Efficacy for Maintenance of Elbow Range of Motion of Two Types of Orthotic Devices: A Case Series

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ABSTRACT

This pilot study was designed to examine the efficacy of maintaining elbow range of motion using two different programs, Ultraflex and bivalve cast, following botulinum toxin type A (BTX) injection and serial casting. The subjects included three children, 7 years of age, with primary diagnoses of cerebral palsy who demonstrated severe-to-moderate spasticity interfering with passive or active movements at both elbows. Before the BTX injection, a baseline evaluation was performed that included the Modified Ashworth Scale, passive range of motion, and caregiver questionnaire. Evaluation occurred pre-BTX, and at 2, 6, and 8 months after BTX. One week after BTX injection, each child underwent an initial serial casting program for both elbows. As the child plateaued with passive range of motion, a bivalve fiberglass long arm cast was applied to one of the involved limbs and a definitive orthotic device, Ultraflex, was applied to the other limb to maintain the range. The use of the Ultraflex showed better maintenance of elbow range of motion when compared with the bivalve cast. Overall, parents preferred the Ultraflex and were pleased with the long-term results. After the serial casting program, the findings suggested that the increase in range of motion was temporary. The results of this study suggest that the Ultraflex offered easier adjustments to the length-tension change at the elbow and ability to maintain range of motion when compared with a bivalve cast, although further research is needed. (*J Prosthet Orthot.* 2003;15: 72–77.)

KEY INDEXING TERMS: cerebral palsy, bivalve cast, muscle spasticity, elbow orthosis.

Individuals with flexion contractures of the elbow caused by increased spasticity are at risk for skin breakdown. It is difficult for the caregiver or client to don and doff shirts and jackets, and to provide adequate hygiene care. Many times the individuals are given oral medication, such as baclofen, to assist with relaxing muscle tone. However, the flexor spasticity at the elbow may persist, resulting in muscle shortening and joint contractures. There is change in the muscle belly, tendon lengths, and balance of the agonist and antagonist muscle groups. Muscle contracture occurs when a muscle or group of muscles have shortened sufficiently to prevent complete range of motion of the joints or the joints they cross. Central nervous system damage can cause spasticity and prolonged fixed postures. The results may include contracture with spasticity and weakness in the antagonist muscle group, causing a muscle imbalance and further development of contractures.

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To effectively control persistent localized spasticity of the upper extremity, the use of botulinum toxin type A (BTX) is commonly used. The neurotoxin acts to inhibit the release of acetylcholine at the neuromuscular junction, causing muscle weakness or paralysis.[1–3] When spasticity of the elbow flexors interferes with elbow extension, BTX is injected into the biceps, brachioradialis, or brachialis to provide temporary relief. BTX is known to weaken the spastic muscle, and prolonged stretching is needed to provide length to the shortened muscles.

Passive stretching has been a treatment approach to restore range of motion when range is limited by loss of soft tissue elasticity. There is greater improvement in range of motion when prolonged stretching is applied at moderate tension, pain free, than by intense stretching of short duration.[4]

Passive lengthening is a technique used by holding a limb in the desired position at submaximal range. Casting may be used to hold joints in desired positions to allow for changes in sarcomere distribution and/or increase muscle or tendon length.[5] Serial casting is a procedure used to improve muscle length by providing prolonged positioning and by re-applying casts that gradually increase range of motion until the desired range of motion is met or range has plateaued. A bivalve cast can be made by cutting the cast in half and applying straps to hold the cast together. It serves as a maintenance orthosis to preserve the gains made by the serial casting program. The bivalve cast is used as a positioning device, ideally to be worn at night.[6,7]

Tona and Schneck[8] designed a pilot study examining the effects of a short-term (48 hour) upper extremity cast, with an 8 ½-year-old girl, with left upper extremity spasticity. The results of this study showed a temporary decrease in spasticity after wearing an inhibitive cast. The effects of inhibitive casting were examined with a 5 ½-year-old girl with spastic quadriplegia. The use of bivalve casts was helpful in preventing further increase of contracture. In addition, improvements were noted in both handling and positioning of the child.[9] The use of bivalve elbow casts was described in a case study for an 11-year-old boy, severely impaired with spastic quadriplegia.[10] Bivalve casts were initially applied to both upper extremities to be worn at school and home. After 5 months, a second set of plaster casts was made with hand splints attached to position the wrist. A third set of casts was made from fiberglass to decrease the weight of the previous plaster casts with the hand splint incorporated. A fourth set of casts was fabricated, but the hand splints were eliminated because of difficulty with wearing tolerance of the previous cast. In summary, the casts were effective only in maintaining but not improving passive elbow extension.[10]

An upper extremity fiberglass bivalve cast is clinically used to position the arm in submaximal range after a stretching program of casting. The bivalve cast is used to maintain the present range of motion, to prevent further deformity, and to permit the child to participate in an active program during the day. It also allows the caregiver access to the limb for hygiene care. Serial casting can be an effective method for reducing contracture and gradually improving passive range of motion.[5,11,12] Controversy exists regarding the most efficacious means of producing a lasting elongation. A bivalve cast has been used clinically after a serial casting program to maintain passive range of motion. However, the bivalve cast does not accommodate the changes in range of motion that may occur at the elbow joint from increase of spasticity or muscle tightness. A bivalve cast is fabricated at a position slightly below maximum stretch or at submaximal range of the joint to ensure comfort. If the bivalve cast is poorly tolerated and causes pressure areas, a new bivalve cast must be made to accommodate the changes in range.

Another method used for maintaining range is low-load prolonged stretch by an orthosis that holds the joint in a position of low magnitude stretch. The orthosis has humeral and forearm cuffs with tension across the elbow into extension. The tension can be varied with a spring tension load at the elbow joint. In a retrospective study, the use of a low-load prolonged stretch orthosis was examined for maintaining range of motion and contracture management.[13] The use of a low-load prolonged stretch orthosis improved range of motion that also improved the subject's functional outcome. A separate study showed an increase of 61% range of motion after use of a Dynasplint (Dynasplint Systems, Inc. Severna Park, MD), which produced low-load prolonged stretch for decreasing contractures on 13 subjects with elbow or knee flexion contracture for an average of 13 weeks.[14]

The Ultraflex orthosis (Ultraflex Systems Inc., Downingtown, PA) is a low-load prolonged stretch device that is used for maintaining and gradually improving range. It has separate humeral forearm/wrist portions made from high temperature plastic, which is formed from the fiberglass impression of the child's arm. The elbow joint has an adjustable tension setting to gradually stretch the elbow joint. Both the Ultraflex orthosis and the fiberglass bivalve cast should provide the same maintenance and positioning after a serial casting program. This study was designed to measure the efficacy of maintaining range of motion with the use of the bivalve long arm cast and the Ultraflex orthosis when worn for an 8-month period. The Ultraflex and the long arm bivalve cast both positioned the elbow into extension, with the forearm and wrist in a neutral alignment.

METHODOLOGY

Subjects

The subjects of this study included three 7-year-old children, with diagnoses of cerebral palsy. Informed consent was obtained before admission into the study. The children demonstrated moderate spasticity interfering with passive or active movements at both elbows (Figure 1). A before and after intervention trial was used, comparing passive range of motion at both elbows after wearing the long arm bivalve cast and the Ultraflex.

Subject 1 was a 7-year-old girl, with a diagnosis of cerebral palsy, spastic quadriplegia. She was born at 41 weeks, 7 lbs. 8 oz., and had a 3 week stay in the intensive care nursery. She had difficulty with seizures and a persistent abnormal neurological examination. She is currently getting gastrostomy-tube feedings. She is dependent in mobility and self-care. She presents with low cognitive and developmental skills. Her current medications are baclofen and phenobarbital.

Subject 2 was a 7-year-old girl, with a diagnosis of cerebral palsy, spastic quadriplegia. She was born full-term, 6 lbs. 7 oz., and had cocaine exposure at birth. She was hospitalized for 4 weeks because of difficulty with feedings. Her mother stated that at 4 months of age her daughter had increased extensor tone and difficulty with meeting any motor milestone. The child is currently receiving nasogastric tube feeds for liquids and blended pureed foods by mouth. The child usually has one seizure every 2 weeks. Current medications are depakote to control her seizures and bacoflen to decrease her muscle spasticity.

Subject 3 was a 7-year-old boy, with diagnosis of cerebral palsy, spastic quadriplegia. He was born at 38 weeks. His mother reported that at 6 months gestation she was infected with cytomegalovirus (CMV). The child was born jaundiced and microcephalic. He was hospitalized for 10 days after birth. He has a history of seizures and is receiving phenobarbital. He also receives baclofen for decreasing muscle spasticity. He requires a gastostomy-tube for feeding, has asthma, and is dependent in mobility and self-care.

Figure 1. Child with bilateral elbow flexion spasticity pre-BTX.

PROCEDURE

Before the BTX injection, a baseline evaluation included the Modified Ashworth Scale (MAS), passive range of motion, and caregiver questionnaire. Evaluation occurred pre-BTX, and at 2, 6, and 8 months after BTX injection. The MAS is a clinical measurement of resistance to passive movement (Table 1) using a numerical scale (0–4) to grade resistance felt by the therapist during a quick stretch maneuver opposite the muscle group being tested.[15] The test was performed by an experienced occupational therapist while the child was seated in his/her wheelchair. Passive range of motion was measured in degrees with a goniometer of the subject's passive range into elbow extension. A caregiver questionnaire was given at baseline to determine previous orthotic devices worn and medications used to manage the child's spasticity. Eight months after the intervention (BTX, serial casting, bivalve cast, Ultraflex) the parents were asked to fill out a questionnaire to determine the caregiver's preference and satisfaction with the device of choice that provided ease of fit and the ability to maintain range of motion. The questionnaire was composed of a combination rating scale, checklist, and several open-ended questions. The rating scale was based on a five-point Likert scale.

Table 1. Modified Ashworth Scale

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end range of motion when the affected parties moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of motion
2	More marked increase in muscle tone through most of the range of motion, but the affected part is easily moved
3	Considerable increase in muscle tone, passive movement is difficult
4	Affected part is rigid in flexion or extension

BTX was administered by one injector into the biceps and brachioradialis in both upper extremities. Each child underwent a serial casting program to both upper extremities 1 week after BTX injection. Rigid elbow casts were initially applied by an occupational therapist experienced in casting. The casts were left in place for 7 to 10 days and replaced with new casts that incorporated any gains in range of motion obtained from the application of the first cast. Four casts were applied. As the child gained improved range into elbow extension, the final two casts were long arm casts (Figure 2). The long arm cast included the elbow, forearm, and wrist. This cast is effective in controlling the position of the forearm, and the wrist is generally positioned in neutral, because forearm rotation influences carpal alignment.[7] As the child plateaued with passive range of motion into elbow extension, a final maintenance orthosis was fabricated for each elbow. A bivalve fiberglass long arm cast was made by the occupational therapist and the Ultraflex orthosis was made by a certified orthotist. Both maintenance devices were custom fitted to each subject's involved limb and randomly assigned to each arm. The bivalve cast and Ultraflex were worn at the same time (Figure 3). The devices were worn by all subjects at night for an average of 4 or more hours each day.

After serial casting to both elbows, significant increase in passive range of motion was noted into elbow extension; this increase was only temporary. As the effects of the BTX wore off, there was an increase in spasticity and each child demonstrated difficulty with wearing either orthotic device. If the child was unable to fit comfortably into either orthotic device and had any pressure areas, the caregivers were instructed to have their child seen in the clinic. By the fifth month there was an increase in spasticity and a gradual loss of passive range of motion. Every child required fabrication of a new fiberglass bivalve cast and the Ultraflex was readjusted to accommodate the amount of tension the child was able to tolerate comfortably.

RESULTS

RANGE OF MOTION

Passive range of motion in the direction of extension improved during the months of serial casting, but only temporarily. The bivalve cast did not improve range but maintained the range from baseline. One subject showed loss of range of motion at the 8-month evaluation. Use of the Ultraflex improved range of motion from the baseline data, although not after the serial casting program of all three subjects (Figure 4).

SPASTICITY

Before BTX injection, the average MAS score was 2. One to two months after treatment, the subjects showed a decrease

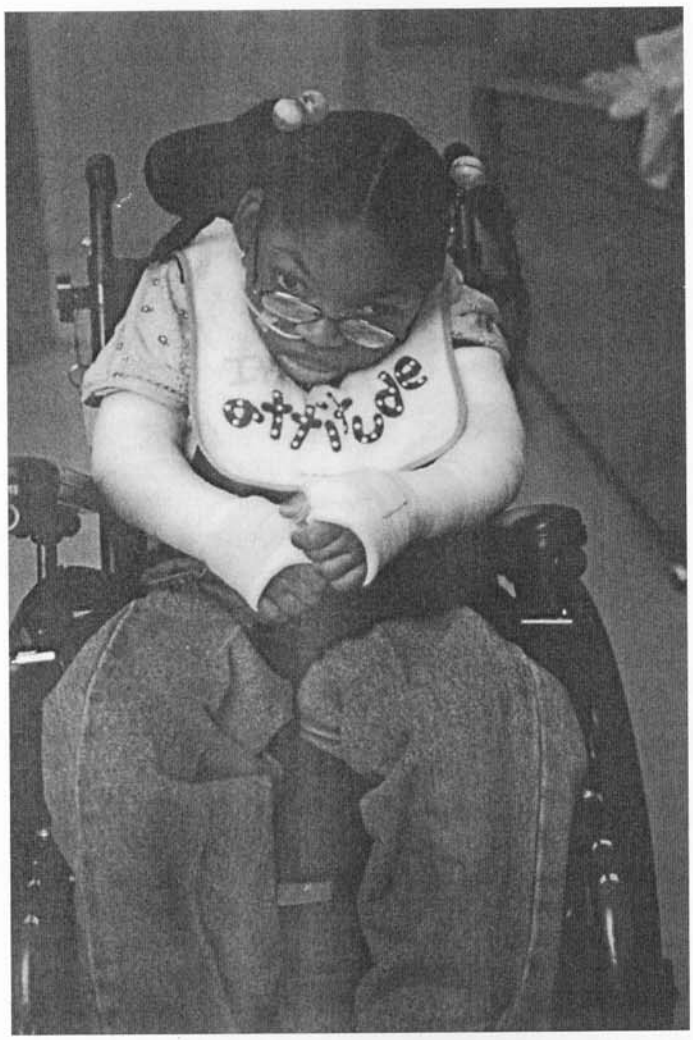

Figure 2. Child with bilateral fiberglass long arm cast.

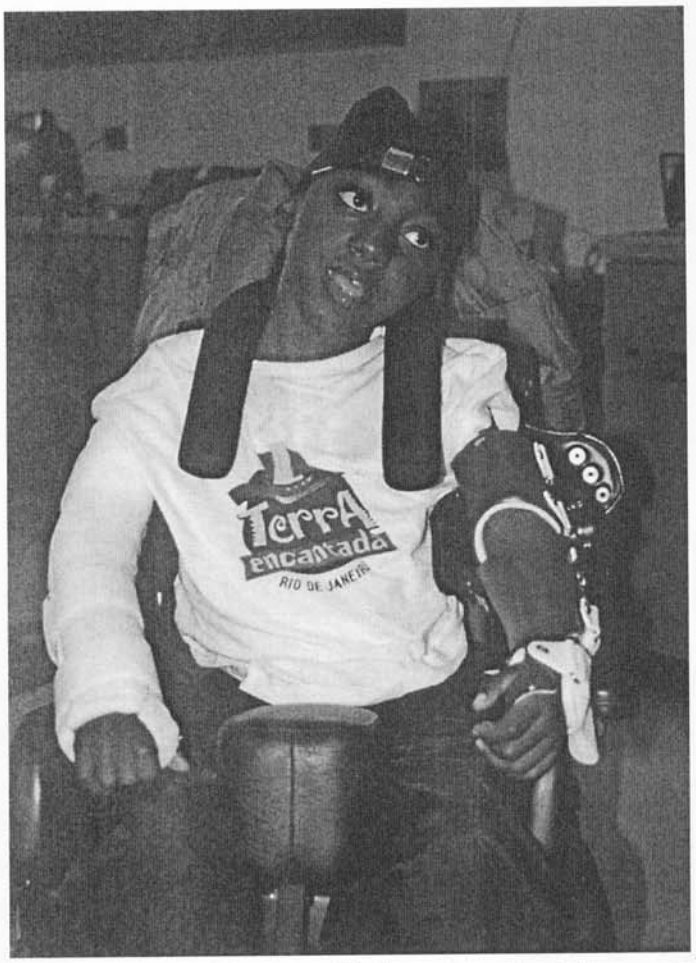

Figure 3. Child with long arm bivalve cast on the right arm and Ultraflex orthosis on the left arm.

in muscle tone of at least ½ point on the MAS resulting in better elbow range of motion, as documented by an improvement in passive range of motion and change of limb position at rest. The improvements were temporary and at 6 and 8 months they declined to baseline status (Figure 5).

CAREGIVER QUESTIONNAIRE

All three subjects were using bivalve casts before the intervention and were receiving baclofen at the time. Before the intervention, two of the subjects' parents indicated that it was "important" that their child have a straight arm, whereas the parent of the third subject indicated that it was "extremely important."

After the intervention (BTX, serial casting, bivalve cast, Ultraflex) the parents were asked to fill out a questionnaire regarding the intervention. The first three questions related to ease of donning either the orthosis (Ultraflex) or the bivalve cast and the ease of stretching the child's arm. A score of 1 on the Likert scale indicated that it was "very difficult," whereas a 5 indicated that it was "very easy." The first question asked how easy it was to donn the Ultraflex orthosis. The mean response was 3. For the donning of the bivalve cast, the mean was 4.6. This, although not statistically significant, indicated that donning the bivalve cast was easier than donning the Ultraflex orthosis. The next questions asked how easy it was to stretch the child's arm if the orthosis or cast had been worn for more than 4 hours. For the bivalve cast the mean response was 3.6, whereas the mean for the Ultraflex was 4.0. All three subjects' parents indicated that, overall, they preferred the Ultraflex to the bivalve cast. In addition, all three mothers felt they almost never had to reposition the bivalve cast or the Ultraflex once placed on the child's arm. Two subjects' parents indicated that their child was able to tolerate wearing both the cast and orthosis for longer than 4 hours a day; whereas one parent indicted that her child could tolerate both the orthosis and bivalve for only 4 hours a day. In the open-ended section of the questionnaire, one parent indicated that the Ultraflex was easier to clean than the bivalve cast. Another parent felt that the bivalve was heavier than the Ultraflex. Another comment described the tension of the Ultraflex as a reason for donning difficulty. One comment indicated that the parent felt that once the orthosis or bivalve cast was removed the child's arm was more flexible on the Ultraflex side.

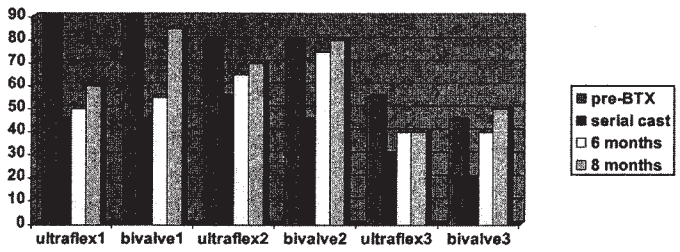

Figure 4. Passive range of motion pre-BTX, after serial casting, and at 6 and 8 months after BTX injection for subjects 1, 2, and 3.

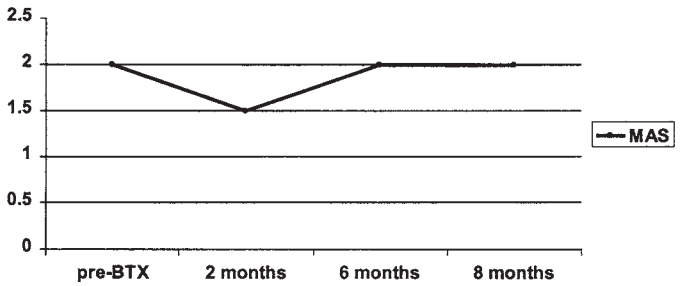

Figure 5. Average Modified Ashworth Scale score for elbow flexion pre-BTX, and at 2, 6, and 8 months after BTX injection.

DISCUSSION

For a child with central nervous system (CNS) dysfunction, in which moderate to severe weakness or paralysis and accompanied tightness are often present in the same muscle, positioning through an orthotic device may be effective in maintaining range at those joints that have no active movement. To prevent further contractures and to maintain range of motion, a follow-up orthotic positioning device is generally applied after a casting program. Prolonged maintenance in the desired position by an orthotic device with a low load length tension may be more comfortable and more effective in gradually improving range of motion because the procedures are carried out for longer periods. The use of the Ultraflex showed better maintenance of elbow range of motion when compared with the bivalve cast. These findings also suggested that after the serial casting program, the increase in range of motion was temporary. The increase in range may be a result of the children wearing a cast for 24 hours a day, 7 days a week. The subjects are wearing the cast consistently versus a maintenance device that can be taken on and off and worn for various periods of time. Wearing the bivalve cast or Ultraflex orthosis is tolerated for less time, and the subjects are generally wearing their device during the night and possibly for part of the day at school or at home. For a child who presents with significant motor involvement, spasticity, and contractures this may indicate that serial casting after BTX injection may be needed only to position the involved limb so the child can fit comfortably into a low-load prolonged stretch type of orthotic device.

Caregivers generally reported improvements initially after the BTX injection and up to the fourth month. Their subjective ratings indicated greater improvements over time with the Ultraflex. They all reported difficulty with donning the Ultraflex and greater time to apply compared with the fiberglass bivalve cast. However, the caregivers were pleased with the result of improved range with the Ultraflex. The Ultraflex offered easier adjustments to the length-tension change at the elbow and the ability to maintain range of motion.

For the child who presents with limited range of motion at multiple joints it is important to gradually stretch one joint at a time to prevent micro tearing. A clinical decision must be made as to what joint to address first in the arm. The Ultraflex had a spring tension at the elbow joint while the forearm and wrist were positioned in neutral with no stretch. Research is needed to establish protocols for the most effective means for maintaining and possibly for gradually improving joint range of motion.

Both the Ultraflex and the bivalve cast demand compliance. Consistent monitoring is necessary to check skin integrity and fit of the orthotic device. Because of ongoing change in the growth and development of children with cerebral palsy, the use of an orthotic device should be monitored and become a permanent part of preventative care. It is important to be realistic of our goals for both functional improvement and improved range of motion.

SUMMARY

This preliminary study compared a static bivalve cast and a low-load prolonged stretch orthotic device, Ultraflex, in maintaining range of motion in 3 subjects with cerebral palsy. The results support the use of the Ultraflex as a maintenance device. The bivalve cast used for prolonged periods may not be cost effective in maintaining range of motion in an arm with long-term spasticity and associated contracture. The Ultraflex could be used immediately after BTX with casting to prepare the arm to fit comfortably into the orthotic device. Further studies investigating the long-term effects of BTX, casting, and Ultraflex are needed.

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