

The FIOR & GENTZ Treatment Guide for Orthotists



Content

General Information	3
CP Guide	8
Stroke Guide	10
Guide to Paraplegia	13
MS Guide	17
Guide to Partial Foot Amputations	21
CMT Guide	24
PAD Guide	27

Note:

In the following chapters, you will find excerpts from the individual FIOR & GENTZ treatment guides. These summaries are aimed specifically at orthotists. If you cannot find all the relevant content, please refer to the respective guides. The QR code on the title pages will take you directly to the relevant guide on the FIOR & GENTZ website. There you will also find the bibliographical references for the sources cited.

Configuration of the Optimal Orthosis

The orthoses listed in this treatment guide, the system joints mentioned and, where applicable, the recommended spring units serve as a general guide for a possible treatment. To plan the optimal orthosis for your patient, you should always carry out a detailed patient examination.

All relevant patient data is collected and entered into the FIOR & GENTZ Orthosis Configurator during the configuration process. Step by step, the user selects the available orthosis types and joint functions to customise the finished orthosis.



Division of Physiological Gait into Different Phases According to Jacquelin Perry

									
Term (Abbreviation)									
<i>initial contact (IC)</i>	<i>loading response (LR)</i>	<i>early mid stance (MSt)</i>	<i>mid stance (MSt)</i>	<i>late mid stance (MSt)</i>	<i>terminal stance (TSt)</i>	<i>pre swing (PSw)</i>	<i>initial swing (ISw)</i>	<i>mid swing (MSw)</i>	<i>terminal swing (TSw)</i>
Percentage of Stride									
0%	0–12%	12–31%			31–50%	50–62%	62–75%	75–87%	87–100%
Hip Angle									
20° flexion	20° flexion	10° flexion	neutral position	5° extension	20° extension	10° extension	15° flexion	25° flexion	20° flexion
Knee Angle									
0–3° flexion	15° flexion	12° flexion	8° flexion	5° flexion	0–5° flexion	40° flexion	60° flexion	25° flexion	0–2° extension
Ankle Angle									
neutral position	5° plantar flexion	neutral position	5°dorsiflexion	8° dorsiflexion	10° dorsiflexion	15° plantar flexion	5° plantar flexion	neutral position	neutral position

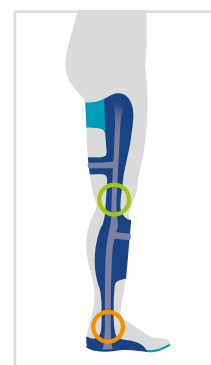
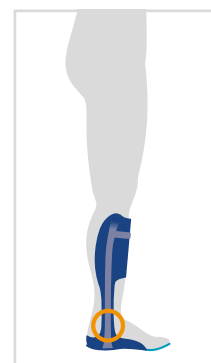
Orthosis Types

Ankle-Foot Orthosis (AFO):

AFOs can be produced in different versions and with different ankle joints. They are employed when primarily the plantar flexors and dorsiflexors are affected. Depending on the type of ankle joint used, AFOs may have a dorsiflexion and/or prevent excessive dorsiflexion by using a dorsiflexion stop [Plö].

Knee-Ankle-Foot Orthosis (KAFO):

KAFOs are designed with an ankle joint and, depending on muscle strength, with free moving, automatic (stance phase controlled) or locked knee joints, and are mainly used in cases of weakness of the m. quadriceps femoris. One indication of this is when the patient places their hand on their thigh while walking to assist with knee extension. The knee compensation in hyperextension or excessive inclination of the torso can also be early signs that a KAFO is required [No].



Ankle Joint Functions (for AFOs and KAFOs)

Dorsiflexion Stop (static and dynamic)



- establishing a stable balance during stance
- physiological knee extension and heel lift from terminal stance
- ankle joints with static or dynamic dorsiflexion stop

Example: NEURO VARIO or NEURO SWING system ankle joint

Dorsiflexion Assist



- during swing phase, the foot is held in slight dorsiflexion
- adjustability of the controlled dynamic lowering of the foot
- adjustability of the knee flexion moment and controlled tibial progression

Example: NEURO CLASSIC-SPRING system ankle joint

Knee joint Functions (for KAFOs)

Free Moving



- knee joint motion remains free
- limitation of the range of motion in the direction of extension (using extension stops)
- lateral support and stability
- improved safety in mid stance due to offset joints

Example: NEURO CLASSIC system knee joint

Automatic



- knee flexion is locked during stance phase and released again during swing phase
- locking and unlocking: mechanical (NEURO MATIC system knee joint) or electronic (NEURO TRONIC system knee joint)
- ideal safety combined with a high range of motion
- also suitable as training equipment for rehabilitation

Locked



- completely locked while walking (no knee flexion possible)
- highest possible safety during stance phase
- manual unlocking is possible (e.g. while sitting)
- Nachteil: Ausbildung von Kompensationsmechanismen, um die fehlende Knieflexion auszugleichen

Example: NEURO FLEX MAX system knee joint



SYSTEM ANKLE JOINTS WITH STATIC DORSIFLEXION STOP

**NEURO
CLASSIC**



**NEURO
VAR:O-CLASSIC**



**NEURO
VAR:O-CLASSIC 2**



**NEURO
VAR:O**



**NEURO
VAR:O 2**



**NEURO
VAR:O-SPRING**



**NEURO
VAR:O-SPRING 2**



**NEURO
VAR:O-SWING**



SYSTEM ANKLE JOINTS WITH DYNAMIC DORSIFLEXION STOP

**NEURO
SWING-CLASSIC**



**NEURO
SWING**



**NEURO
SWING 2**



**NEURO
HISWING**



**NEURO[®]
HISWING**



**NEURO
SWING^{h30}**





FREE MOVING SYSTEM KNEE JOINTS WITHOUT POSTERIOR OFFSET

**NEURO
CLASSIC**
zero



**NEURO
VARIO**
zero



FREE MOVING SYSTEM KNEE JOINTS WITH POSTERIOR OFFSET

**NEURO
CLASSIC**



**NEURO
VARIO**



**NEURO
VARIO2**



**NEURO
VARIO-SWING**



**NEURO
ACTIVE**



**NEURO
ACTIVE**



**NEURO
CLASSIC**
H₂O





AUTOMATIC SYSTEM KNEE JOINTS

**NEURO
MATIC**



**NEURO
TRONIC**



**NEURO
HITRONIC**



LOCKED SYSTEM KNEE JOINTS

**NEURO
LOCK**

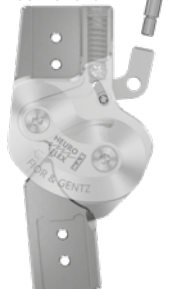


**NEURO
LOCK** **MAX**



**NEURO
FLEX** **MAX**

LOCK FUNCTION



**NEURO
FLEX** **MAX**

STEP LOCK FUNCTION



**NEURO
LOCK** **H₂O**



CP Guide



You can find the complete CP Guide
available for download here.

What is Cerebral Palsy?

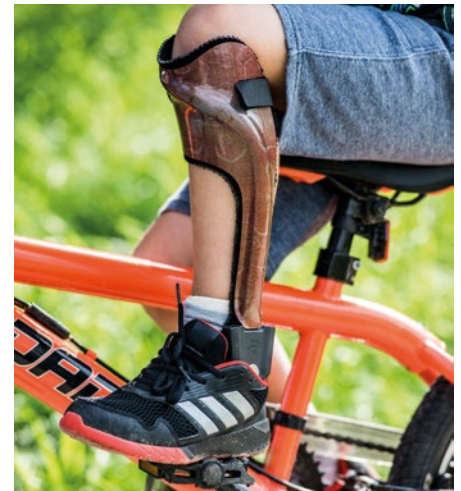
In cerebral palsy, the impulses transmitted by the brain to the affected muscles are false and, as a result, the muscles are excessively, insufficiently or wrongly timed activated. This abnormal activation often leads to dysfunctions of some muscle groups, which normally result in a pathological gait [Gag1, p. 65]. Additionally, these muscular dysfunctions may be accompanied by spasticity [Pea, p. 89], which, in turn, changes the muscle tone in such a way that it may either worsen or improve gait.

Requirements for an Orthosis

A modern orthosis concept is expected to be optimally adjustable to the patient's needs and the course of therapy. It should also allow for a dynamic stability while both standing and walking. Only then can the overall goal of an orthosis be achieved: a physiological gait.

Therefore, all orthoses for CP patients should be constructed with an adjustable ankle joint. It is absolutely necessary to be able to adjust the orthosis alignment, since the position of the patient's foot when producing the cast model differs from its position under load with the orthosis. Thanks to an adjustable range of motion and a variable spring force, the orthotist can react to changes in the gait that may occur during the course of therapy without much difficulty.

The adjustable NEURO SWING system ankle joint has been developed for that exact reason.



Gait Types According to the Amsterdam Gait Classification

Gait Types	Type 1	Type 2	Type 3	Type 4	Type 5
Knee	normal	hyperextended	hyperextended	flexed	flexed
Foot Contact	complete	complete	incomplet	incomplete	complete
Recommendation System Ankle Joint	NEURO CLASSIC-SPRING system ankle joint	NEURO SWING system ankle joint	NEURO SWING system ankle joint	NEURO SWING system ankle joint	NEURO SWING system ankle joint
Anterior Spring Unit	-	white	yellow	yellow	red
Posterior Spring Unit	-	green	green	blue	blue

Stroke Guide



You can find the complete **Stroke Guide** available for download [here](#).

What is a Stroke?

A stroke is a sudden decrease in blood flow in the brain due to vascular causes and it can lead to death or be accompanied by secondary symptoms that last more than 24 hours. The sooner it is recognised and treated, the better the chance of avoiding long-term damages. Mainly, about 80% of all strokes are caused by an acute circulatory disorder (ischaemic stroke) and about 15% by a cerebral haemorrhage (haemorrhagic stroke) [Did, p. 592]. A persistent undersupply of certain cerebral areas causes impairments of various bodily functions.

Movement Restrictions

The undersupply can affect cerebral areas that control the motor function of the musculoskeletal system. As a consequence, the muscles connected to these nerve cells are innervated too early, too late or not at all, thus impairing the muscular stabilisation of the knee and ankle joint.

Compensation Mechanisms

The biomechanical situation of the musculoskeletal system changes due to the dysfunctions, leading to instability in the ankle and/or knee joint when gait and stance. The patient tries to compensate for this instability with other bodily functions. However, these consciously or unconsciously performed compensation mechanisms damage the musculoskeletal system.

Spastic Pareses

If the pyramidal tract of the first motor neuron is damaged after a stroke, the movement restrictions and compensation mechanisms can be accompanied by spastic pareses. If, additionally, the extrapyramidal nerve tracts are damaged, the regulation of the affected muscles' own reflexes is disturbed. This results in an increased muscle tone [Thi, p. 1102]. Spastic pareses can develop or intensify due to perceived insecurities.

Stance Training

Before walking comes standing. Even though standing still is perceived as a simple motor task, it involves the same muscle groups as walking. Many small movements keep the body's centre of gravity above the supportive area, thus creating a stable dynamic balance. These small movements show as minimal swaying of the upper body, the so-called postural sway. A study shows that an early and intensive stance training can shorten the time to regain independent walking [Cum, p. 157].

Dynamic orthoses are a valuable support for a safe stance after a stroke and can prevent or reduce the appearance of spastic pareses. Although the patient might not be able to put the orthosis on themselves, stance training should already begin in the acute phase. For that purpose, the orthosis must be worn as often as possible. In this way, supported stance can also be trained independently of therapy sessions and already in early rehabilitation at the patient's bed alone or with assistance of another person. This early stance training offers the following advantages:

- Regaining the sense of balance is supported.
- Bringing the body into an upright position (verticalisation) has a variety of positive effects on the human organism [Kne, p. 603].
- The controlled load on the muscles can shorten the time to regain independent walking [Cum, p. 157].
- Standing in the acute phase can establish the correct cerebral connections through motor impulses.

Furthermore, a stance training in this early phase of rehabilitation supports the prevention of pes equinus as the muscles are stretched and loaded dynamically. The orthosis also avoids that the foot is in a permanent pes equinus position when lying in bed.



Requirements for an Orthosis

A modern orthosis concept is expected to be optimally adaptable to the patient's needs and the course of therapy. It should also allow for a dynamic stability while both standing and walking. Only then can the overall goal of an orthosis be achieved: a physiological gait.

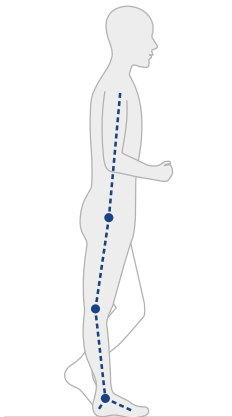
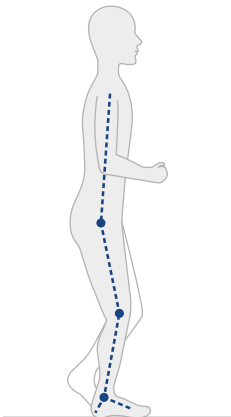
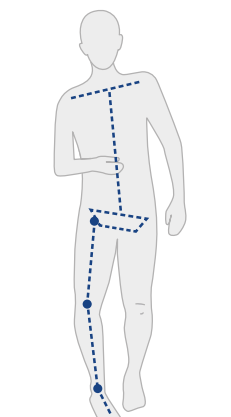
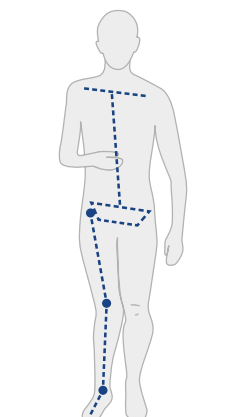
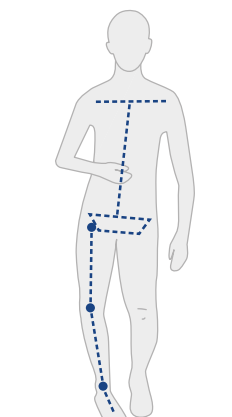
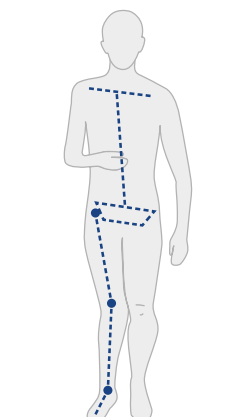
Therefore, all orthoses for stroke patients should be constructed with an adjustable ankle joint. It is absolutely necessary to be able to adjust the orthosis alignment, since the position of the patient's foot when producing the cast model differs from its position under load with the orthosis. Thanks to an adjustable range of motion and a variable spring force, the orthotist can react to changes in the gait that may occur during the course of therapy without much difficulty.

The adjustable NEURO SWING system ankle joint has been developed for that exact reason.

Gait Type according to N.A.P.® Gait Classification

This classification is divided into four basic gait types. In the sagittal plane, there is a malposition of the knee in either hyperextension or hyperflexion in mid stance. Usually, the pelvis is excessively inclined forward.

The patient's goal is to maintain stability using their existing potentials. Depending on the inversion or eversion malposition in the frontal plane the joints further up are also loaded incorrectly.

Knee	Hyperextension		Hyperflexion	
sagittal				
frontal				
Foot	Inversion	Eversion	Inversion	Eversion
Gait Type	Type 1a	Type 1b	Type 2a	Type 2b
Recommendation System Ankle Joint	NEURO SWING system ankle joint		NEURO SWING system ankle joint	
Anterior Spring Unit	yellow		yellow	
Posterior Spring Unit	green		blue	

Guide to Paraplegia



You can find the complete **Guide to Paraplegia** available for download [here](#).

Paraplegia

Paraplegia is a complete or incomplete severance of the spinal cord resulting in organic and/or muscular deficits. The form and level of the injury are decisive for which deficits arise. Paraplegia can have traumatic or atraumatic causes, with traumatic causes being more common among younger patients and the incidence of atraumatic causes increasing respective to the age of those afflicted [McD].

Traumatic causes:

- traffic accidents, occupational accidents and sports injuries
- falls
- suicide attempts
- violent crime

Atraumatic causes:

- congenital (spina bifida)
- degenerative (spinal muscular atrophy)
- inflammatory (multiple sclerosis)
- metabolic (gangliosidoses)
- infectious (neuroborreliosis)
- ischaemic (aortic dissections, embolisms)
- rheumatological (rheumatoid arthritis)
- toxic (methotrexate)
- tumour-related (compressing tumours)

In addition to the primary deterioration in the sensory and motor functions of the skeletal muscle, the failure of certain organs and the loss of bladder, bowel and sexual function is observed. Furthermore, spasticities often develop once the spinal shock subsides [Ber], which can result in further limitations (e.g. contractures).

If both legs are paralysed due to an injury below the cervical vertebrae but there is no impingement of arm function, the condition is referred to as paraplegia. It is entirely possible for the left and right legs to be affected to different extents. The loss of the use of both arms and both legs due to an injury in the cervical spine is referred to as tetraplegia or quadriplegia

Treatment Goal

Acute care is followed by rehabilitation drawing on a wide range of therapeutic measures and provision of treatment appliances which are as customised to the patient as possible with the aim of restoring their independence. Many patients hope to regain or improve their ability to walk. The aim is to achieve the greatest possible mobility so that the patient can return to normal life in society without severe restrictions or assistance from others. The requirements placed on rehabilitation are high, as the better the success of the treatment, the simpler it is for patients to be included again.

In the case of SCI rehabilitation, these requirements are realised by an interdisciplinary team comprising doctors, care staff, physiotherapists and occupational therapists, orthotists, biomechanists and health insurance/cost bearers as well as relatives and patients themselves, all of whom participate in the continued development and implementation of a treatment plan [Kir].

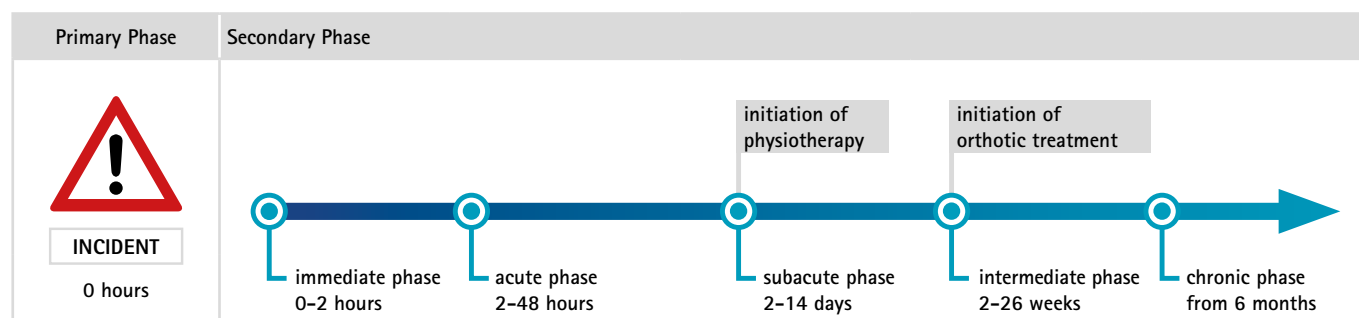
Mobilisation

The progress of rehabilitation is aligned to the phases of a traumatic paraplegia (see below) [Row]. Spontaneous improvements in the clinical condition may occur within the first year following the trauma [Bur], which is why specialists recommend that gait training and corresponding appliances be integrated in the treatment as early as possible [Cur2]. Whilst physiotherapy is already commenced in the subacute phase, patients should be provided with orthotic appliances as early as possible in the intermediate phase, so as to allow the patient to benefit from the orthosis' rehabilitative potential through intensive gait training.

This training should be initiated as soon as possible after the spinal shock subsides, as rehabilitation of the lost spinal connections is possible in the secondary phase. At the same time, the frequency of the gait training is decisive for the success of rehabilitation [Cur2, Kir].

Modern SCI rehabilitation employs partially weight-supported treadmill training and robot-assisted gait training. The patient's first attempts to walk between parallel bars with orthoses are usually the first step towards independent walking. Whilst therapy devices such as exoskeletons and treadmills are predominantly employed in inpatient settings due to their size and costs, orthoses can be employed anywhere and accompany the patient throughout the course of their intensive rehabilitation as well as after returning home. Unfortunately, however, they are often provided to the patient too late, meaning they cannot be used in parallel to the treatment.

Course of a Traumatic Paraplegia



Complete Paraplegia

Complete paraplegia is referred to as ASIA A according to the ASIA Impairment Scale. All of the neural pathways below the level of the injury are completely destroyed and neither sensory nor motor functions are preserved in the S4 and S5 segments of the spine. The prognoses for complete rehabilitation of essential bodily functions are comparatively poor.

With complete paraplegia below T12, the remaining active musculature of the pelvis (quadratus lumborum muscle) allows forward movement of the affected leg, which represents the minimum requirement for walking with an orthosis [Mic]. In addition, coordinative and sensorimotor factors, which influence the muscle strength of the muscle groups, are important for a precise control of the muscle groups.

In the case of injuries in the lumbar and sacral regions, motor and sensory functions are still present even in the case of complete paraplegia. These functions can be utilised to operate an orthosis. Depending on the evaluation of the potential for orthotic treatment, different orthosis and joint functions are required to achieve the necessary stability in stance phase.

Tespite poor prognoses [Cur1], early orthotic treatment within the first year can contribute to an improvement in the patient's ability to walk and the motoric height.

Incomplete Paraplegia

Incomplete paraplegia is classified with ASIA B-D. The spinal cord is only partially damaged below the level of injury. Both sensory and motor functions of the dermatomes and key muscles activated by the S4 and S5 segments of the spine are preserved. The chances of rehabilitation of important bodily functions and thus also the ability to walk are good.

The affected bodily functions and the permanence of the damage to the spinal cord depend both on the severity of the injury and on the particular spinal cord syndrome [Ber]. The spinal cord syndrome refers to the damaged section of the spinal cord.

Due to these spinal cord syndromes, incomplete paraplegia do not always display the same motoric deficits at identical neurological heights, unlike complete paraplegia. It can be assumed that control of some muscle groups is possible without any limitations. However, it is very difficult to estimate the exact extent.

Orthotic treatment is possible in cases of incomplete paraplegia in the lumbar and sacral regions – and even for injuries above T12 if the corresponding muscle strength is confirmed. In the early phase of rehabilitation, orthoses can be used as practical complements to physiotherapeutically assisted gait training. It is even possible that early orthotic treatment may contribute to an improvement in the patient's ability to walk and the motoric height. This potential for improvement is higher in patients classified as ASIA D than in patients classified as ASIA C or even ASIA B [Cur1].

ASIA = American Spinal Injury Association; North American association for treatment, training and research in the field of paraplegia, based in Richmond, Virginia.

Correlation between Level of Injury and Type of Orthosis

As the muscle strength can be estimated based on the level of injury in complete paraplegia (see pp. 18-19), possible orthosis types and joints can also be assigned to each level of injury in the same way. In the case of incomplete paraplegia, the orthosis types and joints shown in the table merely represent the maximum requirement for orthotic treatment. In many cases, orthotic treatment is also possible in cases of injuries above T12. However, in such cases it is essential to determine the precise muscle strength and perform an orthosis configuration (see pp. 24-25).

	AFO	KAFO		
		 free moving	 automatic	 locked
T12	Red	Red	Yellow	Yellow
L1	Red	Red	Green	Yellow
L2	Red	Red	Green	Yellow
L3	Red	Red	Green	Yellow
L4	Yellow	Green	Green	Yellow
L5	Yellow	Green	Green	Yellow
S1	Green	Green	Yellow	Yellow
S2	Green	Yellow	Yellow	Yellow
S3	Green	Yellow	Yellow	Yellow
S4	Yellow	Red	Red	Red

Recommendation
 Alternative
 No recommendation

MS Guide



You can find the complete MS Guide
available for download here.

Diagnosis: Multiple Sclerosis (MS)

Multiple sclerosis (MS) is caused by a malfunction of the immune system, which leads to an attack on the protective layer (myelin sheath) of the axons, resulting in a single centre or multiple centres of inflammation. The affected nerves can either regenerate or scar (sclerose). MS is characterised by recurring relapses and an often progressive course of the disease (see info box).

Causes of MS

Despite intensive research, it is still unclear what exactly triggers the malfunction of the immune system. However, it is suspected that it is caused by a combination of different factors. The predisposition, i.e. the tendency to develop this disease, is also inheritable. Childhood infections, vitamin D deficiency and an unbalanced diet can also contribute to the manifestation of MS.

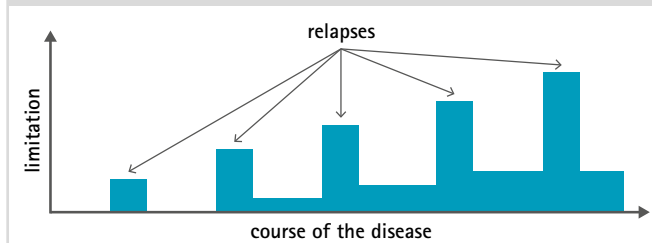
Symptoms of MS

Neurological symptoms arise as a result of damage to the neural pathways. The beginning of MS disease is usually characterised by motor limitations, visual or sensory disturbances, which manifest themselves throughout the course of the disease. In the advanced stages, the reduced strength of various muscles and spastic pareses have a negative effect on the ability to walk. Additionally, articulation and bladder dysfunction, cognitive disorders and depression can severely limit the quality of life.

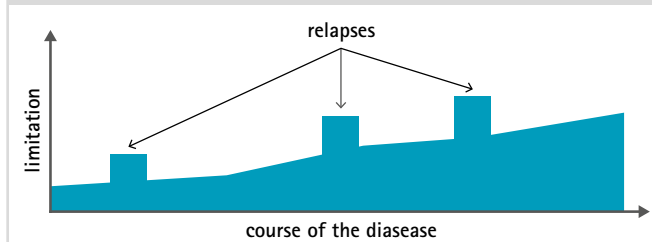
Fatigue

Increased muscular and cognitive exhaustion, known as fatigue, is another symptom that greatly affects many patients' daily lives with MS. Since the ability to walk is highly dependent on muscular performance, fatigue can become a limiting factor for many of the patient's activities.

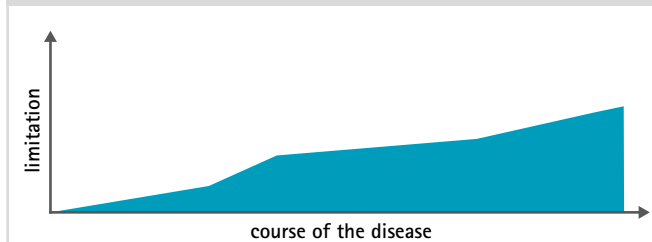
1. Relapsing-Remitting MS (RRMS)



2. Secondary Progressive MS (SPMS)



3. Primary Progressive MS (PPMS)



Requirements for Orthoses

Orthotic treatment should support the patient when standing and walking. This way, pathological consequences resulting from existing muscular deficiencies and compensation mechanisms can be prevented or minimised.

In modern orthotics, a combination of dynamic, supportive and proprioceptive components ensures that mobility is maintained as demanded by physiotherapy. As a result, the therapeutic goal defined by the interdisciplinary team can be achieved without restricting the patient's mobility. An orthosis that is precisely tailored to the patient's needs and planned and adjusted according to the patient's individual data is essential for coming closer to a physiological standing position and gait.

Based on the pathological gait, requirements for an orthotic treatment can be defined, from which concrete mechanical properties of orthoses for MS patients are derived:

Requirements of an Orthosis	Mechanical Properties	Examples
stability when standing and walking	- dynamic dorsiflexion stop with high spring force - anterior tibial shell - foot piece - stance phase control	- resistance in the mechanical ankle joint - rigid or partially flexible foot piece - automatic knee joint
energy recovery	- defined pivot point - high spring force - dynamic dorsiflexion stop	support for heel lift and push off
range of motion of the anatomical joints	- defined pivot point - passive plantar flexion - heel rocker - dynamic dorsiflexion stop	precise positioning of the mechanical pivot point at the anatomic centre of rotation of the ankle
adaptability	- variable spring force - adjustable alignment - adjustable range of motion	adjustable, dynamic ankle joint
low weight	use of lightweight materials	carbon, Kevlar
soft stops	- defined pivot point - high spring force	dynamic dorsiflexion and plantar flexion stop

Consideration of Fatigue

Physical activities such as walking cause muscular fatigue. Such a fatigue has a greater impact on muscle function in people with MS than in healthy people [Pha].

This aspect is particularly relevant for affected patients, as tired muscles in combination with muscular deficiencies can very quickly lead to falls. When producing an orthosis, fatigue should be taken into account in order to ensure the safety required after the muscles tire. Fatigue can be included in the physical examination with the 6-minute walk test.

1. First Muscle Function Test (Without Muscular Fatigue)



2. 6-Minute Walk Test



3. Second Muscle Function Test (With Muscular Fatigue)



Guide to Partial Foot Amputations



You can find the complete **Guide to Partial Foot Amputations** available for download here.

Partial Foot Amputations

Amputation is the complete or partial surgical removal of limbs. Depending on their severity, a division is made into major and minor amputations. In the case of the foot, it is considered a minor amputation if the anatomical ankle joint remains intact. A major amputation is associated with the loss of the anatomical ankle joint. In the case of a partial foot amputation, the distal part of the foot is amputated while the ankle joint remains intact.

The amputation should create a solid basis to restore the ability to walk. The amputation should be done as distally as possible to preserve maximum function. The anatomical lines (on which amputations are performed today) are named after the surgeons who established these amputations (see info box) [Bau, p. 136].

Amputations are always a last resort and are only carried out when there is no possibility of preserving the body part. An amputation may also be necessary if there are serious health consequences or severe chronic pain.

Causes of Amputation

- 87% peripheral artery disease (PAD) and diabetic foot syndrome
- 4% trauma
- 4% tumors and infections
- 0,2% congenital malformations (dysmelia)
- 5% other causes

Therapy Goal – Physiological Stance and Gait

The overall goal of prosthetic treatment is to come closer to a physiological stance and gait. The table below shows the physiological gait in its individual phases [Per, p. 9ff.]. Two factors significantly influence a safe stance and gait:

1. length of the residual limb
2. removal of muscles and tendons

To 1. The length of the residual limb has the following effects on stance and gait: The shortening of the foot caused by the amputation causes a shortening of the forefoot lever depending on the length of the residual limb with the following effects:

- during stance: reduction of the support surface and thus a reduction of stability [Grei, p. 160]
- during gait: movement restrictions due to the changed force

transmission (e.g. reduced step length, asymmetrical gait, reduced walking speed) [Dil, p. 25; For, p. 45]

To 2. The removal of muscles and tendons by amputation causes functional and structural limitations with the following effects:

- reduction of range of motion of the upper and lower ankle joint
- deformity due to muscular imbalance [Grei, p. 160]
- balance difficulties

Due to the muscular imbalance, contractures develop in most cases. Usually, the patient develops mechanisms to compensate for the lost functions [For, p. 45].

Requirements for a Prosthetic Treatment

Depending on the amputation level, there are different biomechanical requirements for the prosthetic treatment. The more proximal the amputation, the more the anatomical ankle joint must be stabilised and the lost function must be compensated for.

A prosthesis for patients with partial foot amputations is designed to restore the function of the forefoot lever, replace the lost muscle function and establish a stable, dynamic balance.

This is relevant for safe stance and for high and/or prolonged loads both, e.g. long walking distances. In order to come as close as possible to physiological gait, the residual mobility in the anatomical ankle joint should only be minimally restricted.

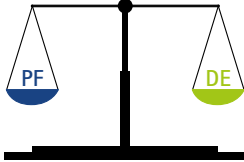
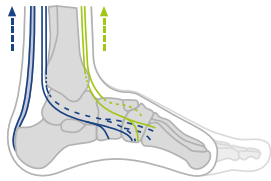
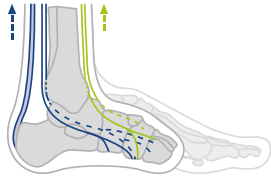
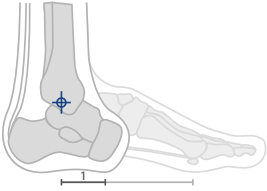
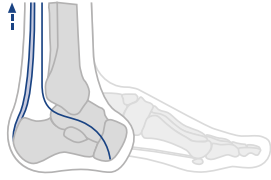
When walking with the prosthesis, the shear forces on the residual limb should be avoided as much as possible. A potential subsequent amputation can severely change the biomechanical requirements for the prosthetic treatment. Likewise, one must expect a continuously increasing pes equinus position and supination.

Classification of Partial Foot Amputations

In order to optimally adapt the prosthetic treatment to the patient, the individual condition of the muscles and foot bones must be taken into account. To structure and systematize prosthetic treatments, the various amputations are assigned to types in which the requirements for a prosthetic treatment are the same.

The classification takes the length of the forefoot lever, the muscular balance between plantar flexors (PF) and dorsal flexors (DF), and the muscle strength of the DF into account.

Example: in type 1, the attachments of the short and long toe flexors and extensors are no longer there, which is why the muscle strength of the DF is restricted despite the muscular balance.

Type	Amputation	Forefoot Lever	Muscular Imbalance	Muscle Strength
	not amputated			
		long	balanced	full muscle strength
1	metatarsophalangeal transmetatarsal (Sharp)			
		long	balanced	limited muscle strength
2	transmetatarsal (Sharp-Jäger) tarsometatarsal (Lisfranc)			
		medium	plantar flexors (PF) dominate	low muscle strength
3	transtarsal (Bona-Jäger) transtarsal (Chopart)			
		short	plantar flexors (PF) strongly dominate	no muscle strength

CMT Guide

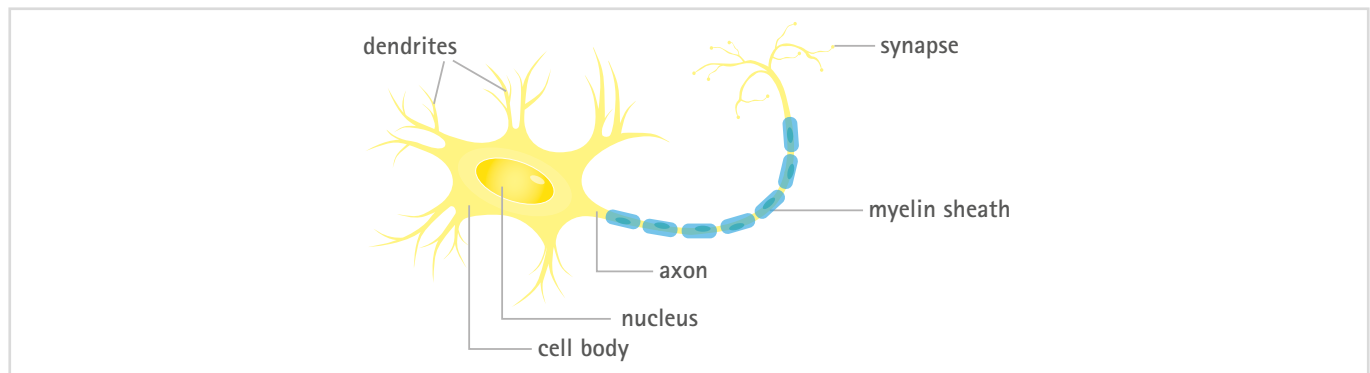


You can find the complete CMT Guide
available for download here.

What is CMT?

Charcot-Marie-Tooth disease (CMT), also known as hereditary motor sensory neuropathy type I (HMSN I), is a group of hereditary diseases that affect the peripheral nerves and are characterised by a progressive loss of muscle tissue and touch sensation in various body parts.

The peripheral nerves are located outside the central nervous system (spinal cord and brain). These nerves control the muscles and transmit stimuli from the arms and legs to the brain to enable a person to perceive touch. A peripheral nerve consists, among other things, of the axon, which is the interior of the nerve conduction, and the myelin sheath, which forms a protective layer around the axon. CMT can affect either the axon of a peripheral nerve, its myelin sheath or both.



The disease is named after the three physicians who first described it: Jean-Martin Charcot (1825–1893), Pierre Marie (1853–1940) and Howard Henry Tooth (1856–1925). CMT is the most commonly inherited neurological disorder, affecting around one in 2500 people.

Causes

CMT is a genetic disorder caused by mutations in one or more genes. These mutations disrupt the structure and function of the axon and/or myelin sheath of the peripheral nerves, causing them to degenerate and impair the transmission of nerve signals between the brain and the extremities. The affected gene can be inherited from one or both parents. In rare cases, a person can be born with the disease spontaneously without inheriting it from their parents. Each of the five main types of CMT has different causes.

Treatment Goal

Currently, there is no cure for the peripheral nerve damage caused by Charcot-Marie-Tooth disease (CMT). Therapy therefore focuses on restoring or maintaining bodily function by treating the symptoms. As the CMT symptoms are strongly centred on the lower extremities, CMT therapy is primarily focused on establishing a basis for painless, efficient and as physiological as possible stance and gait. The physiological gait shown below in its phases can be used as a reference for achieving this treatment goal. CMT therapy can include the following components:

Analgesics: The muscle cramps or nerve damages are often accompanied by pain. Pain-relieving medication enables painless mobility without relieving postures or compensation mechanisms.

Physiotherapy/Occupational Therapy: Targeted and gentle exercises can help to strengthen and stretch the muscles and prevent muscle tension and progressive muscle atrophy.

Surgical Procedures: Severe foot deformities often develop as a result of the disease and lead to severe limitations. In certain cases, surgeries improve the biomechanical situation of the foot and prevent foot deformities from worsening.

Orthopaedic Devices: Medical devices such as orthoses are intended to provide stability when standing and walking. Many lightweight devices have actually been designed to keep a drop foot in a neutral position during the swing phase and thus enable the leg to swing freely.

Requirements for an Orthosis

An unrestricted swing ensures motion without stumbling. Therefore, the most important requirement for an orthosis for CMT patients is that it keeps the foot in an approximately neutral position during swing phase. This position allows the affected leg to swing freely without the patient developing compensation mechanisms. Compensation mechanisms should be prevented, as they result in higher energy consumption when walking and put excessive strain on other body structures (see appendix). Beyond this minimum requirement, the following should be ensured:

1. Maintaining Mobility

As CMT is characterised by a loss of muscle tissue, additional atrophy caused by the complete immobilisation of the anatomical ankle joint in a rigid orthosis must be prevented. Orthoses must also support physiotherapy focused on muscle training and must not impede the success with such immobilisation. Orthoses must therefore allow range of motion in the upper ankle joint.

2. Ensuring Stability

When standing and walking, the forefoot lever generated by the plantar flexors provides the necessary stability in the knee and ankle joint. If the disease affects not only the dorsiflexors, but also the plantar flexors, the forefoot lever is activated externally via a mechanical dorsiflexion stop. Orthoses must therefore provide sufficient resistance to the dorsiflexion when standing and walking.

3. Enabling Adjustments

The symptoms of CMT progress. Even if only the dorsiflexors are initially affected, the muscle weakness can also extend to the plantar flexors at a later stage. Orthoses must be adaptable to the course of the disease to meet the changing support requirements.

New Possibilities for CMT Patients

To determine the level of support provided by a custom-made orthosis and to avoid under- or oversupply, the impaired muscle groups must be identified before planning the treatment.

In CMT patients, the dorsiflexors often are affected first, which is characterised by an isolated foot drop and the compensation mechanisms developed in this context. A visual gait analysis, in which the patient's gait is examined for deviations from the physiological gait, can indicate whether the plantar flexors are also affected. You will find more information on the physiological stance and gait as well as deviations due to weakness of the dorsiflexors and plantar flexors in the following chapters. A muscle function test provides more detailed information about the condition of the muscle groups that may be affected. This is because the weakness of a muscle group does not always have a visible effect on standing and walking.

PAD Guide



You can find the complete **PAD Guide** available for download [here](#).

What is PAD?

More than 230 million people worldwide suffer from peripheral arterial disease (PAD). The percentage of the total population is between 3-10%, although the frequency increases with age and is already at 15-20% in people over 70. Unlike the arterial occlusive disease, this chronic circulatory disorder occurs in the extremities – 90% in the legs and only 10% in the arms. Also frequently referred to as intermittent claudication, PAD is the occlusion of the peripheral vessels (arteries). In addition to the typical symptoms, this occlusion can also cause damage to the nerves, leading to polyneuropathy [1]. PAD cannot be cured, but its progression can be prevented.

Causes

Alongside an ischaemic stroke and a heart attack, PAD is a manifestation of arteriosclerosis or its symptomatic form, atherothrombosis. At 95%, arteriosclerosis is the main cause of PAD. Other causes may be:

- inflammatory causes,
- genetic causes,
- traumatic causes and,
- fibromuscular dysplasia.

Risk Factors

Risk factors indicate which individuals have a comparatively high probability of being affected by a disease. As arteriosclerosis is the main cause of PAD, the risk factors for PAD are also the causes of arteriosclerosis. These include:

- diabetes (mellitus),
- smoking,
- elevated blood lipid levels (hyperlipidaemia),
- high blood pressure (arterial hypertension) and in general,
- advanced age.

There are different reports on the gender split: some sources report that four times as many men suffer from PAD than women; in other sources, the prevalence is higher in women over the age of 75 than in men. In addition, smoking is often the cause of arteriosclerosis in men and obesity in women.

Orthoses as Part of the PAD Treatment

So far, orthoses have rarely been used as part of an advanced PAD treatment although there is great potential for improving many of the symptoms associated with the disease. Patients suffer from the following restrictions, for example:

Pain when Walking

Pain in the foot and lower leg when walking is often a determining factor in the diagnosis of PAD. The symptoms are indicative of claudicatio intermittens. It is treated with gait training, which reduces the pain in the legs when walking. Unfortunately, no orthotic treatment has been provided to date.

Muscle Weakness and Stumbling

The foot lifting muscles (dorsiflexors) are often weakened early on in stage II. This weakening leads to a visible drop foot and stumbling when walking and, just like the muscle pain, to a reduction in the patient's activity. The inactivity of the weakened muscles causes muscle atrophy. A dynamic orthosis can restore foot lifting, support the patient's activity and thus prevent fatigue and muscle weakening. However, there is no or far too little orthotic treatment here either.

Balance Issues due to Paralyses

In many cases, the weakening of the foot lifting muscles (dorsiflexors) is followed by an additional weakening of the calf muscles (plantar flexors). Depending on the course of the disease, this can result in paralysis, which leads to balance issues and a lack of stability when standing and walking. Unlike the weakness of the foot lifting muscles with the distinct symptom of a drop foot, the serious issue of calf muscle weakness unfortunately remains undiagnosed in most cases, as it is not easily identified externally. Even if the weakness of the calf muscles has been identified, insufficient knowledge of the possibilities of modern orthotic treatments often leads to the use of inadequate devices such as simple foot lifter orthoses, which are unable to compensate for the balance issues.

Wounds and Harmful Pressure Peaks on the Foot

If diabetes is the cause of PAD, a diabetic foot orthotics (DFO) is an essential part of the treatment with medical devices. The DFO consists of several layers of soft foam and is primarily used to redistribute pressure on the sole of the foot. Unfortunately, orthoses are rarely used for the treatment of diabetic foot syndrome.

Requirements for Orthoses

Orthoses for PAD patients should fulfil a specific therapeutic purpose. To do so, they must have functions that can be used to achieve specific goals. From stage II of PAD at the latest, patients experience substantial restrictions when walking. In addition, there are the balance disorders caused by polyneuropathy and the necessary pressure relief in the case of possible diabetic foot syndrome. In order to be able to address these restrictions in the best possible way, orthoses must:

1. compensate for existing balance disorders,
2. compensate for paralyses of both the foot lifting and calf muscles,
3. reduce pressure peaks on the foot sole when walking and support pressure redistribution and
4. be adaptable to the course of the disease.

In modern orthoses, the necessary functions are provided using the corresponding functional elements of the system ankle joints, which have the following positive effects on the patient:

- counteract fatigue in the foot lifting and calf muscles,
- strengthen the affected muscle groups by activating them,
- improve balance when standing and walking.

In addition, a dynamic orthosis with the corresponding functional element can significantly contribute to the redistribution and reduction of plantar foot pressure in patients with diabetic foot syndrome: a custom-made orthosis with an anterior shell and rigid foot piece, the dynamics of which are realised, for example, via the NEURO SWING system ankle joint with precompressed spring units, transfers part of the overall pressure exerted on the foot directly into the ground. This results in a reduction in the pressure exerted on the foot. The rigid foot piece also allows the already reduced pressure to be distributed even further over the entire foot area. The treatment is completed by a customised foot orthotic that can be integrated into the foot piece.

