Functional Variations in Thoracic Suspension Orthosis Design

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The thoracic suspension orthosis (TSO), developed at Newington Children’s Hospital in Newington, Connecticut, is an alternative total contact thoraco-lumbo-sacral orthosis (TLSO) used for control of progressive spinal deformities in patients who are poor candidates for traditional spinal orthoses and/or surgery. Based on experience accumulated at Newington Children’s Hospital and other facilities, indications and contraindications for the device’s use have been clearly outlined and the biomechanical mechanisms have been validated. Along with the prescription criteria, the fabrication process has been specifically delineated in the literature and is stringently adhered to in practice.

Contraindications leading to failure of the TSO are uncooperative patient or family, hip joint stiffness with inability to sit, severe athetoid cerebral palsy, gross obesity, and cachexia. Failure to control the initial break-in schedule has also been shown to be a reason for failure. Based on the success or failure of early trials with the thoracic suspension orthosis, the criteria for usage as well as the steps for achieving success with a thoracic suspension patient have been well established. Unfortunately, the presupposition that the orthosis can only achieve success if the fabrication and application of the device conform precisely to the established biomechanical principles, has given rise to a pattern of stereotypical usage.

The variety of secondary complications seen in myelodysplasia and neuromuscular patients (bony defects, gibbouses, paradoxical breathing patterns, older patients difficult for caretakers to handle due to their size and weight, etc.) can and often do affect the final outcome of the use of a thoracic suspension orthosis. In application of traditional spinal orthoses, these complications are taken into consideration when determining the functional design of the orthosis to be used. When a patient is being evaluated for a thoracic suspension orthosis these same complications must be considered and the thoracic suspension orthosis should likewise be modified as needed within the framework of the biomechanical principles to accommodate the individual needs of the patient.

Using the above mentioned hypothesis, as patients are evaluated for candidacy for thoracic suspension orthoses, a careful look is
taken to determine the most functional design for the individual patient and whether the optimal design is compatible with the principles of thoracic suspension. The following examples illustrate the evaluation process and the resulting design choice in each case.

**CASE 1**

This patient is a 3½ year old girl with an L-2 level myelomeningocele, multiple hemi-vertebrae at T10,11,12, slight scoliosis and a thoracolumbar kyphosis of 60 degrees. On observation, the girl sat in a kyphotic posture and used both upper extremities to maintain sitting balance. She was evaluated in clinic for a spinal orthosis to limit progression of her spinal deformity so surgical intervention could be delayed due to her age. The child appeared to be an excellent candidate for a thoracic suspension orthosis. A TSO was considered appropriate rather than a more conventional spinal orthosis due to the severe collapsing nature of her spinal deformity and the fact that she had to use her hands to maintain sitting balance. On examination she had no secondary deformities affecting the design of the TSO. Skin integrity at the level of the spinal bifida defect was excellent (Figure 1).

A single anterior opening TSO was fabricated for this child. The initial break-in period went well and the child subsequently wore the TSO at home and school. By the school’s request, an extra set of suspension brackets were provided for attachment to the school commode (Figure 2).

**CASE 2**

This patient is a nine year old female with myelodysplasia, complete paraplegia with lumbar kyphosis (Figure 3). X-rays revealed a hemivertebrae at L-2 and a spinal angulation of 90 degrees at the L-3 level. The patient has had chronic skin decubiti over her lower back. Modified wheelchair trunk cushions had proven inadequate to prevent recurrent breakdowns. The patient was flexible and the kyphosis reduced partially with distraction. She was chosen as a candidate for a thoracic suspension jacket. At the time of evaluation, the open areas on her back were too many to permit casting. She was sent home for three weeks for
prone positioning to allow the skin over her lower back to heal.

The involved area of the bony defect and kyphosis covered the majority of her lower back. Because skin integrity was so poor, it was felt the entire area would require relief build-ups on the positive plaster model. There was concern that the necessary reliefs would compromise the overall fit of the body jacket. To avoid compromising fit in order to provide sufficient pressure relief, we chose to use a posterior opening orthosis instead of the standard anterior opening design. The width of the posterior opening was increased in the area of the kyphosis, with the plastic shell being trimmed wider and the soft plastazote lining being left in place to prevent any edge pressure (Figure 4).
CASE 3

Optimal placement of closure straps included a strap crossing the area of the kyphosis. To ensure adequate circumferential containment, while still avoiding any pressure contact to the bony defect from the closure strap, an aluminum bar was contoured and placed inside the strap (Figure 5).

This patient is a twenty year old male with Duchennes Muscular Dystrophy who presented a 70 degree progressing C-curve scoliosis and accompanying loss of sitting balance and head control (Figure 6). This patient was still able to operate his electric wheelchair, however, he had sufficient upper extremity weakness to prevent activities of daily living. On evaluation for a thoracic suspension orthosis, he exhibited no precluding medical complications. In spite of his age and degree of involvement, and though he had a reduced vital capacity, he was still a chest breather and had some flexibility in his spine. It was felt that rejection of the standard style orthosis would occur due to his sheer mass and the difficulty attendants would have in applying and removing the orthosis. It was decided that a single attendant would be unable to satisfactorily apply an anterior opening orthosis. A bivalved design was felt to be the only realistic method of donning the orthosis, much less ensuring accurate positioning of the costal margin undercut (Figure 7).

During the initial in-hospital break-in period, it became apparent that though the patient

Figure 6. Twenty year old male with Duchennes Muscular Dystrophy and a 70 degree C curve. Patient has problems with sitting balance and loss of head control.

Figure 7. Patient in TSO with regained sitting tolerance and voluntary but weak head control.

Figure 8. Lateral posterior view of patient in suspension showing simple head rest.
could achieve head control when in the orthosis, he readily fatigued, losing his head balance and was unable to regain it. A simple, removable head support was attached to the posterior shell of the jacket. The support was held in place by a screw in the aluminum upright which rested in a groove in the bracket attached to the posterior half-shell when the upright was slipped through the bracket. This arrangement permitted consistent height placement of the head support, but allowed a small amount of pivoting to take place (Figure 8) so that the head support would move with the patient.

While in the hospital, the patient was evaluated by an occupational therapist and was provided with a balanced forearm orthosis which enabled him to feed himself. At discharge, the patient was tolerating two hours of uninterrupted suspension.

At his three week follow-up clinic appointment, the patient reported tolerating suspension for five hours in the morning, then coming out of suspension for the afternoon and returning to the suspended position for the evening meal. Due to his size, his mother was unable to place him back in suspension in the afternoon, so he remained in the orthosis unsuspended until his father returned home from work. X-rays in the orthosis revealed a reduction in his curve at 48 degrees.

CASE 4

This patient is a five year old male with Werding-Hoffmann Type II spinal muscle atrophy. The child was presented in clinic with a Mulholland chair with scoliosis pads, shoulder supports and head support (Figure 9). The patient had a rapidly progressing C-curve scoliosis which had progressed 51 degrees over a ten month period. X-rays showed a curve of 72 degrees while sitting in the Mulholland chair. Since it was felt that the Mulholland scoliosis pads had not been useful on deterring the progression of his curve, he was evaluated for a thoracic suspension orthosis.

On evaluation, the patient was noted to be emaciated and exhibited a typical christmas tree deformity of the thorax. He was a complete paradoxical breather. He lacked head control while sitting in his chair. His hypotonia was advanced and included total body involvement and he had elbow and knee flexion contrac-

Figure 9. Five year old child with spinal muscle atrophy and a 72 degree scoliosis seated in a Mulholland chair with scoliosis pads.

tures. It was felt that a bivalved orthosis would offer the easiest donning and would provide quick visual assessment of the skin for this fragile appearing child. A large abdominal opening was made in the anterior shell to allow for his paradoxical breathing.

The child tolerated the initial break-in period quite well. Parents found the bivalved jacket design easy to handle. X-rays taken in suspension revealed reduction of his 72 degree curve to 25 degrees. He no longer used the head support, but the head rest was left in place to provide him with the option of using it to rest and to prevent excessive hyperextension of the neck during transportation and wheelchair use over uneven terrain (Figures 10, 11, and 12).

CONCLUSION

The TSO provides an alternative to traditional spinal orthoses for the management of difficult spinal deformities. Variation of the
orthosis design can be successfully accomplished within the framework of the biomechanical principles of thoracic suspension. Thorough evaluation of the patient for appropriateness as a candidate is mandatory. Once the candidacy has been established, the orthotist can build upon this foundation with his knowledge of orthosis design principles to provide the optimum TSO design for the patient.

REFERENCES


AUTHORS

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