# Principle of Orthosis Correction in Gait Problem

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Abstract: Abnormal gait or gait abnormality occurs when the body systems are unable to aid walking in the usual way. Gait abnormality can be caused by musculoskeletal and neuromuscular problems. It can occur among every population from pediatric, adult and geriatric cases. If this abnormal pattern persists, it can alter the biomechanics of the body resulting in more complications such as pain, deformity, and balance problem. One way to facilitate the gait pattern is by using lower extremity orthosis.

## 1 INTRODUCTION

Gait is the reflection of how a person walks. Many factors contribute to constructing a normal gait pattern, such as proper body alignment, musculoskeletal system, neuromuscular system, also balance and proprioceptive mechanism. Disruption to one or more of these systems will alter how the body responds to external force, resulting in gait abnormalities. An orthosis is one of the conservative techniques to correct misalignment of lower extremities to facilitate normal gait patterns. The application of orthosis also can prevent further deformities. This article will explain about principles of orthosis application to facilitate normal gait pattern in several abnormalities.

## 2 DISCUSSION

Treatment and management of an underlying condition causing abnormal gait may vary. Some injuries causing abnormal gait may require surgery or physical therapy to help return the gait to normal. For long-term cases of abnormal gait, a person will likely use assistive devices for treatment. These can include orthosis, crutches, canes, and walkers. Some treatments cannot always correct an abnormal gait completely, but it can at least reduce the severity of symptoms in most cases (Standford Medicine, 2019).

General principles of orthosis correction in gait problems are required to be known to ensure proper prescribing of an orthosis. In correcting gait abnormalities, orthosis was used to provide support, stability, and maintain proper alignment to the hip, knee and ankle joints. Some injury may also cause deformity or malalignment which will contribute to the development of gait problems in the future, thus orthosis were required to prevent the deformity. The design of orthosis prescribed must allow safe and effective ambulation by the patient to allow maximal functional independence. The materials used should be light, sturdy, and resistance to wear. Prescription of orthosis should meet the functional requirement of the client, correlate to the patient's personality and impact of the device upon the patient, so each client should be evaluated individually. It is also important to remember that in some cases orthosis is only one component of the treatment and is not the whole treatment for the patient.

### Types of Orthosis

Orthoses are braces or splints that serve to improve the position of a joint (positioning type) and/or function (functional type) of an injured extremity, it used to modify the structural and functional characteristics of the neuromuscular and skeletal system. Lower limb orthoses are the most commonly prescribed type of orthoses, with Foot Orthoses (FO), Ankle-Foot Orthoses (AFOs), Knee Orthoses (KO), Knee-Ankle-Foot Orthoses (KAFOs) and knee braces (Fox et al, 2019).

Foot orthoses (FO) can be helpful to correct problems in the foot, knee, hip, and spine.



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Prescription for foot orthoses are divided into two categories as defined by the American Podiatric Medical Association, there are (Fox et al, 2019).

1. Functional orthotics to control abnormal motion may be used to treat foot pain caused by abnormal motion; they can also be used to treat injuries such as shin splints or tendinitis. Functional orthotics are usually crafted of a semirigid material such as plastic or graphite.
2. Accommodative orthotics are softer and provide additional cushioning and support. They can be used to treat diabetic foot ulcers, painful calluses on the bottom of the foot, and other uncomfortable conditions.

Two types are custom and non-custom orthoses. Custom foot orthoses start with a thorough examination of the foot-ankle complex to determine limitations in range of motion in both the forefoot and the rear foot, including calcaneal talus alignment. Once this is done, a gait assessment is performed without shoes and socks on. An impression is taken using step-in foam, cast, or a scan (with an optical digitizer) with the foot held in subtalar neutral. Any other type of foot orthosis is non-custom. This includes the type patients may receive from various outlets claiming custom fit. There are many minor foot problems for which non-custom foot orthoses provide appropriate treatment (Nolan et al, 2010). Successful foot orthotic treatment is dependent on the shoes that are used in conjunction with the orthosis. If a person brings in a shoe that barely accommodates his or her feet (too tight or too worn), then placing a foot orthotic into it will lead to failure. After fitting the patient using the proper shoes, the orthotist reassesses the patient's gait to determine whether goals for alignment, posture, pain, and corrections to the foot-ankle complex are being met. Education and follow up is key to a successful outcome (Fox et al, 2019).

Ankle-Foot Orthoses (AFOs) are used for problems dealing with foot and ankle issues. These orthoses include any devices that pass across the ankle joint but stay distal to the knee joint. This orthosis is used for diagnoses that range from ankle sprains to stroke management and potentially be used for any neuromuscular condition requiring support or assistance at the level of the foot and ankle (Fox et al, 2019).

Figure 1. Ankle–Foot Orthosis (AFOs) (Fox et al, 2019).

A study conducted by Nolan KJ., Saalia KK. et al (2010) in the evaluation of a dynamic ankle-foot orthosis in hemiplegic gait showed that there was increased hip flexion at foot strike and toe-off, increased hip sagittal plane angular velocity during the swing phase and decreased abduction. The dynamic ankle-foot orthosis had a positive effect on the participant's overall gait (Nolan et al, 2010). A study conducted by Sankaranarayan H., Gupta A. et al (2016) in Role of ankle-foot orthosis in improving locomotion and functional recovery in patients with stroke showed that ankle-foot orthosis (AFO) improved locomotion and functional recovery after stroke (Sankaranarayan et al, 2019). A study conducted by Ferreira LAB, Neto HP, et al (2013) showed that all types of AFO (Ankle-foot Orthosis) resulted in a significant improvement in gait velocity compared to a control group without the use of an AFO. There have been advances in understanding how AFOs can enhance the patient's ability. This includes functional electrical stimulation devices that replace the traditional AFO with electrical stimulation during various times in the gait cycle (Ferreira et al, 2013).

Knee orthosis (KO) can provide stability, limits motion, and controls the medial-lateral movement of the knee joint. A KO is primarily used when the ankle-foot complex is fully functional and thus a knee–ankle– foot orthosis (KAFO) is unnecessary.

A study conducted by Jeffrey W, Sugar T. et al (2011) showed that patients who got stroke and used

Powered Ankle Foot Orthosis (PAFO) showed significant improvement in cadence, ankle range of motion, and power generation capabilities. (sugar)

Indications for KO (Fox et al, 2019):

- Medial–lateral knee instability
- Post-surgery or injury postoperative stabilization
- Support for medial collateral ligament (MCL), anterior cruciate ligament (ACL), and posterior cruciate ligament (PCL) tears and stress to limit extension or flexion
- Rotational control
- Osteoarthritis


Figure 2. Knee Orthosis tools (Fox et al, 2019).

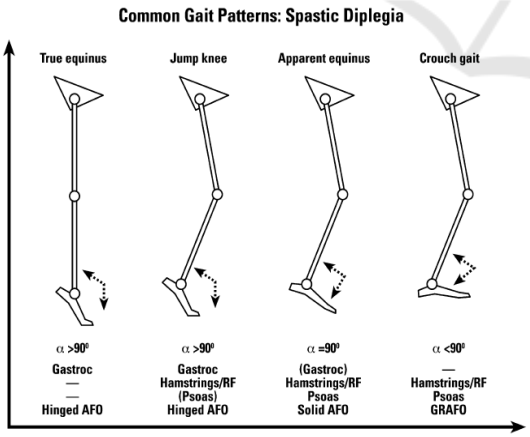


Figure 3. Knee-Ankle-Foot Orthoses (KAFOs) (Fox et al, 2019).

Knee-Ankle-Foot Orthoses (KAFOs) provide stability to the knee and foot when needed during the stance phase of ambulation and knee hyperextension control from midstance to the terminal stance phase in the gait cycle. Clinical indications for a KAFO include instability of the knee and ankle, quadriceps weakness or absence, hyperextension of the knee, varus or valgus deformity correction in children, and paralysis of one or both legs.

Knee braces are designed to transfer load while allowing for normal knee motion. This depends on the amount of leverage the knee brace can provide. Longer braces produce a greater amount of leverage; therefore, athletes typically select the longest brace that provides the best fit to the extremity. The optimal position to apply the leverage depends on the goal of the knee brace (An K et al).

Figure 4. Knee brace (An K et al)

Wedged insoles are one of the treatment options frequently recommended for the management of knee OA. There are two kinds of wedged insoles, laterally wedged insole and medial wedged insole. This orthosis is made from various materials. The most common material is silicon rubber, polypropylene, and ethylene-vinyl acetate. The usual thickness of wedged insole is ¼ inch with the density of a 40-70 durometer scale. The density of insole is the most important consideration regarding its effectiveness. Fisher et al (2007) suggest that the most optimal insole density is within the range of 20% to 50%. Wedged insole application shows reduced in external knee adduction moment.

## Orthosis for Specific Gait Problem

### Cerebral palsy

Cerebral palsy is one of the most common movement abnormalities in children. In children, gait is a prerequisite requirement for socializing and playing. Gait abnormalities in cerebral palsy can be caused by spasticity, abnormal motor tone, loss of motoric control and balance disorder (Baxter et al).

In general, spastic motor patterns are reasonably consistent from stride to stride and from day to day. However, as the age growing and there's some intervention over the longer term, the gait pattern will change. The most common change with age is from a pattern of `toe walking' (because the gastrocnemius is dominant) to a pattern of increasing hip and knee flexion and eventually, `crouch gait' with hip and knee flexion and ankle dorsiflexion (Concept for the Orthotic Treatment of Gait Problems).

Figure 5. Common gait pattern in cerebral palsy diplegic

GRAFO and SAFO are the recommended type of AFO to be used when the GRF directed to the anterior knee. GRAFO is more recommended for a patient with crouch gait to reduce ankle dorsiflexion and increase knee extension moment. GRAFO can control or reduce ankle and subtalar movement. By controlling joint movement more distally, it will change the GRF and also will affect the proximal joint using PF-KE couple principal. A ventral shell of GRAFO will reduce or limit anterior translation of tibia thereby reducing ankle dorsiflexion.[10,11] Harrington et al and Gage reported that GRAFO will limit ankle rocker and it will increase knee extension (Rodda et al, 2001).

**Obesity with knee osteoarthritis**

Common malalignment regarding osteoarthritis is varus and valgus alignment. Knee osteoarthritis which affected the medial compartment will result in a varus alignment, and which affected the lateral compartment will result in valgus alignment. Malalignment will cause GRF response to muscle activation and the moment. These changes will alter the normal gait pattern.

Patients with medial knee osteoarthritis and varus malalignment of the knee are subject to high overload and high angles of dynamic varus in the knee. In these individuals, there is a pattern of gait in external rotation with a reduction of velocity as adaptive factors, yet insufficient to reduce weight-bearing to normal values.

The highest flexor moment presented demonstrates another adaptive mechanism which is to transfer weight bearing from the frontal plane to the sagittal plane. Individuals with medial knee osteoarthritis have less flexion-extension variation, which characterizes with a predominance of flexion. Patients with knee OA demonstrate changes in gait patterns such as increased toeing-out, reduction in gait speed, and lateral sway of the trunk in the stance leg.

In mild to moderate knee osteoarthritis, lateral wedged insole (LWI) is one of the nonoperative realignment strategies for medial compartment knee OA. Several studies reported that LWI will displace vector of GRF from the center of plantar pedis more laterally to reduce medial compartment knee loading. The force that applied on the knee started from the center of pressure on plantar pedis. This force will be transferred superiorly towards the knee. A recent study shows that LWI will reduce external knee adduction moments.

Knee unloader braces with valgus adjustment are a mechanical intervention designed to reduce pain, improve physical function, and possibly slow disease progression. Pain relief is thought to be mediated by distracting the involved compartment via external valgus forces applied to the knee. In so doing, tibiofemoral alignment is improved, and load is shifted off the degenerative compartment, where exposure to potentially damaging and provocative mechanical stresses are reduced.

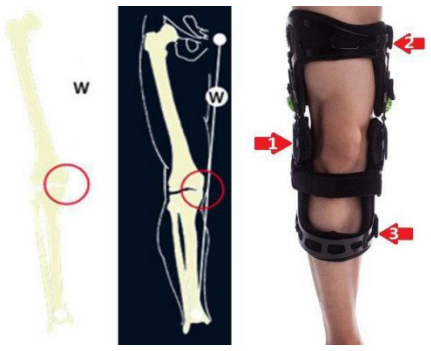


Figure 6. Knee unloader braces with valgus adjustment

Knee unloader braces with valgus adjustment are effective in mediating pain relief caused by knee osteoarthritis and malalignment, bracing should be fully used before joint realignment or replacement surgery is considered. Knee unloader braces with valgus adjustment are reported to be a safe and inexpensive treatment that mediates pain relief and ameliorates function for patients with knee OA.

## 3 CONCLUSIONS

The orthosis is an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system. The orthosis can improve the quality of life of patients, it showed that they can do activity daily living properly especially in gait problems.

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