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The *ABCs* of AFOs

AFOs/Braces are orthotic devices used to hold a part of the body in the correct position to allow function and healing. Bracing is used in the management of CMT to support and hold a part of the body compromised by muscle weakness, muscular atrophy, and sensory impairment.

Many CMT patients consequently need to wear special footwear, foot orthoses and ankle-foot orthoses (AFOs) to maintain independent ambulation. But there are a variety of braces available for ankles, knees, feet, hands, and other areas weakened by CMT. Even your neck and spine can be braced. For many with CMT, braces can bring newfound ability to walk quickly and smoothly and provide greater independence in everyday activities.

Definition of an ankle-foot orthosis (AFO): Any orthotic device for the lower limb that encloses the ankle and foot, does not extend above the knee, and is intended to prevent a foot from dropping due to inadequate dorsiflexion.

Definition of a knee-ankle-foot orthosis (KAFO): Any orthotic device for the lower limb that extends from above the knee to the ankle and foot, and is intended to control the knee joint in addition to the foot and ankle.

Bracing for adults and children: Drop foot and balance loss are the most common complaints CMT patients have when evaluating for AFOs. Balance loss can cause pathological gait to be more exaggerated. With balance loss, CMT patients will need to rely on objects to lean against while standing, and to touch objects, such as walls, while walking.

Bracing for children with CMT should consist of all the same clinical evaluations and goals as for adults. One primary difference is consideration for growth. As growth rates cannot be controlled or clinically predicted, it is the discretion of practitioners as to whether they could build in extra length to the device for potential growth without compromising fit, stability, and function.

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Another difference in treating children is that there may be a more intense focus on correction than with adults, to the point of even over-correction, knowing the ongoing progression of deformity that often occurs in CMT patients. Adults can still achieve significant correction in gait, and this should be the goal in orthotic treatment.

Factors used to determine and prescribe a lower limb orthosis:

- **Tibialis anterior strength (the large muscle on your shin, acts to dorsiflex and invert the foot)**
- **Gastrocnemius strength (muscle that is in the back part of the lower leg)**
- **Quadriceps strength (muscles on the front of the thigh)**
- **Age**
- **Overall strength**
- **Hand involvement**
- **Extent of damage to muscles, tendons, ligaments, bones, joints and balance.**

Pathologic gait affecting ankle and foot:

Pathologic gait is when the strength, joint mobility, and coordination for walking represent only a fraction of normal lower-limb potential.

Ankle and Foot:

- **Inappropriate initial contact**
- **Low heel strike**
- **Flat foot contact**
- **Forefoot contact (toe strike/foot drop)**

All of the above contribute to a steppage gait, where the legs raise abnormally high to compensate for toe drag. Thus, the main goal of orthotic treatment is to prevent the toes from hitting or dragging on the ground, which can cause the person to trip or fall.

Most common symptoms with CMT when evaluating for bracing:

- **Foot drop**
- **Pes cavus deformity (high arch, fixed plantar flexion of the foot)**
- **Varus deformities (inward angulation of the bone below the knee)**
- **Valgus deformities (outward angulation of the bone below the knee)**
- **Muscle atrophy**
- **Balance loss**

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Primary bracing corrections for CMT should address the following:

- **Foot drop**
- **Loss of balance**
- **Gastrocnemius weakness (muscle that is in the back part of the lower leg)**
- **Foot and ankle deformity (surgical intervention may be required)**
- **Slow walking speed**

We can also observe pathologic gait from an AFO that is not performing properly.

Gait deviations with CMT:

What do all gait deviations have in common? They are deviated movements of other muscles and joints of the body to compensate for loss of motor power due to a neuropathy.

Primary gait compensations with CMT:

- **Bilateral hip hiking; causes a steppage gait**
- **Lateral trunk bending**
- **Circumduction; circular movement of the leg to prevent the toes from dragging on the ground.**

All of these gait deviations are due to weakness of the Tibialis Anterior.

Effects of drop foot and balance loss:

- **Increases oxygen consumption**
- **Overtaxes the existing musculature that is working**
- **Early fatigue**
- **High risk for tripping and falling**

Effects of uncorrected foot deviations or deformities:

- **Contractures—the Achilles tendon becomes shortened from a lack of dorsiflexion**
- **Ligamentous laxity—ligaments become overstretched due to improper joint alignment. This causes further instability at the foot and ankle and creates more balance loss**

Bracing correction techniques for CMT:

- **Corrective mold taken properly should incorporate realignment of joint deviations**
- **Lab modifications or corrections**
- **Test braces (diagnostics)**
- **If necessary, Corrective brace fabrication**
- **Final fitting of device (including adjustments)**

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Corrective CMT bracing should consist of:

Tri-planar Correction: The patient's foot and ankle need to be corrected as much as possible in all 3 planes of movement;

- **Ankle Joint or Talocrural Joint**
- **Subtalar Joint (The joint allows inversion and eversion of the foot)**
- **The midtarsal or transverse tarsal joint (separates the rearfoot from the midfoot - allows the midfoot to move independently of the rearfoot)**

Types of orthoses:

1. **Posterior leaf spring Ankle-foot orthosis (AFO)**
2. **Solid ankle AFO**
3. **Floor reaction AFO**
4. **Jointed AFO**
5. **Range-of-motion adjustable jointed AFO**
6. **Energy storing carbon fiber AFO**
7. **Knee-ankle-foot orthosis (KAFO)**
8. **Energy storing KAFO**

Differences between custom and off the shelf orthoses (AFOs):

- **Custom made AFOs are made from a mold of the patient's leg, in order to fabricate a custom fit device which can address different structural deformities.**
- **Off the shelf are not made from individual patients' molds. They are pre-manufactured, and are typically fit by sizes; small, medium, large, left and right.**

Corrective bracing goals for CMT:

- **Triplanar correction**
- **Corrected alignment**
- **Balance restoration**
- **Prevention of further deformity**
- **More functional gait through energy storing mechanics**

1. 

2. 

3. 

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7. 

8. 

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Balance and bracing basic principles:

- **If the patient cannot stand with balance, they cannot walk with balance**
- **Balance requires a stable foundation**
- **If the foot and ankle are not corrected in the brace's footplate, balance can be poor**
- **Balance restoration also requires practice. Physical therapy should be incorporated if needed**
- **Floor reaction brace design helps CMT patients with balance**
- **Energy storing designs can help patients reduce fatigue**

Current materials used in bracing fabrication:

- **Thermoplastics**
- **Metal**
- **Leather**
- **Carbon fiber**

Benefits of carbon fiber:

- **Maintains its shape**
- **Does not torque (bending motion) against rotational forces**
- **Can be structured differently in one device**
- **Can be used for energy storing devices**

It is recommended that CMT patients who experience balance loss, foot/leg pain, or an irregular gait obtain an evaluation by a certified orthotist. Uncorrected gait and balance issues can lead to other complications, including progression of further joint deformity, progression of muscle weakness and fatigue, increased risk for falls, and overall negative impact on quality of daily activities.

This information was provided by Mitchell Warner, CPO, Ortho Rehab Designs Prosthetics and Orthotics, Inc., Las Vegas, NV www.ordesignslv.com; info@ordesignslv.com

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The AFO Checklist

Prior to visiting an orthotist:

- ◯ **Is your orthotist certified? https://www.abcop.org/Pages/default.aspx**
- ◯ **Licensed in the state? https://www.abcop.org/State-Licensure/Pages/state-licensure.aspx**
- ◯ **Be prepared to describe your current and desired lifestyle and activity level**
- ◯ **What kind of shoes do you normally wear? Take them to your appointment and discuss whether or not that heel angle (s) is being taken into consideration.**
- ◯ **Insurance - frequency?**
  - **What if it doesn't work?**
  - **What if it breaks?**
  - **What if there's an anatomic change?**
- ◯ **Will the aesthetic of the brace work for you?**

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The AFO Checklist

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At your visit:

- ◯ **The orthotist should evaluate your gait:**
  - **knee weakness**
  - **exaggerated loss of balance**
  - **overall strength**
- ◯ **The orthotist should evaluate hand weakness & modify closures/straps**
- ◯ **The orthotist should ask if you're allergic to any metals/materials**
- ◯ **The orthotist should evaluate your balance. A manual muscle test should be performed to know what you need to be braced for:**
  - **Dorsiflexion (lift toes up from ankle joint)**
  - **Plantarflexion - pointing toes down**
  - **Quads - extend leg while sitting and hold against resistance**
  - **Hamstrings - extend leg and bend at knee as far as possible**
  - **Hip flexors - bring knees to chest**
- ◯ **If it's decided you require a custom-made device, the process is:**
  - **Casting - to align ankle and knee (up to, or just below the knee)**
  - **Follow-up appointment to get brace**
  - **Follow-up as needed for adjustments (this may take several visits)**
- ◯ **If it's decided an Off-the-shelf brace is right for you, you should ask:**
  - **What correction is being made to my foot and ankle, if needed?**
  - **Will a foot orthotic be added to customize the foot plate?**

Ask the Orthotist

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How will the AFO provide joint corrections for any foot and ankle deformity that I may have?

In order for a custom made AFO to provide maximum joint corrections, to prevent further deformity and to provide maximum balance, it should have triplanar correction controls built into the device.

The first step would be an evaluation of the patient's deformities, and then a corrective mold of the patient's leg which then has to be modified and corrected by an Orthotist.

The foot and ankle moves in 3 planes at the same time while walking. In the frontal plane, the foot moves into eversion and inversion. Deformities in these planes can also be called valgus and varus. When the foot moves up and down, it is dorsiflexion moving up, and plantarflexion moving down, which is in the saggital plane, and is the second plane of movement. In the third plane, the transverse plane, the foot moves outwards which is abduction, or inwards which is called adduction. It is necessary that all three of these planes are corrected in order to provide proper joint corrections.

Am I candidate for an AFO, or should I consult with an Orthopedic surgeon for possible surgical intervention?

If your foot is correctable into a fairly neutral comfortable weight-bearing position by an Orthotist, you would be a candidate for an AFO. This is dependent upon the Orthotist and their evaluation in order to get you corrected comfortably and realigned. The realignment can produce a better gait for you using an AFO. If your foot and ankle has severe deformity where the joints cannot be manipulated into getting you into a proper corrected position, depending on the level of fixed deformity, you may need to see a foot & ankle Orthopedic Surgeon for an evaluation. Most CMT foot and ankle deviations can be controlled with an AFO, but not in all circumstances.

I want to try and run or jog, what type of AFO is recommended?

If one desires to jog, an energy storing AFO would be the best choice. Energy storing AFOs for jogging are generally designed using corrective alignment, balance control, and dynamic response, using technology similar to prosthetic devices for running. They need to incorporate a long upright system from the heel section up to the calf area. When the patient puts weight on the heel and starts to roll over, the upright compresses and stores energy, then releases that energy to propel the leg forward. These devices generally incorporate an upright made out of carbon fiber and/or fiberglass composites.

Ask the Orthotist

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Does the level of my condition call for a custom made AFO?

YES! The person affected by any level of a neuropathic condition must receive a custom treatment capable of adjustments according to the evolution of the pathology. Unfortunately, in the regular practice, there is a tendency to start at the early stages with off the shelve semi-rigid carbon fiber AFOs. Custom devices are considered only when the weakness is severe. This practice is wrong and must be changed. The goal must be to keep as much range of motion, save energy, assist the balance, and make adjustments accordingly. Despite the benefits of the physical properties of the carbon fiber to store energy and weight, these are useless when the user develops gait deviations to void rigid structures. Usually, after breaking several of these pre-fabricated AFOs, the users end up using extra-rigid thick devices. None of them fabricated considering the actual muscle strength, range of motion, activity level, weight, height, and shoe design. One size does NOT fit all!Your shoe size doesn't determine the assistance or resistance need for your conditions.

How will the AFO provide balance support for my condition?

There is NO possibility of providing STABILITY without the accurate CALCULATION of the LOADING FORCES! The stability and balance should be present over slopes and uneven surfaces. If an AFO only works over a flat surface it is because none of the factors that influence stability were considered in the fabrication or design. The patient-related data such as height, weight, gait type, orthopedic limitations, age, activity level, muscle strength, and more need to match with the orthosis related-data, whereas foot piece design, shell position, orthosis height, material, production technique, and joint design play key roles. Only if these elements are in perfect harmony, then the user will sense stability walking over slopes, stairs, running, or walking.

I have weak quadriceps, should I be considering a KAFO?

The knee extensors or quadriceps are essential for keeping the knee firm to prevent the collapse when a single foot is on the floor. Another group of muscles keep the ankle and hip stable to balance the forces. In persons affected by neuropathies where these groups of muscles don't respond appropriately, the body finds a way to create balance under any circumstance. In some instances where the quadriceps are weak, the knee finds stability in hyperextension. This means that the knee will move posteriorly to prevent the collapse at every step. This will also force the compensation of the ankle and the hip. There are certain limits in the muscular values that could help to determine if the knee requires assistance to produce enough stiffness to receive the full weight at every step. Every patient is unique and different, and each condition must be addressed individually. If the AFO produces effective dynamic assistance customizing the resistance forces when the ankle and foot hit the ground, it controls the knee extension. This generates enough support to prevent the use of KAFOs in some instances.

Ask the Orthotist

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I have had triple arthrodesis surgery, what type of brace will help me walk more efficiently?

Ideally a custom made AFO that supports the correction made during surgery but still allows some movement at the ankle joint because we do not want to inhibit motion where we don't need to. Generally when a joint is fused, then excessive motion will start to occur above and below the fused joint, which could cause problems down the road. Something similar to a dynamic carbon fiber custom brace would work.

How long will it take me to get used to my new gait and brace?

It all depends on how much correction/alignment the brace has to do, how well it fits, how long the patient has been compensating for gait abnormalities, and if physical therapy is done. It can take anywhere from a few weeks to several months.

How often should you be wearing them?

Generally at least 8 hours per day when ambulatory.