RECIPROCATING ORTHOSES FOR CHILDREN WITH MYELOMENINGOCELE

A COMPARISON OF TWO TYPES

DAVID L. PHILLIPS, RICHARD E. FIELD, NIGEL S. BROUGHTON, MALCOLM B. MENELAUS

From the Royal Children's Hospital, Melbourne, Australia

Since 1987, 22 children with myelomeningocele have been fitted with reciprocating orthoses. The level of the spinal lesions ranged from T10 to L4 and 13 had associated spinal deformities. Twelve of the patients currently use a Reciprocating Gait Orthosis, seven use a Hip Guidance Orthosis or Parawalker, one has progressed to a Knee Ankle Foot Orthosis, one has died and one has been lost to follow-up.

The reciprocating orthoses are worn for a mean of 3.5 hours per day (1 to 6.5); daily usage by girls is almost twice that by boys. The mean daily usage by community walkers is 4.2 hours (13 children) as against 2.8 hours by household ambulators (8 children). Active hip flexion is not essential and fixed-flexion contractures up to 35° can be accommodated. The average breakdown rate is 0.45 per year with an average of 1.5 adjustments each year. The average annual cost of a reciprocating orthosis is Aus\$750 (£375, US\$570); this includes fabrication, adjustments and repairs.

J Bone Joint Surg [Br] 1995;77-B:110-3.

Received 19 April 1994; Accepted 17 June 1994

Children with myelomeningocele affecting segments proximal to the mid-lumbar level have considerable problems with prolonged standing and ambulation (Hoffer et al 1973). Standing can be assisted by a variety of static orthoses, but functional ambulation remains difficult. Children with more distal myelomeningocele are usually able to walk with a swing-through gait, but those with more proximal lesions cannot sustain the energy required for this. Additional problems include lack of motivation and other cognitive deficits, hydrocephalus, joint contractures, lack of muscle strength and spinal deformity.

The development of reciprocating orthoses has allowed

these children to ambulate more easily (McCall and Schmidt 1986), and a variety of different types is available. We have experience with the 'Reciprocating Gait Orthosis' (RGO; Fillauer Inc, Chattanooga, Tennessee) (Yngve, Douglas and Roberts 1984) and the 'Hip Guidance Orthosis' (HGO or 'Parawalker'; Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, UK) (Rose 1979). Both systems necessitate the use of either crutches or a walker frame, and the child ambulates using a four-point gait.

We have reviewed our patients to assess the factors that influence the use of the two types of orthosis as well as their relative merits and limitations.

PATIENTS AND METHODS

Both the RGO and the HGO have supportive trunk and lower-limb components which are connected at movable hip joints (Fig. 1). The RGO has a dual-cable system attached to coupling plates on the hip joints. Ambulation is achieved by advancing one leg, by active hip or abdominal flexion or by trunk extension, while using a diagonal weight shift. This activates the cable system to extend the opposite (stance) hip and allows the swing leg to clear the ground. The HGO has thrust-bearing hip joints which are interconnected by a rigid pelvic bar. In both systems, the hip and knee joints can be unlocked for normal sitting. The RGO is cosmetically better because it can be worn beneath clothing.

The prerequisites for prescription of a reciprocating orthosis are good upper-limb strength and co-ordination (Mazur, Shurtleff and Menelaus 1989) and enough motivation to stand and ambulate. The criteria which influenced our choice of the RGO or the HGO were the child's age, weight, muscle strength, joint motion, spinal deformity, and cosmetic requirements. All assessments and reviews were by a team which included an orthotist, a physiotherapist and an orthopaedic surgeon.

We collated data from the spina bifida database of the Royal Children's Hospital (Broughton et al 1993), from medical, orthotic and physiotherapy records, and from our multidisciplinary Paraplegic Ambulation Clinic. We recorded each child's age, sex, level of spinal lesion, lower-limb joint contractures and deformities, hip stability, spinal deformities, lower-limb muscle strengths, body-weight and

D. L. Phillips, BPros Orth, Senior Orthotist/Prosthetist
R. E. Field, PhD, FRCS Ed, Research Fellow
N. S. Broughton, FRCS, FRCS Ed, FRACS, Consultant Orthopaedic Surgeon
M. B. Menelaus, MD, FRCS, FRACS, Senior Orthopaedic Surgeon
Royal Children's Hospital, Flemington Road, Parkville, Victoria 3052, Australia.

Correspondence should be sent to Mr M. B. Menelaus.

©1995 British Editorial Society of Bone and Joint Surgery
0301-620X/95/1911 \$2.00

Fig. 1

The Reciprocating Gait Orthosis (RGO; left) and Hip Guidance Orthosis (HGO or 'Parawalker'; right). Both designs have supportive trunk and lower-limb components which are connected at moveable hip joints. In the RGO, a dual-cable system is attached to coupling plates on the hip joints.

any operations performed to facilitate the fitting of the orthosis. For each type of orthosis we recorded the age when fitted, the duration of orthosis usage, hours of use per day, ambulation aids, ambulation class, level of independence, and number of brace adjustments and breakdowns.

We assessed 110 children born since 1978, with myelomeningoceles from levels T10 to L4. Of these, 22 have been prescribed a reciprocating orthosis. One child has been lost to follow-up, leaving 21 children as the basis of this report.

At review the ages of the children ranged from 20 months to 14.5 years (mean 7 years). There were 12 girls and nine boys, and the levels of their spinal lesions were T10 (3), T12 (8), L1 (3), L3 (1), and L4 (6). Of the eight children recorded as T12 two had that level on one side with contralateral levels of L3 and L5 respectively. Eighteen of the children had ventriculo-peritoneal shunts.

All patients had joint contractures; 13 at the hip ranged up to 35° flexion with a mean of 10.3°; 16 at the knee ranged up to 30° flexion with a mean of 11.4°. As expected there was a wide variety of foot and ankle deformities. Radiographs showed unilateral dislocation of the hip in six children and bilateral dislocation in two. Thirteen children had spinal deformity, including scoliosis, lordosis, kyphosis

and a combination of these; they exceeded 30° in four cases.

Muscle power of MRC grade 3 or above was recorded in the quadriceps of seven children, in the hip flexors of nine children and in the abdominal muscles of 15 children. Twelve children had tendon-lengthening procedures or soft-tissue releases or both to facilitate the fitting of an orthosis. These operations were at the hip in six, at the knee in three and at the ankle or foot in six children.

RESULTS

Twelve of the 21 children use an RGO and seven use an HGO; five of the latter group were initially prescribed an RGO. Two children no longer use a reciprocating orthosis. One has progressed to full-time use of a Knee Ankle Foot Orthosis after three years in an RGO; the other was prevented from using the orthosis by rapidly progressive scoliosis, and died six months after ambulation ceased. We have included details of these two children up to the time at which they abandoned their orthoses.

The age at first fitting of a reciprocating orthosis ranged from 17 months to 9 years 5 months (mean 4 years 10 months). The average age at the first fitting of an RGO was

Fig. 2

Average age of first fitting of the RGO and HGO and progression from the RGO to the HGO's.

4.5 years and of an HGO 7.9 years (Fig. 2). Children have used reciprocating orthoses for a mean period of 2 years 6 months (3 months to 6 years).

None of the current HGO users has either quadriceps or hip flexor power above MRC grade 1. Nine children have achieved satisfactory ambulation at some time in the RGO despite the same degree of motor deficit.

The mean time of use of a reciprocating orthosis was 3.5 hours daily (1 to 6.5). The average daily use by girls was 4.5 hours compared with less than 2.5 hours by boys. The difference does not reach statistical significance (T value 2.98; $p = 0.093$; Student's *t*-test).

Thirteen of the 21 children use their reciprocating orthosis in the community (class III: Hoffer et al 1973) for a mean of 4.2 hours per day. Eight use it in the home (Hoffer class II) for a mean of 2.8 hours per day. Half the children use crutches and half use a Kaye Walker (Rollator). All the children are independent when ambulating, but all require assistance in donning their orthosis. Six children can remove the orthosis unassisted. In standing from a sitting position and sitting down again, 13 children require assistance and eight are fully independent. The latter group are all community ambulators.

The number of visits to the Orthotics and Prosthetics Department annually for brace adjustment ranged from 0 to 15, an average number of adjustments of 1.54 per user per annum. The number of breakdowns of the orthoses ranged from 0 to 7, an average rate of 0.54 per user per annum. These figures do not include adjustments carried out in the initial training period which are a necessary part of the gait-training programme. Twelve of the children live in the city of Melbourne, eight in rural Victoria, one in another state and one overseas. Domicile made no significant difference to usage or rate of breakdowns.

DISCUSSION

It is widely agreed that adults with no active hip flexion are best able to conduct daily activities from a wheelchair, but

the wisdom of trying to achieve ambulation in children with myelomeningocele is debatable. In childhood, the relatively better power:weight ratio allows ambulation, even if only for a few years, and ambulation undoubtedly enhances a child's psychological and intellectual development. It is known that children who have achieved this, even temporarily, will outperform those who have never done so (Mazur et al 1989).

Our preference for the RGO as the first reciprocating orthosis to use is mainly because components for the HGO are not available for children under about five years of age. We have also found it easier to teach ambulation in the RGO, assisted by the relative lack of obesity and spinal deformity in the early years. We find that children with spina bifida gain weight rapidly and commonly develop significant spinal deformity between the ages of 8 and 10 years. Five of our seven HGO users have progressed from the RGO for these reasons. All five children felt more secure in the less flexible HGO and were better able to concentrate their efforts on ambulation rather than on staying upright. The mean age at which these children changed from the RGO to the HGO was 7 years 5 months, a little earlier than Campbell suggested (Fig. 2). We believe that body shape is more important than the level of the lesion when selecting an orthosis.

It is unusual that all the children in our group have attained household or community ambulation. We believe that this success is explained by the use of stringent criteria for selection of users and the effectiveness of a multi-disciplinary team to assess, train and service the children and their families. Nine children with no active hip flexors have been able to ambulate in an RGO; this has encouraged us to prescribe the device for children with higher lesions. Since the reported review, two children with mid-thoracic levels of lesion have successfully ambulated with an RGO. The presence of hip and knee flexion contractures does not preclude the use of reciprocating orthoses: we have been able to accommodate hip and knee flexion contractures of up to 35° and 30° respectively.

Community ambulators spend more time in their orthoses than household ambulators, probably because the household ambulators all need assistance to change from sitting to standing and do not usually remain in their orthoses once their standing and walking period is over. The community ambulators wear their orthoses while in their wheelchairs and get up, independently, when they want to stand or walk.

We did not anticipate the gender difference in orthosis usage. We could not identify any difference in motivation between boys and girls, but suspect that the explanation may be in the relative abilities of the two genders to engage in the usual social activities of their healthy peers while wearing their orthoses.

We have tried to assess the cost of providing reciprocating orthoses and serving their usage. To date, five children fitted with an RGO have progressed to an HGO after RGO use averaging 18 months (13 to 24). Only two children have required prescription of a second RGO because of growth, one after 4 years 8 months and the other after 3 years 1 month. The overall frequency of returns to the Orthotic Department for adjustments and breakdowns is running at two per patient year. The cost of components to fabricate the orthoses averages Aus\$900 (£450, US\$680) and we estimate that the total cost for each orthosis for an assumed four-year lifespan averages Aus\$3000 (£1500, US\$2270); this includes fabrication, training and maintenance.

Conclusions. Reciprocating orthoses are a cost-effective method of achieving ambulation for children with high-level myelomeningocele. As they grow, the children are likely to progress from the RGO to the HGO type of orthosis. We do not yet know when users will abandon their reciprocating orthosis, but anticipate that most of them will choose a wheelchair-only lifestyle in their early to mid-teens. We do not advocate that therapists should strive unduly for ambulation in every case, but we do believe that, with appropriate selection, reciprocating orthoses can enhance the present and future quality of their users' lives.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

- Broughton NS, Menelaus MB, Cole WG, Shurtleff DB.** The natural history of hip deformity in myelomeningocele. *J Bone Joint Surg [Br]* 1993;75-B:760-3.
- Hoffer MM, Feiwell E, Perry R, Perry J, Bonnett C.** Functional ambulation in patients with myelomeningocele. *J Bone Joint Surg [Am]* 1973;55-A:137-48.
- Mazur JM, Shurtleff D, Menelaus M.** Orthopaedic management of high-level spina bifida: early walking compared with early use of a wheelchair. *J Bone Joint Surg [Am]* 1989;71-A:56- 61.
- McCall RE, Schmidt WT.** Clinical experience with the reciprocal gait orthosis in myelodysplasia. *J Paediatr Orthop* 1986;6:157-61.
- Rose GK.** The principles and practice of hip guidance articulations. *Prosthet Orthot Int* 1979;3:37-43.
- Yngve DA, Douglas R, Roberts JM.** The reciprocating gait orthosis in myelomeningocele. *J Pediatr Orthop* 1984;4:304-10.