Case Study: Use of the Dynamic Movement Orthosis to Provide Compressive Shoulder Support for Children With Brachial Plexus Palsy

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ABSTRACT

Children with obstetric brachial plexus palsy often present with shoulder alignment issues. Shoulder subluxation may occur as a result of shoulder girdle muscle weakness and overstretching of the ligamentous support structure around the glenohumeral joint. Optimal alignment and support of the glenohumeral joint is essential for active functional shoulder movement and distal control. Shoulder support options are limited for children, because materials may not be suitable for daily wear and compliance is often poor. The purpose of this case study was to evaluate the effectiveness of a custom-fitted shoulder orthosis, the Dynamic Movement Orthosis (DMO), and its ability to support and improve upper limb function during active wear. The Wolf Motor Function Test assesses 17 tasks (2 strength based, measured by weight lifted and grip, and 15 function based, measured using time to completion). This test was used to objectively quantify active shoulder and elbow movements with and without the use of a custom-fitted DMO. This case study suggests that the DMO supported the shoulder during functional task and optimized active strength distally in the wrist and elbow. (*J Prosthet Orthot.* 2011;23:159–164.)

KEY INDEXING TERMS: shoulder orthosis, brachial plexus palsy, shoulder weakness, shoulder subluxation, shoulder brace, obstetric brachial plexus palsy

Obstetric brachial plexus palsy (OBPP) is a complication that may occur during a difficult delivery; however, delivery by caesarian section does not exclude the possibility of a birth palsy.[1] The incidence of OBPP is 1 per 1,000 live births.[2] The most common type of OBPP involves the upper trunk (C5-C6), sometimes in combination with a C7 injury. There are fewer injuries of the entire plexus (C5-T1) and rarely the lower trunk (C8-T1) can be involved.[3]

During the early years of life, neurological recovery is an important factor in determining a child's active range of motion of his/her arm. After an OBPP, an infant is generally seen for occupational or physical therapy on a regular basis to improve muscle strength in recovering muscles, prevent joint deformity, and monitor the baby's developmental milestones. Muscle imbalances and incomplete or delayed nerve regeneration can pose serious secondary upper limb concerns.

A common problem seen in infants with OBPP is shoulder weakness, glenohumeral joint deformity, contractures, and capsular tightness. In addition, shoulder dislocation, subluxation, or instability can occur about the glenohumeral joint. Glenohumeral stability plays an integral role in the function of the shoulder. Shoulder weakness or subluxation decreases the ability to stabilize the kinetic chain for active use of the arm distally. Providing stability to the shoulder post-OBPP has historically been a challenge in the child with significant weakness. If the axillary nerve is involved, the child demonstrates limited active movement into humeral flexion and abduction. The axillary nerve branches off the posterior cord of the brachial plexus and carries the nerve fibers from C5 and C6. It supplies the muscles of the shoulder, including the rotator cuff and the deltoid. Deltoid atrophy due to axillary nerve involvement can be seen by observation, noting the prominence of the acromion. There may also be signs of shoulder dislocation or subluxation, which is seen with increased spacing between the humeral head and acromion.

In a normal shoulder, the alignment of the humeral head within the glenoid fossa is supported and maintained by an intricate muscle balance, the shape of the glenoid fossa, and rotator cuff muscles; which is reliant on the integrity of the sensory and motor tracts. Weakness of the shoulder girdle and inability to actively lift the arm places the arm in a dependent position with potential for shoulder subluxation. Limited ability to abduct or flex the shoulder against gravity may be due to weakness or paralysis of the deltoid and supraspinatus. Any contraction of the muscles distally may be less effective due to the decreased proximal stability of the

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shoulder. As the elbow attempts to flex or extend, the ligaments/tendons attached to the scapula and humerus may become further overstretched and weak.

Tension on the taut joint capsule, with overstretched tendons and ligaments, over time, can further increase the weakness of muscles controlling the elbow, forearm, and hand. Overlengthened muscles do not have an optimal length-tension curve, decreasing their ability to generate force during a contraction. There are numerous studies with the adult stroke population documenting the efficacy of reducing shoulder subluxation with different types of supports for the involved hemiplegic shoulder.[4–6] There are limited data supporting the effectiveness of bracing children with shoulder subluxation. However, a case study described a custom-fitted, child-sized shoulder support that reduced subluxation and maintained alignment through extended periods of the day.[7] The shoulder support was worn directly on the skin to provide maximum support and was made from a Velcro-compatible fabric, with a perforated neoprene. The disadvantage of the custom shoulder brace was that a caregiver was required to don the brace, and the patient was unable to independently apply the straps and adjust tension for optimal support. The perforated neoprene material was heavy, and during the summer months, the brace retained heat and perspiration.

Similar to the custom-fitted brace, the Dynamic Movement Orthosis (DMO) is made from a Lycra material, which is more breathable and can be treated to wick away perspiration. Each panel or section of the Lycra material is measured using specific tensions and directions of pull to support the child's need for maintaining biomechanical alignment. The shoulder DMO is measured to provide a snug fit and to support the shoulder girdle and arm, and to improve the control of movement and function. The case study described will evaluate the custom-fabricated DMO and the efficiency of movement while wearing the DMO.

METHOD

The DMO is designed to improve function and sensory awareness in various parts of the body. Lycra reinforcements are strategically added to assist weak muscles or influence muscle imbalance due to tone or stiffness.

The DMO is a very close-fitting orthosis; therefore, careful measurements are required to obtain a snug fit and provide an optimal outcome. In this case, 16 linear and circumferential measurements were taken including the chest, shoulder/axilla, and arm (Figure 1). Two additional Lycra reinforcements were added to the DMO to control shoulder subluxation. First, a back crossover strap was used with the back reinforcement panel to control a typically subluxing shoulder. The back crossover strap reinforcement starts at the acromion, crosses over the thoracic area, and finishes one centimeter below the axilla. Second, reinforcement was added over the shoulder to provide a lifting force to support the humerus and reduce subluxation. As this patient is very active and the DMO includes the axillary area, the brace was given a silver treatment. Silver provides antimicrobial, moisture-wicking, and anti-odor properties.

The measurements and reinforcement specifications are electronically sent to the manufacturer (DM Orthotics, Cornwall, UK). The orthosis is fabricated and shipped through the United States distributor (Boston Brace, Avon, MA). When the orthosis is received, a fitting is scheduled with the orthotist and therapist. The patient is instructed in the application of the orthosis, and the DMO checked for fit and function. Over the first week, the wearing time is started at 1 hr for the first day, 2 hrs for the second day, 4 hrs for the third day, and 8 hrs for the fourth day. On the fifth day, the DMO should be worn 8–10 hours. Continue this schedule 7 days a week. The manufacturer states that the DMO should not be worn at night.

The DMO is a dynamic brace and works best in conjunction with a therapy program. The DMO can become too tight if the patient grows or has significant changes in circumference. The patient and caregiver are instructed to check for cold hands, fingers, and limbs becoming blue. Use of the DMO should be discontinued if this occurs, and a member of the clinic team must be contacted. After fitting and instructions on application, use, and care, a 2-week follow-up is usually scheduled.

In this case, the DMO was designed to reduce shoulder subluxation and improve overall arm function. The standard DMO shoulder stability orthosis ends distally above the elbow; however, for this patient, it was decided to extend the arm portion to the wrist and add a zipper for ease of donning (Figure 2). The patient has significant biceps atrophy and extending the arm portion to the wrist would provide greater support to the involved limb (Figure 3).

CASE

S01 is a 16-year-old boy with OBPP of his left arm secondary to a traction injury during the delivery process. This resulted in a C5, C6, and C7 avulsion of the cervical nerves. He required a nerve transfer procedures, commonly performed for repair of severe brachial plexus injury at the age of 6 months. At the age of 8 years, S01 had a Steindler Flexorplasty surgery to restore elbow flexion. In this procedure, the origin of the flexor-pronator mass was moved proximally onto the humeral shaft.

Presently, S01 works on a strengthening program to improve his core stability and strength of his trunk, with greater control of his abdominal obliques and scapula stabilizers. His left shoulder is in a forward position, and passive range of motion of his left upper limb is within normal limits.

He presents with limited shoulder girdle and humeral mobility. Using a manual muscle test rating of 1 = trace, 2 = poor, 3 = fair, 4 = good, and 5 = normal, his upper trapezius 4/5, middle and lower trapezius 2/5, rhomboid 2/6, serratus anterior 2/5, anterior, middle, and posterior deltoid muscle was a 1/5, pectoralis major and minor 2/5, external rotators 1/5, internal rotator 2/5.

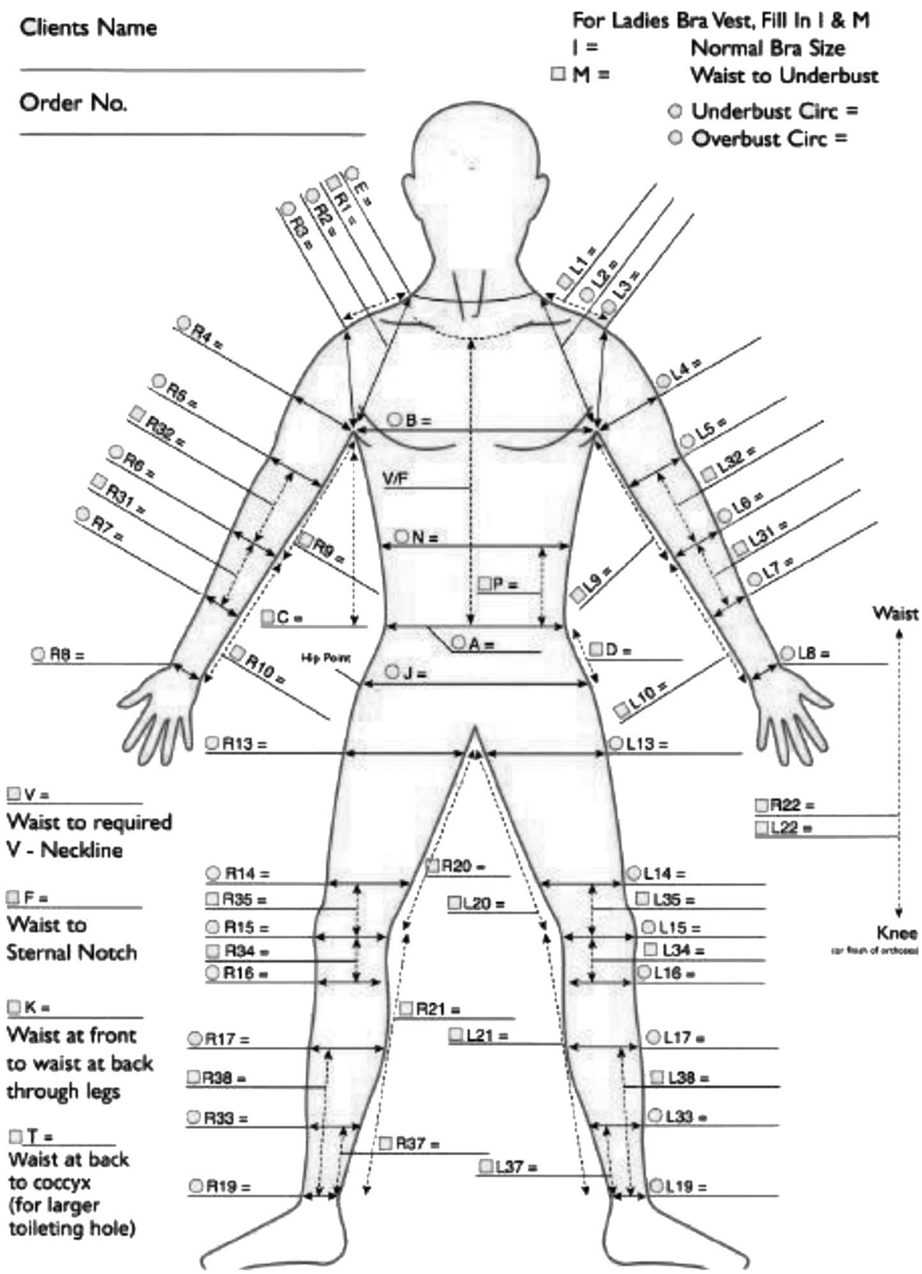

Figure 1. Dynamic Movement Orthosis measurement form.

S01 is able to actively abduct his arm to 30° against gravity, although most of his attempted movement to lift his arm is accomplished through compensating by lower back extensors. He demonstrates active triceps 3/5, and biceps 3/5, although was unable to take resistance. His wrist strength into extension 3/5 and flexion 4/5, and hand scored 4/5. He demonstrates functional use of his hand but limited control of his shoulder because of his 0/5–1/5 shoulder girdle strength.

S01 is a very active tennis player and stated that he typically let his left arm hang while playing the game. He uses trunk momentum to fling his left arm to throw the tennis ball in the air and hit the ball with the racket using his uninvolved right arm. The DMO shoulder support was discussed as a bracing option because it would maintain the integrity of the shoulder girdle and support the humerus and distal arm during functional use.

MEASURES

Data Collection and Instruments

The Wolf Motor Function Test (WMFT) is an evaluation that has been designed for stroke rehabilitation studies. It was originally developed to determine the time required for patients with stroke to perform everyday tasks with the involved upper limb. Changes in time and strength to perform

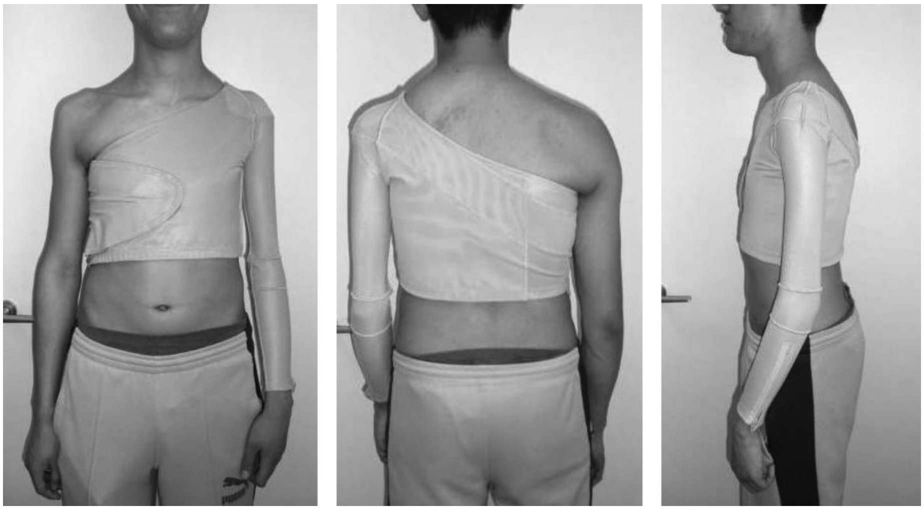

Figure 2. Subject wearing the Dynamic Movement Orthosis.

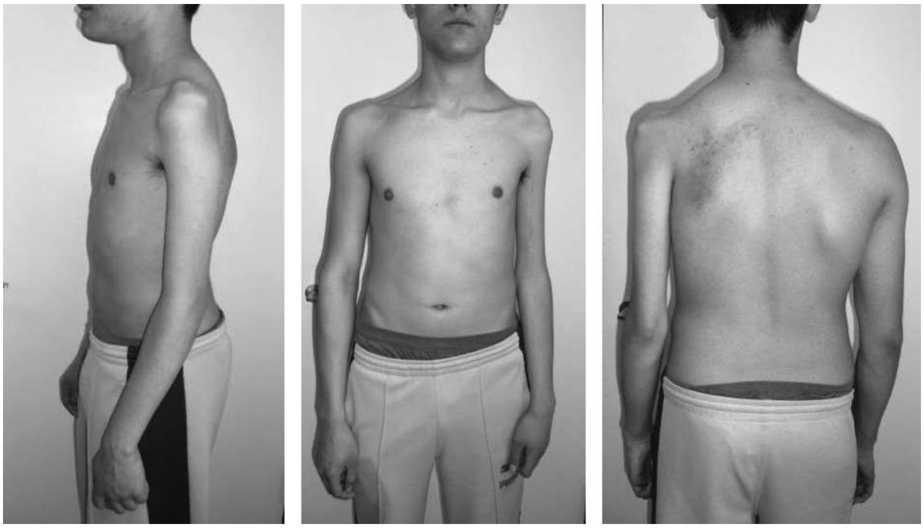

Figure 3. Subject with left upper limb involvement.

tasks may be assessed comparing scores following therapeutic interventions. Although the WMFT was targeted for patients with stroke, it is a test that can be applied to OBPP with varying upper limb movement abilities. The WMFT is a time-based instrument to evaluate upper limb performance with interrater reliability and validity.[8,9] The subject was given the WMFT with no DMO brace on. The WMFT contains 17 tasks (2 strength based, measured by weight lifted and grip, and 15 function based, measured using time to completion). Examples of function-based items included lifting forearm from lap to table, hand from lap to table, lift pencil, flip cards, fold towel, etc. The subject was given 14 of 17 items; 3 items were omitted because of inability to perform the task. In the WMFT, if the examiner feels that the patient cannot possibly complete the task, they can terminate the task performance. The times to be recorded would be 120+ seconds. Note three items were removed from the test, as well as including the 120+ seconds.

Grip strength was measured with a dynamometer. The dynamometer used was a standard, adjustable-handle Jamar dynamometer. Standardized positioning of elbow at 90°, forearm neutral, was used for hand strength measurement. The average of three trials with and without the brace was compared. Usually, grip strength for a child with OBPP would be compared with the uninvolved side to determine involvement. In this case, comparison was made on the same side with and without the DMO to evaluate changes in the time and strength to perform tasks.

Hand to nose touching was timed. The hand was initially positioned by side of body and brought to nose and repeated five times was given at the end. Again, this would normally be compared with the uninvolved side but, for the purpose of the study, was assessed with and without the DMO.

The subject was given a 30-minute break before donning the DMO shoulder orthosis, and the WMFT was repeated, as well as measurement of grip strength and the timed hand to nose task.

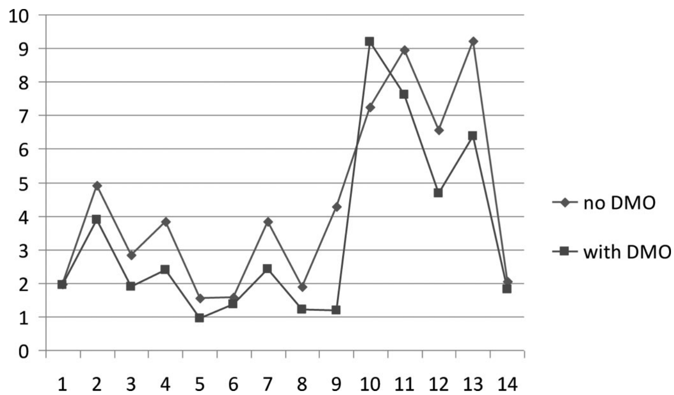

Figure 4. Wolf Motor Function Test 1 to 14 items, performance in seconds 0 to 10.

RESULTS

Thirteen of the 14 timed tasks from the WMFT showed improved speed while wearing the DMO, total 61 seconds with no brace versus 47 seconds while wearing the DMO (Figure 4). In item 10, stacking checkers, there was a 2-second difference with speed without the DMO. However, in total, there was a 14-second difference in speed while wearing the DMO, which is a 23% improvement. Comparing strength using the dynamometer, with no brace he scored 47.5 lb and with the DMO brace he scored 50 lb; there was 2.5-lb increase while wearing the DMO. An additional timed test, hand to nose, was given with results of 6 seconds with no brace and 5 seconds while wearing the DMO, a 1-second difference in speed.

DISCUSSION

The findings from this case study may support the functional status of the involved arm as measured by the WMFT, dynamometer, and timed task improved following the application of the DMO. The 1-second increase in hand to nose represents a 2% decrease in time, which may or may not affect function depending on the task. The subject reported ease in donning and doffing the DMO independently, and the feeling of a "lighter arm," and ease of using his supported involved arm. The proprioceptive input provided by the compression of the DMO resulted in the subject feeling stable, with a greater compliance of daily wear.

For a child with OBPP, weakness and muscle imbalance often occur in the involved shoulder girdle. Careful clinical assessment of all the muscles about the shoulder girdle is recommended before the decision of the type of paneling for the DMO, as well as improvement in postural alignment. The ability to hold the humeral shaft for support by providing a longer sleeve to the forearm and the use of the zipper for closure may be an important feature of the design for a consistent snug fit.

The WMFT evaluates the ability of the involved arm to function during timed task performance and provides detailed information regarding the subject's ability and disability. It seemed to be adequately sensitive to document the change associated with wearing of the DMO. The items of the WMFT were applicable to the population for whom it was developed, but it also seems to be a valid measurement tool for children with muscle weakness from OBPP. Thus, the WMFT may have a wider application than to the population of adult stroke, a hypothesis that will require empirical testing. This assessment seems to provide the sensitivity to measure change, particularly for children with muscle weakness of the shoulder girdle, and improvement may be very subtle.

The WMFT, grip strength, and timed hand to nose test were able to detect the subtle changes in upper limb control, speed, and strength while wearing or not wearing the DMO. Although this case study demonstrated an association between the wearing and not wearing the DMO, additional studies are required to measure outcome of the DMO with a larger population.

LIMITATIONS

This study found positive effects of the shoulder DMO for a person with obstetric brachial plexus injury. It enabled us to examine the effects of a specially designed garment for a person with shoulder subluxation. S01 appeared to demonstrate greater use of his left arm and described the comfort and stability he felt while wearing the garment. However, the generalizability of the results is limited because this is only a single case study. Additional studies involving a larger group of subjects are needed to determine the effectiveness of the DMO for children with OBPP with shoulder weakness and subluxation. Future studies, possibly through radiographs, should assess the position of the humerus in relation to the glenoid fossa, with and without the DMO, to determine whether the DMO assists in supporting the humerus in better alignment and measuring how this affects function. Surface electromyography of distal musculature, including the deltoid, biceps, and wrist extensors, with and without the DMO, would give information concerning the effects of proximal stability on distal control for strength and function. There are limited shoulder orthoses that provide the stability and more individually fitted devices are needed for this population.

SUMMARY

Shoulder weakness is a common problem for children with OBPP. The inability to stabilize the shoulder to promote function for activities of daily living and leisure time skills can be debilitating. The DMO with the shoulder panels to support and align the shoulder girdle, and the long sleeve with the zipper closure at the forearm, seemed to provide shoulder stability and improved distal control during a functional task.

An important factor to consider in the decision to provide a patient with a custom-fit DMO is the compliance with the patient and family and preference of wear. The DMO fabric promotes greater compliance with daily wear, because it is thin and breathable. The use of the DMO can be key for participation in activities of daily living or leisure activities in patients with OBPP and should be considered by therapists.

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