screws thereby increasing the potential for the shoes to become loosened from the plates. Finally, it is primarily only used to treat tibial torsion.

Shoes or AFOs Without Bars

Ipos Anti-Adductus Shoe. The French made Ipos Anti-Adductus (I.A.A.) shoe is split in the frontal plane and incorporates a central hinge about which an abductory forefoot force is applied to treat metatarsus adductus (Fig. 6). This well-padded high-top shoe is available in several sizes from 75 mm to 160 mm in length. Two external, and one internal strap helps to seat the foot snugly in the shoe. The abductory force is generated by a laterally positioned spring connecting the forefoot and rearfoot shoe segments; three springs of varying tensions are provided with the shoe to provide a greater corrective force.

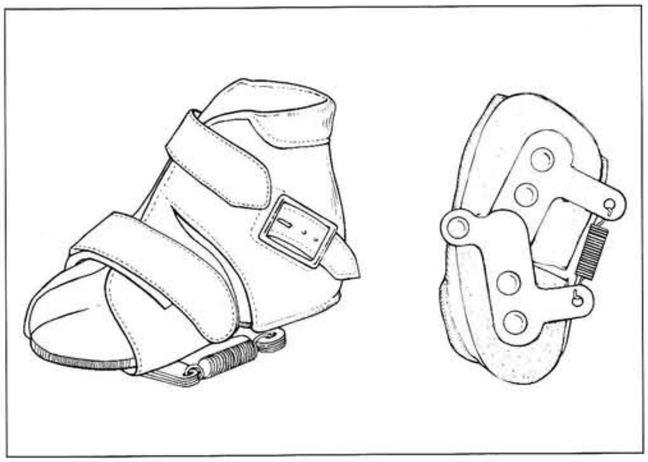

Figure 6. The Ipos Anti-Adductus Shoe

The primary advantage of the I.A.A. shoe, as with other similar shoes or AFOs, is its ability to treat unilateral deformities while leaving the contralateral extremity free. Moreover, the child's mobility is enhanced with these devices because the limbs are not bound together. The I.A.A. shoe also provides a constant force and does not need periodic adjustments of position.

The common disadvantage of shoes and AFOs is that these devices (with the exception of The Wheaton Bracing System) are non-adjustable.

Consequently, the site of corrective force changes as the child grows. This may necessitate the purchase of larger braces as the child grows. Furthermore, these devices are relatively expensive and generally have limited treatment indications.

Care should be taken when using the I.A.A. shoe to change the lateral spring as it loses tension with use. Finally, the I.A.A. shoe does not offer midfoot and forefoot support while providing its transverse plane force on the foot. This may induce subtalar and midtarsal joint pronatory changes in the unprotected pediatric foot if too strong of a corrective force is applied.

The Bebax Shoe. Similar to the Ipos Anti-Adductus shoe, the French-made Bebax orthosis is a shoe split in the frontal plane with two universal joints attached to the soles (Fig. 7). The forefoot and rearfoot universal joint of each shoe is connected by a non-malleable bar which allows triplane forefoot to rearfoot correction in the treatment of metatarsus adductus and calcaneovalgus. Once the desired position of the shoe is attained and the straps are tightened, the universal joints are locked into place with the supplied allen wrench. The shoe is custom ordered based on the length of the foot as measured from the back of the heel to the tip of the hallux. Sizes range from 7.5 cm to 13.5 cm.

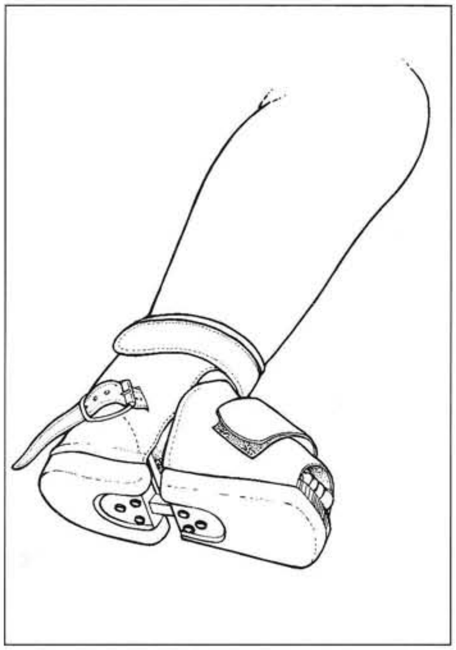

Figure 7. The Bebax Shoe

The Bebax orthosis, like the I.A.A. shoe, is well-constructed with high quality materials; however, it is also expensive. The advantage of the Bebax over the Ipos is its triplane forefoot and rearfoot control enabling it to treat both calcaneovalgus and metatarsus adductus, while averting subtalar and midtarsal pronatory changes.

The Wheaton Brace & Bracing System. The Wheaton Brace is a polyurethane AFO used to treat metatarsus adductus (MTA) and post-surgical or flexible talipes equino varus (TEV) (Fig. 8A). Similar to casting, the Wheaton Brace corrects metatarsus adductus by applying three-point pressure to the foot while holding the rearfoot firmly. Laterally directed pressure occurs at the first metatarsal head and medial heel by pre-molded polyurethane. Medial pressure is directed at the fifth metatarsal base by tightening a Velcro strap (Fig. 8B).

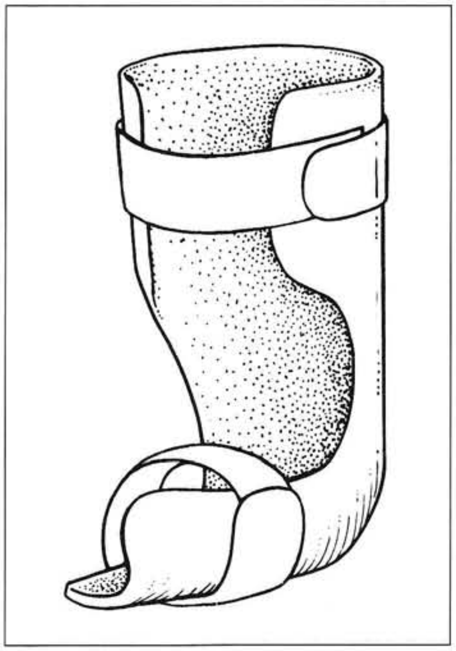

Figure 8A. The Wheaton Brace for treatment of metatarsus adductus

The Wheaton Brace is available in five lengths and three series. The lengths range from 8.3 cm to 14.0 cm and are measured from the back of the heel to the tip of the hallux. The three series are MTA, TEV and CRB (Counter Rotational Balance). The MTA series is used to treat children from 0-8 months of age and provides 15 degrees of ankle plantarflexion. Whereas the TEV and CRB are for children 0-36 months old and holds the ankle dorsiflexed at 90 degrees. Specifically, the TEV series is used in children 0-15 months of age for the

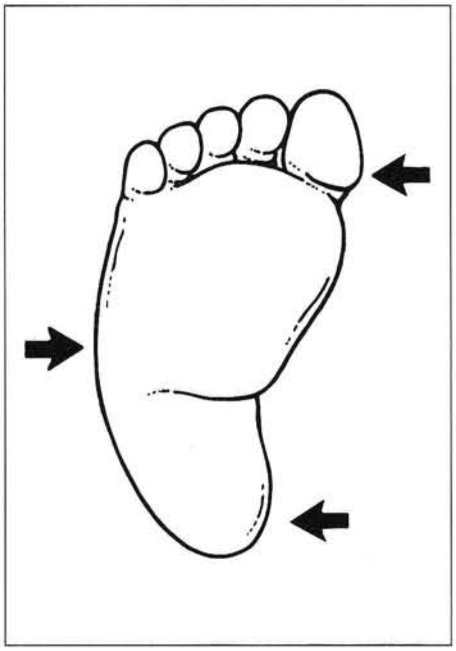

Figure 8B. Arrows denote the three points of pressure applied to the foot.

maintenance of TEV correction where plantarflexion is not indicated. The CRB series is available for children 16-36 months old who are ambulatory.

The Wheaton Bracing System combines the Wheaton Brace (or lower component) with a telescoping upper component to apply a transverse torque on the tibia (Fig. 9). The velcro attachment on the posterior aspect of the brace allows adjustments of length and rotation.

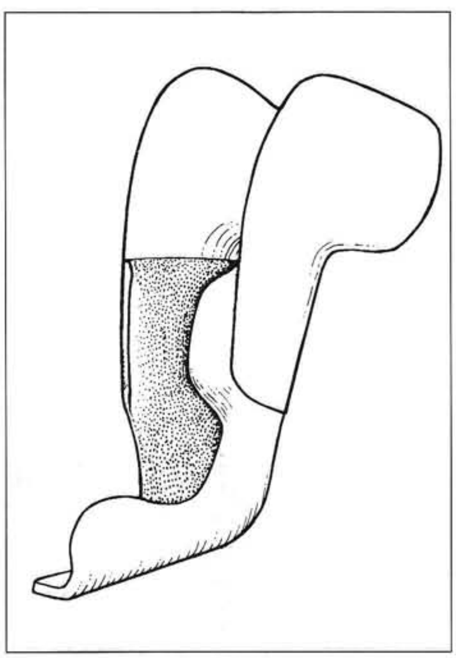

Figure 9. The Wheaton Bracing system for treatment of metatarsus adductus and internal tibial torsion (shown without straps).

The Wheaton Bracing System provides a more effective force in the correction of tibial torsion than bars or moving bars. With the knee flexed at 90 degrees, the corrective force is applied only to the tibia, whereas the force generated by bars or moving bars is somewhat dissipated in the knee, femur, and hip.

The disadvantage of the Wheaton Brace is that its force is preset in one position, and precision heat gun modifications of the device can be difficult and time-consuming. Additionally, the device requires a non-professional (i.e., the parent) to apply a corrective force to the child's foot by applying tension on the velcro strap.

Although expensive, The Wheaton Bracing System is probably the best overall treatment device for tibial torsion. The device is versatile in both adjustment and indications. It can be adapted to correct any torsional deformity and may be used to treat compound deformities such as internal tibial torsion, metatarsus adductus, and flexible TEV. However, it is important to note that these devices are custom fit, not custom molded, and skin pressure complications may result.

CONCLUSION

Lower extremity pediatric devices can be used to correct mild to moderate deformity based on the physiological principles of Wolff's and Davis' Laws. Initially, casting and manipulation are used to reduce deformity in infants. Pediatric braces may then be used to achieve or maintain final correction. However, as the child ages, both parent and patient become less tolerant of restrictive casting, and braces become more efficacious.

The selection of a pediatric brace is based on the type and severity of deformity, as well as the cost of the brace (Table 3). It is important to realize the additional costs associated with prescribing braces: bars require the purchase of new shoes or the use of a current pair of shoes; parts and labor may be associated with fixing shoes to shoe plates; biomechanical modifications or adjustments to shoes or braces may be necessary; and the replacement value of the device if outgrown.

The foot and ankle specialist may choose to stock braces to decrease the lapse in treatment time. When selecting a brace to stock, it is best to choose one which is inexpensive, has several treatment indications, and is adjustable as the child grows.

Table 3

COMPARISON OF PEDIATRIC FOOT & LEG BRACES

Brace	Indications				Cost	Advantages	Disadvantages
	MA	ITT	CV	TEV*			
D-B/FILLAUER BAR Fillauer Inc. Chattanooga, TN 800-251-6398		√		√	$18/bar plus shoes	• Inexpensive • Sturdy • Adjustable bars available	• Biomechanical padding required • Fillauer clamps may not hold shoes securely • Only transverse plane force • Frequent force adjustments necessary
UNIBAR Spectra Industries Corp. Yeadon, PA 800-220-7050		√		√	$25/bar plus shoes	• Inexpensive • Triplane foot support • Length adjustable	• Child may break bar • Only transverse plan force • Frequent force adjustments necessary
GANLEY SPLINT Various Supply Houses	√	√	√	√	$25/bar plus shoes	• Inexpensive • Versatile indications/adjustments • Triplane FF to RF & RF to leg forces • Can remove transverse torque bar to Tx unilateral deformity	• Shoe mounting is time consuming • Frequent force adjustments necessary
C.R.S. Langer Biomechanical Group, Inc. Deer Park, NY 800-233-2687		√		√	$130/kit plus shoes	• Allows child mobility • Easily applied to shoes	• Expensive • Only transverse plane force • Frequent force adjustments necessary • Shoes may not stay fixed to plates • Bar not adjustable for length
IPOS ANTI-ADDUCTUS SHOE Ipos North America, Inc. Niagara Falls, NY 800-626-2612	√				$49.50 per shoe	• Allows child mobility • Does not require force adjustments • Can Tx unilateral deformity • Securely held to child's foot	• Expensive • Biomechanical padding required • Limited indications • Spring loses tension • Child may out grow shoe
BEBAX SHOE Camp International, Inc. Jackson, MI 800-492-1088	√		√		$61.50 per shoe	• Allows child mobility • Triplane FF to RF forces • Can Tx unilateral deformity • Securely held to child's foot	• Expensive • Child may out grow shoe
WHEATON BRACE (MA) Wheaton Brace Co. Carol Stream, IL 800-227-6769	√			√	$55.00–75.00 per brace	• Allows child mobility • Can TX unilateral deformity • Securely held to child's foot • Heat moldable	• Expensive • Child may out grow brace • Heat molding difficult • Inconsistent force application by parent
WHEATON BRACING SYSTEM (MA & ITT) Wheaton Brace Co. Carol Stream, IL 800-227-6769	√	√		√	$55–75 per lower cmpnt. $45–50 per upper cmpnt.	• Force can be isolated to tibia • Versatile indications/ adjustments	• Expensive • Lower component subject to disadvantages of Wheaton Brace

* Flexible or post-surgical TEV

The most important aspect of treatment outcome with the use of pediatric braces, is directly related to the amount of time the brace applies a corrective force. In an attempt to maximize results, the prescribing physician should instruct parents to present the brace in a positive environment such as during the child's play time. Positive reinforcement techniques should be used when the child wears the brace, to nurture compliance and ultimately enhance correction of the deformity.

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