Department of Prosthetics and Orthotics

AFO Designs, Components, and Fabrication

General AFO Functions

Each part of the AFO has a specific function:

- The shell / cuffs allow for pressure distribution and provide structural strength
- The joints (if prescribed) allow a desired range of motion
- The straps help to control movement and distribute forces
- The length and flexibility of the footplate provide different levels of function and control

Variations of AFO Designs

- Posterior Shell AFO
  - o Rigid design
  - o Flexible design
  - o Jointed
- Anterior Shell AFO
  - o Rigid design
  - o Jointed
  - o Ground Reaction
- Conventional AFO
- PTB AFO

Posterior Shell Rigid AFO

Specific Functions

- Stops Plantar flexion and dorsiflexion
- Stops inversion/eversion
- Limits knee flexion or extension

(if correctly aligned)

Reinforcement

- The stiffness of a solid AFO is influenced by material choice and thickness and the location of the trim lines which should be anterior to the malleoli to help resist movement

- Reinforcements may be incorporated at the ankle section of a solid AFO to increase stiffness.

Posterior Shell Rigid AFO

Trim-lines

Standard Trim-lines

- **A** - The top must be horizontal, 2 cm below the fibula head.
- **B -** At the ankle, pass the line 1 cm anterior to the tip of the malleoli
- **C -** At the forefoot, leave the sides of the toes and the head of the metatarsus completely clear and pass the trim line below them
  - *This will allow the polypropylene to follow the movement of the metatarso-phalangeal joints*

Trim Line To Correct Forefoot Adduction

A The top must be horizontal, 2 cm below the fibula head

B Increase coverage of the lateral midfoot, passing in front of the cuboid, *to enlarge the area of pressure*

C At the forefoot, the line must be proximal to the 5th metatarsal head

D Decrease coverage of the medial mid-foot at the navicular/malleoli, *to facilitate donning*

E At the forefoot, cover the medial side of the metatarsal head and toe, *to correct forefoot adduction*

Trim Line to Correct Forefoot Abduction

(A) The top must be horizontal, 2 cm below the fibula head.

(**B)** Decrease coverage at the level of the lateral malleoli, *to ease donning*.

(**C)** At the forefoot, the line must be distal to the 5th metatarsal head, *to avoid metatarsus abductus*

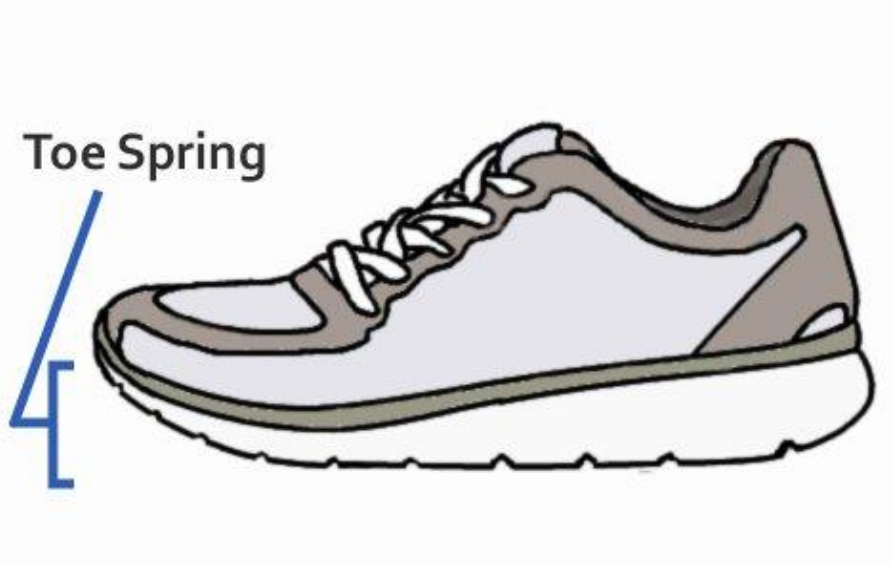
(**D)** Increase coverage of the medial mid-foot at the level of the navicular, *to increase mid-foot support*

(**E)** At the forefoot, the line must be proximal to the 1st metatarsal head

Toe-spring

- **Toe spring** is the elevation of your shoe's **toe** box above the ground or supporting surface (10-15 degrees)

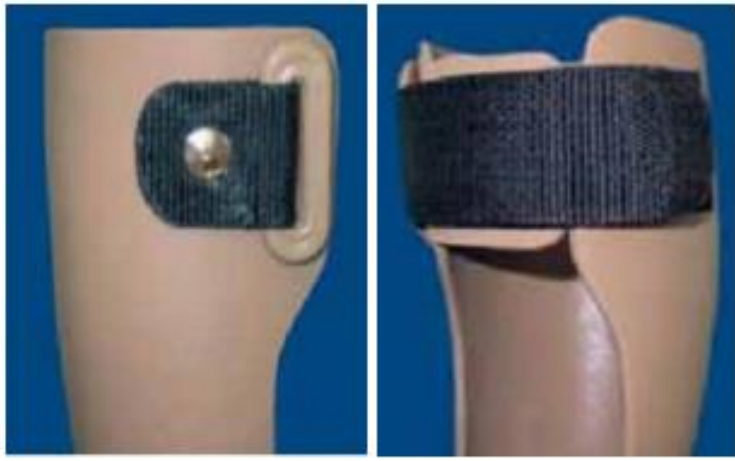
- With a rigid AFO, toe-spring is also important to allow the orthosis to roll over during terminal stance phase.



Posterior Shell Rigid AFO

Strap attachment

Proximal strap



- To hold the orthosis on the leg , particularly during terminal phase as the orthosis tends to rotate posteriorly
- The belt holding the loop should be on the medial side and placed 1.5 cm below the proximal trim line. The loop should not be in contact with the patient's leg.
- Insert the belt through the loop to measure the required length.
- The strap should be placed on the lateral side. Make sure the strap is perfectly horizontal before fixing it.
- Cover the surface of the strap in contact with the patient's leg with 3 mm EVA

Distal strap

- Depending on the patient's footwear and whether strong spasticity is present, a distal strap may or may not be required. This can be decided at the time of fitting

- There are 2 techniques for the distal strap construction in the AFO
  - **To hold the ankle joint in neutral position**, the strap is placed 45 degrees to the tibia bone
  - **To control valgus or varus**, the strap will pass through a slot cut in the polypropylene. The position of the strap is still kept 45 degree to the tibial section

Distal strap

If there is spasticity

If there is NO spasticity

Distal strap

- **If there is valgus or varus of subtalar joint**

Indications and contraindications

Indications

- ✓ High tone or spasticity in the plantar-flexors, a gastrocnemius contracture
- ✓ Significant medio-lateral instability of the foot and ankle
- ✓ A need for the AFO to influence the knee or hip
- ✓ Control is needed in the sagittal plane and the subtalar joint and possibly to control the forefoot too

Contra-indication

- **X**. When there is motion at ankle joint
- **X**. Fluctuating Odema
- **X.** Excessive scarring on areas of contact
- **X.** Unstable knee joint

Advantages and Disadvantages

Advantages

- Provide maximum stability of the foot and ankle
- Allow stabilization of knee and hip if correctly aligned

Disadvantages

- May be difficult to walk up and down hill
- May be hot
- Does not allow for volume change
- Cause muscle atrophy

Anterior Shell Rigid AFO

Specific Functions

- Stops Dorsiflexion and Plantarflexion
- Controls inversion/eversion
- Controls knee flexion by preventing or control tibial progression especially when the plantar flexors are weak

Anterior Shell AFOs are not usually made flexible because this would place pressure on the tibia and boney dorsum of the foot

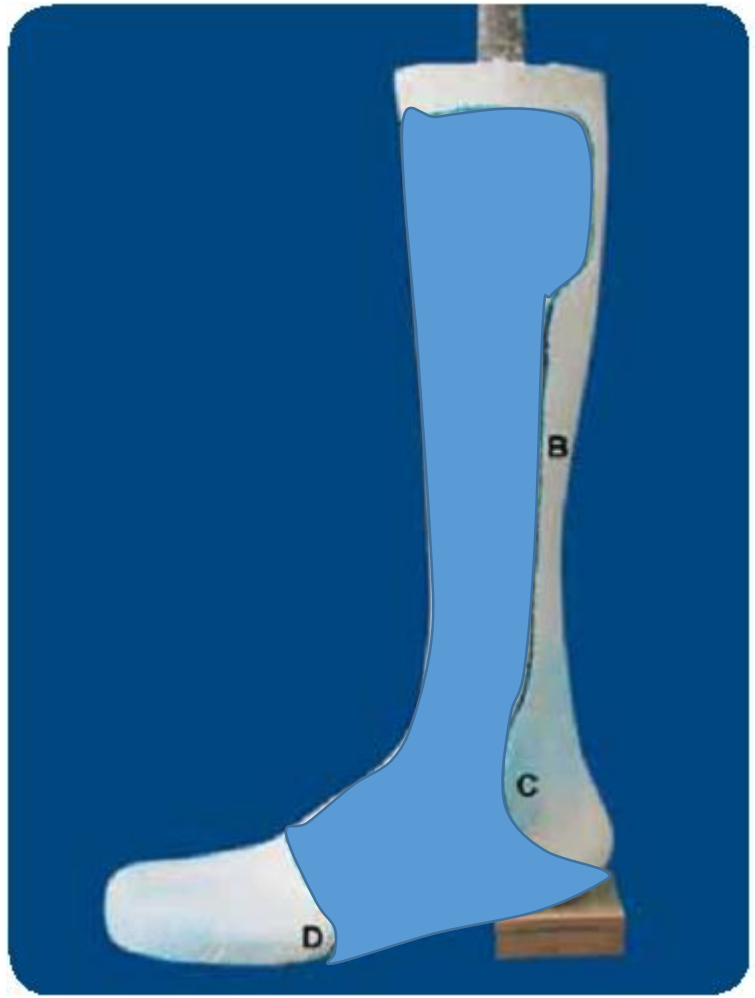
Trim-lines of anterior shell rigid AFO

(A)The top must be horizontal, 2 cm below the tibial tubercle

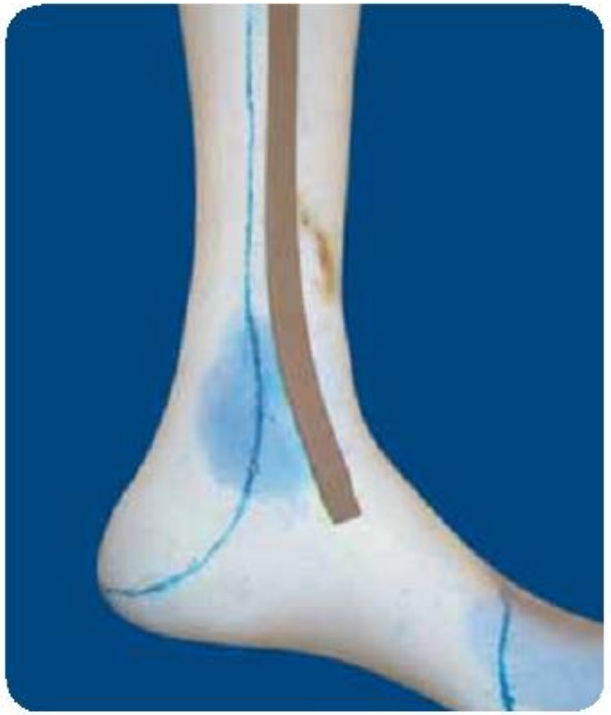
(B)On the leg, 1 cm posterior to the mid-line

(C)On the ankle, at the top of the malleoli to facilitate donning

(D)On the forefoot, clear the sides and top of the toes and the head of the metatarsals completely in order to *allow the polypropylene to follow MTP joints*



EVA liner is needed to promote comfort and to prevent skin breakage for patients with sensation loss



Indications and contraindications

Indications

✓Excessive knee flexion during stance

Contra-indication

X. Knee hyper extension

X. Loss of protective sensation over tibia and dorsum of the foot

X. Fluctuating Oedema

Advantages and Disadvantages

Advantages

- Larger area for posterior-directed force in knee flexion gait

Disadvantages

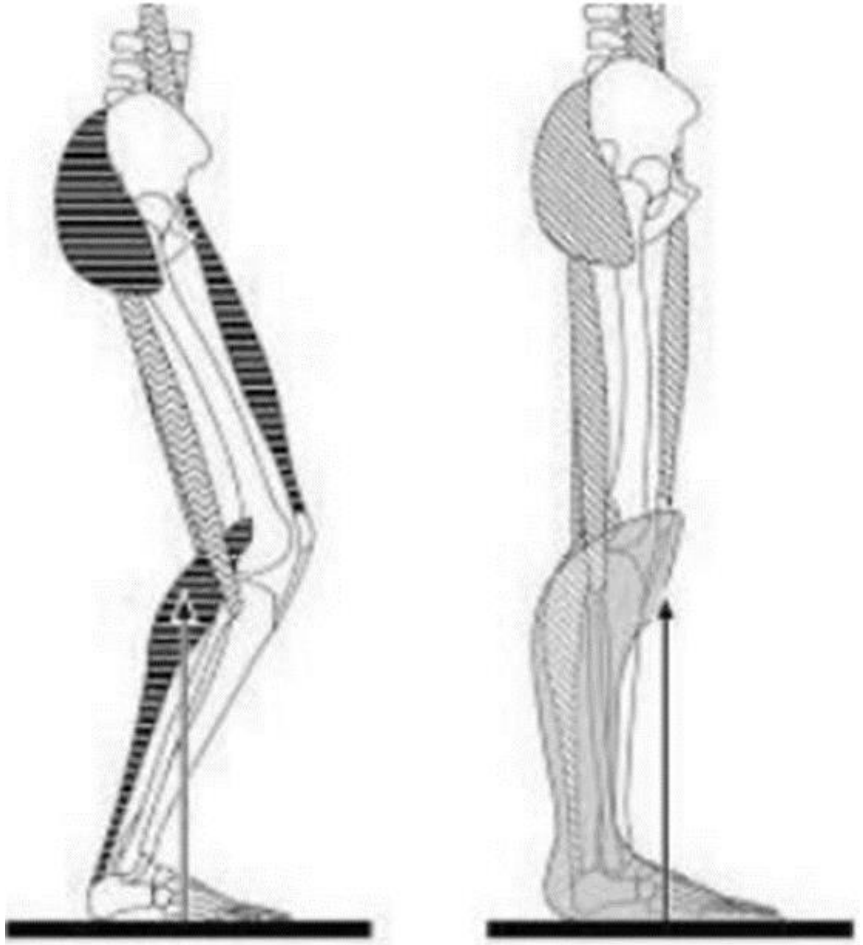
- Must be carefully molded over tibia and dorsum of the foot to avoid unwanted pressure
- Can be difficult to done and doff
- May be difficult to fit in the shoe

Ground Reaction AFO (GRAFO)

Introduction

- A Ground Reaction AFO (GRAFO) is a form of solid AFO designed to maximize the indirect orthotic control of knee flexion during stance phase

- To control the excessive knee, a GRAFO must be very stiff with good alignment so as to ensure that the ground reaction force is anterior to the knee in mid to late stance, generating an external knee extension moment



Indications

- A GRAFO is generally used for patients affected by neurological conditions such as spina bifida and cerebral palsy.

- During stance phase these patients will exhibit excessive knee flexion (crouch gait) or knee instability in the sagittal plane usually due to quadriceps weakness and excessive dorsiflexion.

Specific Functions

- Stops Plantar flexion and Dorsiflexion
- Limits inversion and eversion
- Limits knee flexion
- Also limits knee extension if correctly aligned

Posterior leaf Spring or Flexible AFO

Specific functions

Stance phase

- Permits plantar flexion action to absorb the torque at heel strike
- Allows forward progression during the 2nd rocker
- Permits “spring” at push-off

Swing phase

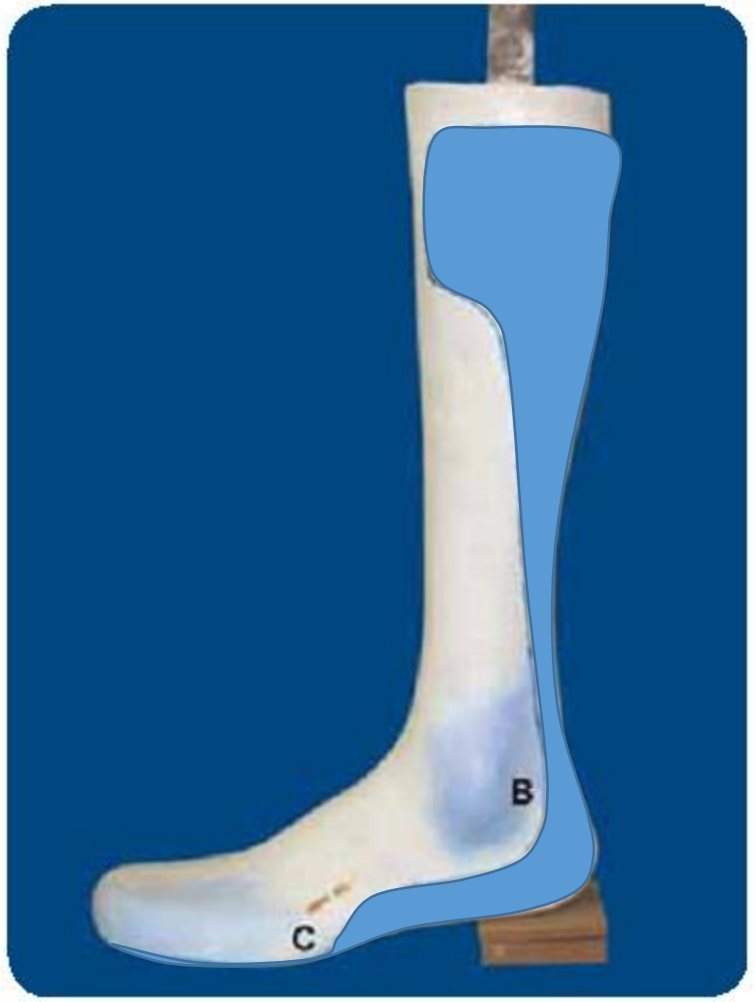
- To prevent foot drop for ground clearance particularly at mid swing

Trim-lines

A The top is horizontal, 2 cm below the fibula head

B At the ankle, pass 2 cm behind the tip of the malleoli to allow flexion of the polypropylene

C At the forefoot, leave the sides of the toes and the head of the metatarsus completely clear and pass the trim line below them. *This will allow the polypropylene to follow the movement of the metatarso-phalangeal joints*



Straps

- For the proximal strap attachment is the same as a Rigid AFO

- A distal strap might be needed, depending on the capacity of the patient's shoe to hold the foot inside the orthosis. If this is needed, follow the procedure described in a Rigid AFO

Indications and contraindications

Indications

✓Drop foot due to weak dorsiflexors with or without mild M-L instability of subtalar joint (STJ)

Contra-indications

X. Moderate to server STJ instability

X. Spasticity

X. Genu recurvatum or excessive flexion

X. Weak plantar-flexors

Advantages and Disadvantages

Advantages

- Less bulky
- Allows plantar action
- Minimize knee flexion moment
- Allows forward tibia progression during the second rocker
- Easy to put inside shoes

Disadvantages

- Provides less stability of STJ due to short trim-lines
- Cannot influence tibial progression or knee position

Articulated or Jointed AFO

Introduction

- A jointed AFO is a custom ankle foot orthosis made of plastic and orthotic joint is incorporated (attached) according to the treatment goals

- There are a number of mechanical ankle joints which may be incorporated into Jointed AFOs to allow or assist motion in one direction while preventing or limiting motion in another

- The design can be either anterior shell or posterior shell

Overall functions

- Limits Inversion and Eversion
- Sagittal function depends on joints used and trim-lines
  - May stop, limit, assist, resist or allow dorsiflexion/plantarflexion
  - Can limit extension of the knee if plantarflexion is stopped and device is correctly aligned

Specific functions of Posterior Shell AFO with plantar flexion stop

- Similar as a rigid AFO during loading response.
- Allows normal forward progression of tibia from mid stance to terminal stance.

Prerequisite for a posterior shell AFO

- Adequate passive range of dorsiflexion approximately 5-10º dorsiflexion with the knee fully extended.
- No spasticity in Gastrocnemius

Indications and contra-indications

Indications

- Able to control forward progression
- Foot drop with mild instability of STJ
- Knee hyper-extension in stance phase
- Toe-walker without excessive knee flexion
- Mild to moderate spasticity

Contra-indications

X. Unable to control forward progression of tibia

X. Dorsiflexion makes STJ and mid-foot unstable

X. Spasticity catch with designed RoM

X. Not able to produce 5-degree of dorsiflexion

Advantages and disadvantages

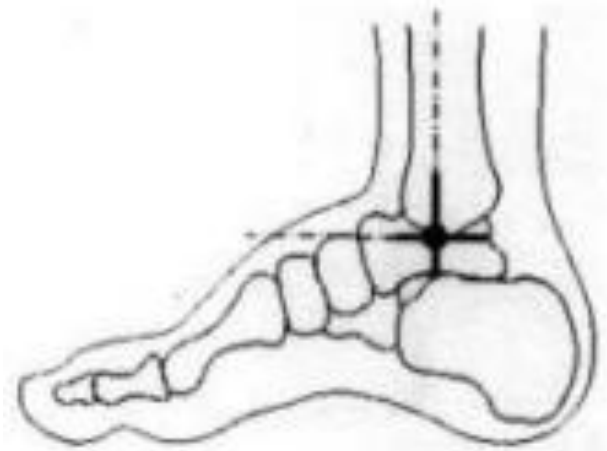
Advantages

- Allows dorsiflexion in ankle joint
- Can be used to stretch mild tightness of Gastrocnemius

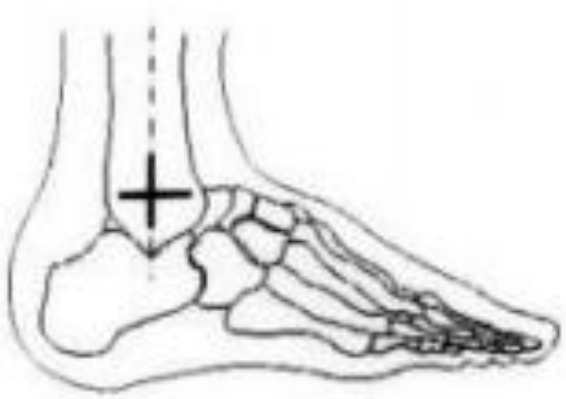
Disadvantages

- Bulky at ankle joint
- Can cause STJ & midfoot unstable if no dorsiflexion available.
- Can cause excessive knee flexion if forward progression is not well controlled

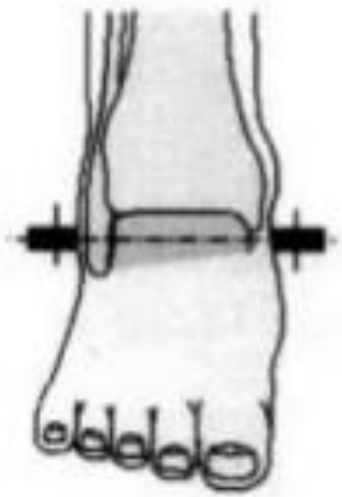
Position of ankle Joint



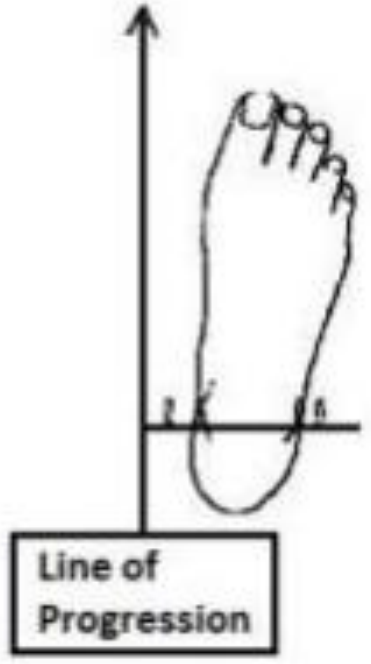
Medial



Lateral



Coronal



Tamarack Flexure Joint

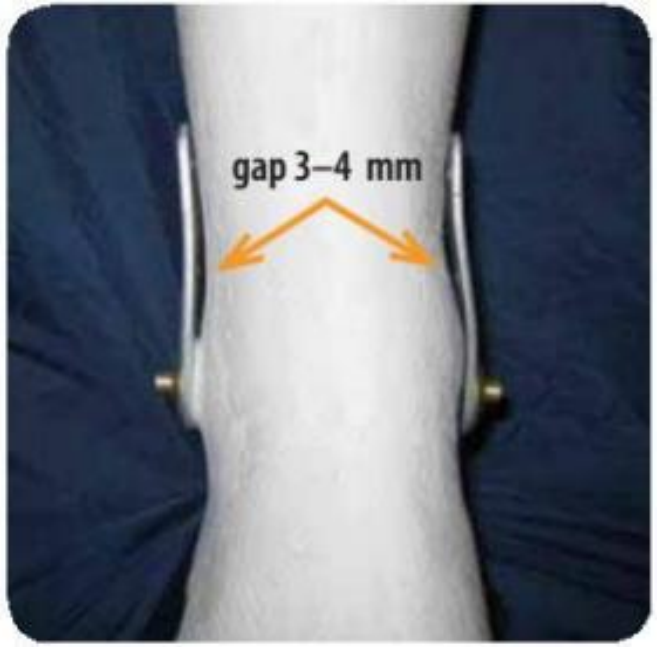
Installation

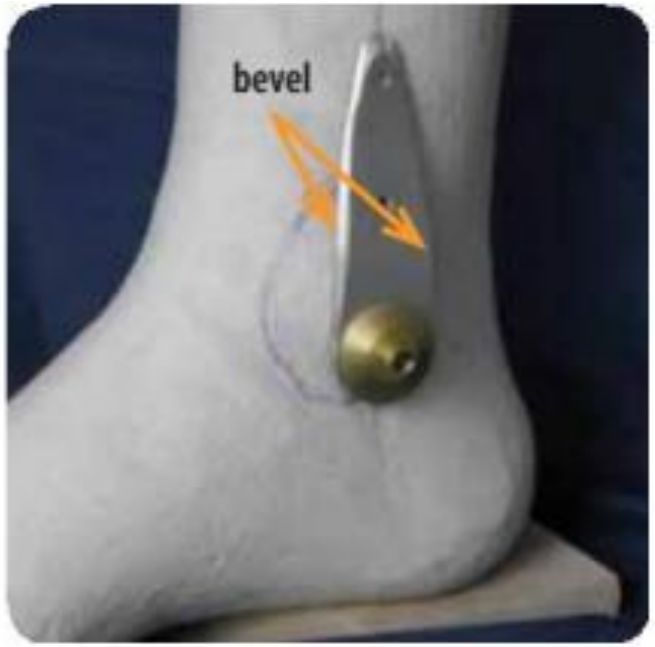
Trim-line with Plantar flexion stop

Trim-line to allow free Motion of ankle Joint

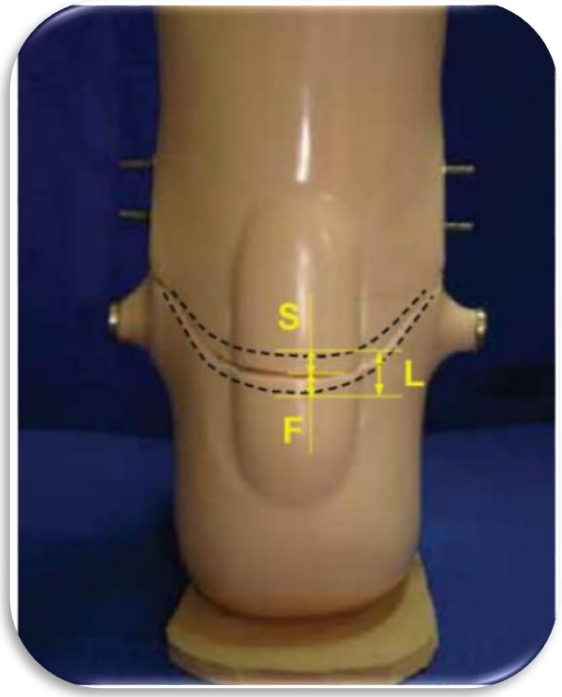
Free-motion ankle joint (FMAJ)

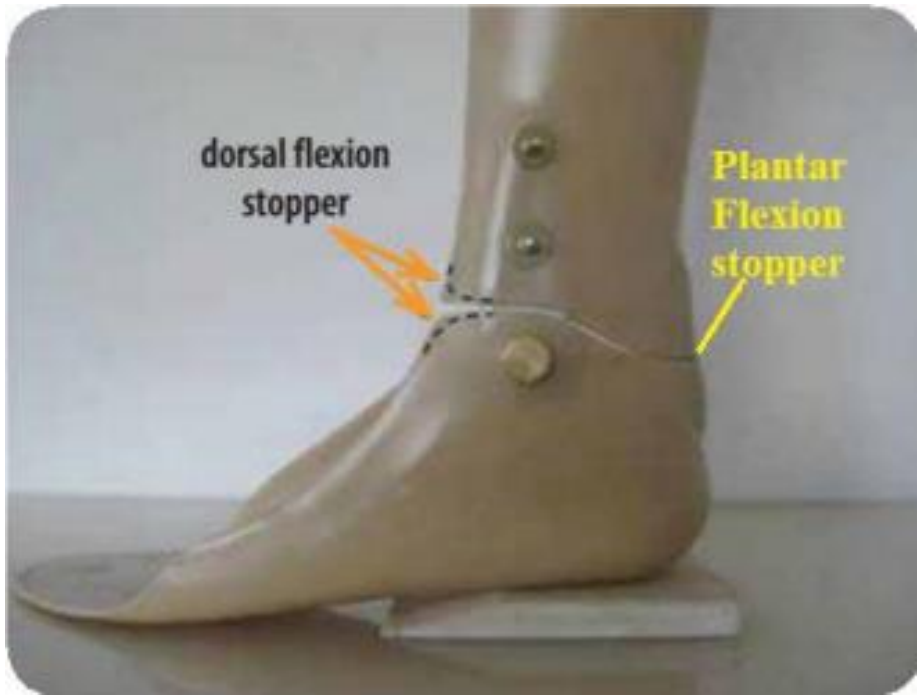
Installation Free-motion ankle joint (FMAJ)



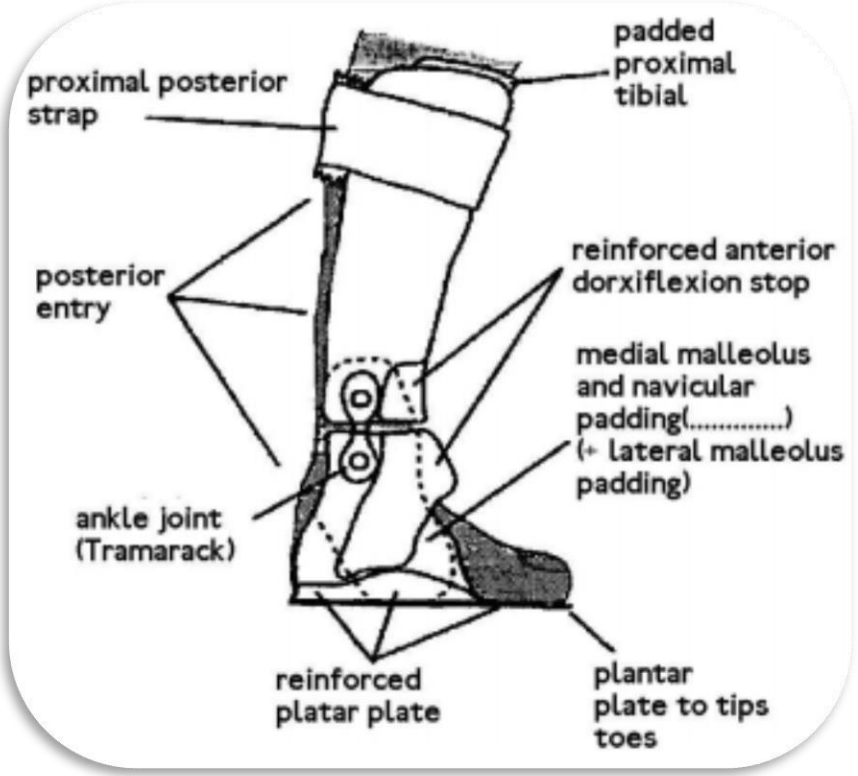


Free-motion ankle joint Fabrication





Anterior Shell Jointed AFO



Function:

- Allows plantar flexion
- Limits Dorsiflexion
- Limits inversion/eversion
- Limits knee flexion

- A Jointed Anterior Shell AFO usually allows free plantarflexion but stops dorsiflexion
- This allows for the normal shock-absorbing action of the ankle after heel-strike but then stops the ankle moving into dorsiflexion to stabilize the knee

Indications and contra-indications

Indications

- Excessive flexion during stance phase
- Isolate week plantar flexors

Contraindications

- Weak dorsiflexors
- Fluctuated Oedema
- Spasticity of Gastrocnemius
- Sensitive on anterior tibia and dorsum of the foot

Advantages and Disadvantages

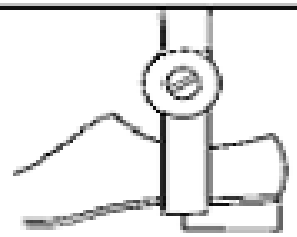
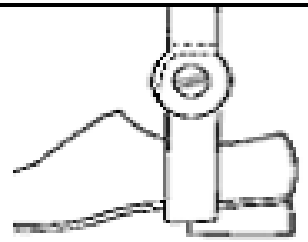
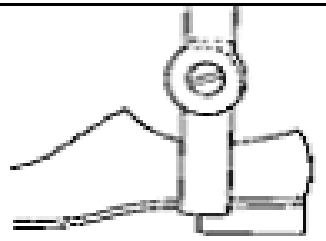
Advantages

- Larger area for posterior-directed force in knee flexion gait

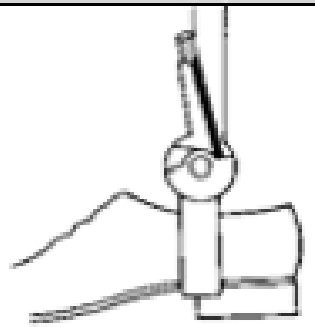
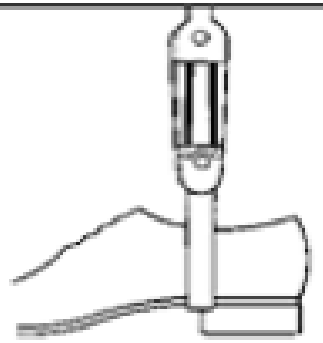
Disadvantages

- Bulky at ankle joint
- Must be carefully molded over tibia and dorsum of the foot to avoid unwanted pressure
- Can be difficult to done and doff
- May be difficult to fit in the shoe

Types of Orthotic Ankle Joint

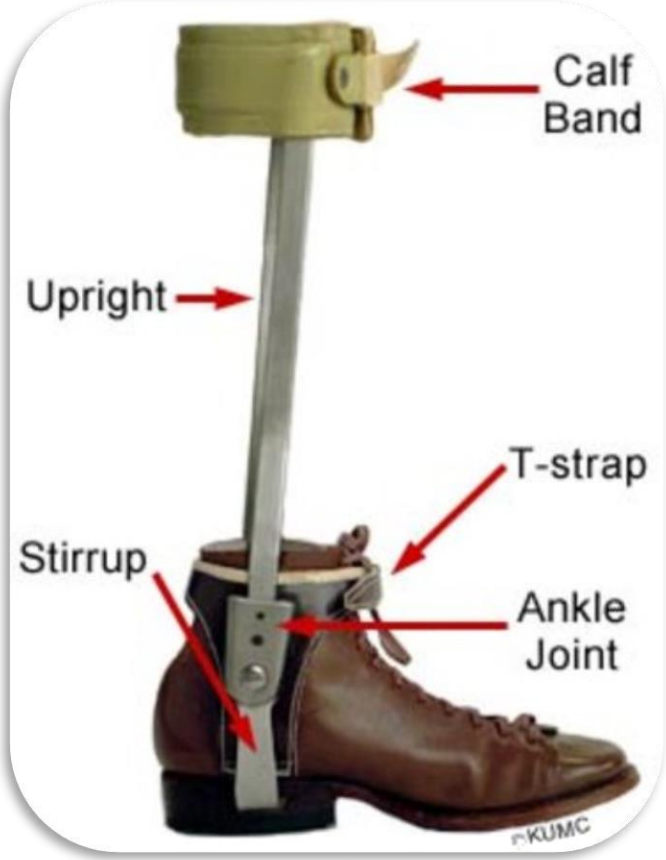
Ankle joint Description	Function	Indication	Joint Design
(1) Free	Free motion of the joint in plantar and dorsiflexion	M-L Instability around ankle	
(2) Plantarflexion stop	Free movement in dorsiflexion The amount of plantarflexion allowed is limited	Mild spasticity of plantarflexors Knee hyperextension	
(3) Dorsiflexion stop	Free movement in plantarflexion The amount of dorsiflexion allowed is limited	Weak plantarflexors Excessive tibial progression (knee collapse) (crouch gait)	

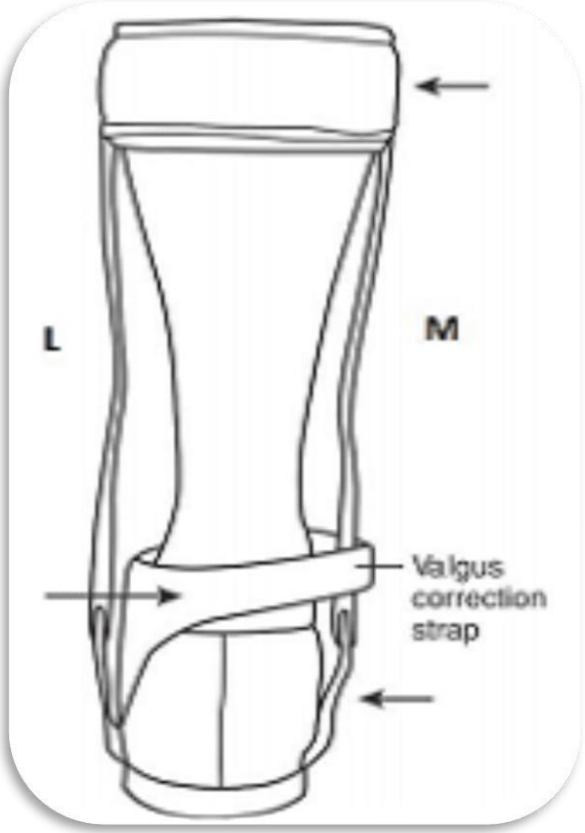
Types of orthotic ankle joints

(5) Dorsiflexion assist (Klenzak)	Assists dorsiflexion with a spring Stop plantarflexion	Weak dorsiflexor muscles (drop foot)	
(6) DFL/PFL assist (Double Klenzak)	Assist dorsiflexion and plantarflexion with a spring and/ or Control ROM of dorsiflexors /plantarflexors	Weak dorsiflexors **and** plantarflexors	

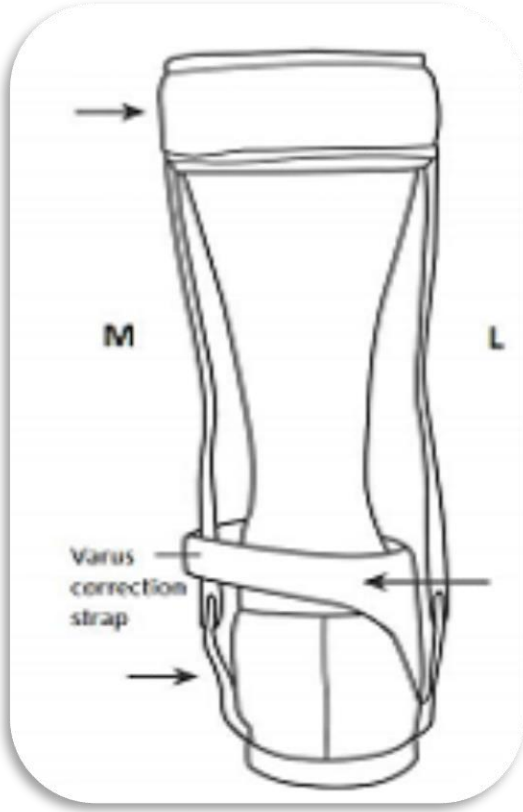
Conventional AFO

Components for a conventional AFO





Y-Strap



T-Strap

Indications and contra-indications

Indications

- Fluctuating Oedema
- Large/Heavy patients
- Skin problem
- Excessive sweating

Contra-indication

- Cosmetic concern
- Patient lives and works in muddy or wet conditions

Advantages and Disadvantages

Advantages

- Allow for changes in volume
- Less warm

Disadvantages

- Shoe must be modified and usually used with one shoe only
- Poor cosmoses
- Metal may get rusty
- Heavy
- Less area for pressure distribution
- Difficult to repair

The Patella Tendon Brace (PTB) Orthosis

Introduction

- The PTB Orthosis is designed to provide circumferential pressure (hydrostatic pressure) to unload the lower limb
- It is mainly used for fractures of the tibia and/or fibula or when the ankle needs to be completely off-loaded
- The medial tibial flare and calf muscle complex are used to take some of the body weight so that full weight does not pass through the lower leg and ankle
- In a fracture, the surrounding tissue is contained and the bones are held in the correct alignment. This can allow the patient to walk and can promote healing.

Indications and Contra-indications

- **Indications**
  - Immobilization for simple distal fractures
  - Pain in Ankle complex due to weight bearing

- **Contraindications**
  - Proximal Fractures
  - Compound or Open Fractures
  - Scars in weight bearing areas

Advantages and Disadvantages

* Advantages

- Large area to apply posterior directed force to control knee flexion gait

* Disadvantages

- Difficult to fit with shoe
- Difficult to don
- Bulky at ankle (jointed AFO)
- Need to mold carefully to avoid unwanted pressure over the tibia and dorsum of the foot

Questions ?

Thank you