CLINICAL NOTE

Conservative Treatment of Neuromuscular Scoliosis in Adult Tetraplegia: A Case Report

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Abstract

We report successful correction of new onset neuromuscular scoliosis without spinal surgery in a man who is 30-years post-American Spinal Injury Association Impairment Scale grade A C6 injury with new onset of left neuromuscular scoliosis (Cobb angle 45°) after a motor vehicle collision. Interventions included nightly low-load prolonged stretching (LLPS) (4h left side lying over bolster), a series of 6 botulinum toxin injections (BTIs) at 3-month intervals, and progressive seating adjustments to counteract the spinal curvature. Monthly seating adjustments included rear quadrant wedging, lateral supports, and hip blocking to promote erect and symmetrical posture. A normative Cobb angle (5°) was achieved after 8 months of treatment. Improvements in alignment were demonstrated in physical examination outcome measures at the final session and follow-up. LLPS, seating adjustments, and paraspinal BTI are nonsurgical options for treating neuromuscular scoliosis in adults with tetraplegia. Further studies are necessary to determine optimum protocols and examine generalizability of these treatment methods.

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Neuromuscular scoliosis is a common secondary complication after spinal cord injury (SCI) occurring because of muscle imbalances that can eventually lead to complications, including chronic pain, pulmonary insufficiency, and reduced lung capacity.1 In many cases, surgical intervention can correct neuromuscular scoliosis before dangerous side effects occur. Although improvements in surgical technique have been able to decrease the invasiveness of corrective procedures, research has shown that surgical correction is still associated with major complications, including reduced mobility,2,3 a significant concern for the SCI population.

Currently, there is a lack of research into nonsurgical methods to correct neuromuscular scoliosis and address muscle imbalances for people with SCI. Recent research into low-load prolonged stretching (LLPS) through use of night splinting and serial casting has shown improved muscle length and reduced spasticity for people with traumatic brain injuries, stroke, and cerebral palsy.4,5 Success with other upper motor neuron injuries suggests that LLPS will also improve muscle length and reduce spasticity for people with SCI. Therefore, it is plausible to suggest that LLPS targeted at the shortened soft tissue will lead to improved symmetry and reduction of postural deformation.

Neuromuscular scoliosis occurs in the presence of asymmetrical tone of the paraspinal and lateral trunk musculature. The condition is frequently compounded by gravity. Functional scoliosis is the result of the force of gravity working on unsupported structures when gravity creates a lateral trunk flexion moment. Corrective seating may be used to stop progression of functional scoliosis. Posture studies support the use of the wheelchair and seating system as an orthotic device to encourage proper posture, reduce the risk of scoliosis, and enhance posture recovery in patients with SCI.5,9 Corrective seating strives to promote optimum posture by correcting flexible deformities instead of accommodating them. Research has shown favorable results for use of botulinum toxin injections (BTIs) to augment the effectiveness of LLPS.6,7 Additionally, BTIs have shown beneficial reductions in spasticity and improvement in daily functioning for people with SCI.10 Current research demonstrates reductions in contractures of isolated muscle groups (eg, wrist flexors, extensors, intrinsic muscles of the hand).11 These findings indicate that BTIs may also have success in larger, postural muscles.


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Case description

The purpose of this case report is to describe the successful correction of neuromuscular scoliosis with nonsurgical intervention using LLPS, a series of paraspinal BTIs, and progressive seating changes in an adult with C6 tetraplegia. The subject of this case report was a 48-year-old man with tetraplegia (American Spinal Injury Association Impairment Scale grade A C6 injury) of 30 years secondary to a diving accident. Onset of asymmetrical truncal hypertonicity occurred in late summer 2009 after a motor vehicle collision (MVC). At the time of the MVC, the subject was cleared of spinal injury and other fracture by magnetic resonance imaging and radiograph. The subject began to note asymmetrical tone and deteriorating posture and function, with a perception of significant seated instability and side bend to the right. A seating specialist was consulted in January of 2010; the specialist recommended a stretching program and parameters for seating system adjustment and provided a temporary modification to seating. The subject reported poor compliance for both the stretching program and seating changes. Left neuromuscular scoliosis was confirmed with a Cobb angle of 28° in June 2010. The subject then sought a custom seating system fabrication and passive stretching at outpatient physical therapy services. The Cobb angle was measured at 45° in August 2010 (fig 1), and spinal surgery was recommended for stabilization. At this time the client returned to the seating specialist initially consulted in January and requested to be followed directly by this therapist. New seating adjustments and a strict stretching protocol were prescribed beginning in September 2010 with monthly appointments for physical measurements and seating assessment. The specialist prescribed LLPS and wheelchair seating changes, and referred the subject for a series of BTIs to his lumbar paraspinal muscles. The subject recovered normative spinal alignment by May 2011. This research was approved by the institutional review board (PT1112-001). Consent was received from the subject.

Two authors independently and retrospectively reviewed the subject’s medical and physical therapy records. Data extracted included physical measurements, specific seating system adjustments, postural assessment, and radiographic and photographic measurements. We compared extraction forms to ensure completeness of all data and developed a single spreadsheet to reference for data analysis. Disputes were settled with a collaborative chart review when necessary. We used notable changes in measures and graphic analysis to determine effectiveness of the specific interventions.

The client had acquired a custom fabricated seat and back system between initial consultation with the seating specialist and September 2010, when the seating specialist took charge of the intervention plan. The specialist initially attempted to work with this system but determined it was perpetuating the malalignment, and the system was discarded in favor of corrective interventions. Seating changes, intended to correct the flexible functional scoliotic curvature and accommodate inflexible deformity, consisted of alterations of wedging, lateral support, hip blocking, and seat cushion changes. Corrective seating was progressively reduced as the physical examination findings changed secondary to interventions. Wedging initially consisted of a 25.4-cm piece of full height base wedge in the left rear quadrant (fig 2). The wedge was thinned as physical measurements changed indicating resolving pelvic obliquity. Lateral support was configured to counteract spinal curvature using 3 points of control consisting of each lateral and a hip block as the control points (see fig 2). The right lateral support was removed prior to final measurement because the subject was able to maintain desired posture without input from the right lateral.

The LLPS program initially consisted of nightly side lying over a 3.8-cm diameter half-roll foam bolster for 4 hours per night and prone lying as tolerated. The bolster was positioned under the subject’s left side between the ribs and pelvis. The bolster was progressed in diameter to 10.2cm as tolerated by the subject. A series of 6 BTI sessions were performed by a physician at intervals of approximately 3 months between initial and follow-up sessions with the seating specialist (fig 3). Each session consisted of 4 injections of 25 units to the lumbar paraspinal muscles of the concave side. One session included 1 injection of 25 units to the convex side of the curvature.

Physical measurements were recorded at each physical therapy appointment, approximately every month. Initial measurements were taken at the seating consultation. Final measurements were taken 8 months later when radiographs showed normative spinal curvature. Follow-up measurements were taken during 3 additional sessions, with the final follow-up measurement taken 7 months after normative spinal curvature was established (15mo after initiation of treatment). Frontal plane spinal curvature was estimated using 2 measures: angle between the plane of the anterior superior iliac spine (ASIS) to the bisection of the sternum.

List of abbreviations:

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<tr>
<td>ASIS</td>
<td>Anterior superior iliac spine</td>
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<td>BTI</td>
<td>Botulinum toxin injection</td>
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<td>LLPS</td>
<td>Low-load prolonged stretching</td>
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<td>MVC</td>
<td>Motor vehicle collision</td>
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<td>SCI</td>
<td>Spinal cord injury</td>
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Fig 1  (A) Cobb angle of 45° (August 8, 2010); (B) normative spinal curvature (May 2011).
Fig 2  (A) Use of the left side wedge in the left rear quadrant with the right hip block to prevent slipping to the right. (B) Arrows indicate the 3 points of control. Upper 2 arrows represent the location of lateral support, whereas the lowest arrow represents the location of hip block support.

and the ASIS to rib height. The ASIS to sternum angle was measured with a goniometer with the fulcrum and stationary arm placed on a line between the right and left ASIS with the moving arm aligned parallel to the sternum and the subject in a supine position. Spinal alignment for this measure is considered 0° when the sternum is perpendicular to a line between the bilateral ASIS. This measure has not been validated. The goniometer has a SE of measurement of ±4°. The ASIS to rib height measured the distance in centimeters from the ASIS to the inferior border of the directly superior rib with the subject in a supine position. Normative alignment for this measure consists of equal results bilaterally. This measure has not been validated. Transverse plane orientation was measured by supine ASIS vertical height and supine acromion vertical height. Measurements were taken with a ruler. Normative alignment for these measures consists of equal results bilaterally. This measure has not been validated. Cobb angle measurements taken by radiologists were extracted from the subject’s medical record. These measures were taken 1 month prior to treatment initiation and 9 months later, near the final measurement. The Cobb angle assessment on radiographs has an SE of measurement of 5°.13

Eight months after initiation of LLPS, progressive seating changes, and a series of paraspinal BTIs, the subject achieved a normative Cobb angle indicating resolved neuromuscular and functional scoliosis (see fig 1). From initial to final measurements, notable improvements occurred in the ASIS to sternum angle (15° to 7°), side-to-side symmetry with rib to ASIS height (difference side to side decreased from 5.1–1.9 cm), and symmetry of supine ASIS vertical height (difference side to side decreased from 2.5–6 cm), shown in figure 3. No notable changes were detected in supine acromion vertical height. At follow-up, continued improvement was noted in the ASIS to sternum angle (7° to 2°). Improvements were maintained in the ASIS to rib height. An increased side-to-side difference was noted in the supine ASIS vertical height involving a reversal of the transverse plane asymmetry; therefore, the left ASIS was forward of the right (see fig 3). No clinically meaningful side-to-side differences were noted for the ASIS to rib height (fig 3) or supine acromion vertical height.

Discussion
Seating changes that corresponded to improvements in physical measurements were initiating 3 points of control with lateral supports11 and hip controls, application of wedging to the lower
side of the pelvis, and rejection of custom-molded seating. The interventions of this case were intended to stop progression of functional spinal scoliosis, reverse soft tissue shortening contributing to neuromuscular scoliosis, and remove seating supports with the return of the subject's ability to maintain neutral alignment. Over the course of treatment, the subject was able to return to normative spinal alignment. Because all 3 interventions were used simultaneously, it is not clear which intervention made the largest contribution to the success of this case. However, we are able to make some inferences based on the curve of the graphs. For instance, there was a large drop in the ASIS to sternum angle between the second and third sessions (see fig 3). Two interventions occurred between these sessions. First, seating was adjusted to add laterals as 3 points of control countering the curve to impede progression of scoliosis. Second, the subject received the first BTI. This injection was performed 4 days prior to measurement. The latency period for BTI is 4 to 6 days, therefore, its contribution to the change may be limited. Furthermore, there were no large drops after subsequent injections suggesting that the BTI did not have a large contribution to the initial drop in the ASIS to sternum angle. This lack of change suggests a notable contribution of noncontractile soft tissue shortening, which would be unaffected by BTI. Therefore, it is presumed that initiation of laterals as 3 points of control had the largest impact on the early change in the ASIS to sternum angle by halting the gravity-driven progression of functional scoliosis. However, the continuous use of LLPS likely also contributed to the gradual improvement in symmetry and positioning. LLPS was used to counterclock soft tissue shortening on the concave side of curvature and reverse asymmetrical forces on the spine. Nightly stretching likely increased soft tissue extensibility and length. Botulinum toxin likely enhanced the stretching by decreasing resting tone at the neuromuscular junction. Progression of lateralized took advantage of the new tissue extensibility supporting the subject in best posture, reducing the torque gravity was able to apply to the spine. Therefore, we propose that the 3 components acted to complement each other: botulinum toxin releases spastic muscle tissue, nightly stretching increases tissue range, and progressive seating uses new range in functional activities, maintaining the postural gains and tissue length.

Supine ASIS vertical height and supine acromion vertical height monitored progress of trunk symmetry in the transverse plane. Supine acromion height varied little. Supine ASIS height initially had a large side-to-side difference, with the right higher than the left. This is consistent with expectations for the left thoracolumbar curve. From initial measurement to final measurement, this difference decreased to only .64cm, demonstrating good side-to-side symmetry. Interestingly, between the final and follow-up measurements, the subject developed a reversal of asymmetry; therefore, the left was higher than the right by .254cm. This could be because of decreased right paraspinous muscle tone secondary to BTI.

A major concept of the intervention in this case is to accommodate fixed deformities while correcting flexible deformities using the wheelchair as an orthosis as established by Hastings. A flexible functional deformity occurs when gravity creates a lateral flexion force caused by the head or upper body being out of alignment with the base of support and unsupported. In this instance, support can directly reverse deformity. A fixed deformity is one in which bony changes have occurred, is unlikely to be reversed, and must therefore be accommodated. An inflexible deformity may be held by asymmetrical tone and/or soft tissue shortening and must initially be accommodated. This deformity occurs because of changes in soft tissue and can be reversed with proper attention. In this particular case, the subject's scoliosis was an inflexible deformity caused by soft tissue contracture compounded by gravity-induced functional scoliosis. It is hypothesized that the source of soft tissue shortening was asymmetrical tone in response to an unidentified noxious stimulus secondary to the MVC. The inflexible soft tissue asymmetry had to be addressed before correction of the functional malalignment could occur.

Study limitations

The main limitations of this study are that it is a single subject case review with limited generalizability to a larger population. The individual interventions also overlapped; therefore, it is not clear which specific intervention exactly observed changes. Another limitation is that the subject occasionally made small adjustments to the seating setup, which were confirmed or rejected by the seating specialist at subsequent appointments.

Conclusions

The results of this case report imply that neuromuscular scoliosis can be corrected through individualized conservative interventions. Further implications are that the seating system can be used as an orthosis to reverse negative postural changes, particularly by reducing the asymmetrical influence of gravity in functional scoliosis. Careful physical measurements should be used to direct seating adjustments, and measurements should address all 3 planes (sagittal, frontal, transverse). Further research is needed in conservative treatment of scoliosis.

Keywords

Botulinum toxins; Rehabilitation; Scoliosis; Spinal cord injuries; Wheelchairs

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