

Physiotherapy clinical considerations in the prescription of ankle-foot orthoses in post-stroke patients

Klever Armando Bonilla Yacelga¹
Jorge Gabriel Maldonado Cornejo²
Samuel Olegario Iñiguez Jiménez^{1,3*}

1. Pontificia Universidad Católica del Ecuador. Physiotherapy career. Quito, Ecuador.
<https://orcid.org/0000-0002-8270-7426>
2. Universidad Central del Ecuador. Physiotherapy career. Quito, Ecuador
<http://orcid.org/0000-0002-0508-7286>
3. Centro de Investigación para la Salud en América Latina (CISeAL). Quito, Ecuador.
<https://orcid.org/0000-0002-4722-7611>

*Corresponding author. e-mail: iniguezjimenez@gmail.com

ABSTRACT

Introduction: Cerebrovascular accident (CVA) is one of the main causes of deterioration of motor function, the prescription of ankle-foot orthoses (AFO) has systemic effects on joint movement to optimize walking.

Objective: To analyze based on current scientific evidence, the main clinical considerations in physiotherapy for the prescription of ankle and foot orthoses in patients with sequelae of stroke.

Development: There are different types of ankle-foot orthoses, among the most used are: rigid, dynamic, and articulated AFO, each with its respective characteristics. A comprehensive evaluation of strength, balance, muscle tone, reflexes, sensation, gait, and functionality should be performed. When using AFO, the duration of use and care should also be considered, especially when it comes to skin care. Over time, it is necessary to establish to promote the patient's function in activities of daily living (ADL).

Conclusions: The use of AFO in post-stroke patients depends on various aspects such as muscle strength, muscle tone and degree of joint instability. It is essential to consider the type of orthosis to be prescribed, whether rigid, dynamic, or articulated; The state of sensitivity and musculoskeletal difficulties will guide the choice of the material to use. Based on these criteria and the evaluation carried out by the physiotherapist, the most appropriate orthosis will be prescribed to allow safe and effective walking.

Keywords: ankle joint; foot orthoses; orthopedic devices; stroke.

RESUMEN

Introducción: El accidente cerebro vascular (ACV) es una de las principales causas de deterioro de la función motora, la prescripción de ortesis de tobillo-pie (AFO) tiene efectos sistémicos en el movimiento articular para optimizar la marcha.

Objetivo: Analizar con base en la evidencia científica actual las principales consideraciones clínicas en fisioterapia para la prescripción de ortesis de tobillo y pie en pacientes con secuelas de ACV.

Desarrollo: Existen diferentes tipos de ortesis tobillo-pie, entre las más utilizadas se encuentran las AFO rígidas, dinámicas y articuladas, cada una con sus respectivas características. Se debe realizar una evaluación integral de la fuerza, el equilibrio, el tono muscular, los reflejos, la sensibilidad, la marcha y la funcionalidad. Al utilizar AFO, también se debe considerar la duración del uso y el cuidado, especialmente en lo que respecta al cuidado de la piel. Con el tiempo es necesario establecer objetivos para promover la función del paciente en sus actividades de la vida diaria (AVD).

Conclusiones: El uso de AFO en pacientes post-ictus depende de diversos aspectos como la fuerza muscular, tono muscular y grado de inestabilidad articular. Es fundamental considerar el tipo de órtesis a prescribir, ya sea rígida, dinámica o articulada; el estado de sensibilidad y las dificultades osteomusculares guiarán la elección del material a utilizar. En base a estos criterios y a la evaluación realizada por el fisioterapeuta, se prescribirá la ortesis más adecuada para permitir una marcha segura y eficaz.

Palabras clave: accidente cerebrovascular; articulación del tobillo; aparatos ortopédicos; ortesis del pie.

INTRODUCTION

Currently, one of the main causes of permanent physical disability and cognitive impairment in adults potentially life-threatening, is stroke or cerebrovascular disease.^(1,2,3) These outcomes are attributed to its multiple consequences at the sensory, cognitive, motor, and emotional levels, which restrict the person's ability to perform basic activities of daily living.⁽¹⁾ Stroke refers to a group of pathologies that cause sudden neurological deficits due to alterations in the blood supply to structures of the nervous system. It is worth noting that 1 in 6 people will experience a stroke in their lifetime.⁽⁴⁾

One of the most common sequelae of stroke related to physiotherapy is partial or total loss of movement, as well as decreased strength, propensity for falls, muscle tone alteration, and coordination and balance problems.^(2,3) Generally, orthoses are prescribed to assist in controlling these impairments and improve functionality of the affected limb.⁽⁵⁾ Regarding orthoses, their application in the lower limb is widely used in stroke rehabilitation to address joint instability, inadequate oscillation, and non-plantigrade support, with the goal of achieving safer and more effective gait.⁽⁵⁾ In most cases, anti-equinus orthoses are recommended, which can be metallic or thermoplastic.⁽⁶⁾ On the other hand, in recent years there have been developments in orthotic manufacturing with technological advancements and new materials, resulting in dynamic ankle-foot orthoses.⁽⁶⁾ These allow for maximum patient autonomy by addressing both structural and functional deficiencies and improving limb alignment and correction of deformities.⁽⁷⁾ Some studies have analyzed the prescription of foot or ankle orthoses in post-stroke patients, for example, Guerra Padilla et al.⁽¹⁾ examined the effect of AFO on postural control after stroke, concluding that this device could be recommended in early post-stroke stages to improve gait, as well as speed, cadence, stability, and postural control, enabling the patient to perform daily activities with greater ease. Likewise, in the literature review by Prieto⁽³⁾, it was determined that the prescription of AFO resulted in notable improvement in gait speed, dorsiflexion movements, "drop foot", and reduced the risk of falls for participants. However, few studies mention the clinical physiotherapeutic considerations in the prescription of dynamic ankle-foot orthoses in post-stroke patients. Some general principles in prescribing these devices include prior evaluation of the patient's pathology and determining the objective of the orthosis, as well as its type and duration based on the need.⁽⁸⁾

A documentary review was conducted from January to June 2023 using two databases: PubMed and Web of Science, with the following MeSH terms: "stroke," "orthotic devices," "ankle," "ankle joint," "orthotic devices," "foot."

Included studies met the following criteria: free full-text, full-text, clinical trial, randomized controlled trial, within the last 10 years, human subjects, English, or Spanish language.

The objective of this review was to analyze the main clinical considerations in physiotherapy for prescribing ankle and foot orthoses in patients with stroke sequelae, based on current scientific evidence.

DEVELOPMENT

Types of lower limb orthoses

What terminology is used?

The recommendation is to use international terminology. In the lower limb, we have orthoses that cover the entire limb to those placed under the sole of the foot: THKAFO (Trunk-Hip-Knee-Ankle-Foot Orthosis), THO (Trunk-Hip Orthosis), HO (Hip Orthosis), HKAFO (Hip-Knee-Ankle-Foot Orthosis), KO (Knee Orthosis), KAFO (Knee-Ankle-Foot Orthosis), AO (Ankle Orthosis), AFO (Ankle-Foot Orthosis), FO (Foot Orthosis), and FO (Finger Orthosis).⁽⁹⁾

Which ones are most used in patients with neurological disorders?

The most used are AFO and FO.⁽¹⁰⁾

Ankle-Foot Orthoses are used to stabilize and align the ankle and foot joints, as well as facilitate ankle dorsiflexion, walking ability, and improve gait patterns.

What types of AFO are available on the market?

There are various types with different functions, indications, and usage goals: SAFO (Solid AFO), DAFO (Dynamic AFO), GRAFO (Ground Reaction AFO), FRO (Floor Reaction Orthosis), PLS (Posterior Leaf Spring), HAFO (Hinged AFO), and SMO (Supramalleolar Orthoses).^(4,11)

Articulated AFO can be bilateral with articulation (Tamarack, Ultraflex) or unilateral with free articulation or with blocking of dorsiflexion and plantar flexion.⁽⁴⁾

Materials

Orthoses can be made from materials such as steel and aluminum metals, as well as low-temperature thermoplastics like orthoplast and aquaplast, and high-temperature thermoplastics like polyethylene, polypropylene, PVC, with additional materials such as leather and carbon fiber.

Nowadays, thermoplastics are more commonly used due to their advantages in terms of full contact with the body, better adaptation, lightweight, aesthetics, ease of removal, but they are contraindicated for patients with sensory difficulties or edema.

According to the mentioned information, the types of AFO differ within each group based on the material they are made of:⁽⁸⁾

- Metallic (monotutor, bitutor with free joint, bitutor with Klenzack, Codivilla spring).
- Prefabricated thermoplastics (simple or modified “c”).
- Custom-made thermoplastics (spiral, hemiespiral, Denver T, Tone-Inhibiting Ankle-Foot Orthosis TIAFO, Dynamic AFO, Neurophysiologic Ankle-Foot Orthosis NPAFO), and carbon fiber (AFO light, walk-on, Matrix Max).

Muscle strength or balance assessment

It is done by comparing resistance against movement on both sides and graduating the intensity from 0 to 5.

Scale to grade muscle weakness. Medical Research Council.⁽¹²⁾

Muscle Tone

Spasticity is a clinical symptom that should be systematically assessed and explored. The Ashworth scale scores spasticity between 0 (normal tone) and 4 (rigid limb).⁽¹³⁾

Osteotendinous reflexes

For the prescription of an AFO, the patellar and Achilles reflexes should be evaluated. The Seidel scale can be used.

Pathological reflexes

Pathological hyperreflexia, along with spasticity, is another crucial characteristic of upper motor neuron involvement. The Babinski sign, also known as the extensor plantar reflex, occurs when the outer side of the foot is stroked with an object from the heel to the toes, resulting in extension of the hallux (“big toe”).

Sensitivity

Superficial sensitivity informs us about the external environment and its receptors are located in the skin or immediate underlying layers.

Deep sensitivity also informs us about the external environment (e.g., pressure), but also about how our body is positioned and moves in space. Some of its receptors are found in the skin, while others are located internally within our body (in muscles, tendons, etc.).

In the prescription of an ankle orthosis, dermatomes L4, L5, and S1 should be evaluated.⁽¹³⁾

Joint balance

Joint balance involves quantifying hip, knee, and ankle contractures, as well as possible torsional abnormalities.

Hip flexion contracture can be evaluated using the Thomas maneuver.

The popliteal angle quantifies hamstring tightness in the knees.

The Duncan-Ely test assesses rectus femoris tightness.

The Silfverskiöld test evaluates calf muscle (triceps surae) tightness.⁽¹⁴⁾

Gait Observation Scales

There are various scales used to assess human gait, with the most used ones for neurological patients being:

Wisconsin Gait Scale (WGS) was specifically created to assess gait abnormalities in patients with hemiparesis followed by a stroke.

Tinetti Gait Scale (TGS) was developed to analyze gait abnormalities in geriatric patients. Additionally, video-based gait assessment systems can be used, such as Kinovea, which is a free software designed for analyzing and studying images and videos.⁽¹⁴⁾

Functional Assessment Scales

Functional assessment scales are instruments used to evaluate functional status and measure function. Among the most used scales are:

The Barthel Index assesses Activities of Daily Living (ADLs) and is one of the most widely used for measuring limitations in functional activity.




The Katz Index assesses ADLs and was developed to study prognosis and treatment outcomes in chronic and elderly patients.⁽¹⁵⁾

The prescription of AFOs is related to muscle tone, range of motion, and muscle strength. For instance, when discussing a Rigid AFO, the muscle tone will be in the range of 2 to 4. As for the range of motion, it can be in plantarflexion of -5° or maintained at 0°, and muscle strength can vary from 0 to 2.

In the prescription of a Dynamic AFO, the muscle tone is between 1 and 1+, the ranges of movement can range between 10° of plantarflexion to 10° of dorsiflexion, and the muscle strength can be from 0 to 3.

Finally, for an Articulated AFO, the muscle tone can be between 1 and 1+, the ranges of movement are between 15° plantarflexion and 15° dorsiflexion, and muscle strength can be from 1 to 5 according to the MRC scale, as mentioned in Table 1.^(4,16)

Table 1 - AFO prescription

AFO type	Muscle tone according to the Modified Ashworth Scale	Ranges of motion according to goniometry	Muscle strength according to the Medical Research Council (MRC) Scale
Rigid AFO 	2, 3, 4	From 0° to -5° Plantar Flexion and Dorsiflexion 0°	0, 1, 2
Dynamic AFO 	1, 1+	1° - 5° Plantar Flexion 6° - 10° Plantar Flexion 1° - 5° Dorsiflexion 6° - 10° Dorsiflexion	0,1, 2, 3
Articulated AFO 	1, 1+	6° - 10° Plantar Flexion 11° - 15° or more Plantar Flexion 6° - 10° Dorsiflexion 11° - 15° or more Dorsiflexion.	In 1 or 2 of muscle strength, active mechanical joints are used. In 4 or 5 of passive mechanical joint muscle strength.

Source: Self-edited

The prescription of AFOs should be analyzed according to Table 2 presented below:

- In case of weakness in the plantar flexor muscles of the foot, the use of a rigid AFO is recommended if the patient has spasticity in the gastrocnemius-soleus muscles in addition to the weakness. A dynamic AFO is recommended when there is flaccidity at the ankle-foot level.
- In case of weakness in the dorsiflexor muscles of the foot, articulated, rigid, or dynamic type AFOs can be used. These will facilitate ankle dorsiflexion, especially the articulated and dynamic type. The rigid one, on the other hand, will help keep the ankle in a neutral position.
- In case of mild clubfoot, a hinged or rigid AFO will be used. The first will help with dorsiflexion and the second will place the ankle in a neutral position. The dynamic type is not recommended as it will not be able to act on the clubfoot.
- For patients who have full range of the ankle-foot joint, any type of AFO can be used, whether articulated, rigid, or dynamic, because range of motion or muscle tone is not altered. The prescription will be made to provide greater safety to the patient during ambulation.
- When the user tends to walk with semiflexion of the knee, the use of an articulated or rigid AFO is recommended that will help in knee extension. However, when the patient ambulates with knee extension, the use of an articulating, rigid, or dynamic AFO is recommended. This type of AFO blocks the knee, preventing hyperextension of the knee from occurring, facilitating ambulation.

Table 2 - AFO prescription analysis

Deficit	Articulated AFO	Rigid AFO	Dynamic AFO
Plantar flexor weakness of the foot	X	✓	✓
Foot dorsi-flexor weakness	✓	✓	✓
Mild equinus-varus foot	✓	✓	X
Full ankle-foot joint range of motion	✓	✓	✓
Knee in semi-flexion	✓	✓	X
Knee in extension	✓	✓	✓

Indicated (✓) or not recommended (X), considering motor deficit and splint alternatives for post-stroke patients.

Care in the use of AFO

There are multiple aspects to consider when verifying the suitability of a prescribed orthosis. The general objective of the tests is to determine if the device is acceptable in terms of fit, function, comfort, and aesthetics. First, it must be determined if the orthosis meets the original prescription. Patients are examined to see if they are experiencing weight gain, limb edema, or other changes that may affect the fit or function of the orthopedic device. The orthoses should be assessed in both static and dynamic situations. It should fit comfortably on the patient's foot.⁽⁸⁾

The ankle joint should align with the medial malleolus to meet the principle of joint alignment. Screws should be tightened and cut lines should be smooth. When prescribing an orthotic device to improve gait dysfunction, gait should be evaluated to ensure that the device meets its objectives. For example, if the orthotic device is designed to correct foot drop during the swing phase of gait, there should be no foot drop present. The proximal end of the AFO should be at least 2.5 cm below the head of the fibula. After use, the skin should be examined for erythema lasting more than 5 to 10 minutes and skin lesions. Patients should feel that the device is acceptable and that they will continue using it during their daily activities.⁽⁸⁾

Time of use of AFO

For good adaptability of the orthosis, it is important to perform a joint evaluation that allows for knowledge of the alignment of the hindfoot, midfoot and forefoot to avoid overcorrections that may lead to poor tolerance of the orthosis, as well as the ankle dorsiflexion angle.

Most AFO are rigid and designed with the objective of limiting plantar flexion and reducing equinus. The sustained and regulated use of these orthoses can delay the onset of muscular contractures in areas such as gastrocnemius-soleus and consequently, the onset of possible equinus or joint deformities, in addition to being able to defer or avoid surgery.

How long should an orthosis be worn to see results?

As it is known, passive stretching for a short period of time has no positive effects on muscle tissue. However, in literature, we do find evidence of improved range of joint movement and decreased spasticity when stretching is maintained for a prolonged period. The optimal usage time for these devices has been studied by several authors^(4,16) overtime recommending the use of night splints for at least 6 hours to achieve changes in muscle tissue. They

described that 90% of patients included in this study were able to maintain a 10° ankle dorsiflexion angle in ambulatory patients and a range of 0° in non-ambulatory patients.^(9,17)

Finally, the clinical physiotherapeutic considerations before prescribing an ankle-foot orthosis in a post-stroke patient are of great importance, as a comprehensive evaluation is necessary to make the decision of which AFO is most suitable and functional for use during their activities and rehabilitation. The use of AFO in post-stroke patients varies depending on factors such as muscle strength, muscle tone, joint instability, and sensitivity. Different types of AFO, including rigid, dynamic, articulated, and bandages, as well as functional electrical stimulation (FES) systems, each with their own characteristics, can be used based on the evaluation, adaptation, and goals sought for the patient. It is necessary to know the material to prescribe for the fabrication of the AFO, considering the patient's situation. Currently, most orthoses are made of thermoplastic material as they offer better contact, adaptation, are lightweight, more aesthetically pleasing than metal orthoses, and can be easily removed. This last point is important as it is recommended that they are not worn all the time for patients with stroke or sequelae and should be periodically removed.

BIBLIOGRAPHY

1. Padilla MG, Molina F, Diego IMA. Efecto de la ortesis de tobillo pie en el control postural tras el accidente cerebrovascular: revisión sistemática. *Neurología*. 2014; 29(7):423–32. DOI: 10.1016/j.nrl.2011.10.003
2. Purroy F, Montalà N. Epidemiology of stroke in the last decade: a systematic review. *Revista de Neurología*. 2021; 73(09):321. DOI: 10.33588/rn.7309.2021138
3. Rouanet C, Silva GS. Aneurysmal subarachnoid hemorrhage: current concepts and updates. *Arquivos De Neuropsiquiatria*. 2019; 77(11):806–14. DOI: 10.1590/0004-282x20190112
4. Fior and Gentz. *Stroke Guide: A Concept for the Orthotic Treatment of the Lower Extremity following a Cerebral Vascular Accident*. 4th ed. 2023 [acceso: 02/07/2023]. Disponible en: <https://www.fior-gentz.de/en/orthotics/indications-and-clinical-pictures/stroke.html>
5. Casares C. Prescripción de ortesis y otro material de adaptación en pacientes con hemiparesia. *Rehabilitación*. 2000 [acceso: 20/06/2023]; 34(6):438–46. Disponible en: <https://pesquisa.bvsalud.org/portal/resource/es/ibc-4949>
6. Ricardo D, Raposo MR, Cruz EB, Oliveira R, Carnide F, Veloso AP, et al. Effects of ankle foot orthoses on the gait patterns in children with spastic bilateral cerebral palsy: A scoping review. *Children (Basel)*. 2021; (10):903. DOI: 10.3390/children8100903
7. Pourhosseingholi E, Farahmand B, Bagheri A, Kamali M, Saeb M. Efficacy of different techniques of AFO construction for hemiplegia patients: A systematic review. *Medical Journal of the Islamic Republic of Iran*. 2019; 33:50. DOI: 10.34171/mjiri.33.50
8. Cifu DX. Braddom. *Medicina Física y Rehabilitación*. 6a ed. Elsevier; 2022.
9. Cornejo J, Calle B, García A, Moral B, Caro I, Pomares G. *Ortesis de miembro inferior en patología neurológica en la infancia y en la adolescencia*. Sociedad Española de Rehabilitación Infantil; 2020.
10. Assenza C, Cacciatore D, Manica M, Iosa M, Foti C, Gobetti T, et al. Assistive products and childhood neurodisability: a retrospective study on factors associated with aids/orthoses prescription. *European Journal of Physical and Rehabilitation Medicine*. 2020; 56(4):412–420. DOI: 10.23736/s1973-9087.20.06224-3
11. Abstracts of the 31st annual meeting of the European academy of childhood disability (EACD). *Developmental Medicine & Child Neurology*. 2019; 2(S2):4–82. DOI: 10.1111/dmcn.14244
12. Naqvi U, Sherman AI. *Muscle Strength Grading*. Nih.gov. StatPearls Publishing; 2022 [acceso: 20/06/2023]. Disponible en: <https://www.ncbi.nlm.nih.gov/books/NBK436008/>
13. Kumar A, Jadav V. *Orthoses in Spinal Cord Injury Rehabilitation Management and Improving Quality of Life*. In: *Spinal Cord Injury - Current Trends in Acute Management, Function Preservation and Rehabilitation Protocols*. IntechOpen; 2023.1:1–108; DOI: 10.5772/intechopen.105427
14. Rueda F, Molina MC. *La marcha humana: biomecánica, evaluación y patología*. Panamericana; 2020.
15. Taylor-Rowan M, Wilson A, Dawson J, Quinn TJ. Functional assessment for acute stroke trials: Properties, analysis, and application. *Frontiers in Neurology*. 2018; 9:1–10. DOI: 10.3389/fneur.2018.00191
16. de Paula GV, da Silva TR, de Souza JT, Luvizutto GJ, Bazan SGZ, Modolo GP, et al. Effect of ankle-foot orthosis on functional mobility and dynamic balance of patients after stroke: Study protocol for a randomized controlled clinical trial. *Medicine (Baltimore)*. 2019; 98(39):e17317. DOI: 10.1097/md.00000000000017317
17. Chang J-L, Chen H-J, Chen P-Y, Chou L-W, Lai C-H, Lu Y-H, et al. Validating stroke-induced bilateral ankle coordination deficits using bilateral ankle measure relationship with motor functions in lower limbs. *Journal of NeuroEngineering and Rehabilitation*. 2023; 20(1):1–13. DOI: 10.1186/s12984-023-01157-0

Conflicts of interest statement

The authors of this research have no conflicts of interest to declare.