A Comparison of Knee-Ankle-Foot Orthoses with Either Metal Struts or an Adjustable Posterior Strut in Hemiplegic Stroke Patients

Shinichiro Maeshima, PhD, MD, Hideto Okazaki, MD, PhD, Sayaka Okamoto, MD, PhD, Shiho Mizuno, MD, PhD, Naoki Asano, MD, PhD, Hirofumi Maeda, MD, Mitsuko Masaki, MD, Hiroshi Matsuo, MD, Tetsuya Tsunoda, MD, and Shigeru Sonoda, MD, PhD

Background: We investigated differences in factors affecting judgments regarding the creation of new adjustable posterior strut knee-ankle-foot orthoses (APS-KAFO) and knee-ankle-foot orthoses with metal struts (traditional KAFO) for hemiplegic stroke patients for whom KAFO were created in rehabilitation wards. *Methods:* Subjects were 50 patients with hemiplegia due to new-onset stroke (cerebral infarction: n = 25, cerebral hemorrhage: n = 25) who were prescribed KAFO. Patient ages ranged from 36 to 90 years, and the mean duration from stroke onset to hospitalization was 28.8 ± 13.8 days. Neurologic symptoms, cognitive function, activities of daily living, duration from hospitalization to orthosis creation, hospitalization duration, walking ability at discharge, outcome after discharge, and so forth were compared. *Results:* Fourteen patients were prescribed APS-KAFO, and 36 were prescribed traditional KAFO. Those prescribed APS-KAFO had somewhat milder neurologic symptoms and cognitive dysfunction and a shorter hospitalization duration than those prescribed traditional KAFO. Patients prescribed APS-KAFO also had a higher score and efficiency on functional independence measure at admission and discharge. Walking independence at discharge was seen in 8 of the 14 patients for whom APS-KAFO were created and 8 of the 36 patients for whom traditional KAFO were created. *Conclusions:* APS-KAFO was chosen for patients with a high level of activity in the ward and with a higher likelihood of acquiring walking ability using APS-AFO at discharge, whereas traditional KAFO tended to be chosen for patients with relatively severe symptoms who were not expected to acquire practical walking ability. **Key Words:** Adjustable posterior strut orthoses—knee-ankle-foot orthoses—stroke—hemiplegia.

The use of foot orthoses for hemiplegic stroke patients promotes active rehabilitation and facilitates a quick return home by improving activities of daily living.[1] In the Japanese Guidelines for the Management of Stroke 2009, ankle-foot orthoses (AFO) were recommended for hemiplegic patients with clubfoot to improve walking ability.[2] The use of orthoses with struts allows patients to gain stability in their paralyzed foot and walk with good dynamic balance.[3,4] However, although there are few reports on orthosis therapy for stroke patients exhibiting more severe hemiplegia, knee-ankle-foot

From the Department of Rehabilitation Medicine II, School of Medicine, Fujita Health University, Tsu, Japan.
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Address correspondence to Shinichiro Maeshima, PhD, MD, Department of Rehabilitation Medicine II, School of Medicine, Fujita Health University Nanakuri Sanatorium, 424-1 Oodori-cho, Tsu, Mie 514-1295, Japan. E-mail: shinichiromaeshima@gmail.com.
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orthoses (KAFO) have been used in Japan since before World War II.[5-10] These traditional orthoses are AFO with metal struts plus mounted knee joint and thigh cuff, and provide good support even in patients with severe hemiplegia, allowing therapists and others to easily assist the patient with walking.[8-10]

Adjustable posterior strut (APS) orthoses that allow adjustment within a short period of time have recently been developed.[11,12] APS orthoses are usually used as AFO (APS-AFO), although patients with severe paralysis are sometimes prescribed APS-KAFO with an added thigh cuff. However, the criteria for determining the right orthosis for each patient are vague, and the orthotic choice is currently the decision of the prescribing physician. In the present study, we retrospectively investigated the characteristics of hemiplegic stroke patients prescribed KAFO in rehabilitation wards for investigating the different factors affecting judgments regarding the creation of APS-KAFO and traditional KAFO.

Subjects and Methods

Subjects

Subjects were 50 (33 men and 17 women) patients newly prescribed KAFO chosen from 363 patients with hemiplegia from new-onset stroke hospitalized between April 2013 and March 2014. Patient ages ranged from 36 to 90 years (67.9 ± 13.5 years). The underlying disease was cerebral infarction in 25 patients and cerebral hemorrhage in 25 patients. The duration from stroke onset to hospitalization was 28.8 ± 13.8 days. Because of severe hemiplegia and/or sensory impairment, none of the patients could support themselves with their affected lower limb, and they were prescribed KAFO for standing or ambulation exercise.

Indications for Exercise and Orthosis Therapy

Directly after admission, rehabilitation patients are encouraged for ambulation and to start adopting a standing position as soon as possible. KAFO are prescribed when (1) the patient's general condition has stabilized and they are able to start standing or walking training, but the knee and ankle joints are unstable because of severe paralysis; (2) the patient exhibits spasticity patterns predominantly in the flexor muscles and cannot hold their knee in the extended position; and (3) the patient displays abnormal knee joint movement, such as flexion contractures of the knee joint.[6-8] Until the orthosis is casted and completed, orthoses available at the training room are used to initiate standing training. Walking training is performed in patients who show improvement in standing balance from wearing a KAFO, even if support with the affected lower is poor. In patients whose affected lower limb has severe paralysis from the outset, the therapist assists rehabilitation with a KAFO. The knee and ankle joints of the orthosis are adjusted as needed; and if support with the affected lower limb can be achieved and walking is possible without fixing the knee joints, the orthosis is modified (cut down) to an AFO by removing the thigh cuff.

APS-KAFO and Traditional KAFO

APS-AFOs have a good outer appearance because they have a single posterior carbon strut. In addition, they have hinge joints that allow plantar and dorsiflexion range of motion to be adjusted precisely and easily. APS-KAFO are modified APS-AFO, with an added knee joint and a thigh cuff. Its lower portion consists of a foot section, a shank, hinge joints, a posterior strut, and a leg cuff, whereas the thigh portion consists of inner and outer struts, ring locks, a kneepad, and a thigh cuff (Fig 1). APS-KAFO is light (total weight = 1100 g); and because of the nature of the simplified construction, patients using APS-KAFO should not weigh more than 80 kg, but the leg and thigh portions of the apparatus can be easily detached. As a result, patients can use it as a KAFO during walking training and as an AFO at other times. Traditional KAFO are equipped with bilateral metal struts,

Figure 1. *The APS-KAFO and traditional KAFO. Abbreviations: APS, adjustable posterior strut; KAFO, knee-ankle-foot orthoses.*

Table 1. *Differences between APS-KAFO and traditional KAFO*

	APS-KAFO	Traditional KAFO
Orthosis weight (g)		
Total weight	1395	1460
Thigh portion	750	770
AFO portion	500	690
Reinforcement parts	95	
Foot portion thickness; heel portion (mm)		
Posterior	32	3
Sole	10	8
Metal shank	Present	Present

Abbreviations: AFO, ankle-foot orthoses; APS, adjustable posterior strut; KAFO, knee-ankle-foot orthoses.

ring lock knee joints, and double Klenzak ankle joints (total weight = 1780 g; Fig 1). It can be used as an AFO by removing the portion for the knee joints and thigh; however, plastic AFO are sometimes created in the aim of the weight trimming (Table 1). The suppliers of the APS-KAFO and traditional KAFO are Tomei Brace Co., LTD, Seto, Japan.

Assessment

Patients were divided into 2 groups; 1 group included patients prescribed APS-KAFO and a second group included patients prescribed traditional KAFO. The clinical assessment involved the evaluation of the following items and compared between groups: (1) the Canadian Neurological Scale score,[13] (2) Mini-Mental State Examination score,[14] (3) functional independence measure (FIM) score[15] on admission and at discharge, (4) duration from admission to completion of the orthosis, (5) hospitalization duration, (6) walking ability at discharge, and (6) whether or not the patient was discharged home. In addition, to understand the course of orthosis therapy, we examined the status of orthosis use at discharge.

Results

APS-KAFO were prescribed for 14 patients, and traditional KAFO were prescribed for 36 patients. There were no differences in age, sex, disease, or paralyzed side between the 2 groups; however, patients using APS-KAFO spent less time from onset to hospitalization and had somewhat milder neurologic symptoms and cognitive dysfunction (Table 2).

Orthoses were cut down by removing the thigh cuff during the course of rehabilitation for 12 of the 14 APS-KAFO patients; these patients underwent walking training with APS-AFO. Eight of them had gained walking independence by the discharge. Orthoses were cut down by removing the thigh cuff during the course of rehabilitation for 19 of the 36 patients for whom traditional KAFO were created; they underwent training with APS-AFO; however, plastic AFO (4 patients) and APS-AFO (3 patients) were created. Cut-down modification was not possible in the remaining 10 patients who continued rehabilitation with KAFO. At discharge, walking independence was gained in 3 of the 19 patients whose KAFO was cut down to an AFO, all 4 patients for whom plastic AFO were created, and 1 of the 3 patients for whom an APS-AFO was created (Fig 2).

Table 2. *Comparison between APS-KAFO and traditional KAFO*

	APS-KAFO	Traditional KAFO
Mean age (y)	70.3 ± 9.9	66.9 ± 14.6
Sex (male/female)	8/6/2014	11/25/2014
Disease (hemorrhage/infarction)	6/8/2014	19/17
Paralyzed side (right/left)	6/8/2014	20/16
Onset hospitalization duration (d)*	22.0 ± 10.3	31.4 ± 14.3
CNS (/11.5)**	5.5 ± 1.9	3.9 ± 1.1
MMSE (/30)*	23.9 ± 5.0	17.4 ± 7.9
Admission to orthosis completion (d)	12.1 ± 2.3	11.4 ± 5.1
Duration of hospitalization (d)*	68.6 ± 29.5	93.4 ± 30.9
FIM on admission (/126)**	50.2 ± 14.7	35.0 ± 13.5
FIM at discharge (/126)*	77.9 ± 23.0	61.1 ± 27.3
FIM score	27.6 ± 14.5	26.1 ± 20.1
FIM efficiency***	.46 ± .26	.26 ± .16
Walking independence (%)*	57.1	22.2
Home discharge (%)	71.4	58.3

Abbreviations: APS, adjustable posterior strut; CNS, Canadian Neurological Scale; FIM, functional independence measure; KAFO, knee-ankle-foot orthoses; MMSE, Mini-Mental State Examination.

*$P < .05$, **$P < .01$, ***$P < .005$.

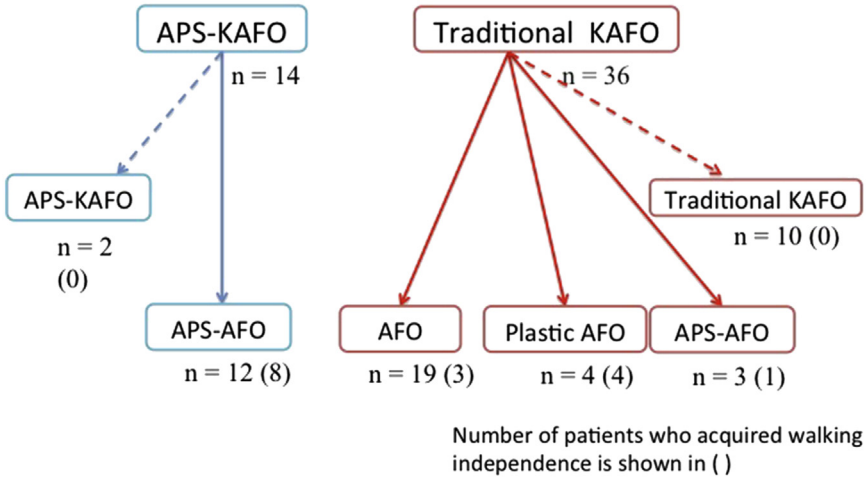

Figure 2. *The course of orthosis therapy. Abbreviations: AFO, ankle-foot orthoses; APS, adjustable posterior strut; KAFO, knee-ankle-foot orthoses.*

No difference was seen in the number of days from admission to completion of the orthosis, although the hospitalization duration was shorter for those prescribed APS-KAFO. FIM score and FIM efficiency on admission and at discharge were both higher for those prescribed APS-KAFO. No difference was seen in the rate of return home after discharge (Table 2).

Discussion

We previously reported that improvements in training motivation, abilities of transferring to and from a wheelchair, and mobility capabilities, as well as shortening of the hospitalization duration can be expected from independent training using KAFO in which the patient's family participates.[8-10] This training is designed so that patients who experienced severe stroke can easily and safely perform exercises with their family. In other words, patients with severe stroke who undergo intensive standing and walking training with a KAFO created early during hospitalization can return home sooner, thanks to an improvement in their activities of daily living capabilities. The patients in the present study had not undergone orthosis therapy with their acute-care physicians when they transferred to the rehabilitation hospital. All patients had severe paralysis and poor support with their affected lower limb; however, by undergoing physical therapy using a KAFO, most patients were able to continue rehabilitation with a KAFO cut down to an AFO by removing the thigh cuff. Walking independence was gained by the discharge in 57% (8 of 14) of patients for whom an APS-KAFO was created and 22% (8 of 36) of patients for whom a traditional KAFO was created. However, 2 patients using APS-KAFO, and 10 patients using traditional KAFO could not have their orthoses cut down to an AFO. The practicality of KAFO after discharge is questionable in hemiplegic patients for whom a transition to an AFO is difficult.[3] These patients often cannot use their orthosis in everyday living situations, such as transferring to and from a wheelchair and using the toilet, because of difficulties putting on and removing KAFO. This is often linked to the caregivers' burden,[4,5] resulting in a low frequency of practical use at home. Not a few therapies were therefore implemented for independent living training in the rehabilitation ward by removing the thigh cuff from KAFO during hospitalization. KAFO are often impractical in home life because of the inconvenience of putting them on and removing them; however, if lower limb support becomes better, the orthosis can be cut down by removing the thigh cuff and used as an AFO. Transfer to and from a wheelchair is often practiced using an AFO with the thigh cuff removed during the time when patients are not in the standing and walking trainings in the rehabilitation ward. This is a major advantage of APS-KAFO, in which attaching and detaching the thigh cuff is easy. On this occasion, APS-AFO is light because of the nature of the simplified construction, and it has hinge joints that allow plantar and dorsiflexion range of motion to be adjusted precisely and easily. Meanwhile, APS orthoses are supported by a single posterior strut; thus, being different from metal struts, which have bilateral axes. Hence the support provided by APS orthoses is rather unstable compared with the traditional KAFO with bilateral metal struts. This is likely why traditional KAFO are chosen for severe impaired patients.

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be chosen for patients with relatively severe stroke for whom the acquisition of practical walking ability was considered difficult. To date, KAFO have been described as heavy, ugly, and difficult to put on and remove. However, APS-KAFO could become an innovative orthosis that covers all these issues.

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