STUDY OF ACTIVE ORTHOSIS

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ABSTRACT: The design and prescription of orthoses can be aided by an understanding of the biomechanical principles of the upper limb.Orthoses are classified into static, dynamic and hybrid orthoses. Upper limb orthoses are more often accepted by patients when there is a well-defined therapeutic programme and when the orthoses provide a desired function that cannot be achieved otherwise. The complexity of the hand, elbow or shoulder requires that orthosis design places equal importance on mechanical efficiency and precision of fit, as comfort is essential for acceptance.
Specific training is required to meet the high design and fabrication requirements resulting from small segments (levers), limited soft tissue padding and multiple joints. If the biomechanics can be optimised, then the resulting improvements in kinematics will not only have an immediate effect on gait, joints and muscles, but can also provide a therapeutic environment that can contribute to long-term benefits.

Keywords : Orthosis, dynamic, active, AFO, metal

1.Introduction

Since antiquity the human body has been studied in its totality even today, it, by its amazing complexity, leads researchers to describe it as a "machine built down to the smallest details reached perfection". Optimal communication and transdisciplinary education occurs when the patient, doctor, orthotist and therapist are all present for the assessment of the patient. The goal of active orthotics is to provide a low amplitude force for a period of time to reshape new tissue. The force is provided by the traction of the elastic band located in the supporting part of the orthosis. The dynamic orthosis should heal the tissue and joint stiffness, but the stretching should not be painful. The patient should bring the medical device to each visit for reassessment and readjustment. There is no specific time for how long the orthosis should be worn, as many factors can have a great influence such as: soft tissue tolerance to stretching and the patient's adaptation to the medical device. My goal is to bring different orthotics from a structural and functional point of view to the patient's attention, due to the lack of information and possibilities in our country from an orthotic point of view.

2. Types of orthoses

There is a wide range of orthoses on the market designed for use in certain conditions of the osteo-articular system, made of quality material in accordance with the latest technology and the requirements of the European Community in the field of orthopedic equipment and devices. The purpose of the orthosis is to replace atrophied or absent muscles, protect injured segments by limiting range of motion or loading, or prevent anatomical deformities. Orthotics are used in hand rehabilitation, their therapy consists of maintaining a fixed position in both dynamic and static cases. Their design is such that they do not injure tissue following trauma, once designed and molded they support weak muscles and counteract the pull of healthy muscles, applying an external force to counteract the imbalance of internal forces. The dynamic orthosis is the application that contains an active force that remains constant as part of the movement, the use of that guidance system ensures the direction of the traction force obtained by pulling the elastic (see figure 1).

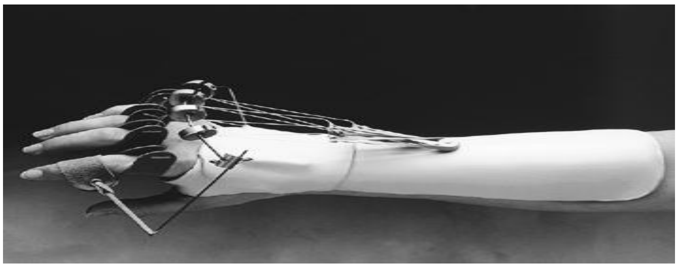


Fig. 1. **Dynamic hand-fist-finger orthosis**

Elbow orthoses (EO) are commonly used immediately after trauma or surgery. Typically, a three-point force system is used, along with a hydraulic lock of the semiliquid tissues around the fragments, to hold the fracture fragments as a single unit during the healing process (Figure 2).

Fig. 2. **Active elbow orthosis**

The hip orthosis used to treat a posteriorly dislocated hip is generally proximal to the knee. A well-fitting pelvic band suspends the orthosis and provides a fixation point for the hip joint. A hip joint with adjustable range of motion, placed laterally, capable of controlling flexion, extension, abduction, and adduction, attaches to a hip joint that fits snugly. thigh cuff that maintains the hip in 10 to 20 degrees of abduction and allows 0 to 70 degrees of flexion [7]. This joint position combined with properly fitting pelvic and thigh components provides a kinesthetic warning against excessive flexion, adduction, external rotation (see figure 3).

Fig.3. **Hip orthosis**

Knee-ankle orthosis adapted to provide independent methods of walking for a person with impaired gait, paralysed lower limb or lost muscle function due to spinal injury or accident. A knee-ankle orthosis presents problems in locking and unlocking the knee joint [4].

The simplest orthoses have a manual locking and unlocking device for the thigh frame and calf frame, when walking the user locks the joint, while when sitting, they unlock the joint to flex the knee With such an orthosis the knee joint is locked during gait and the user is forced to walk with a fixed knee, the gait is no longer natural and he is forced to exert more effort [3].The aim of dynamic orthoses is to provide a low amplitude force for a period of time until the new tissue remodels. The force is provided by the traction of the elastic band located in the supporting part of the orthosis [9].The dynamic orthosis should heal the tissue and joint stiffness, but the stretching should not be painful, e.g. HKAFO orthosis (see figure 5).

Fig. 5. **Orteza HKAFO**

The foot, an integrated part of the human skeleton, together with the ankle, forms the anatomical-functional complex that supports the entire body and plays a significant role during gait due to its major importance in both static and dynamic gait [12].

The foot provides stability, mobility, balance, acceleration and deceleration during gait. The ankle joint is a particularly important joint because of its role in the execution of lower limb movements and can have major consequences for the stability and mobility of the lower limb, and therefore the whole body.

Various orthotic devices are used in modern medicine to correct various dysfunctions that occur in the ankle joint and the foot. Ankle and foot orthoses are recommended for numerous conditions such as ankle sprains, ankle and foot fractures, Achilles tendon ruptures, plantar fasciitis, Hallux - Valgus, Tallus - Valgus, Varus Equinus, flatfoot, but also to protect the ankle joint during various sports [5].

The clinical objectives to be achieved by the use of orthotics are: pain relief, deformity correction, motion control, increased range of motion, reduced healing time, injury prevention, etc.. In their achievement, orthoses must decrease or eliminate dysfunction of the segment on which they are applied,with a high degree of comfort, aesthetic, and low manufacturing cost. Orthoses are external devices applied to an anatomical segment of the body to prevent or correct dysfunctions of that segment (restoration of normal functions and abilities by controlling movement, correcting deformities and compensating for various dysfunctions) [7].

The ISO/TC Technical Committee in conjunction with the American Academy of Orthopaedic Surgeons and the American Orthotic and Prosthetic Association have proposed naming prosthetic devices according to the anatomical segment and the joint(s) undergoing bracing (Table 1). The proposed acronyms have been accepted and used internationally, even by non-English speakers [2].

Tabel 1 [6]

Categoria	Denumirea	Acronimul	Denumirea	Acronimul
Orteze de membru inferior Lower Limb orthoses	Orteză pentru picior Foot orthosis	FO	Orteză pentru gleznă-picior Ankle-foot orthosis	AFO
	Orteză pentru genunchi Knee orthosis	KO	Orteză pentru genunchi-gleznă-picior Knee-ankle foot orthosis	KAFO
	Orteză pentru şold Hip orthosis	HO	Orteză pentru şold-genunchi-gleznă-picior Hip-Knee-ankle foot orthosis	HKAFO
			Orteză reciprocă de mers Reciprocal Gait orthosis	RGO
Orteze de coloană vertebrală Spinal orthoses	Orteză cervicală Cervical orthosis	CO	Orteză cervico-toracică Cervical-Thoracic orthosis	CTO
	Orteză toracică Thoracic orthosis	TO	Orteză cervico-toracică-lumbosacrală Cervical-Thoracolumbosacral orthosis	CTLSO
	Orteză sacrală Sacral orthosis	SO	Orteză toraco-lumbosacrală Thoracolumbosacral orthosis	TLSO
	Orteză sacroiliacă Sacroiliac orthosis	SIO	Orteză lumbosacrală Lumbosacral orthosis	LSO
Orteze de membru superior Upper Limb orthoses	Orteză pentru mână Hand orthosis	HdO	Orteză pentru încheietura mâinii şi mână Wrist-Hand orthosis	WHO
	Orteză pentru încheietura mâinii Wrist orthosis	WO	Orteză pentru cot, încheietura mâinii şi mână Elbow-Wrist-Hand orthosis	EWHO
	Orteză pentru cot Elbow orthosis	EO	Orteză pentru umăr şi cot Shoulder-Elbow orthosis	SEO
	Orteză pentru umăr Shoulder orthosis	SO	Orteză pentru umăr, cot, încheietura mâinii şi mână Shoulder-Elbow-Wrist-Hand orthosis	SEWHO

3. Action of orthoses

There are 3 categories of orthotic devices, grouped according to the anatomical areas of the human body: trunk, upper limb and lower limb.

Clinical objectives of orthotic treatment [2]:

- Pain relief.
- Correction of deformities.
- Prevention of excessive range of motion, postoperative immobilization .
- Development of range of motion.
- Compensation of dimensional abnormality of anatomical segments.
- Stimulation of abnormal neuromuscular function.
- Reduction of healing time and tissue protection.
- Suppresses motor deficit or postural feedback or injury prevention, etc.

Types of actions performed by the orthosis :

Stability refers to fixing an anatomical structure in a balanced position so that its shape does not change. Given the exoskeletal application of the orthosis, the affected area must be well immobilized if the orthosis is extended and stabilizes the supra and underlying joints.

Posture is a position, an attitude different from normal. In orthotics, a joint or anatomical segment must be maintained or even forced into a certain adapted position, and there are two types of position:

- Static when the orthosis is fixed, does not allow any movement and does not change with changes in position. This allows a balance of forces to be established.
- Dynamic when a posture is maintained with an orthosis that adapts to changes in anatomical position, developing a constant direct force that generates energy capable of producing movement.

In terms of joint movement, there are two main types of ankle and foot orthoses:

1. Static (fixed) orthoses: they restrict movement around the joint or the anatomical segment they surround and their main objective is stabilisation. Static orthoses are flexible or rigid orthoses that keep the joint in a fixed position, with the vertical part at the back of the calf and the horizontal part below the sole of the foot supporting weakened or paralysed segments of the lower limb.

2. Dynamic orthoses (Ankle Foot Orthosis AFO): these are orthoses used to facilitate body movements and allow the anatomical segment to function. These orthoses provide subtalar stabilisation, allow ankle dorsiflexion and plantar flexion, which can be free or limited, in some cases even blocked [5].

Active Ankle Foot Orthosis (AAFO): is a new generation of dynamic orthoses powered by an actuator. Actuation provides controlled force to compensate for muscle deficiencies around the ankle. This force is calculated by a controller that receives both biological (EMG) and physical (ground reaction, angle in the joint) feedback. Regardless of the type of actuator, it must be able to provide sufficient force for the movement and have the properties required by the muscle (low impedance, low friction, etc).

The impedance of the orthotic joint can be changed throughout the gait cycle. During controlled plantar flexion, biomimetic control is applied by torsion spring where the stiffness of the orthotic joint is actively adjusted to minimise foot collision with the ground (see figure 6).

All orthotics control spinal motion through a combination of dynamic and passive mechanisms. Dynamic control describes the significant role of the intrinsic musculature in actively stabilizing the spine and is a major component in the effect of most orthoses [17].

In addition to improved function through better posture, improved proximal/distal stability and reduced involuntary movements, other benefits may include pain relief, reduced associated reactions, easier transfers and improved therapy sessions. Over time, the desired effect would be to experience improved function and movement control when the orthosis is removed - i.e. continuation of the effects experienced when wearing the orthosis [18].

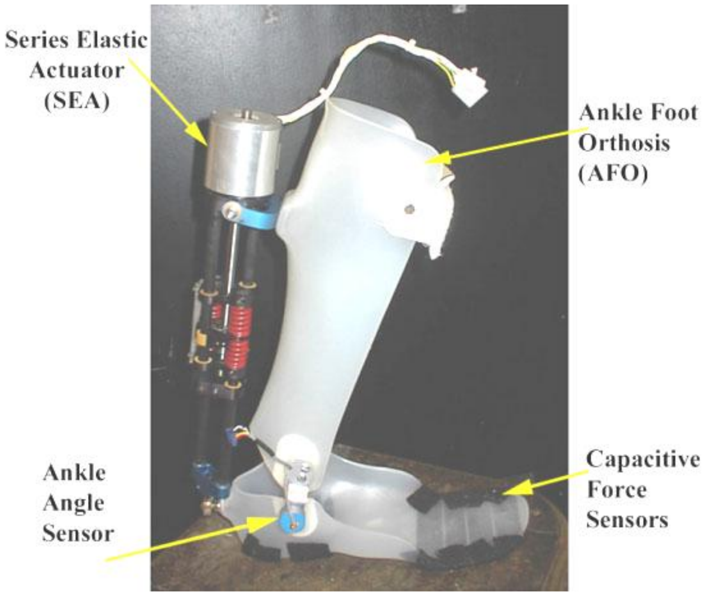


Fig. 6. **Orthosis AAFO**

Depending on the pathology of the ankle or foot, various types of ankle-foot orthoses are recommended to be used:

- Method of manufacture: Typical, available in different sizes, they are used directly.
- Pre-fabricated (custom-fitted), custom-made orthoses, custom-fitted/modified.
- Custom-made, specially made, individualised for a specific patient.

A custom-made orthotic device is manufactured based on a model (physical or computerized) of the patient's affected anatomical segment. The purpose of use is (functional) treatment, rehabilitation or sport [14].

Period of wear: day/night or duration of wear: temporary or permanent or mode of wear, in shoe or over shoe.

There are four main types of Ankle-Foot Orthosis (AFO) [1]

- Flexible AFO (see figure 7a).

- Dorsiflexion support.
- Subtalar joint stabilisation.

- Rigid AFO (see figure 7b).

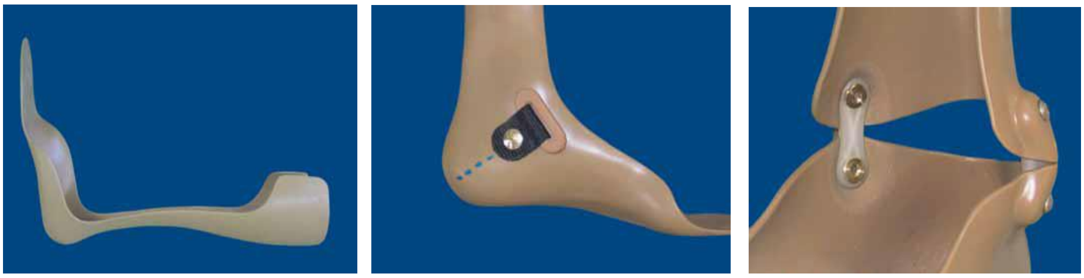
- Blocks ankle movement.
- Mediolateral stabilisation of the subtalar joint.
- Ability to control forefoot adduction/abduction.

- AFO with Tamarack Flexure Joint TM (see figure 7c).

- Mediolateral stabilisation of the subtalar joint.
- Free dorsal ankle extension.
- Free or restricted plantar flexion of the ankle.

- Anti-talar AFO (see figure 7d).

- Blocks ankle movement. Particularly effective in preventing dorsiflexion of the ankle.
- Poor mediolateral stabilisation of the subtalar joint.



a) b) c)

d)

Fig 7. **Ankle-Foot Orthosis (AFO)**
AFO FLEXIBLE (a), AFO Rigid (b), AFO Tamarack (c), AFO anti talus (d)

Foot orthoses for various pathologies such as Hallux Valgus with prominence of the first metatarsal and medial displacement of the hallux to the inside of the foot. Hallux - Valgus pathology can occur due to certain diseases such as rheumatoid arthritis, uncomfortable, tight shoes and heels aggravate this condition,also flat feet and obesity can favor the occurrence of this deformity [13].

Hallux Valgus Orthosis - the principle of correction applied by this orthosis is based on the principle of leverage, by applying pressure force to the hallux at the metatarsophalangeal joint and laterally in the metatarsal area (Figure 8a). An orthosis is made up of the following components: the hallux support, the foot support, the guide piece, the multifilar cable and the assembly elements (screws, rivets and staples).The materials proposed for the construction of the orthosis are: thermoformable material (hallux support and foot support), aluminium (guide piece), rolled stainless steel (multifilar cable) and Velcro strips (see figure 8b)[2].

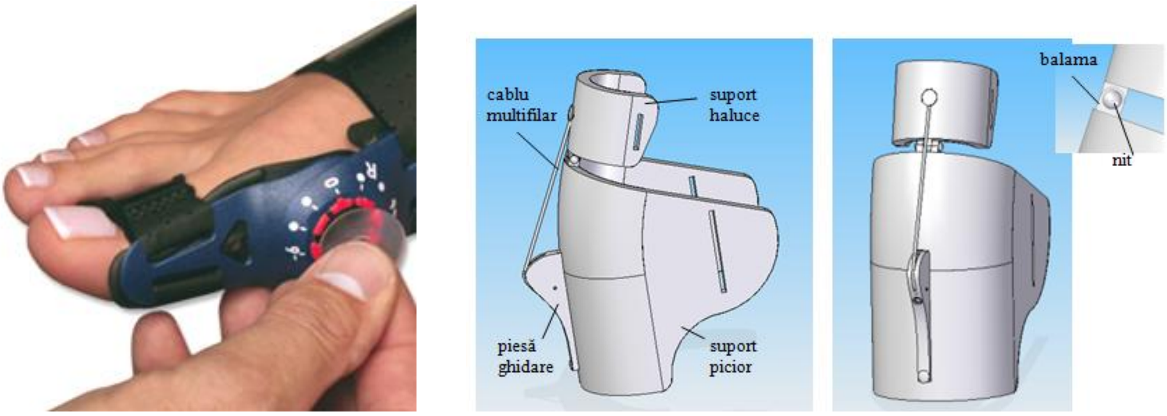


Fig. 8. **Hallux Valgus Orthosis**
a) active hallux orthosis b) hallux valgus orthosis

4. Conclusions

Orthoses are tailored to individual patient variables, these generate a wide variety of orthosis configurations specifically designed to achieve distinct therapeutic goals.

The patient must understand the purpose of the orthosis, accept the benefits it can provide and have the appropriate knowledge and skills to use the orthosis appropriately.

Orthoses are orthopaedic devices that are applied directly to the human body to: supplement, compensate for or correct a physical deficit.

Orthoses need to be accepted by the patient and a real process of acceptance, integration and identification needs to take place where they lose their status as an object of external reality in relation to the patient and become parts of his body.

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