# Balanced Cranial Suspension for Intraoperative Correction of Cervical Kyphosis

[1]Michael T. Talerico, MD
[2]Venus Vakhshori, BS, BA
[1]Andrew H. Milby, MD
[1]Adam T. Griska, MD
[1]Harvey E. Smith, MD
[1]Vincent M. Arlet, MD

[1]Department of Orthopaedic Surgery, University of Pennsylvania, Philadelphia, PA

[2]Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

## Introduction

Cervical spinal deformity may result in significant neurologic and physical impairment, either in the form of pain, myelopathic symptoms, or chin-on-chest deformity. The relative intolerance of the cervical spinal cord to manipulation renders any correction of cervical spinal alignment inherently dangerous. As such, any reduction or correction maneuvers must be performed in as gradual and controlled a manner as is possible. Classically, posterior correction of cervical spinal deformity relies upon the use of osteotomies and instrumentation to maintain correction. It is often necessary to have a member of the surgical team manipulate the Mayfield headrest in order to achieve the desired correction once osteotomies have been performed. We present a technique that may be of use in the correction of cervical spinal deformity to decrease the risk of intraoperative neurologic injury. Herein we describe the application and potential benefits of balanced cranial suspension via halo traction in cases of cervical kyphotic deformity correction.

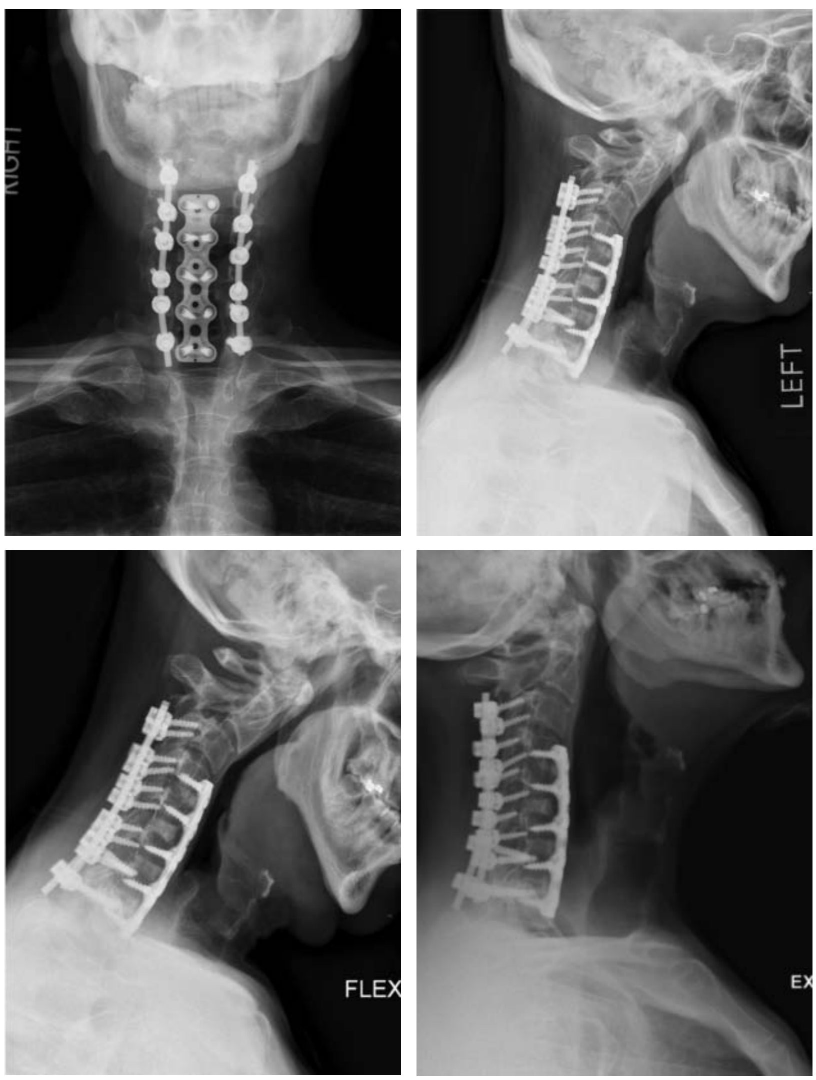


**Figure 1.** Antero-posterior and lateral plain radiographs in neutral, flexion, and extension of the cervical spine of a 41 year-old male who presented with severe axial neck pain and the inability to hold his head upright. The patient had previously undergone anterior-posterior cervical fusion for cervical spondylotic myelopathy. Prior surgery involved extensive laminectomy cranially to C3 with disruption of the posterior ligaments at C2-3. Junctional kyphosis with anterolisthesis of C2 on C3 is present cranial to the prior fusion construct.

**Corresponding author:**
Vincent M. Arlet, MD
Director, Penn Orthopaedic Spine Center
Professor of Orthopaedic Surgery
University of Pennsylvania
3400 Spruce Street,
2 Silverstein Pavilion
Philadelphia, PA 19104
vincent.arlet@uphs.upenn.edu

## Indications

Cervical kyphosis may be the result of a number of etiologic factors. Fixed chin-on-chest deformities may be seen with progressive ankylosing spondylitis, resulting in an inability to maintain horizontal gaze and significant impairment of activities of daily living.[1,2] Relatively inflexible kyphosis may also be seen with advanced spondylosis, ossification of the posterior longitudinal ligament, or disseminated idiopathic skeletal hyperostosis.[3] Flexible deformity is more likely in the setting of systemic myopathy, either primary or secondary to other systemic processes or medication toxicities, and may be associated with position-sensitive neurologic symptoms.[4] Another important cause of progressive, flexible deformity is injury to the posterior ligamentous complex, either from prior trauma, or iatrogenic following cervical laminectomy without stabilization.[5-9] While progressive kyphosis may eventually result in myelopathy due to anterior cord compression, patients may also complain of neck pain, the inability to hold their head up, dysphagia, arm pain, or low back pain secondary to compensatory lumbar hyperlordosis. All of these factors must be considered when planning a potential surgical intervention for correction of cervical sagittal alignment.

Intraoperative stabilization of the head and neck must account for factors specific to the patient's pathoanatomy and accommodate for the potential need to reposition during the procedure. Stabilization for posterior cervical spinal procedures is typically achieved via use of a Mayfield headrest. This affords excellent stability of the head and neck during surgery, though intraoperative adjustment often requires that a member of the surgical team adjust the clamp in a non-sterile fashion. The Mayfield headrest also does not accommodate changing patient position due to Trendelenburg or reverse-Trendelenburg adjustments of the operating room table, or even the execution of posterior osteotomies, and may result in inadvertent traction if such adjustments are not properly anticipated. Traction via Gardner-Wells tongs allows for a more consistent level of longitudinal traction regardless of positioning, though at the expense of some rotational and translational stability. In addition, the level of longitudinal traction alone necessary to maintain head position may itself be dangerous for the spinal cord. Following completion of an osteotomy, longitudinal traction alone may induce translation of the cervical spine, and a single traction vector offers somewhat less flexibility with regard to purely translational intraoperative adjustments, if needed. Placement of a circumferential halo frame allows for the attachment of weights at multiple points, resulting in multiple traction and/or suspension vectors. Intraoperative alteration of head position is facilitated by direct manipulation of the head through halo and/or weight adjustments. In addition, gradual and sequential adjustments of the weights are less likely to require a member of the surgical team or to result in sudden position changes that could result in neurologic injury.

**Figure 2.** Axial and lateral photographs demonstrating patient positioning after induction of general anesthesia and halo placement with balanced cranial suspension in place. 15 lbs. of longitudinal traction and 10 lbs. of 45° suspensory traction are present.

## Surgical Technique

General anesthesia is induced by the anesthesia team with consideration given to the need for fiberoptic intubation and intraoperative neuromonitoring, if available. After induction, neuromonitoring leads are placed and baseline signals established prior to positioning. The halo ring is placed in the standard fashion. A minimum of six pins are recommended to achieve sufficient stability for traction placement. Ropes are attached to fixation points along the halo in order to produce the desired traction and suspension vectors. The patient is then positioned in accordance with the planned surgical approach, with special attention paid to perfusion pressure and the stability of neuromonitoring signals during and after positioning. It is useful to place a stockinette or other elastic material across the table below the level of the head to serve as backup restraint in the event of halo or traction failure. For flexible deformities, traction weights may gradually be added at the outset to produce the desired correction. This correction

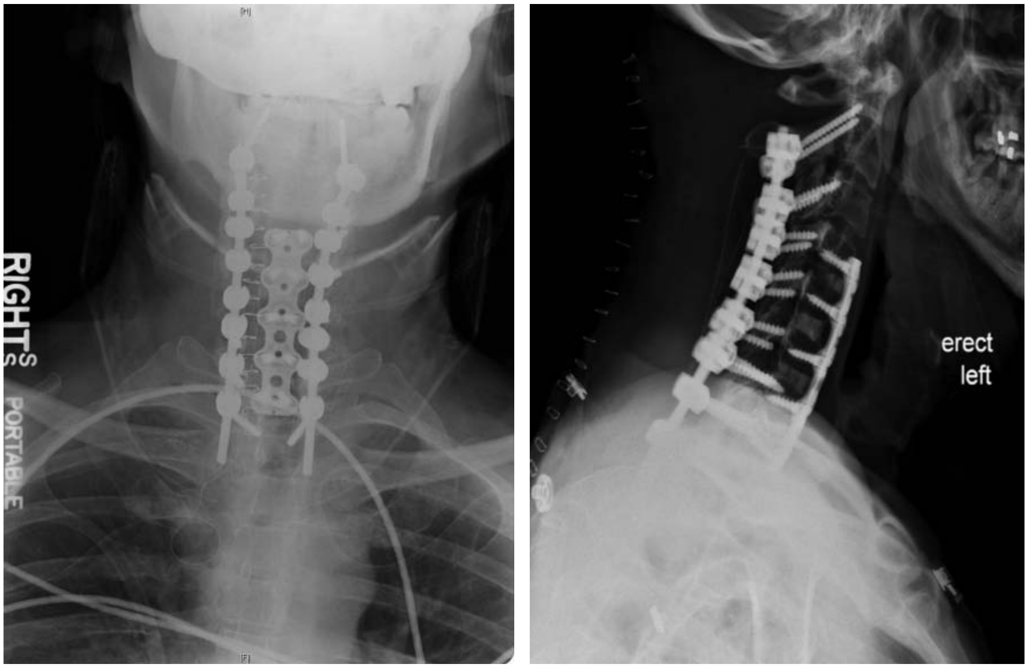


**Figure 3.** Postoperative antero-posterior and lateral plain radiographs following revision posterior decompression with deformity correction via posterior osteotomies at C2-3 and C3-4 and extension of fusion construct with pedicle screw placement at C2, C7-T2 demonstrating restoration of cervical sagittal alignment.

may be verified with C-arm fluoroscopy prior to incision. Fixed deformities or revision surgery may require osteotomy and/or instrumentation removal prior to achievement of correction. In such cases, the traction apparatus may still be used to maintain head position until flexibility is achieved, at which time it functions in a manner similar to that of a counterweight in a sash window allowing for controlled and gentle deformity correction. Prior to performing any reduction maneuver, it is important to perform a thorough decompression of any structures that have the potential to cause impingement once the desired alignment has been achieved.

After deformity correction, the definitive instrumentation may be placed and the fusion bed prepared with the use of either allograft or autograft as indicated. The halo may be left in place until satisfactory alignment and instrumentation placement are radiographically confirmed. The halo is then removed, the pin sites are dressed in the standard fashion, and a cervical orthosis is applied as dictated by the extent of correction and quality of fixation.

## Discussion

Halo traction has an established role in the gradual preoperative correction of flexible spinal deformities prior to and during definitive surgical correction and fusion.[10-13] It is of special importance in cases of poor bone quality or where limited fixation options prevent the use of intraoperative correction maneuvers typically possible with pedicle screw fixation. Halo traction alone has also been successfully employed as definitive treatment of certain flexible cervical spinal deformities, albeit in limited numbers.[14,15]

The use of intraoperative vectored (i.e. non-longitudinal) traction has been previously described by Koreckij *et al* for use in thoracolumbar deformity correction with special attention paid to the optimum traction angle to reduce facial contact pressures during prolonged prone procedures.[16] In their series of 10 patients undergoing adolescent idiopathic scoliosis correction, 15 lbs of traction at an elevation angle of 45° was found to minimize facial contact pressures. As in our reported case (Figures 1-3), halo placement facilitates the combination of multiple traction vectors, allowing for both deformity correction and mitigation of the risks associated with lengthy prone positioning.

## Conclusion

Correction of cervical spinal deformity presents significant treatment challenges. Careful preoperative planning, including patient positioning, neuromonitoring, and thorough preemptive decompression may help reduce the inherent risk of neurologic complications with intraoperative reduction. In addition, halo placement may allow for the use of balanced cranial suspension to assist in deformity correction, reduce the risks of prone positioning, and allow for controlled intraoperative repositioning. Further prospective study is needed to refine the indications for its use relative to other established means of patient positioning for cervical spinal procedures.

## References

1. **Hoh DJ, Khoueir P, Wang MY.** Management of cervical deformity in ankylosing spondylitis. *Neurosurg Focus* 2008;24:E9.

2. **Scheer JK, Tang JA, Smith JS, et al.** Cervical spine alignment, sagittal deformity, and clinical implications: a review. *J Neurosurg Spine* 2013;19:141-59.

3. **Scheer JK, Ames CP, Deviren V.** Assessment and treatment of cervical deformity. *Neurosurg Clin N Am* 2013;24:249-74.

4. **Gerling MC, Bohlman HH.** Dropped head deformity due to cervical myopathy: surgical treatment outcomes and complications spanning twenty years. *Spine* 2008;33:E739-45.

**5. Bell DF, Walker JL, O'Connor G, et al.** Spinal deformity after multiple-level cervical laminectomy in children. *Spine* 1994;19:406-11.

**6. Guigui P, Benoist M, Deburge A.** Spinal deformity and instability after multilevel cervical laminectomy for spondylotic myelopathy. *Spine* 1998;23:440-7.

**7. Deutsch H, Haid RW, Rodts GE, et al.** Postlaminectomy cervical deformity. *Neurosurg Focus* 2003;15: E5.

**8. Hansen-Schwartz JC, Kruse-Larsen C, Nielsen CJ.** Follow-up after cervical laminectomy, with special reference to instability and deformity. *Br J Neurosurg* 2003;17:301-5.

**9. Fassett DR, Clark R, Brockmeyer DL, et al.** Cervical spine deformity associated with resection of spinal cord tumors. *Neurosurg Focus* 2006;20:E2.

**10. Sponseller PD, Takanaga RK, Newton P, et al.** The use of traction in the treatment of severe spinal deformity. *Spine* 2008;33:2305-9.

**11. Takeshita K, Lenke LG, Bridwell KH, et al.** Analysis of patients with nonambulatory neuromuscular scoliosis surgically treated to the pelvis with intraoperative halo-femoral traction. *Spine* 2006;31:2381-5.

**12. Rinella A, Lenke L, Whitaker C, et al.** Perioperative halo-gravity traction in the treatment of severe scoliosis and kyphosis. *Spine* 2005;30:475-82.

**13. Mac-Thiong JM, Labelle H, Poitras B, et al.** The effect of intraoperative traction during posterior spinal instrumentation and fusion for adolescent idiopathic scoliosis. *Spine* 2004;29:1549-54.

**14. Graziano GP, Herzenberg JE, Hensinger RN.** The halo-Ilizarov distraction cast for correction of cervical deformity. Report of six cases. *J Bone Joint Surg Am* 1993;75:996-1003.

**15. Graziano GP, Hensinger R, Patel CK.** The use of traction methods to correct severe cervical deformity in rheumatoid arthritis patients: a report of five cases. *Spine* 2001;26:1076-81.

**16. Koreckij J, Price N, Schwend RM.** Vectored cranial-cervical traction limits facial contact pressure from prone positioning during posterior spinal deformity surgery. *Spine* 2011;36:E993-7.