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ABSTRACT

Background: Hemispherotomy is a procedure that can be used to treat cases of epilepsy that exhaust all other treatments. One of the side effects of the procedure can be spastic hemiplegia. For people with spastic hemiplegia, movement requires more effort. One intervention that has shown promise for decreasing the effort of movement is an orthotic. The purpose of this case report is to describe the process of choosing an orthotic for a pediatric patient with spastic hemiplegia following hemispherotomy. **Case Description:** The individual in this case report is a 10-year-old boy who underwent a hemispherotomy for pharmaco-resistant epilepsy. His resulting spastic hemiplegia created difficulty with movement so he and his mother presented for a physical therapy evaluation to determine if an orthotic would be beneficial for him. **Intervention:** An interdisciplinary team involving the individual and his mother, physical therapists, an orthopedic specialist, and an orthotist determined the best orthotic for the individual. The physical therapist made their recommendations based on best-available evidence, association fact sheets, and available manufacturer choosing guides and manuals. **Outcome Measures:** The outcome measures selected to evaluate the efficacy of the intervention were the Dynamic Gait Index (DGI), individual report, and gait observation. **Discussion:** The evidence and choosing guides produced similar recommendations for this individual. Qualitative results show a positive impact following beginning using the ankle-foot-orthoses (AFO). Measurable outcome measures did not show a significant change one day after receiving the AFO.

Keywords: Physical Therapy; rehabilitation; spastic hemiplegia, ankle-foot orthosis, cerebral palsy, custom-molded orthotic, pediatric

INTRODUCTION

Epilepsy is a neurological disorder that causes seizures. There are several treatments to treat epilepsy including pharmacology, nutrition, and procedures including brain surgery. In 30% of cases of epilepsy, the disorder is described as pharmaco-resistant.[1] Pharmaco-resistance means the seizures are not controlled by standard treatment and more drastic options need to be explored. One surgical option is a disconnection of the parts of the brain that are causing seizure activity. If this option does not produce results, a hemispherotomy may be suggested. A hemispherotomy disconnects the cerebral cortex on one hemisphere of the brain to treat seizures. A secondary effect is spastic hemiplegia, which develops following a brain lesion to one side of the brain such as stroke, hemorrhage, or cerebral palsy.

Disconnecting the motor cortex results in hemiplegia of the opposite side of the body, which can lead to spasticity, increase or decrease in tone, weakness, or paralysis. For many people with hemiplegia, walking and movement becomes difficult or impossible. A typical gait for a person with hemiplegia involves excessive plantarflexion and toe-first initial contact on the affected side.[2] A reason for this can be weakness of the dorsiflexors of the ankle causing drop foot. Drop-foot creates compensations in walking and increases the likelihood of tripping. Tripping can lead to more injuries, and increased difficulty walking can lead to lower fitness levels. Both of which lead to secondary complications that decrease the health of the person.

Orthotics are an intervention that can compensate for drop-foot and can improve a person's walking ability. There are several types of orthotics ranging from covering just the foot to going all the way up to the hips. The most common types used for hemiplegia are ankle-foot orthoses (AFO), which cover from the midfoot or toes to below the knee and control ankle position and tibia translation. AFOs come in several designs including carbon fiber, off-the-shelf, custom-molded, hinged, and more.

There are several points in the gait cycle the AFO effects to improve gait and create a normal pattern. AFOs have been found to increase stride length, decrease cadence, and reduce excessive ankle plantarflexion compared to no orthoses.[3] They have this positive effect by affecting the initial contact and swing phases of gait.[4] Initial contact is effected because the AFO holds the ankle in neutral rather than having the foot contact in plantarflexion, which acts as a braking force.[5] The increase in gait speed may occur because the AFO decreases time in double support which makes weight acceptance more efficient.[5] Another way AFOs have positively affect gait is by putting joints in optimal position for movement and reducing spasticity.[6] For people with hemiplegia, the AFO works to increase gait symmetry to normalize the gait cycle by addressing plantarflexion and dorsiflexion. Most AFOs limit plantarflexion, which sometimes leads to an increase in dorsiflexion to improve gait.[7] Normalizing gait allows effort for gait to decrease. One study found oxygen demand decreased with the use of an AFO.[7] The goal of an AFO is to improve gait and ease movement by addressing deficits in the gait cycle.

The improvements in gait that come with the use of AFOs do not come without negative effects on other portions of gait. A typical AFO impairs plantarflexion at push-off during terminal stance because most AFOs limit plantarflexion range of motion.[8] This can create difficulty with stair ambulation, but one study did find that the use of and AFO did not impair stair ambulation for children with hemiplegia.[9] Some types of AFOs are designed to keep push-off intact. The decision on whether to use an AFO that allows push-off depends on several factors.

In general, the choice of what type of AFO to use involves several factors. Many studies compare the various types of AFOs and describe specific populations that benefit from each type. Despite these comparative studies, the process of choosing an orthotic best suited for a specific individual remains unclear. Thus, the purpose of this case report is to describe the process of choosing an orthotic for a pediatric patient with spastic hemiplegia following hemispherotomy.

CASE DESCRIPTION

A 10-year-old boy presented to physical therapy with left spastic hemiplegia and foot drop following disconnection and hemispherotomy of the right hemisphere. The procedure was done 2 years ago to treat pharmaco-resistant epilepsy that developed when he was 5 years old. He has been seizure-free since the procedure. Following the procedure, he participated in inpatient and outpatient physical therapy that helped him to regain independent walking. Prior to our evaluation, he had been walking for over a year.

His mother noticed increased effort with movement and sought a referral to physical therapy from the boy's neurologist to determine if an orthotic and episode of physical therapy would be beneficial. They were also interested in beginning therapy services to work on his movement. Outpatient physical therapy was halted after he regained walking because the family lives in a rural area with few local therapy resources. His mother is a single parent and the time commitment for therapy became a barrier to care. The main goals for the individual and his mother involved easier mobility moving sideways, changing elevation, and less effortful walking.

CLINICAL IMPRESSION #1

This case study focuses on the intervention of an orthotic to address the individual's foot drop to improve his ease of movement. The individual had regained independent walking, but the distance and quality of his gait was impacted by his left-sided weakness and foot drop. AFOs have good potential for decreasing the effect of foot drop on ambulation by decreasing the effect of excessive plantarflexion.[3] For people with spastic hemiplegia, there is good evidence that AFOs decrease the energy demand for walking.[7] To determine which type of AFO would be most beneficial for this individual we took into account our examination as well as the individual and his mother's preferences and needs. Our examination involved observation of his gait, testing his balance, and assessing the range of motion and strength in his left leg.

EXAMINATION

The individual and his mother were already interested in pursuing an orthotic so the examination focused on deciding whether he would benefit from an AFO and what other areas could be addressed with an episode of physical therapy. He was very active and enjoyed several activities including swimming, basketball, and bike riding. The hometown of this individual was in the Midwest, and because most of his preferred activities were outdoors, he was limited in activities during the colder months. Having an AFO could increase his available activities indoor. He also reported he had infrequent falls, 2 or 3 at school in the previous year that did not result in injuries. The examination of range of motion showed decreased left knee and ankle motion. He had tightness in the left hamstrings and gastrocs. His left ankle dorsiflexion was limited with less than 5 degrees of dorsiflexion. His alignment was abnormal with left lateral trunk flexion and a leg length discrepancy with the left leg being shorter than the right. The left lower and upper extremities had decreased strength and increased tone compared to the right. Balance is important for improved mobility, so single-limb balance was tested. This was limited on the left leg to 1-2 seconds. Another finding on examination was increased difficulty isolating joint movements of the left upper and lower extremities. Overall the impression from examination was that his left leg and trunk weakness was limiting his functional mobility.

CLINICAL IMPRESSION #2

Deficits found on examination were consistent with typical deficits for people with spastic hemiplegia. This individual was most limited by his gait abnormality and postural asymmetries that impact his functional movement and endurance and increase his risk of falling and developing other

injuries. Throughout the examination, we determined this patient would likely benefit from an AFO to address his postural asymmetries and an episode of physical therapy to address his strength and endurance. These interventions aimed to increase his ease of movement and decrease his likelihood of falling. Several outcome assessments were utilized to determine the impact of the interventions, including gait observation, dynamic gait index, and individual and family report. These outcome measures were measured at examination and one day after receiving the AFO. A successful intervention would result in a higher score on the dynamic gait index, individual and family report of ease of movement, and observed improvements in gait quality.

ANKLE FOOT ORTHOSES DECISION-MAKING PROCESS

While additional physical therapy interventions addressing strength and coordination of movement were provided, this case study focuses on the decision process of choosing an orthotic. An interdisciplinary team of an orthopedic specialist, neurologist, physical therapist, and orthotist worked with the boy and his mother to choose the type of AFO that would likely benefit him most.

The Academy for Pediatric Physical Therapy (APPT) of the American Physical Therapy Association (APTA), as well as some manufacturers have developed choosing guides for providers to use when deciding on an orthotic for an individual. These guides are helpful for easily deciding what the manufacturer recommends for correcting different gait deviations. Using the best evidence, fact sheets, manufacturer manuals, and individual goals determined the AFO that would most likely best benefit this individual was the PLSAFO. The decision-making process is outlined in Figure 1. We recommended a custom-molded posterior leaf spring AFO to the orthopedic physician. The orthopedic physician then communicated with the orthotist who then crafted the PLSAFO.

AFO Decision-making Flow-chart

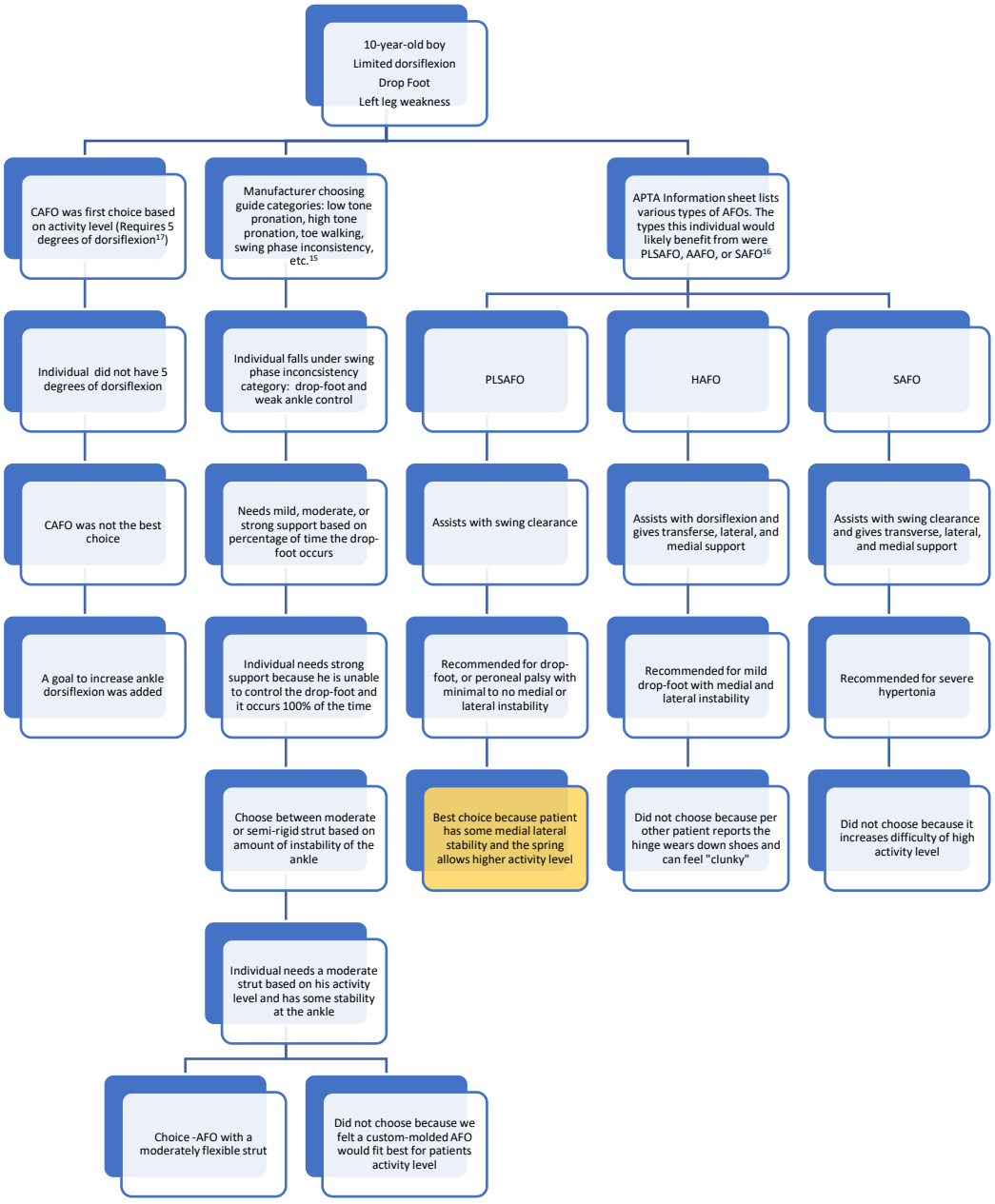

Figure 1. Flow chart describing the decision making process for choosing whether each type of AFO would be the best option for our individual.

OUTCOMES

The outcome measures chosen to evaluate the effect of an AFO and episode of physical therapy include the dynamic gait index (DGI), gait observation description, and patient and family report. Gait observation was chosen because the goal of the intervention was to improve gait mechanics. Most methods of measuring gait mechanics require equipment not available to physical therapists.

Observation of gait is done with most evaluations, so it was chosen as the best available method of measuring gait mechanics. Patient and family report was chosen as an outcome because in order for the AFO to have an effect, the individual needs to feel it is worth using. If the individual's report is, they are having decreased difficulty with movement, that will be a successful outcome. The DGI was chosen as an outcome measure that is specific and measurable. Because our individual was active and walking fairly well, we wanted to choose an outcome measure that he had a chance to show improvement on.

A pilot study by Lubetzky-Vilnai suggested the DGI is feasible and valid for children from 8 to 15 with typical development.[10] This individual does not have typical development, but we could demonstrate a change using this instrument. There are no MDC or MDICs for the DGI in a pediatric population. Of the validated populations, people with stroke are the closest to our individual. The MDC for stroke patients in 4 points.[18] For elderly patients, a score of less than 19 is predictive of falls.[18] Our main reason for choosing the DGI was because it was an outcome measure that this individual had the ability to show improvement on and has been validated in other populations similar to the individual.

Table 1: Outcome measures before and after receiving an AFO

	DGI	Gait observations	Individual report
Evaluation	13/24	Asymmetric cadence, decreased stance time on left, increased lateral trunk shift	Movement is effortful
1-day post AFO	15/24	Increased hip flexion, decreased trunk sway Ankle remains in neutral	Mother noticed an improvement in the ease of walking, the boy notes he likes the AFO and felt his walking was faster at school.

CONCLUSIONS

The individual demonstrated improvements in observation and individual report. The increase of 2 on the DGI does not meet the MDC of 4 for the outcome measure. Improvements in gait observation included decreased lateral trunk sway, increased left hip flexion in swing phase, and decreased ankle plantarflexion in swing phase. His gait remained asymmetric and he still had decreased stance time on the left, but overall his gait was improved. Both the individual and his mother reported the AFO appeared to ease the effort of walking, and the individual liked wearing the AFO because he felt he could walk faster. These outcomes were all collected the day after receiving the AFO. The individual did not have sufficient time to grow accustomed to the AFO, so further improvements might be possible. His report of improvement with walking could have been because the AFO was new and his walking was different. Further testing may have found different results on the outcomes than we found. These results showed the immediate difference after receiving the AFO.

DISCUSSION

In addition to choosing guides, available evidence provides input for selecting an orthotic. Several studies compare hinged AFOs, custom-molded solid AFOs, and Carbon fiber AFOs to suggest which type works best for specific individuals. Additional studies compare stiff vs. spring leaf AFOs.[11] Overall, the consensus is that all types of AFO can improve gait. Several studies found no significant difference between types such as solid and dynamic or hinged AFOs in overall gait quality.[3,4,6,11,12] Changes occur

in various phases of gait for each type of AFO. A Carbon Modular AFO can be modified based on functional development.[12] The benefit of this type of AFO is that as a child grows, they don't need to keep molding a new AFO. A hinged AFO allows for more dorsiflexion during movement.[7] A spring-type orthosis can improve the push-off in gait more than a stiff type.[11] A carbon-fiber AFO allows for still limited, but improved push-off in terminal stance.[13] The improved push-off is beneficial for individuals with high activity levels. The different advantages of various AFOs mean that multiple factors need to be addressed when choosing an orthotic.

The best available evidence describes the benefits and drawbacks of each type of AFO. Overall, the evidence suggests combining individual, family, and provider goals with the individual's characteristics. Design and cost should also be addressed in choosing the orthotic.[14] The providers should develop their goals by identifying gait deviations and functional deficits after examining range of motion, ankle and foot alignment, and gait mechanics.[14] Combining these variables allows the provider to choose the orthotic that will best benefit the individual.

Using an interdisciplinary approach was important for choosing the best option for this individual. Each provider involved in his care has an area of expertise and goals for the effects of the AFO. By combining everybody's input, there was consensus that a custom-molded, partially flexible AFO would be the best option. Most importantly, using the individual and his mother's input increases the likelihood that the AFO addresses the aspects of gait that match their goals. Our hope is that this increases the likelihood he will wear the AFO regularly and continue to see the benefit from this one and future orthotics.

This case report focused on the process of using resources for choosing an AFO for a specific individual. The manufacturer manuals and fact sheets were helpful for thinking through what type of AFO would best work for this individual. Using these resources led to a choice of an AFO consistent with the best available evidence. Although our results are very preliminary and do not demonstrate long-term benefit from wearing the AFO, gait observation and individual report both suggest a change after receiving the AFO. Future research could investigate whether these choosing guides are accurate for most individuals and work towards developing a choosing guide unrelated to a specific manufacturer. Other research could investigate gait improvements in specific individuals who increase their dorsiflexion range and switch to a carbon fiber AFO. If research supports switching AFOs, using the goal of increasing dorsiflexion will be a much higher priority.

Overall, the research suggested using an AFO is beneficial for patients with spastic hemiplegia.[2,5-7,12-14] For our individual, his outcome measures show promise for the AFO improving his ease of movement, although those were preliminary results. The long-term effect of the PLSAFO will be important for the boy's future function. This case highlights the clinical decision-making process of an interdisciplinary team, with emphasis on the physical therapy perspective, when determining the likely best choice for an orthotic device to assist an individual with spastic hemiplegia

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