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GRAND ROUNDS

Correction of dropped head deformity through combined anterior and posterior osteotomies to restore horizontal gaze and improve sagittal alignment

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Abstract

Objective The aim of this study is to present our technique for a large focal correction of a partially flexible dropped head deformity through combined anterior and posterior osteotomies, as well as anterior soft tissue releases.
Methods One patient with dropped head deformity underwent an anterior and posterior osteotomy with anterior soft tissue release.
Results The patient recovered well, with postoperative radiographs demonstrating significant improvement in coronal and sagittal alignment. His C2–C7 sagittal vertical axis improved from 7.5 cm preoperatively to less than 4 cm postoperatively and his C2–C7 sagittal Cobb improved from 35° of kyphosis to 10° of lordosis.
Conclusion In this report, we present our technique for a large focal correction of a partially flexible dropped head deformity through combined anterior and posterior osteotomies and anterior soft tissue releases. These more conservative osteotomies permitted gradual deformity correction and alleviated the need for pedicle subtraction osteotomy. We were able to restore horizontal gaze and improve sagittal malalignment. Although the technique we present here is one of many possible options for managing the deformity, we believe this combined approach is safe and effective and well tolerated by patients.

Keywords Dropped head syndrome · Spine · Cervical spine · Kyphosis · Deformity · Correction · Anterior osteotomy · Posterior osteotomy · Sagittal alignment · Horizontal gaze · Surgical correction · Alignment

Case presentation

This is a 64-year-old male, former smoker and IV drug user now on methadone, with a past medical history of Hepatitis C and diabetes, who presented with worsening neck pain and deformity over several years. He was involved in a motor vehicle accident 30 years prior, during which he sustained multiple injuries including an unknown cervical spine injury. For the past 2 years, he has been unable to lift up his head, causing him to rest his chin on his chest wall. This was particularly debilitating, resulting in difficulty with hygiene and eating, and an inability to maintain horizontal gaze. Given the worsening deformity and difficulty with horizontal gaze, the patient was indicated for surgical correction.

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Diagnostic imaging section

On physical exam, he had a tilted and kyphotic posturing of the cervical spine (Fig. 1). His chin–brow vertical-angle (CBVA) measured approximately 30° (Fig. 2). He was partially able to passively extend his head. There was webbing of the anterior neck suggestive of chronic shortening of the anterior tissues. Neurovascular evaluation was otherwise normal.

Radiographs demonstrated kyphotic alignment with sagittal imbalance (Figs. 3, 4, 5). On the lateral radiograph, kyphotic alignment was noted to be 75° between C4–C6 and 85° between C2–C7, with partial flexibility of the deformity. CT scan demonstrated kyphosis and fusion of C4–C5 (Fig. 6). The angle measurements revealed 65° of kyphosis between the C4–C6 segments in this CT scan. Flexion and extension radiographs and MRI (supine) demonstrated partial flexibility of the deformity, with the C2–C7 kyphotic segment measuring 10° and the C4–C6 segment measuring circa 30° (Fig. 7).

Historical review of the condition, epidemiology, diagnosis, pathology, differential diagnosis

Dropped head syndrome is a rare condition characterized by loss of neck extensor function, eventually resulting in a chin-on-chest deformity. While multiple etiologies are thought to underlie the condition, the exact cause is largely unknown [1–5]. The condition has been associated with various neuromuscular, neurologic, muscular, and

Fig. 1 Preoperative frontal and side view of patient with dropped head deformity

Fig. 2 Chin–brow vertical-angle (CBVA) measuring approximately 30°

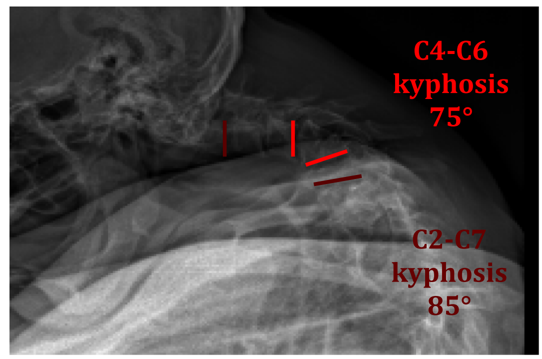

Fig. 3 Standing radiograph demonstrating kyphotic alignment with sagittal imbalance

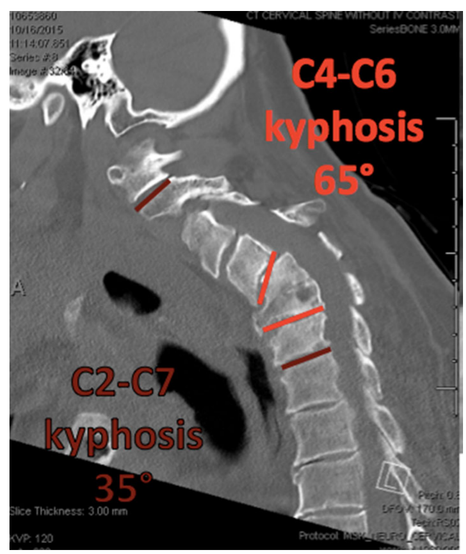

Fig. 4 CT scan demonstrating kyphotic alignment with sagittal imbalance

Fig. 5 Standing full length lateral radiograph demonstrating kyphotic alignment with sagittal imbalance

iatrogenic causes. It is important to rule out these other etiologies and to treat the underlying condition that the patient may be presenting with. As the disease progresses, the ability to maintain neck extension is lost, affecting basic activities related to hygiene, eating, and horizontal gaze.

Diagnosis of dropped head syndrome typically involves various imaging modalities to further classify the degree of deformity. Plain standing radiographs are employed, alongside magnetic resonance imaging (MRI) to evaluate for spinal cord compression. CT scan can also be used to demonstrate the possibility of autofusion of spinal levels [6].

Rationale for treatment and evidence-based literature

Although there is a paucity of literature guiding surgeons on the appropriate surgical management of these patients, when surgery is indicated, there is a trend towards using an all-posterior approach, with an anterior approach reserved for anterior releases or when a flexible deformity is present [6].

The most extensive series to date was reported by Bohlman [7], who reported on nine patients with dropped head syndrome with an average follow-up of 6 years. All were treated with posterior instrumentation and anterior soft tissue release if the deformity did not correct on flexion–extension imaging. The complication rate was

Fig. 6 CT scan demonstrating kyphosis and fusion of C4–C5

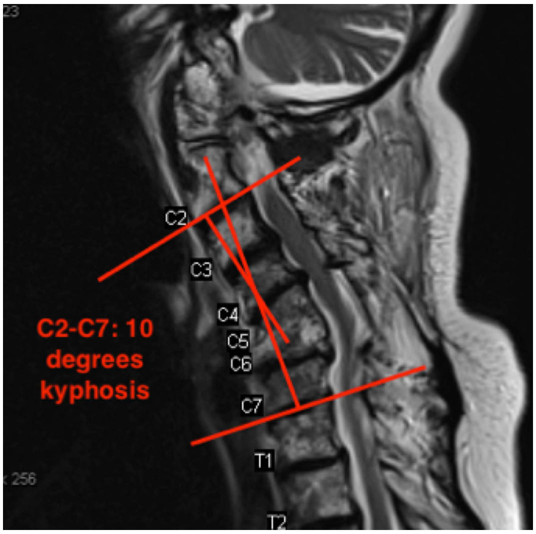

Fig. 7 Flexion and extension radiographs and MRI (supine) demonstrating partial flexibility of the deformity

high, with 6 of the 9 experiencing 11 complications including pneumonia, pneumothorax, pseudarthrosis requiring revision, implant failure, chronic dysphagia, and skin ulcer. Despite the high complication rate, seven of nine patients were reported to have good to excellent results using Odom criteria, and good to excellent self-satisfaction scores.

Similarly, there remains little standardization with respect to the surgical approach to patients with dropped head syndrome and cervical deformity patients in general. A recent paper by Smith et al. highlights the controversies in surgical techniques [8]. They assembled 18 cervical spine deformity cases and surveyed 14 deformity surgeons. There was wide variation in recommended treatment, with the least complex deformities having little agreement on approach (50% combined anterior and posterior, 25% anterior only, and 25% posterior only), number of fusion levels, and types of osteotomies.

Regarding the types of osteotomies, Theologis, et al. recently compared lower cervical and upper thoracic three-column-osteotomies (3CO) for correction of rigid cervicothoracic kyphosis [9]. They found that 3CO at the cervicothoracic junction restored regional sagittal alignment and improved quality of life of the patients enrolled in the study. There was, however, a high complication rate, especially for the cohort that underwent the lower cervical osteotomy. In our case, the patient's C2–C7 SVA improved from 7.5 cm to less than 4 cm. These results are similar in magnitude to that of Theologis et al. where the SVA was reduced from 8.1 to 4.3 cm and 6.0 to 4.2 cm in the cervical and thoracic osteotomy groups, respectively. In addition, there was a significant reduction in the Neck Disability Index (NDI) in the aforementioned study for patients undergoing osteotomies, as there was a subjective improvement in this patient's sense of disability, following the deformity correction. Thus, this case report supports some of the facets represented in the above 3CO study.

Although there is wide variability in the literature in terms of surgical management, there is recent data to support a combined approach in cervical deformity patients. Kim et al. performed a retrospective review of 61 patients with cervical deformity who underwent either anterior (ATO), Smith-Petersen type (SPO) or pedicle subtraction osteotomies (PSO) and compared their radiographic and operative data [10]. Patients who underwent PSO had significantly higher blood loss (712.5 ml vs 232.7 for SPO, 183 for ATO, or 325 for ATO/SPO combined). Average OR time was also higher for the PSO group. The PSO group did, however, have a larger angular correction per level than the combined ATO/SPO group (34.5° vs 27.8°). The largest correction per level for the ATO/SPO group was 66.7°. The authors concluded that a combined ATO with SPO procedure, when possible, could provide equivalent correction, equal OR time and less blood loss than PSO alone. In the case presented here, our focal correction at the C4–5 level was 85° and the regional correction from C2 to C7 was 70°, making this the largest such correction reported in the literature. The magnitude of the correction is attributed to the power afforded by the technique of removing the uncovertebral joints and the large focal preoperative deformity at the C4–5 level.

There is additional focus on the role of the C7-slope parameter and the possibility that thoracic instrumentation may improve alignment. Le Huec, et al. have demonstrated this parameter through a cohort of asymptomatic volunteers [15]. They found that the C7 slope has a direct correlation with the sagittal balance parameters of the cervical and thoraco-lumbar spine. The study revealed that degenerative thoracic hyper-kyphosis would be difficult to compensate for patients whose initial C7 slope was marked, whereas it would be easier to compensate for in those whose initial slope was slight. The patient in this study had an initial C7 slope of 32°, which decreased to 26° postoperatively. Thus, thoracic instrumentation, as demonstrated in this report can improve the C7 slope parameter. This may serve a unique role in the management of other forms of deformity correction with thoracic instrumentation.

A novel parameter that has recently been proposed by Protopsaltis, et al. is the cervical-thoracic pelvic angle (CTPA) [11]. The CTPA is an angular measure of cervical sagittal alignment that remains constant despite degrees of lower extremity compensation and pelvic retroversion. It is formed by an angle subtended by a ling formed from the center of C2 to the femoral heads and a line from the femoral heads to the center of T1. This parameter would be of use in the presented case, as it may be more reliable and consistent in terms of fluctuations that occur in variations of compensations, given that this patient in this case has significant deformity and may be more compensated on some days as compared to others. This patient had a preoperative CTPA of 8° and a postoperative CTPA of 5°. However, CTPA has yet to be correlated with HRQOL measurements, so its clinical utility is yet to be determined. Thus, additional research may seek to analyze the role that CTPA has on cervical sagittal deformity and its impact on quality of life for patients.

Lastly, the T1 sagittal angle is the angle between a horizontal line and the cranial end plate of T1. It is a novel parameter for evaluating the whole sagittal balance with fewer measurement errors as it takes into account the head position [12]. Yang, et al. have shown, through the use of multiple regression models, that the T1 sagittal angle could be predicted through an algebraic equation. The angle, however, was only moderately correlated with SVA, a more commonly used measurement in the assessment of spinal deformity. Additionally, the angle does seem to play a role in the valuation of thoracic kyphosis, but this parameter still requires additional studies before it will play a role in preoperative planning for cervical deformity and kyphotic curvatures beyond the thoracic spine.

Procedure/procedure imaging section

First stage: anterior

The patient underwent general anesthesia and was positioned supine with a transverse shoulder roll. Gardner-Wells tong traction was applied to initiate traction reduction of his kyphosis (Fig. 8). The anterior spine was exposed through a standard Smith Robinson approach.

Caspar pins were placed in C4–C5 and an annulotomy was created. The entire disc and PLL was resected from foramen to foramen. The longus coli were elevated from the C4, C5 and C6 vertebral bodies. The Penfield 4 was then passed lateral to the uncovertebral joint and medial to the vertebral artery. Thus, the vertebral artery was protected while utilizing the high-speed bur and Kerrisons to completely resect the uncovertebral joint and perform a circumferential release of the annulus bilaterally (Fig. 9). This completed the Grade 4 anterior osteotomy [13], which was then repeated at C6–C7. A simple discectomy was performed at C3–C4. Lordotic PEEK stand-alone cages were placed at the three levels and screw fixation was performed into only one of the adjacent vertebra to allow for further correction following the posterior portion of the procedure. C5–C6 was not addressed as it was found to be completely fused (Fig. 10).

The sternocleidomastoid muscles were noted to be tense preoperatively (Fig. 11), and release of the sternal heads bilaterally was performed using the bipolar cautery and sharp dissection (Fig. 12). This was performed through the same extensile incision as the anterior osteotomies on the left and through a small 2 cm transverse incision on the right side. After completion of the bilateral partial sternocleidomastoid release there was significantly less tension in these muscles, allowing a more relaxed anterior tissue envelope.

Second stage: posterior

The Gardner-Wells traction was removed, the Mayfield device was applied and the patient was placed prone onto a Jackson cradle. A midline incision from C2 to T10 was made. Posterior fixation included bilateral pedicle screws placed at C2, lateral mass screws at C4, C5 and C6, and pedicle screws from T1–T10. Because of the increased kyphosis of the upper thoracic spine, a shorter construct would end at the apex of this kyphosis, creating a lever arm at the cervicothoracic junction that would predispose to

Fig. 8 Gardner-Wells tong traction was applied to initiate traction and reduce patient's kyphosis

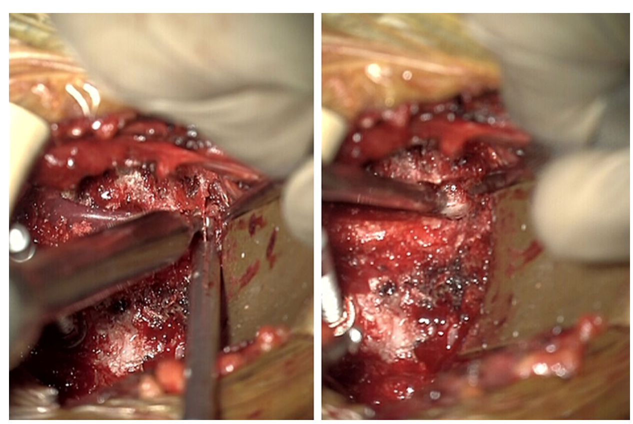

Fig. 9 Resection of the uncovertebral joint and circumferential release of the annulus, bilaterally

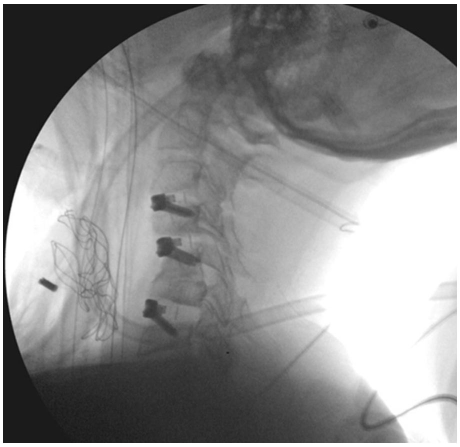

Fig. 10 Intraoperative fluoroscopic image after anterior stage

Fig. 11 Sternocleidomastoid muscles preoperatively, notably tense

early instrumentation failure or distal junctional breakdown.

A laminectomy was performed at C4–5, followed by a posterior Grade II, Smith-Petersen type osteotomy [14]. The decompression and osteotomy included resection of the ligamentum flavum and complete removal of the inferior and superior articulating processes of the C4–5 facet joints. At the remaining facet joints from C2 to T10, grade I facet osteotomies were performed. Precontoured, patient-specific tapered 5.5–3.5 mm rods were placed and a gradual capture of the rods was performed utilizing an implant system that utilizes reduction screws. With the rods captured, the grade II osteotomies were subsequently found to be closed. The C4–5 foramina were probed and found to be adequately patent. Bone grafting consisted of iliac crest autograft and allograft cancellous bone applied to the decorticated posterior elements.

There were no intraoperative monitoring changes throughout the procedure. The total estimated blood loss from the procedure was 2000 mL. The anterior portion was

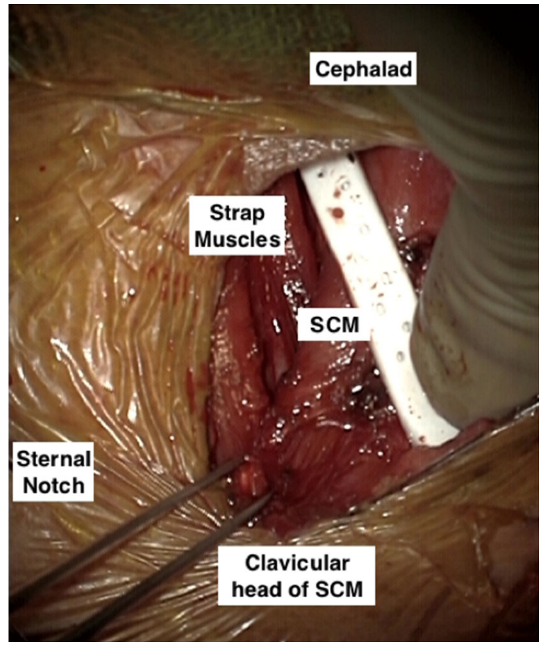

Fig. 12 Release of the sternal heads bilaterally using the bipolar cautery and sharp dissection

approximately 3.5 h in duration. The posterior portion was approximately 6 h. Both were performed in the same setting. The patient was extubated in the operating room and admitted to the ICU postoperatively.

Outcome/follow-up

Postoperatively, the patient remained neurologically intact. The patient was placed in a cervical thoracic orthosis (CTO) brace, which he wore until his 6-month follow-up visit. He remained in the ICU for 2 days before being transferred to the general medicine service for an additional 3 days. There were no postoperative complications during the remainder of his hospital course. Clinically, he did well and was discharged to inpatient rehab on postoperative day five, before going home. His recovery was without complication, and he was able to walk with marked improvement in horizontal gaze. The patient also reported subjective improvement in his quality of life at the most recent, 13-month follow-up. His chin–brow vertical-angle was restored to neutral (Fig. 12). Postoperative radiographs demonstrated significant improvement in coronal and sagittal alignment (Figs. 13, 14, 15). The C2–C7 sagittal vertical axis (SVA) improved from 7.5 cm preoperatively to less than 4 cm postoperatively. The total rigid deformity correction was 45°, from 35° of kyphosis (C2–C7) to 10° of lordosis (Figs. 15, 16). C7 slope decreased from 32° to 26° and the craniocervical angle decreased from 130° to 100°.

Fig. 13 Postoperative restoration of chin–brow vertebral angle (CBVA) to neutral

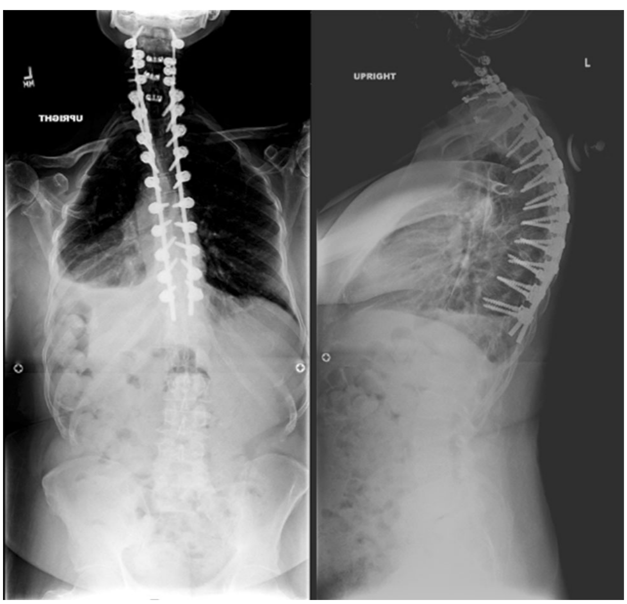

Fig. 14 Postoperative radiograph demonstrating significant improvement in coronal and sagittal alignment

Despite a large sagittal correction, some residual coronal deformity remained. Preoperative C2–C7 Cobb was 30°, while postoperatively remained at 15°. While clinically the patient appeared to have appropriate upright posture without residual head tilt, the radiographs do demonstrate residual coronal deformity occurring throughout the subaxial spine. Asymmetric posterior osteotomies or further compression and distraction along the rods could potentially have improved the alignment. Had a pedicle subtraction osteotomy been performed, asymmetric osteotomy could also have been used to correct the coronal tilt.

Fig. 15 Preoperative and postoperative radiographs demonstrating significant improvement of the kyphotic deformity

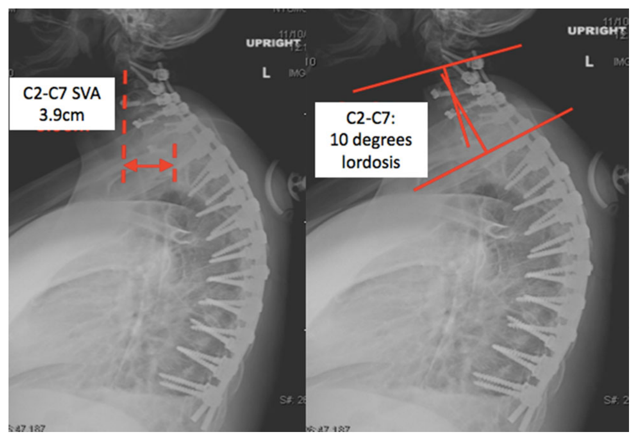

Fig. 16 Improvement of the C2–C7 sagittal vertical axis (SVA) from 7.5 cm preoperatively to less than 4 cm postoperatively and C2–C7 sagittal Cobb improvement from 35° of kyphosis to 10° of lordosis

We presented our technique for a large focal correction of a partially flexible dropped head deformity. Using both anterior and posterior osteotomies, as well as anterior soft tissue releases, we restored horizontal gaze and improved sagittal malalignment. Although the technique we present here is one of many possible options for managing the deformity, we believe this combined approach is safe and effective and well-tolerated by patients.

Compliance with ethical standards

Conflict of interest Wesley Bronson and Michael Moses do not have any conflicts of interest. Themistocles S. Protopsaltis serves as a consultant for Medicrea, NuVasive, Globus, and Innovasis. His institution receives research support from Zimmer Biomet and the Cervical Spine Research Society.

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