Orthotics and Prosthetics, Vol. 34, No. 2, pp. 14-20, June 1980

Parapodium Design With Knee and Hip Locks

JAMES A. BROWN, CPOA[1]
MARTHA GRAM, RPT[2]
EDWIN KINNEN[3]

The parapodium developed by W.M. Motlock at the Ontario Crippled Children's Center, Toronto, Canada, has proven to be a useful orthosis for children with paralysis from the waist down (1). The hip and knee lock design, however, has been difficult to manage, particularly in the case of young children.

Because the hip and knee controls require use of both hands, the disabled child often finds the maneuvers necessary to get in and out of a chair much too difficult as well as frightening.

To sit, the child must lean back in an inclined position against the chair, and the knee and hip locks are rotated so that both joints flex simultaneously and he can collapse into a partially sitting position. The simultaneous release of both hip and knee locks is frightening to most children under 10 years of age. The hip and knee lock design also complicates the stand-from-sit motion, since the body of the child must become fully extended before any locking is possible. Again, this locking requires the use of both hands. For some chairs, particularly wheelchairs, there may be insufficient room on the side to permit rotation of the locking levers.

It seemed reasonable to attempt to design a system that would separate the hip and knee lock controls, in order to permit the child to unlock and flex his hips when sitting while the lower portion of the brace remains rigid and supportive. The knees could be unlocked by a subsequent action. At the same time the new design would also allow both hip locks and both knee locks to be released by a single lever action with the control possibly located on the child's dominant side, thus freeing one arm for control of balance. Locking could be made automatic upon extension. It was felt that these features would simplify the sitting and standing maneuvers by allowing the child to concentrate on one locking or unlocking action at a time, while maintaining support with one hand. It was felt that such a feature would eliminate much of the fear observed when the young disabled child attempts to sit or to stand in the Toronto Parapodium.

Design

The objective was to redesign the parapodium with independent knee and hip locks, single lever action for knee and hip lock release, and automatic lock on extension. It was intended that the lateral upright supports be modified from the Toronto design for connection to commercially available hinges. Other components of the orthosis were to be designed

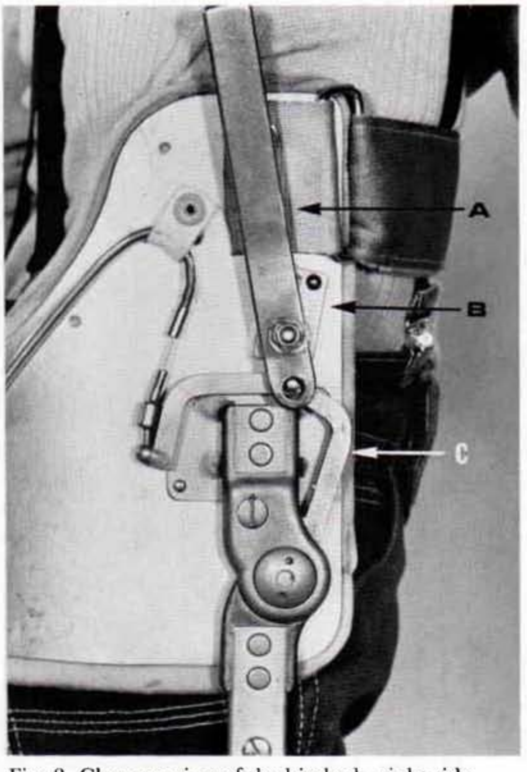

Fig. 2. Close-up view of the hip lock, right side.

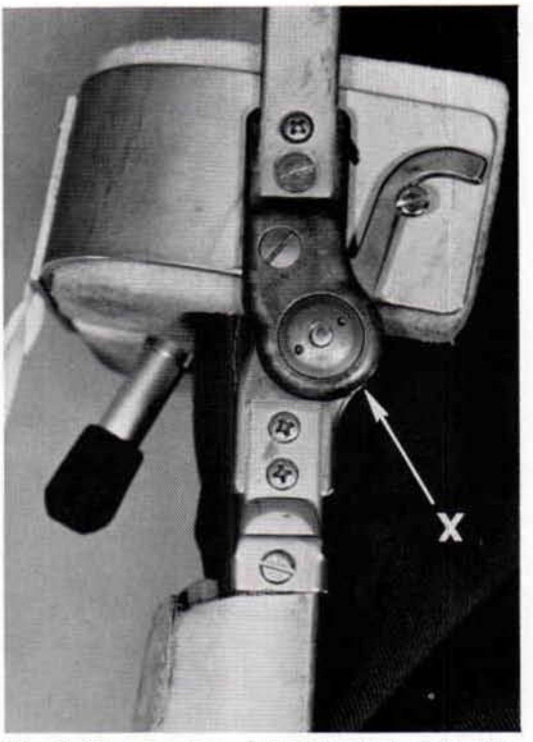

Fig. 3. Close-up view of the knee lock, right side. Part of the flexible pull strap attached to the superior anterior edge of the pretibial band can be seen at the extreme right.

for fabrication in a well-equipped orthopaedic shop.

Three models were constructed. The following description and figures are limited to the third model.

The redesigned parapodium is shown in Figure 1; the patient is 10 years old and 101 cm tall.

Details of the hip and knee locks are shown in Figures 2 and 3.

The hip joint assembly (Fig. 2) is based on stainless steel 17B23 Otto Bock knee joints, right and left outside. These joints flex anteriorly when released by anterior motion of manual lever "A". The release lever, "C" can engage detents at 105 deg, 145 deg, and 185 deg angles of flexion. A standard triple-swivel connection, projecting superiorly, is silver-soldered to the release lever. A standard cable with cable housing assembly as used in arm prostheses connects to the opposite hip release lever through a second triple swivel, so as to allow both joints to be locked and unlocked in unison. The manual lever can be mounted on either the right or left side.

A base block with bullet catch, "B", attached to the manual lever, maintains the hip joints in the unlocked condition until the manual lever is returned to the upright position. This permits the child to move around into a full sitting position without the hip becoming relocked. Locking is automatic upon extension to the standing position when the manual lever is upright.

The knee joint assembly (Fig. 3) is

Fig. 4. Initiating the sitting maneuver. The hip locks are released while weight remains supported by the orthosis.

Fig. 5. When seated, the knee locks are released by a slight rotation of the pretibial band provided by a pull on the strap on the anterior surface.

based on stainless steel 17B23 Otto Bock knee joints, right and left outside, inverted to flex posteriorly. A pretibial band of aluminum 3.175 cm wide lined with Plastizote knee blocks, pivots on 10/32 stainless steel screws and bearing sleeve, "X". The J-shaped locking lever rides on a trip screw to release the knee lock when the strap located on the anterior aspect of the pretibial band is pulled upward (Fig. 1). Spring loading relocks the system upon full extension.

The pelvic band is T32023 aluminum 1.6 mm thick, with a 6.35 mm Plastizote lining. Velcro is used for the chest strap closure.

Lateral uprights are 16 or 20 mm x 4 mm stainless steel or aluminum, depending on patient strength and size. Growth adjustment is in 1.5 cm increments for a 7 cm range, with 8/32 screws for fixation. The base supports for the lateral uprights are shaped from T32024 angle aluminum 76.2 x 101.6 x 9.5 mm stock.

The knee extension assist bar is made from telescoping 11.9 and 12.7 mm aluminum tubing, and using 6 mm diameter cords to maintain tensions for returning the assembly to its original position. The attachment block is shaped from 25 x 90 mm aluminum bar stock.

The foot plate is T32024 aluminum plate, 2.2 mm thick. The plantar surface is covered with linoleum to reduce friction over carpets.

Operation

Figures 4 through 7 are views of the critical stages in the maneuvers from standing to sitting and from sitting to standing. In Figure 4 the child has approached the chair, turned, and using one hand, has removed the manual hip

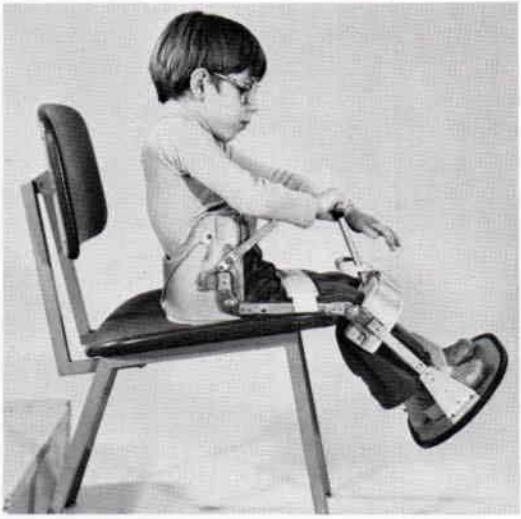

Fig. 6. Beginning the standing maneuver. The knee extension assist bar is used to secure the knee locks.

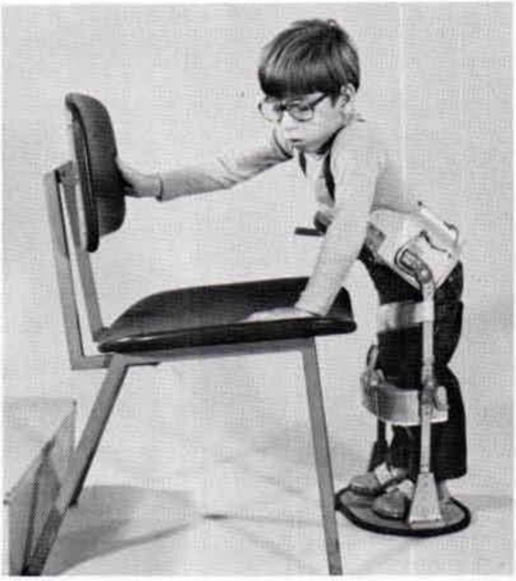

Fig. 7. The standing maneuver is completed by extending the hip to the point where the lock engages automatically.

release lever forward (Fig. 2). In this position, the hip locks are released while the knee locks remain secured. The child's weight is supported by the orthosis as long as his center of gravity is not moved forward. Both arms are positioned in this figure for lifting his weight onto the seat. When the patient is stable on the seat (Fig. 5), a pull on a flexible strap loop connected to the pretibial band (Fig. 3) releases the knee lock, and the sitting motion is completed.

To regain the standing position, the child initially extends his knees by pulling back on the knee extension assist bar (Fig. 6) until the knee lock clicks into position. The child can then roll over and off the seat, again with the lower portion of the orthosis providing full support for body weight. If the hip release lever is now returned to its original position, the child can push upright with both arms (Fig. 7) to secure the hip locks automatically.

The tension adjustments for the hip and knee locks were found to be critical for the youngest patients, and required individual fitting. This was not a problem for the older children. Some special training in the use of the redesigned parapodium is indicated, or a self-taught skill may have to be relearned.

The lateral uprights in this design permit some lateral motion during swivel gait. This flexibility appears to aid forward motion.

The weight of the new design is estimated to be about 10 percent greater than the Toronto Parapodium.

Results

CASE STUDY I

The first child to wear the redesigned parapodium, J.N., was a girl of three with a diagnosis of approximately T-12 level meningomyelocele. She had worn a Toronto parapodium since the age of 10 months. Following fitting in the redesigned parapodium, J.N. received some special instruction on the use of the locks but then resumed a normal therapy schedule, which consisted of a reevaluation once a month and a task assignment to be carried out at home. After one month, J.N. could get to a sitting position in a chair and back to standing with minimal assistance. Some adjustment of the tension on the hip and knee locks was needed. Following these adjustments and another month of practice, J.N. was able to sit and stand independently. Her mother, in fact, reported that she often would get in and out of her "TV" chair at home without help. With the original design she had been unable to even begin this task of sitting unaided.

CASE STUDY II

The second child fitted with the new lock design was K.Z., a 10-year-old boy, diagnosed meningomyelocele approximately at the T-12 level. He had worn a Toronto Parapodium since the age of four. After working with his mother without any special instruction over a period of several weeks, K.Z. had learned both to sit and move to a standing position from a chair independently, using only a desk for added support. This new freedom of getting up and down from a chair triggered the learning of several other activities of which K.Z. had previously been frightened. He began an independent swivel gait without an assistive device and developed a much more confident swing gait. K.Z. received further training from his physical therapist at school, and is learning to sit and stand without a desk. He does this with minimal assistance. He can also move in and out of his wheelchair unassisted.

CASE STUDY III

The third child to receive the new design was A.C., eight years of age. She had worn the Toronto Parapodium since the age of three or four. She had a diagnosis of meningomyelocele of fairly high level. A.C. had previously been unable to manage the locks on her Toronto Parapodium for the sitting or standing maneuvers. After fitting with the redesigned orthosis and some special instruction in the use of these new locks, A.C. continued her regular physical therapy schedule of one-hour sessions twice a week in the special school she attended. Of the three children placed in the brace up to this point, A.C. had the weakest upper limbs. She had some success in unlocking to sit, but had a great deal of difficulty using the extension assist in preparation for standing. A.C. wore the new Parapodium for several months before entering the hospital for surgery. At this point she died unexpectedly.

CASE STUDY IV

J.D., the fourth child to be fitted with the new lock design, was three-years old with meningomyelocele at approximately the L-3 level, and had worn her Toronto Parapodium since approximately one year of age. She had done well in all brace activities but had found sitting and standing difficult. After some specific training, J.D. also resumed her regular physical therepy training schedule of once-a-month sessions. She has worn the redesigned parapodium for approximately three months, and can now sit and stand with minimal assistance. She still has some difficulty with the tensions on the knee lock and handling of the extension assist, but is improving.

Conclusions

The objectives of the alternate Parapodium design were accomplished in the construction of three prototype units. These have been fitted successfully to young patients for evaluation. Preliminary observations indicate that in all cases, the patients were able to perform sitting and standing maneuvers when previously they had been unable or fearful to do so. Depending on age and degree of disability, the three surviving children developed the skill for sitting and standing that was superior to that previously accomplished. In some cases this new "freedom" led to increased confidence and skill in other areas.

It appears, therefore, that additional study and use of the redesigned Parapodium is justified.

Acknowledgment

This report describes the work and contributions of the members of the Biomechanics Group of the Birth Defects Clinic, Department of Pediatrics, School of Medicine and Dentistry, University of Rochester, Rochester, New York 14642.

Partial support for this work is from a grant by the J.M. McDonald Foundation, Cortland, New York.

References

1. Motlock, W.M., *"The Parapodium: an orthotic device for neuromuscular disorders", Artif. Limbs,* 15(2):36-47, 1971.

Footnotes

[1]Rochester Orthopedic Laboratories, Inc. Rochester, New York 14618

[2]Birth Defects Clinic, Department of Pediatrics University of Rochester, Rochester, New York 14642

[3]Department of Electrical Engineering University of Rochester, Rochester, New York 14627