Pediatric Orthoses: An Overview—Part 1

The prescription of custom foot orthoses in children utilizes growth and skeletal maturation to produce improvement in structure and function.

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Goals and Objectives

To discuss the unique characteristics of pediatric orthoses

To present a historical perspective on their design

To enumerate their benefits

To review their indications and types

To introduce the functional UCBL

To expound on the importance and rationale for their use in the conservative management of the developmentally deficient foot

To offer illustrative guidelines for their prescription

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*Following this article, an answer sheet and full set of instructions are provided (pg. 156).—**Editor***

In 1896, a prominent American orthopedist, Royal Whitman, MD designed and introduced the first foot brace, the Whitman Plate.[1] This relatively heavy steel device worked on the "pain principle" of correction: i.e., as the excessively pronated child's foot rolled medially into the steel flanged arch segment of the device, it became so intolerable that the child would reflexively supinate the foot in order to avoid further discomfort.[2]

Another early device that worked along these lines was known as 'Spitzy's ball'.[3] This "active correction" device consisted of a moveable, wooden, marble-size ball sewn into the longitudinal arch region of a straw-soled sandal. And finally, in the strange but true category, a patient told me that when he was a child, his father, who was a physician, hammered a nail in the longitudinal arch region of his shoes, forcing him to walk on the outer border of his feet. Thank God since that time, the design and principles guiding the prescription of pediatric foot orthoses have radically changed.

With the advent of new understanding of foot and ankle biomechanics and the introduction of cutting-edge technology along with the availability of space-age materials, pediatric foot orthoses no longer have to rely on the pain principle, no longer have to be used as a crutch, and no longer have to "support" the medial longitudinal arch to be effective.

Considerations

The foot of the young child differs from that of the adult foot in that it is

Continued on page 148

Pediatric Orthoses *(from page 147)*

more flexible and moldable than its relatively rigid adult counterpart. The prescription of foot orthoses for the pediatric patient must reflect these fundamental differences in terms of material selection, rigidity, degree, and type of correction. Due to the increased and varied activity level present in children, orthotic design must be geared toward dynamic function. It is for this reason that computer assisted and observational gait analyses play an important role in their successful prescription.[4,5]

Polypropylene is an ideal shell material for an active child four years of age.

Effecting Structural Change

Although there are many clinical benefits derived from pediatric foot orthoses, the one upon which all others are derived is the improvement in alignment and function during periods of growth and development, thereby effecting structural change (Figure 1). "As the twig is bent so the tree is inclined" is a tenet for the correction of pediatric orthopedic deformities by serial plaster immobilization and is the basis for the practice of orthodontics in dentistry.[6] Through Wolff's Law of Bone, functional adaptation of the osseous segments will take place positively, permanently altering structure.[7-12] This is especially true and of major significance in the management of lower extremity musculoskeletal deficiencies in the developing child. According to Huurman "As in other congenital abnormalities, growth and development can be effectively used as long as the orthotic is worn faithfully and for a prolonged period of time.[12] As might be expected, the longer the orthotic is worn, the greater the improvement."[12]

FIGURE 1:

Characteristic Benefits of Pediatric Orthoses

- Realignment of osseous and soft tissue structures
- Restoration of normal lower extremity function
- Redirection of pathologic ephiphyseal stresses
- Improved COF and COG pathways
- Rectus forefoot
- Locked midtarsal joint
- First ray stability
- Reduced talocalcaneal angle
- Reduced talar declination
- Increased calcaneal inclination
- Reduced midstance phase of gait
- Increased propulsive phase of gait
- Reduced Q angle
- Reduced lumbosacral angle
- Reduced lumbar and cervical lordosis
- Reduced dorsal kyphosis
- Improved posture
- Improved postural complex alignment
- Knee and hip extension
- Increased height

By limiting pathologic pronation at the subtalar and midtarsal joints, pediatric orthoses encourage proper sequencing of the lower extremity musculature, allowing them to work effectively and efficiently at appropriate points in the gait cycle. Through Davis' law of soft tissue, pediatric orthoses encourage muscles and tendons that have become pathologically elongated to now contract and those that have been adaptively contracted to lengthen.[13]

Figure 2: The shell of this device precisely conformed to the medial longitudinal arch upon dispensing yet there is noted an absence of wear in that region. This is due to and is an indicator of proper rear and forefoot alignment with concomitant improvement in dynamic function, allowing the arch to "support" itself, resulting in a normal "footprint in the sand" wear pattern.

Additionally, due to the learned response of orthotic function, tissue memory and the "mimicking effect", pediatric foot orthoses will improve foot and limb function for a period of time even after they are removed from the shoe. Of course, if the device were not worn for the prescribed length of time, some reversion to its original form would take place.

Pediatric Orthoses

Two tenets in the management of pediatric orthopedic deformities are that the earlier treatment is instituted and the more flexible the deformity the more favorable the outcome. Failure to intervene loses the brief 'golden window' of opportunity that once passed can never be retrieved. In a 10-year study by Rose, of 154 children with flexible pes planus treated with a modified AFO (lateral bar with medial "Y" strap), only six children were not able to achieve a stable position following treatment and all of these six subjects were over six years of age at the start of study. All other subjects were under one year of age when treatment began.[14] Rose concluded, "Nevertheless because the ultimate condition can be so disabling and the treatment so readily tolerated, some degree of over-correction is acceptable and desirable."

Continued on page 149

Pediatric Orthoses (from page 148)

"A Dynamic Guidance System"

A properly designed pediatric biomechanical orthotic device is not an arch support designed to buttress the longitudinal arch and randomly supinate the foot but rather a retainer to re-align the osseous and soft tissue segments and to influence and direct motion in a precise manner. A foot orthotic is not a brace but a dynamic guidance system providing stable fulcrums for the intrinsic stabilizers and extrinsic prime movers to function effectively and efficiently.[15] This is achieved through the use of appropriate rear and forefoot posting so that the arch supports itself. In fact, there should be little or no wear evident on the orthotic in the longitudinal arch region (Figure 2).

Much like orthodontics in dentistry, the prescription of custom foot orthoses in children utilizes growth and skeletal maturation to produce improvement in structure and function.[7-12,14] With continued and periodic modifications, long-term pain and disability may not be inevitable as an adult.[10-12,6-18]

Since the deficiency in the excessively pronated pediatric flatfoot is one of excessive mobility, orthotic materials should be rigid to semi-rigid. Non-compressible polypropylene and graphite composites depending on their shell thickness have been proven to be effective and well tolerated (Figure 3). The orthotic should have a deepened heel seat (at least 20-25mm) and broader shell width as compared to an adult device (Figure 3).

These modifications serve to better align, control, and stabilize the fat, flat, and floppy child's foot. Additionally, the greater width allows distribution of anti-pronation forces over a broader surface area. In the presence of significant equinus compensation, a more flexurally forgiving shell may be indicated to allow for some modicum of oblique axis midtarsal joint compensation, thereby improving tolerance while at the same time fostering compliance.

The increased activity level and accompanying on-forefoot position in most children over three years of age are better suited with a full foot device. Forefoot posting extended to the sulcus enhances control during this newly acquired propulsive phase of gait. The resulting orthotic resembles one prescribed for adult sports participation (Figure 4). Due to the fleshy nature of the child's foot, aggressive but not overly corrective posting is suggested.

Pediatric foot orthoses are not arch supports. Arch supports act as static props, empirically buttressing the longitudinal arch and randomly supinating the foot. This contrived raising of the longitudinal arch shifts the line of gravity laterally, thereby unlocking the longitudinal axis of the midtarsal joint, which results in forefoot instability and repetitive lateral displacement of the foot on the device. Unlike arch supports, a pediatric foot orthosis acts as a dynamic guide not as a static "crutch" for the foot and leg to lean on.

The properly prescribed pediatric orthotic re-aligns the osseous and soft tissue structures the number of degrees that they are out of alignment in the forefoot and in the rearfoot (Figures 5, 6).[6] Antagonistic muscle groups in the lower extremity can now act in an appropriate and balanced manner. It is in this position that the arch can support itself and is not in need of external support.

The original Whitman steel plate functioned on the pain principle.

Figure 3: Graphite composite shell with markedly deepened heel seat, reduced undercut and medial and lateral flanges.

Indications for Use

Although the majority of pediatric foot orthoses are prescribed to control the excessively pronated foot, there are nonetheless other important indications for their use (Figure 7). These include stabilization post-serial plaster immobilization as employed in the management of talipes equinovarus, metatarsus adductus, and calcaneovalgus. The effects of equinus deficiencies respond well to orthotic control (Figure 8). Prescription foot orthoses reduce apophyseal traction forces in Sever's disease. Orthoses limit painful motion in the juvenile rheumatoid arthritic foot.[19] They restrict abnormal motion and limit peroneal spasm in tarsal coalitions.[20]

Pediatric orthoses may be prescribed to provide foot and ankle stabilization in the management of ankle instability. Additionally, these devices may be used to effect a beneficial change in postural alignment by negating the effects of a medially displaced line of gravity.

In the knee, foot orthoses reduce the Q angle and limit abnormal transverse and frontal plane forces that precipitate, perpetuate, or aggravate conditions such as patellofemoral pain syndrome, Sinding-Larsen-Johanas-

Continued on page 150

Pediatric Orthoses *(from page 149)*

sen syndrome, and Osgood Schatter's disease.[21] Pediatric orthoses may be employed to re-direct ephiphyseal forces.

Prescription pediatric foot orthoses may be used to improve performance and reduce fatigue by encouraging optimal function. In-toe and out-toe gait problems may be treated with foot orthoses in children as well as in children with dropfoot and equinus gaits.[5,21-24] Metatarsus adductus, metatarsus primus adductus, and brachymetatarsia may be treated with prescription orthotic devices. They may be utilized to act as functional braces during fracture treatment as well as to off-load forces in that area and prevent recurrence. Additional indications include: pain reduction or resolution, encouragement of normal development, equalization of functional and structural limb-length discrepancies, injury prevention, etc.

Prescription foot orthoses are indicated in the treatment of overuse injuries in the young athlete. These conditions include anterior and posterior medial tibial stress syndromes, tendinitis, stress fractures, and genicular disorders as noted.

Figure 4: Full foot polypropylene pediatric orthoses with broadened rearfoot posts and 1-4 forefoot posting extended to the sulcus after one year of use by an active 7 year old boy.

Flexible Pediatric Flatfoot

The prescription of custom foot orthoses in the flexible pediatric flatfoot has been the topic of debate for over a century. Most authors agree that the symptomatic flexible flatfoot in the pediatric patient should be treated; however, the disagreement begins in discussing whether or not to treat the asymptomatic pediatric flatfoot. The primary underlying objection of those advocating not to treat is that these feet will positively undergo some degree of developmental correction early in life, so why intervene. "Don't worry, they'll grow out of it" is a phrase that's heard all too often in practice from adult patients recalling professional advice given to their parents.

Figure 5: The orthotic should conform to the foot and contain the appropriate rearfoot and forefoot correction necessary to achieve optimal alignment upon weight-bearing.

The problem with this philosophy is that in those children where there is a persistence of deformity growth and development structurally embeds these imperfections into the musculoskeletal system, perpetuating the need for unending compensatory adjustments in function in response to the unaddressed abnormalities retained in structure.[25]

The other issue is how to know which children will grow out of it and which ones won't. The real question here is not whether or not to treat asymptomatic flexible flatfeet in children but whether or not to treat pathologically pronated feet in children. There are a number of studies which state it should not be treated since normal development proceeds towards the formation of a longitudinal arch.[26-31] However, there are no long-term double-blind studies in the conservative management of the asymptomatic pediatric flatfoot in which subjects have received no treatment or various forms of non-operative care, thereby confirming or denying these statements.[32] Absence of evidence should be never be construed as evidence.

Additionally, the infant foot is immature, malleable, malaligned and subject to the deforming effects of gravity at a time when marked ontogenetic changes are taking place. When compensatory pathologic forces are added to this clinical picture, it fosters retention of in-utero positions, discourages or delays ideal development, and promotes progressive dysfunction, deformity, and ultimately disability. Symptomatology may not occur until the second or third decades of life.

As a further point, the American Academy of Pediatrics-Section on Orthopaedics and the Pediatric Orthopaedic Society of North America in a recent position paper advised its members not to prescribe or recommend custom foot orthoses for children with minimally symptomatic or asymptomatic flat feet.[35] These groups further recommend that if an arch is present when "standing on tiptoe" then the condition can be managed with obser-

Continued on page 151

Pediatric Orthoses *(from page 150)*

vation or over-the-counter orthotics.

Their recommendations are based on the findings of two papers—one by Wegner and the other by Staheli—and the somewhat biased views of one paper's lead author.[27,36] The primary study that these two groups refer to in dismissing the effectiveness of shoes, inserts, and UCBL-type devices in the management of the pediatric flexible flatfoot was performed by Wegner, et al.[36] This study radiographically assessed the results of these modalities over a three-year period in 129 flatfooted children under six years of age and concluded that wearing these devices or modifications does not influence the course of flexible flatfoot.

However, upon closer examination, it can be readily seen that all radiographic parameters had a positive correlation between the initial angle and change in radiographic angle with intervention. Patients with the largest initial angle had the most change independent of the method of treatment. Furthermore, the UCBL group started with a greater deformity but ended with a smaller deformity. Finally, even though equinus was identified in this group of children, it was never utilized in the study either by prescribing an appropriate stretching program or elevating the heel region of the device or prescribing a more flexurally forgiving shell. Eliminating the equinus subjects might show an even greater positive change due to the intolerability of UCBL type devices in the presence of equinus forces.[5,37,38]

On the other hand, there are also a number of studies which recommend intervention since no one is able to accurately predict which children will "grow out of it" and which children won't.[32,33,39-48] Experts agree that adult acquired flatfoot almost always begins with a pre-existing pediatric flatfoot.[33,49,50] Orthopedist Justin Greisberg states, "Perhaps the most important treatment for an acquired adult flatfoot is prevention. If the at-risk foot can be identified early, intervention might prevent the deformity."[49]

By ages 5-8, the majority of structural form in the foot has been completed.

Posting Pediatric Orthoses

In the orthotic management of the excessively pronated pediatric foot, the amount of rearfoot and forefoot posting that should be employed is the number of degrees required to re-align the osseous and soft tissue structures in subtalar joint neutral position and also does not allow any visible pronation to be observed during stance or ambulation. This posting is individually determined after thorough lower extremity biomechanical evaluation both static and dynamic, with or without computer assisted gait analysis, and to some extent is age-dependent.

Children under six years of age possess a profound developmental potential with rapidly changing foot and leg alignment. The feet of children in this age range are usually floppy, flat, and fat with the youngest in the group being the most noticeably affected. It is no wonder that this foot has been described as a loose bag of bones floating in a mass of soft tissue. These factors coupled with rapidly changing foot and leg alignment dictate the need for more aggressive orthotic control.

In the adult foot, posting is prescribed in order to accommodate the full degree of deformity captured in the neutral position cast. In the developing foot, complete neutralization of structural deficiencies noted in the neutral position cast may encourage the retention of neonatal imbalances by "setting" the deformity in its abnormal position while at the same time discouraging ideal development. It is important to note that the major portion of the developmental process is not achieved until six to eight years of age (with a gradual tapering off so that complete maturity may not occur in some individuals until they are 14-16 years old), and complete neutralization of structural deficiencies in children less than seven years of age is ill advised.

Since most adults retain a minimum of 2-4° of subtalar varus and usually 2-3° of tibial varum, the addition of a 2-4° rearfoot varus post and as much as 6-7° in severe cases is not contra-indicated and may in fact enhance the effectiveness of the device. The effectiveness of the rearfoot post may be further enhanced by lengthening it distally. Additionally, a deepened heel seat (20-25mm) generally recommended in pediatric orthoses adds to control as does reduction of the rearfoot post-taper or "undercut" (Figure 3).

Regarding forefoot posting in the beginning walker, the usually present

Continued on page 152

Figure 6: Successful realignment of the osseous and soft tissue structures.

Pediatric Orthoses *(from page 151)*

approximately 8-12° forefoot varus should not be completely neutralized with an extrinsic post. As much forefoot varus as possible should be reduced while performing the impression cast, either by dorsiflexing the hallux, thereby plantarflexing the first metatarsal, or by supplying plantarward pressure to the medial segment of the dorsum of the forefoot while the plaster is hardening.

This technique is also helpful in reducing large amounts of forefoot varus in older children. Ultimately, and at any age, the same dictum applies, i.e. the amount of forefoot varus posting that should be employed is the minimum amount necessary to neutralize all visible pronation and provide optimum subtalar joint neutral position alignment during stance and ambulation. Periodic monitoring of changes in forefoot varus is necessary since the varus deformity may reduce, and thus posting should be modified accordingly and in a timely manner. Reduction in deformity may be due to encouragement of normal development, orthotic-induced resolution of forefoot supinatus, as well as improvement in overall pedal performance and alignment.

Forefoot posting may be extrinsic, intrinsic, or a combination of the two. Extrinsic posting is most efficient and may either be a 1-5 bar, 2-5 bar, 1st met head tip post, 1-5, 2-4, or 2-5 post extended to the sulcus. Due to the high percentage of on-forefoot activity seen in most active children, forefoot posting extended to the sulcus provides better propulsive phase control. For less active children under two years of age, a bar type post should suffice. In those cases where a high degree of forefoot deviation correction is necessary, it may not always be possible to fit the required amount into the child's shoe. In these cases, combining extrinsic with intrinsic posting allows the orthotic to fit more easily into footwear and is usually more readily tolerated.

As an example, let's look at the forefoot posting considerations for an active eight year old that measures 13° forefoot varus upon clinical examination. We are able to reduce the deformity to 9° by applying plantarward pressure to the medial forefoot segment during suspension neutral position plaster impression casting and/or by dorsiflexing the hallux. The amount required to achieve a vertical calcaneus with the forefoot in contact with the supporting surface was 8°.

An extrinsic post of this amount may be difficult for the child to adjust to as well as being somewhat difficult to fit in shoes; therefore, it was decided that 5° would be placed extrinsically in the form of a 1-5 post extended to the sulcus and 3° intrinsic forefoot varus posting would be added to the positive model so when pressed, the shell would reflect this angulation. Another alternative to reduce some of the bulk of the sulcus 1-5 varus post is to have it only extend laterally to the 4th MPJ where it would be feathered to 0°.

This modification more closely approximates the morphological characteristics of the deformity (Figure 4). Continuing with this same example, if this child were two years of age, one would first reduce the forefoot varus as much as possible in the cast, perhaps to 8° or 9°, next determine the minimum amount of posting necessary to achieve correction, let's say 7°, and finally achieve correction with intrinsic and extrinsic posting, preferring to utilize more intrinsic than extrinsic in this age group since it does not present as much of an obstacle to normal development as does an extrinsic post. A semi-rigid to rigid, non-compressible device to the metatarsal heads with an appropriate reduced rearfoot post and minimally necessary extrinsic forefoot bar plus intrinsic forefoot post would be the end result.

Management of pedal deficiencies in the established walker from two to four years of age differs from that of the beginning walker in that structural deficiencies should be more closely observed. Evalua-

Continued on page 153

FIGURE 7:

Selected Indications for Pediatric Foot Orthoses Modified After RO Schuster, DPM

- Pronation in children anytime the navicular differential from neutral is greater than 3/8" or 9mm with or without pain
- Foot instability related to spastic or flaccid paralysis of congenital or acquired deformity
- Juvenile hallux valgus and varus
- Juvenile hammertoes
- Arthridities or Osteochondritis of the metatarsal heads
- Calcaneal apophysitis
- Hypermobility
- Metatarsus Primus Elevatus
- Morton's syndrome
- Plantarflexed 1st metatarsal
- Brachymetatarsia
- Flaccid metatarsals
- Forefoot varus or valgus
- Rearfoot varus or valgus
- Metatarsus adductus
- Accessory navicular avulsion, fracture, stress
- Metatarsal fractures or avulsion type injuries
- Sesamoiditis fractures and dislocation
- Protection of lateral ankle, foot, heel, talus, base & 5th met head
- Protection of medial ankle, navicular, base and head of 1st met
- Protection of protruding growth or neoplasm anywhere in an area covered by the shoe
- Gross deformities requiring protection from shoe pressure
- Gross deformities requiring immobilization
- Calcaneal fractures
- Dorsal exostoses
- Cuboid dislocation or subluxation

Pediatric Orthoses *(from page 152)*

tion of individual developmental trends is important in ascertaining whether or not additional neutralization of these imbalances is indicated. As previously stated, no visible pronation should be permitted and the subtalar joint should be maintained in its neutral position. Since an adult-like gait pattern is achieved by three years of age, the ability of the foot to provide a rigid lever for propulsion is of paramount importance in the management objectives for this age group.

In children between four and seven years of age, the same caution must be exercised regarding the complete neutralization of structural deficiencies. Since we are closer to the point at which the majority of developmental parameters should be achieved and the skeletal framework is basically set, additional neutralization of these deficiencies may be appropriate. In the child over eight years of age, neutralization of structural deficiencies is indicated with the caveat that periodic monitoring of alignment and function must be performed in order to ascertain whether or not existing posting may be reduced or eliminated.

In any event, no visible pronation should be observable in stance or during gait with the subtalar joint held in neutral alignment and the forefoot and rearfoot positioned to allow contact with the supporting surface. This structural repositioning will promote a normal sequencing of events during the gait cycle, thereby improving foot and leg function.

One additional note regarding the initial prescription of pediatric foot orthoses is that the degree of correction may be limited by the ability of the patient to tolerate the device due to the extent and type of pathology present. This is especially true in the presence of equinus influences. Additionally, any inability to obtain an ideal subtalar neutral impression may not reveal the full nature of pathology in the positive. In these instances, the orthotic management program may be staged. This is especially apparent in the case of peroneal spasm, in which case the practitioner may be unable to achieve neutral subtalar position during impression casting; however, as the spasm subsides. a closer to neutral impression cast may be performed, thereby enhancing control.

Another example occurs in the case of high degrees of forefoot supinatus secondary to equinus compensation or ligamentous laxity. In this instance, the forefoot control posts should be lowered as the soft tissue component of the deformity resolves. Of course, any posterior group contractures should be stretched to improve tolerance and compliance.

In general, improvements are expected in all children's feet after a period of orthotic use. Monitoring the alignment, fit, and function of each device periodically and recasting when foot structure or performance has changed, even if the child has not outgrown the original device, is appropriate and recommended.

Orthotic Modifications to Enhance Control

There are some children's feet that are unable to be adequately controlled with standard pediatric orthoses. In these cases orthotic modifications to increase control may be necessary. One significant method of increasing control is the Blake inverted orthosis, which is discussed in Part II of this article.[51] Another well-tolerated orthotic modification to enhance orthotic function is known as the Kirby skive.[52] This technique involves pouring of the positive cast 5-10° inverted that enhances rearfoot control. In children less than seven years of age, plantarflexion of the medial metatarsal heads during casting improves forefoot alignment, especially in those children with a high degree of forefoot varus.[52,53]

Deepening of the heel seat up to 1" and extending the rearfoot post length with a medial flareout will improve orthotic performance. As noted, reduction of rearfoot post tapering and long high medial and lateral flanges improve control and limit forefoot transverse plane motion and midtarsal joint subluxation. Flanges may be thinned and/or cushioned medially to offer greater tolerability.

Sheldon Langer, DPM, founder of Langer Laboratory, said that the most influential portion of the orthotic device is the calcaneal inclination region that is capable of securely and precisely positioning the entire foot and ankle within a range permitted and dictated by the accompanying and appropriate rear and forefoot posts.

Along these lines, a modification to enhance orthotic control and effectiveness is enhancement of the calcaneal inclination angle in the plaster positive. This can range from 1/8"-3/8" or greater depending on the individual and is very useful in controlling the otherwise difficult-to-control pediatric flatfoot. This modification effectively controls sagittal plane motion at the oblique midtarsal joint axis by elevating the anterior process of the calcaneus. To stabilize the lateral column, a similar enhancement can be made in the

Continued on page 154

FIGURE 8:

Selected Indications for Pediatric Orthoses in the Presence of Equinus Influences

- Equinus Symptoms
- Posterior knee, calf and Achilles pain
- Posterior calcaneal exostosis or Haglunds's deformity
- Sever's disease
- Anterior ankle "jamming"
- Medial and lateral ankle retinaculum pain
- Stressing of secondary plantarflexors at origins and insertions
- Calcaneal bursitis inferior or posterior
- Plantar fascial strain
- Patella pain inferior; Sinding-Larsen-Johanassen, Osgood-Schlatter

Pediatric Orthoses (from page 153)

calcaneocuboid region of the device.

In those cases where the foot is unable to be repositioned and remains laterally displaced from the center of gravity (despite appropriate and aggressive orthotic modifications), the device must begin to extend up the leg for additional leverage. The supramalleolar (SMO) device extends above the malleoli, and if that is insufficient, an ankle foot orthosis (AFO) extending further up the leg may be considered.

Factors to Evaluate

Most children today wear sneaker-type athletic footwear. While some are better constructed than others, for the most part, these shoes do not contain a rigid shank, thereby allowing the midfoot to collapse. This is especially damaging in those children with equinus-induced oblique axis midtarsal joint compensation. As a result, and as a general rule, pediatric foot orthoses should be non-compressible, relatively rigid, and possess torsional flexibility.

Since children are in essence fledgling Olympians on the go from dawn to dusk, the device must possess a degree of flexural "forgiveness" while still being able to resist deformation as well as retain its non-compressible nature. Compressibility will depend on the weight of the child, type of material, module thickness, and forces directed through it. Based on the child's age, weight, diagnosis, and activity level, a good laboratory will be able to guide you in your selection.

When four year old Zachary decides he is going to in re-enact a Spider Man leap, it would be safer if he does not land on a device that may fracture and cause injury. Examples of inflexible or rigid device materials include Rigidur™ (polydur) or fiberglass, both of which possess a high-tensile strength and a lower degree of elasticity, thus making them more prone to fracture. A semi-rigid device would be able to absorb impact without its elastic limit being exceeded, and thereby dissipate forces without module deformation or fracture. Examples of semi-flexible or semi-rigid device materials include polyethylene, polypropylene, subortholene, and graphite composites.

The prescription of non-compressible but flexible pediatric orthoses such as leather laminates, "rubber butter" (latex/cork combinations), or "zote" type materials are not ideal for most pediatric applications. This is due to several reasons, the first being that flexible orthoses in flexible footwear such as sneakers allow the entire system to bend in the midfoot region. This undesirable midfoot flexibility allows unimpeded oblique axis midtarsal joint pronation to take place.

The second reason is that materials used in the fabrication of a flexible device subject the module to rapid deformation and loss of function. This is especially true in the case of a leather laminate-type device that is fabricated by wetting and pressing the leather to conform to the plaster positive. Because of increased temperature and perspiration inside the shoe, this "moulding" process continues, thereby changing the shape of the device according to the abnormal forces directed through it. This deformation is rapid and alters its originally intended function. **PM**

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Pediatric Orthoses *(from page 154)*

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CME **EXAMINATION**

SEE ANSWER SHEET ON PAGE 157.

1) The orthotic should conform to the child's foot and after a period of use in an optimally functioning device, there should be no evidence of wear in which one of the following areas?

- A) calcaneus
- B) longitudinal arch
- C) metatarsal heads
- D) sulcus and digital region

2) An ideal shell material for an active child four years of age would be which one of the following?

- A) leather
- B) fiberglass
- C) polypropylene
- D) Plastazote

3) A valuable addition to improve orthotic control in the fat, flat, and floppy child's foot is which one of the following?

- A) deepened heel seat
- B) Kirby skive
- C) enhanced calcaneal inclination
- D) all of the above

4) The original Whitman steel plate functioned on which one of the following principles?

- A) pain principle
- B) law of soft tissue
- C) law of recapitulation
- D) adaptivity

5) The conservative orthopedic management of congenital pediatric musculoskeletal deformities utilizing splints, orthotics, braces, or serial plaster immobilization relies on improvements in alignment and function during periods of growth. This is referred to as:

- A) Wolff's Law of Bone
- B) Haeckle's Law of Recapitulation
- C) Morton's syndrome
- D) Law of Reciprocal Inhibition

6) In the presence of equinus influences in the child's foot and in addition to an appropriate posterior group stretching program,

Continued on page 156

the following orthotic modification may be helpful:
A) increased shell flexibility to allow flexural forgiveness without deformation
B) increased rearfoot posting
C) Kirby skive
D) forefoot posting extended to the sulcus

7) Which of the following orthotic modifications would address increased forefoot activity and enhance orthotic effectiveness in the active child over two years of age?
A) forefoot posting extended to the sulcus
B) reduced rearfoot posting
C) reduced undercut
D) heel elevation

8) Which of the following age groups represents the time period when the majority of structural form in the foot has been completed?
A) 4-6 years
B) 6-8 years
C) 8-10 years
D) 10-12 years

9) Since most adult foot deformities begin in childhood, the most important treatment for an acquired flatfoot is which one of the following?
A) periodic monitoring
B) surgical intervention
C) muscle strengthening
D) prevention

10) Complete neutralization of identified structural deficiencies in children under what age is ill-advised?
A) 7 years
B) 9 years
C) 11 years
D) 13 years

SEE ANSWER SHEET ON PAGE 157.

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EXAM #4/19
Pediatric Orthoses: An Overview—Part I
(D'Amico)

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1.	A	B	C	D	6.	A	B	C	D
2.	A	B	C	D	7.	A	B	C	D
3.	A	B	C	D	8.	A	B	C	D
4.	A	B	C	D	9.	A	B	C	D
5.	A	B	C	D	10.	A	B	C	D

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A B C D

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