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Clinical experiences with a convertible thermoplastic knee-ankle-foot orthosis for post-stroke hemiplegic patients

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Abstract

As rehabilitation for post-stroke hemiplegic patients has become widely accepted practice, there has been an increase in patients who are more difficult to treat.

In the prescription rationale of orthoses for hemiplegics, the knee-ankle-foot orthosis (KAFO) for the lower limb has generally been underestimated because of its inhibitory effect on the normal walking pattern and also its interference with gait training. The authors had an experience of 28 hemiplegics with severe physical impairments who were fitted with a convertible plastic KAFO. Among these patients, there were 11 cases in which the KAFO was replaced by an ankle-foot orthosis (AFO) within 1.5 to 8 months (average 4 months) following initial prescription when they were able to control their knee actively.

Ambulatory capability in these patients was superior to that of the remaining KAFO group. The Barthel index of the AFO group patients was higher than the KAFO group ($p<0.01$). However neither age, sex, severity of hemiplegia, starting time of rehabilitation following onset of stroke, time of fitting with the orthosis, nor the functional recovery stage were critical factors between the two groups, only the incidence of major complications affected ambulatory capability.

Introduction

Attainment of functional ambulatory capability in hemiplegic patients remains a challenge, and considerable time and effort are required for ambulation training and orthotic management. Functional ambulation capability is one of the most important daily living activities for rehabilitation of the post-stroke hemiplegic patient. An ankle-foot orthosis (AFO) is thought generally to be the most suitable lower-limb orthosis to overcome the gait deficit related to ankle and knee instability (Ofir and Sell, 1980; Waters *et al.*, 1985). There are, however, some cases with severe gait abnormalities requiring a knee-ankle-foot orthosis (KAFO); because they cannot passively control the knee locked in extension during stance-phase. A conventional KAFO with knee lock, however, is thought rarely practical for hemiplegics because it inhibits normal walking pattern and also it interferes with gait training (Lehmann, 1986). Besides, a KAFO with metal uprights has several disadvantages such as clumsiness and heaviness, difficulty in locking and/or unlocking of the knee joint (especially with the ring lock type), and also in donning and doffing (Lehmann, 1986).

To solve some of the difficulties mentioned above, the authors prescribed a convertible KAFO. A plastic shoe-horn type AFO was connected with a knee orthosis using a metal plunger lock (Fig. 1). The meaning of convertible is that the KAFO can be replaced by an AFO depending on the physical improvement of the patient. The patients prescribed were those hemiplegics whose functional recovery had been less than expected. The advantage of this orthosis is that it is light, comfortable, more cosmetically acceptable, as compared to a conventional KAFO, and finally it could be changed into the usual type of plastic AFO after functional recovery of active knee control. This paper discusses the follow-up results of 28

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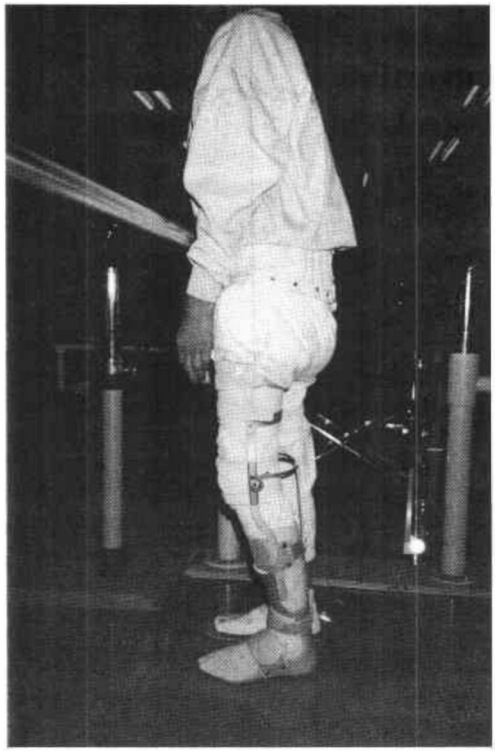

Fig. 1. The convertible KAFO.

hemiplegics who have been fitted with this type of KAFO.

Material and results

The selected subjects, 28 patients (29-88 years, average 54.5 years old; 14 males and 14 females), were fitted with a convertible plastic KAFO. Etiologies of the stroke were intracranial haemorrhage in 12 cases (42.9%), cerebral infarction in 14 cases (50%) and subarachnoidal haemorrhage in 2 cases (7.1%). The site of the palsy was: left side 13 cases; right side 15 cases; none with double sites. Patients were grouped according to the starting time of rehabilitation after onset of stroke: 10 cases were treated within one month, 12 cases treated within one to six months, and the remaining 6 cases more than 6 months after the onset. The incidence of major complications among these patients was 60.7% for moderate to severe sensory disturbances, 42.9% for shoulder hand syndrome, 34.3% for aphasia, 25% for unilateral spatial neglect, 17.9% for apraxia, 17.9 for dementia.

Time of fitting with the orthosis was when they started gait training after onset of stroke. The actual timing varied by the case, i.e. within three months in 12 cases, between three and six months in 9 cases, and more than six months after onset of stroke in 7 cases. During the period of observation, 11 patients could control their knee actively between 1.5 months and 10 months (average 4 months) after initial prescription of the orthosis. Their KAFOs could be changed to plastic AFOs (AFO group). Seventeen cases were unchanged and remained at their initial status (KAFO group). The outcome of ambulation capabilities in the AFO group was as follows: outdoor independent, 3 cases; indoor independent, one case; and indoor dependent, 7 cases.

In the KAFO group, on the other hand the outcome was, indoor independent, only 2 cases; indoor dependent, 11 cases; and the remaining 4 cases were non-ambulant.

To investigate ambulation capability between those two groups, the modified Barthel index (Granger *et al.*, 1987) was used. Table 1 compares the results of several factors between AFO and KAFO groups. Factors were compared between these two groups, using an unpaired two-tailed Student's t-test and Cramer's coefficient of association (X^2 test). Neither age, sex, severity of hemiplegia, starting time of rehabilitation following onset of stroke, time of fitting with the orthosis, nor the functional recovery stage were statistically significant between these two groups in respect of outcome, with the exception of the incidence of major complications.

Discussion

Although various types and designs of lower limb orthoses have been developed for hemiplegics, it is an accepted opinion that patients wearing a KAFO cannot ambulate effectively. According to the statistical survey performed by the Japanese Association of Rehabilitation Medicine (1979), the rate of functional ambulant (those who were able to walk more than 500 metres independently(was 41.0% in AFO group; on the contrary there was only 2.3% in KAFO group. With the rapid progress in medical technology, there are however, more opportunities for treatment of patients with severe impairments. The goal should be at least the possibility to ambulate so that they are not bound to wheelchair and/or

Table 1. Patients' characteristics

		AFO group	KAFO group	Total
Number:	total	11	17	28
	male	6	8	14
	female	5	9	14
Average age:		60.6 ± 11.5	61.3 ± 5.9	61.0 ± 8.1
Etiology:	infarction	5	9	14
	haemorrhage	5	7	12
	subarachnoid haemorrhage	1	1	2
Site of palsy:	left	5	8	13
	right	6	9	15
Time interval between stroke and start of rehabilitation (days):		84.9 ± 91.2	84.0 ± 95.2	84.4 ± 93.2
Time interval between stroke and fitting of KAFO (months):	1<	4	6	10
	1-6	5	7	12
	>6	1	5	6
Barthel Index (at final period):		72.8 ± 7.2	*43.1 ± 4.6	54.7 ± 5.6

mean ± standard deviation. *p<0.01 between the two groups

bed. Therefore, the significance of the KAFO as an early treatment orthosis should be reconsidered and more effort expended on the recovery of ambulatory capability no matter how long the chances of success.

Prescription rationale for KAFO in hemiplegia

It is generally thought that functional recovery of neurological deficit comes to the maximum plateau twelve weeks after onset of stroke (Andrews *et al.*, 1981; Jørgensen *et al.*, 1995; Partridge *et al.*, 1987; Skilbeck *et al.*, 1983). However, there are still chances for functional recovery six months after the onset of stroke, the recovery rate being 40% in upper limbs and 10% in lower limbs (Niki, 1982). A candidate for a KAFO, should have at least adequate sitting tolerance, have no severe flexion contractures at the knees (less than 15 degrees) and ankle in the paralyzed limb, and finally should have the capacity to follow instructions by the trainer. The time-scale for prescription of the orthosis is different according to the physical condition of the patient. A time frame of between two and four weeks following the initiation of physical therapy is advisable.

Design of KAFO for the hemiplegic

In the prescription of a KAFO, selection of the orthotic knee joint is controversial. Regardless of the recent progress in orthoses, an effective knee joint made of plastic to control the required range of motion is still unavailable. The plastic knee joint reported by Morinka *et al.* (1982; 1984) seems to be ineffective for the severe motor deficit patient. Therefore, either a ring-locked knee, or a plunger-locked knee, or rarely an offset knee, will be selected. Some patients should be fitted with a locked knee to compensate for the collapse of the paralyzed knee joint due to quadriceps weakness in the stance phase. However, for those patients with expected functional recovery of active knee motion, a locked-knee orthosis will be undesirable because of the possibility of establishing a bad gait pattern. In such cases, a reversed double Klenzak joint seems to be another solution to control the required range of knee motion.

If the patient with a KAFO has recovered active knee motion, then the orthosis should be replaced by an AFO. To make a new AFO is one solution. If the original KAFO could continue to be used, the upright of the KAFO should be cut just above the cuff level of the leg, or be changed by using the prefabricated overlapping upright and the connected parts fixing by bolts, as proposed by Bangham (1990). The convertible plastic KAFO described

here is very effective for this conversion. Some problems, i.e. modifying the initial alignment, refitting the leg cuff to compensate for calf atrophy still exist. The weight of the conventional KAFO is a burden for the hemiplegic patient with severe neurological deficit and with physical strength less than that of a normal person (Lehmann, 1986). The energy required to use the conventional KAFO might be lessened in the convertible plastic KAFO, because the weight of the latter is approximately one half of the conventional. Anticipated problems during walking such as twisting (Morinaka *et al.*, 1982) is not a big problem in terms of the authors' experience, because most patients are not so active during ambulation training.

Effect of KAFO on the hemiplegic

A substantial effort has been made during the past decade to restore functional ambulatory capability among moderate motor deficit hemiplegics. The prime purpose of early fitting a KAFO for the patient with severe neurological deficit is, not only to facilitate contraction of the paralysed lower-limb extensors and trunk muscles in relation to postural reflex, but also to prevent the disuse syndrome, and finally to be a potential tool for the recovery of visual and spatial recognition which are disturbed due to cerebral dysfunction. The ratio of patients whose KAFO could be replaced by an AFO with the recovery of active knee motion, has been reported: 64-77% in an early treated group, and 22-40% in a delayed treated group (Niki, 1982).

Major etiologies for non- or partial ambulant are complications such as severe dementia, severe unilateral spatial neglect, and severe motor impairments including trunk instability. Although the KAFO will not be a practical tool for such disabled patients, still its role in orthotic treatment should be re-examined.

REFERENCES

ANDREWS K, BROCKHURST JC, RICHARDS B (1981). The rate of recovery from stroke – and its measurement. *Int Rehabil Med Med* **3,** 155-161.

BANGHAM RA (1990). Two in one KAFO. *J Prosthet Orthot* **2,** 173-174.

GRANGER CV, ALBRECHT GL, HAMILTON BB (1987). Outcome of comprehensive medical rehabilitation: measurement by PULSES profile and the Barthel Index. *Arch Phys Med Rehabil* **60,** 145-154.

JAPANESE ASSOCIATION FOR MEDICAL REHABILITATION (1979). Annual Report for Standardization of Prosthetics and Orthotics. (Japanese).

JØRGENSEN HS, NAKAYAMA H, RAASCHOU HO, OLSEN TS (1995). Recovery of walking function in stroke patients; the Copenhagen study. *Arch Phys Med Rehabil* **76,** 27-32.

LEHMANN JF (1986). Lower limb orthotics, In: Orthotics etcetera./3rd edition./edited by Redford JB–Baltimore: Williams & Williams. p278-351.

MERRITT JL (1987). Knee-ankle-foot orthotics: long leg braces and their practical applications. *Phys Med Rehabil: State Art Rev* **1,** 67-82.

MORINAKA Y, MATSUO M, NOJIMA M, MORINAKA S (1982). Clinical evaluation of a knee-ankle-foot-orthosis for hemiplegic patients. *Prosthet Orthot Int* **6,** 111-115.

MORINAKA Y, MATSUO M, NOJIMA M, INAMI Y, NOJIMA K (1984). Biomechanical study of a knee-ankle-foot-orthosis for hemiplegic patients. *Prosthet Orthot Int* **8,** 97-99

NIKI R (1982). Early prediction of the outcome of stroke rehabilitation. *Jap J Rehabil Med* **19,** 201-223. (Japanese, abstract in English).

OFIR R, SELL H (1980). Orthoses and ambulation in hemiplegia: a ten year retrospective study. *Arch Phys Med Rehabil* **61,** 216-220.

PARTRIDGE CJ, JOHNSTON M, EDWARDS S (1987). Recovery from physical disability after stroke: normal patterns as a basis for evaluation. *Lancet* **I,** 373-375.

SKILBECK CE, WADE DT, HEWER RL, WOOD VA (1983). Recovery after stroke. *J Neurol Neurosurg Psychiatry* **46,** 5-8.

WATERS RL, GARLAND DE, MONTGOMERY J (1985). Orthotic prescription for stroke and head injury. In: Atlas of Orthotics./2nd edition./American Academy of Orthopaedic Surgeons–St. Louis: CV Mosby. p 270-286.