



Al-Mustaqbal University  
Collage of Engineering  
Prosthetics and Orthotics Engineering  
Second Stage

---

## **ORTHOTICS I**

**Prof. Dr. Mohammed Hamzah Daham**

**2<sup>nd</sup> term – Lecture 8**

**2025-2026**

[mohammed.hamzah.daham@uomus.edu.iq](mailto:mohammed.hamzah.daham@uomus.edu.iq)

**UOMU0103054**

# HIP KNEE ANKLE FOOT ORTHOSIS (HKAFO)

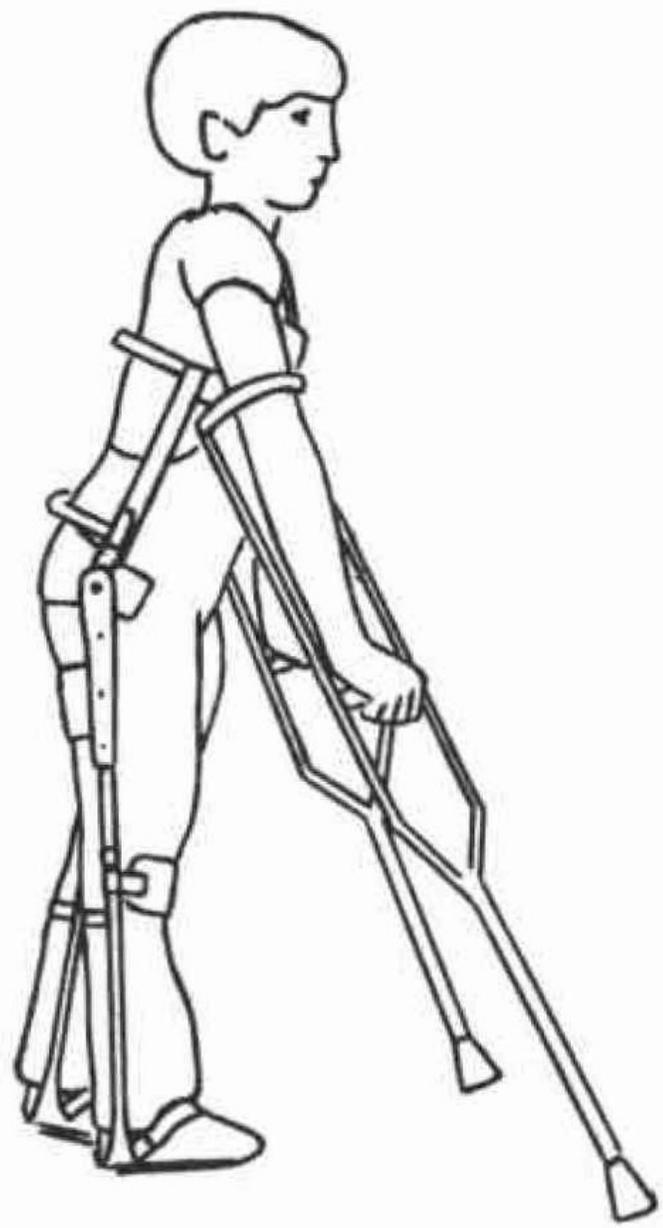
---



# INTRODUCTION

---

- HKAFOs are essentially KAFOs that extend across the hip joint, connecting to a pelvic band or, when more trunk stability is required, lumbar or thoracic spinal support.
- Hip guidance orthoses (HGOs) and reciprocating gait orthoses (RGOs) are examples of HKAFOs.
- HGOs, such as the Para-Walker (The patient walks by using the arms and walking aids to move the trunk forward the weight), consist of bilateral KAFOs linked via specially designed low friction hip joints with flexion/extension stops and a release mechanism that allows for sitting.
- Reciprocating gait orthoses has hip joints linked by a cable so that extension occurs on one side causes flexion on the other side. The patient pushes down both the crutches and pulls pelvis forward leaning on one side. Non-weight bearing leg moves forward with the help.



# ADVANTAGES OF HGO AND RGO

---

- HGO

- Has low energy consumption
- Allows user to achieve walking speed of 50% of normal individual
- Easy to wear and take off.

- RGO

- Cosmetically acceptable
- Lighter and Gives ability to the patient to stand unsupported

# CONT.

---

- It is being given when there is no power around hip, knee and ankle. This limb is also known as flail limb.
- The lateral bar, hip, knee and ankle foot orthosis (HKAFO) was developed for patients who need an orthosis beyond the Parapodium.
- This orthosis has been successfully used for patients with muscular dystrophy, spina bifida, cerebral palsy and traumatic injuries resulting in parapareses or paraplegia.
- Variations in design and materials have made it possible to fabricate orthoses for a broad age group of patients with neuromuscular involvement.
- In the case of spina bifida, the patient who graduates to the HKAFO from a Parapodium will sacrifice the free-standing feature of the Parapodium, but may gain the opportunity to ambulate with a reciprocating or swing-type gait

## Parapodium

- ❑ Worn over clothing
- ❑ Allows standing without crutches
- ❑ Permits child to sit and stand



# INDICATIONS

---

- Spina bifida
- muscular dystrophy
- traumatic paraplegia
- cerebral palsy, osteogenesis imperfecta
- rotational issues at the hip.

# PRINCIPLES

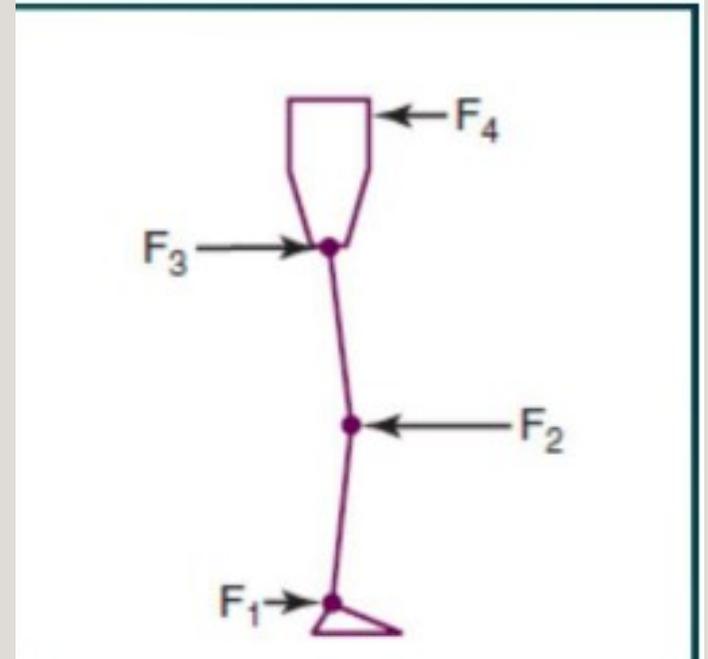
---

- Use only as indicated and for as long as necessary.
- Allow joint movement wherever possible and appropriate.
- The orthotic ankle joint should be centered over the tip of the medial malleolus.
- The orthotic knee joint should be centered over the prominence of the medial femoral condyle.
- The orthotic hip joint should be in a position that allows the patient to sit upright at 90 degrees.
- Patient compliance will be enhanced if the orthosis is comfortable, cosmetic and functional.

# PRINCIPLE OF EQUILIBRIUM

---

- This system applies corrective and assertive forces which are implemented at surface of orthosis through skin and transmitted to underlying soft tissue and bones .
- To remain stable ,the body has to have one point of pressure opposed by two equal points of counter pressure.
- Hip joint:  $F_3 = F_2 + F_4$ , Knee joint:  $F_2 = F_1 + F_3$ .
- Forces  $F_1$ ,  $F_2$ , and  $F_3$  control knee flexion, while forces  $F_2$ ,  $F_3$ , and  $F_4$  control hip flexion.
- The corrective force is directed towards the angular or deformed area to be corrected and other two counter forces are applied distal and proximal to the corrective forces.
- The greater the distance between the force and the counter force, the less counter force required



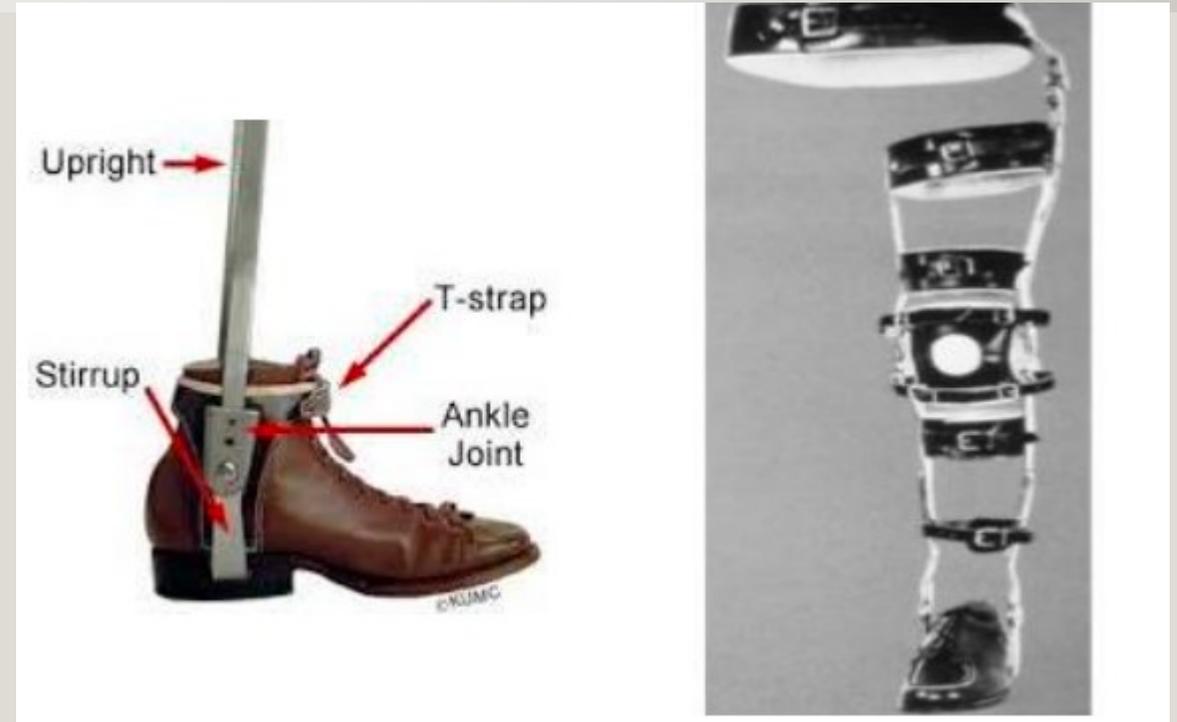
# PARTS OF HKAFO

---

- The standard HKAFO consists of following parts:
  - Ankle Stirrup: This is most distal part of the caliper which is attached to base of heel of orthopedic boot with the help of rivets
  - Joints: Each HKAFO has 3 joints:
    - ❖ Ankle Joint: Ankle joint is attached to ankle stirrup.
    - ❖ Knee Joint: Usually, lock is given in the knee joint so that person can sit easily on chair by unlocking. Knee joint is not given in children below 5 years so as to keep orthosis light. C
    - ❖ Hip Joint: Hip joint is attached proximally with the pelvic belt and distally with the single outer upright.
  - Upright: 2 uprights made-up of aluminum or mild steel are used for giving erect posture to the child. All the 3 joints are attached in the uprights.

# CONT.

- Band: Every HKAFO has 4 bands which are given posteriorly:
- Pelvic band b. Ischial Band
- Thigh Band
- Calf Band
- Knee Cap: It provides 3 points pressure on anterior part of orthosis which is attached to the middle of caliper by 4 leather straps).



# CONT.

---

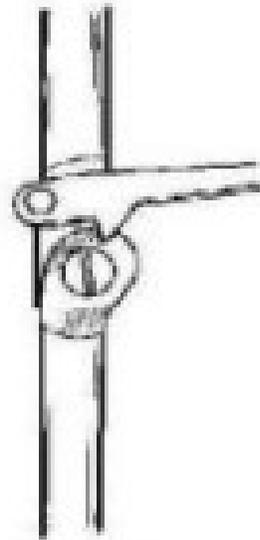
- Some time lumber frame is also attached to the HKAFO when there is a weakness of paravertebral musculature.
- The addition of the hip joint and pelvic section provide control to selected hip motions.
- These selected motions about the hip are front to back, side to side, and rotation.
- One reason the hip section is added to a KAFO is to reduce or minimize the risk of the hip moving out of proper position or dislocating.
- Another common reason is to stabilize the hip and lower spine in cases where the patient is weak or paralyzed.



① Free Motion



② Drop Lock



③ Swiss Lock



④ Off-Set



⑤ Dual Axis

# FABRICATION PROCESS OF PLASTIC HKAFO: I- AFO

---

- Step 1: Creating a negative plaster mould of patient's lower leg and foot
- Step 2: Cutting and removing plaster mold from patient
- Step 3: Pouring liquid plaster into the negative plaster mold
- Step 4: Modifying the positive plaster cast



# CONT.

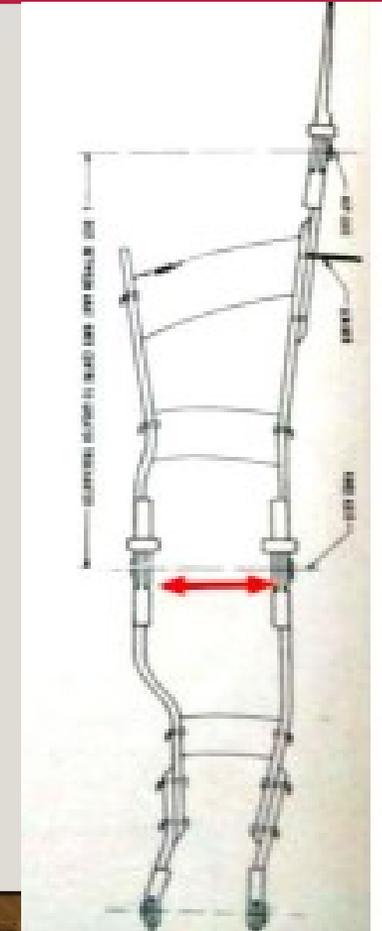
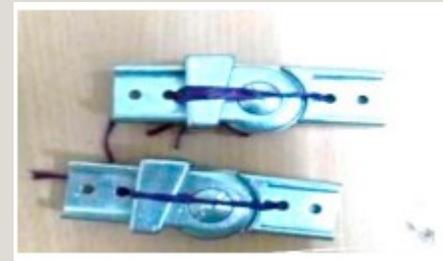
---

- Step 5: Moulding the HDPE plastic
- Step 6: Removing & Cutting the plastic from positive cast
- Step 7: Finishing the plastic shape
- Step 8: Fitting the patient



# CONT.

- Two upright (medial and lateral) attached to the drop lock knee joint from above and below and connects AFO & lower thigh band respectively.
- Straight set knee joint allows free flexion and prevents hyperextension.
- It is used with drop lock which is a wedge-shaped metal piece that is placed on upright bar. When knee extends it drops over the joint and locks it.
- Width at knee joint = Anatomical knee width + 10 to 12 mm



## 2- QUADRILATERAL THIGH SECTIONS

---

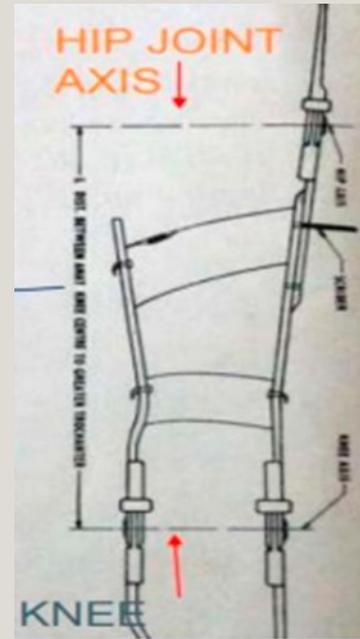
- The quadrilateral thigh section is designed to permit partial transfer of the patient's weight through the KAFO during stance phase which is made of HDPE plastic .
- This brings more effective balance to the patient's gait as the resultant stance period.



# 3-HIP JOINT

---

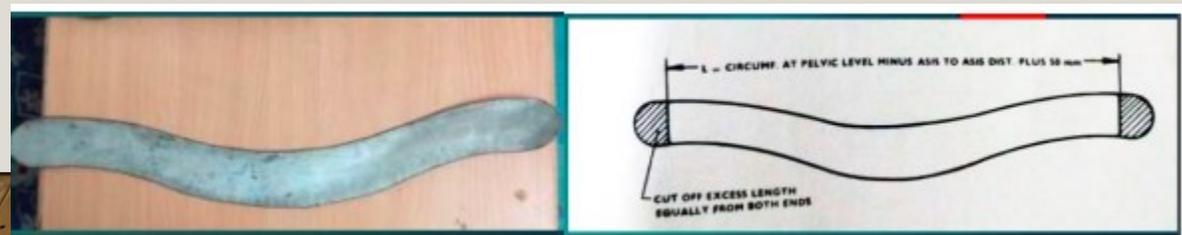
- Hip joint is attached to KAFO which allows flexion extension only.
- Movement of hip with a uniaxial hip joint with drop lock which is locked during walking.
- Distance between knee axis to greater trochanter is measured.
- Hip joint is placed on the lateral side of brace till the axis of hip joint is at the measured distance from knee joint axis to greater trochanter.
- Hip joint bar attached to knee joint bar with nails



## 4- PELVIC BAND

---

- A pelvic band which is padded rigid steel band extending posteriorly and laterally which fits between iliac crest and greater trochanter.
- In front it is fastened with a soft Velcro or buckle strap fastener .on the lateral side it is attached to hip joint.
- Measurement of pelvic band: length of pelvic band =(circumference at pelvic level –ASIS to ASIS distance) + 50 mm.
- Cutting off excess length of pelvic band if required equally from both side & banding is done



# RECIPROCAL GAIT ORTHOSIS (RGO)

---

- A reciprocating gait orthosis (RGO) is an HKAFO that uses a mechanical system that connects the two sides of the brace by:
  - Iso-centric bar (IRGO).
  - Double cable (LSU RGO).
  - Single push/pull cable system [advanced (RGO ARGO)].



# PRINCIPLE OF OPERATION

---

- The RGO allows stable, upright balance at minimal metabolic energy cost. As the patient starts to walk, several physical functions are taken in sequence.
- Step 1 The patient's weight is shifted over one leg (normally the stance leg that will execute the push-off function).
- This is accomplished by elbow extension with the contralateral arm, tilting the trunk toward the leg.
- This results in a slight elevation of one leg and allows it to clear the floor as the swing phase is initiated.
- Step 2 The patient exaggerates lordosis by shoulder retraction and back extension.
- Applying force against the posterior thoracic strap of the RGO applies force on the thoracic uprights creating a moment about the hip joint of the stance leg and forces it to undergo hip extension.
- Step 3 The dual-cable mechanism links the two hip joints and transmits part of the torque created about the hip of the extremity (leg) in stance phase of gait, to the contralateral hip in a reciprocal manner, initiating hip flexion. This results in the execution of the swing phase simultaneous with the contralateral push-off.

# CONTRAINDICATIONS

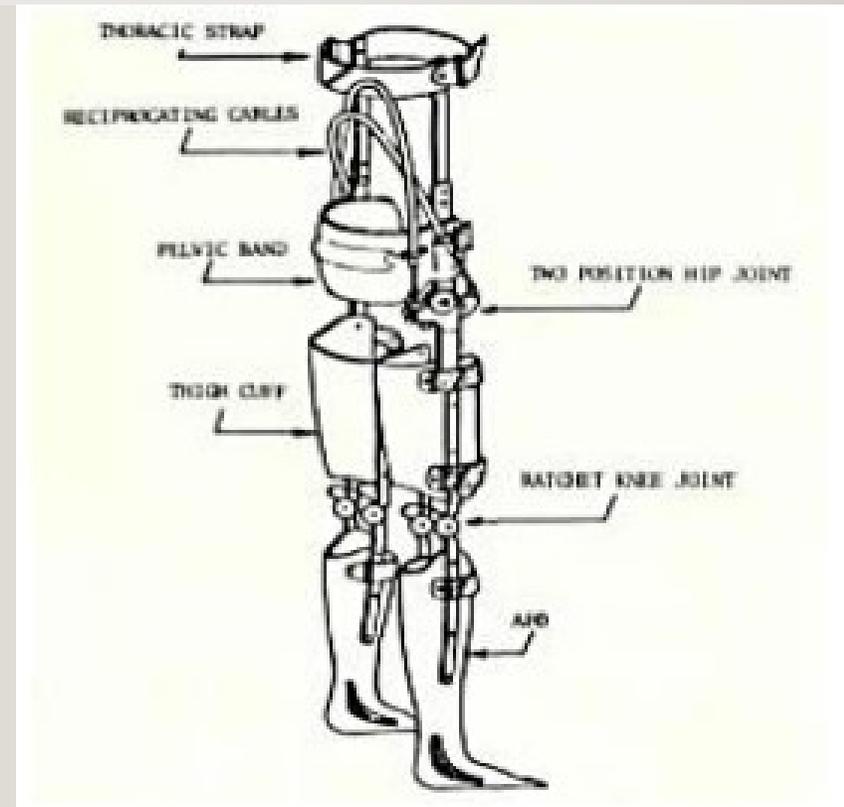
---

- Severe fixed hip and knee contractures that prevent the establishment of normal alignment.
- Spasticity or other involuntary muscle activity that prevents free and coordinated mobility
- Marked obesity
- The higher the ratio of weight to height, the increased energy utilization for ADL and ambulation. Additionally, with marked obesity, the increased size of the pelvic componentry sidebars and related components (straps, pads etc.) comes increased weight and bulk, thus making it more difficult to accomplish daily activities such as transfer and ambulation.
- Poor upper extremity strength
- The reasoning for the need for increased upper extremity strength, is not only for transfers and ADL, but for donning, doffing of the orthosis, mobility using crutches or a walker for these activities.
- Contractures greater than 30° in the hips, knees or ankles

# COMPONENTS

---

- AFO
- Hip joint
- Knee joint
- Pelvic band
- Uprights
- Cables
- Thigh cuff
- Thoracic straps



# PHYSICIANS & THERAPISTS RECOMMEND STANDING FOR MANY REASONS

---

- Pressure relief
- Optimizing of kidney and bladder functions
- Improving digestive and bowel function
- Increasing bone density
- Improving flexibility and decreasing spasticity
- Greater circulation
- Improving respiration

# CONT.

---

- **Bones:** Continuous sitting inhibits weight bearing, which causes weakening of the bones and ultimately, osteoporosis. According to the Journal of Applied Physiology, passive standing can reverse the loss of bone density.
- **Muscles:** Joints lose flexibility and contractures in the knees, ankles and hip joints can form. Additionally, continuous sitting often causes tightening or shortening of the leg muscles. Spasticity is a muscular problem often found in spinal cord injury cases and other neurological disorders. Use of standing devices increases flexibility and decreases spasticity in the legs.
- **Circulation:** Continuous sitting contributes to poor blood circulation, which can result in pooling of blood in the lower extremities. The result is often fatigue, nausea, and dizziness.
- **Breathing:** In the supine, or sitting, position a person cannot contract muscles for maximum inhaling and exhaling, which can lead to reduced respiratory efficiency and impairment such as pneumonia.