Ankylosing spondylitis (AS) is an inflammatory disorder leading to ossification of joints and ligaments, resulting in autofusion throughout the spinal column. In patients with fixed, kyphotic cervical deformities, which cause an impaired horizontal gaze and severe neck pain, surgical intervention is warranted. Although several articles have described the anterior and/or posterior surgical treatments used to address the fixed kyphosis, few sources present the key operative steps and technical nuances. The purpose of this technical report was to provide detailed surgical steps, representative photographs, and an operative video demonstrating multilevel anterior cervical osteotomies, uncinatectomies, and a posterior osteotomy for the correction of a fixed cervical deformity secondary to AS.

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KEYWORDS cervical osteotomy; uncinatectomy; ankylosing spondylitis deformity

Methods

Patient History, Workup, and Preoperative Imaging

History and Examination

A 61-year-old male with AS and psoriatic arthropathy presented with several years of neck pain and right upper extremity (RUE) pain. The patient reported neck pain at the base of the skull and neck area that improved when lying down. He had seen multiple surgeons who said an osteotomy could be done with no guarantee of pain relief. An electromyography and nerve conduction study showed a C6-7-8 left radiculopathy. Physical examination revealed a protracted neck with cervicothoracic kyphosis. The patient had a 5/5 strength classification and was neurologically intact.

Preoperative Imaging

Standing radiographs were obtained and showed a fixed kyphotic deformity with no movement on flexion or extension (Fig. 1A–C), except at the unfused O–C2 joints. The preoperative C2–7 sagittal vertical axis was 6.5 cm and C2–7 cervical lordosis was not present, with +1.0° of cervical kyphosis. CT showed fused anterior disc spaces and...
posterior facet joints (Fig. 1D–F), and MRI revealed no evidence of spinal cord or nerve root compression, despite the RUE radiculopathy (Fig. 1G). Although not pictured, the patient had lumbar hyperlordosis of $56^\circ$ (pelvic incidence of $58^\circ$) to compensate for a fixed, kyphotic cervical spine.

Positioning and Operative Technique

After a successful endotracheal intubation, the patient was positioned supine on a Jackson flat bed, with sheets under the shoulders, demonstrating his fixed, kyphotic cervical spine (Fig. 2A). Additional sheets were applied behind the head to facilitate lordosis after the anterior osteotomies were performed (Fig. 2B). Intraoperative neuromonitoring baselines were established and monitored throughout the case.

Video 1 highlights key operative steps.

VIDEO 1. Video describing the key steps in multilevel anterior cervical osteotomies, uncinatectomies, and a posterior osteotomy for the correction of a fixed cervical deformity secondary to AS. Copyright Jacob L. Goldberg. Published with permission. Click here to view.

Further detail regarding the operative steps, rationale, and corresponding video time stamps can be found in the Operative Technique section below.

Postoperative Course

Immediately after surgery, the patient was flipped supine, and an obvious improvement in cervical alignment was seen with his head touching the bed and the anterior chin-to-chest distance significantly widened (Fig. 2C). He was extubated, awoke neurologically intact, and was transferred to the postanesthesia care unit. He began eating the 1st day after surgery and was discharged on the 2nd day. Postoperative anteroposterior, lateral, and standing radiographs demonstrated changes in cervical as well as overall alignment, with restoration of cervical lordosis and an absence of lumbar hyperlordosis (Fig. 3A–F). The majority of the lordosis was achieved at the C4–5 level.
(16°), with a more gradual lordosis at the caudal levels of C5–6 (7°), C6–7 (8°), and C7–T1 (8°). The alignment changes were apparent on clinical examination (Fig. 3G and H). Significant improvement was seen in all cervical and global radiographic variables (Table 1).

Operative Technique
Anterior Operation Steps (Video 1, 0:00–5:53)
1) The skin is prepped and draped in a sterile fashion, and dissection is performed by incising the platysma, using a finger to bluntly dissect inferiorly to the sternal notch and superiorly to the angle of the mandible, followed by a handheld retractor medially. The omohyoid is cut and the edges cauterized. Once down to the spine, a curved clamp is attached to the longus colli muscle, and radiography is performed to confirm the level. Although in this instance it does not matter, in degenerative cases we do not use a needle to identify the disc space, and we do not incise it in case it is not the operative level.

2) Once down to the spine, the prevertebral fascia is incised with a Metzenbaum scissor in the right hand and a pickup with teeth in the other, using the “pickup, cut, plant, spread” technique. The fascia is picked up and cut, and both the forceps and scissor are planted and spread in a crossed fashion to expose the operative levels (Video 1, 0:17).

3) The longus colli muscle is then elevated with a bipolar and Penfield 2 dissector (Codman). The surgeon cauterizes on top of the lateral edge of the longus colli to cauterize feeding vessels, and underneath the longus colli, being mindful to stay above the periosteum to avoid bony bleeding (Video 1, 0:24).

4) Once the longus colli muscle is elevated, retractors are
then placed with large, 10-cm cottonoid patties on both sides to protect soft tissue and skin (Video 1, 0:31).

5) The disc spaces are identified by the “raised” portion of the spine, just like in a nonankylosed spine, except no soft annulus is seen. In the absence of a soft disc space, the “peaks” are still the disc spaces, and the “valleys” are still the anterior vertebral bodies, despite the lack of soft disc. Once the raised portion is identified, the high-speed burr is used to find the disc space. Drilling is continued, and some small amount of disc material may be encountered, which can be removed with a knife, pituitary, and curettes (Video 1, 0:33).

6) Once the midline decompression is done to the posterior longitudinal ligament, Caspar pins are then placed to obtain distraction. An important difference from a normal anterior discectomy and fusion is that Caspar distractor pins are placed after the central decompression has been done in the case of a fused spine. If Caspar pins are placed before, no movement can occur, and they inhibit the working channel.

7) After Caspar pins are placed, a small spacer is inserted into the disc space. Spacers are used to wedge open and widen the osteotomy site. A 5-mm spacer is used initially and it barely fits in the interbody space (Video 1, 0:52).

8) Next, the osteotomy is performed, which requires bilateral uncinatectomies. The contralateral uncinatectomy is performed first. A Penfield 2 or 4 is used to dissect the lateral border of the uncinate, to serve as the lateral border for subsequent drilling (Fig. 4A). Drilling is then started from an anterior (front of vertebral body) to posterior (back of vertebral body) fashion. As the surgeon is drilling anteriorly to posteriorly, close attention is paid to not drifting laterally. In addition, drilling is done in a superior/lateral fashion, to mimic the “smile” of the uncovertebral joints (Fig. 4B and C). Once the posterior drilling is done, a curette is used to remove any remaining thin bone adjacent to the exiting nerve root (Fig. 4D). The ipsilateral uncinatectomy is performed in the same way. Venous bleeding can be encountered from

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<th>TABLE 1. Preoperative and postoperative spinal parameters</th>
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<tr>
<td>C2–7 sagittal vertical axis, cm</td>
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<td>C2–7 cervical lordosis, °</td>
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<td>C7–sagittal vertical axis, cm</td>
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the venous plexus surrounding the vertebral artery, reminding the surgeon of their proximity to the vertebral artery. Venous bleeding is controlled with flowable collagen material and a thrombin-soaked patty. Anterior-to-posterior drilling is performed in the same fashion as for the contralateral uncinate (Video 1, 0:57).

9) Once the bilateral uncinatectomies have been completed, the anesthesiologist is asked to remove one of the sheets from under the patient’s head such that the head is now suspended in the air by 3 cm to 5 cm. While levering the 5-mm spacer cranially and caudally, the patient’s forehead, which is underneath the sterile drapes, is simultaneously pressed down. This widens the disc space. The space is maintained by distracting the Caspar pins. The steps are repeated with sequentially larger spacers until the widened disc space eventually accommodates a 9-mm spacer (Video 1, 1:39; Figs. 5A, 5B, and 6).

10) Once the disc space has been widened, a stand-alone interbody is placed with one screw to prevent extrusion during the subsequent posterior part of the operation. Two screws are not used, since that restricts further correction that can be achieved during the posterior operation (Video 1, 2:46). Steps 5–10 are repeated at each subsequent osteotomy level.

11) After the osteotomy is done at the most caudal level, an interbody spacer packed with cadaveric allograft is placed, along with a plate. Only the caudal level is plated to expedite surgical time and because the caudal level is most at risk for loss of correction, collapse, and pseudarthrosis.

12) The anterior portion is closed meticulously. First, Surgicel (Ethicon) is placed under the edges of the longus colli. Bone wax is then placed on top of the plate. Surgiflo (Ethicon) is used to stop any minor bleeding, followed by vancomycin powder. Additional vancomycin powder is placed, followed by an anterior Penrose drain. The skin is closed with an interrupted Monocryl suture (Ethicon) (Video 1, 5:47).

FIG. 5. Spacers are used to widen the osteotomy. A: Before the uncinatectomy, a 5-mm spacer is inserted. B: As movement occurs after bilateral uncinatectomies have been performed, a 9-mm spacer is placed and moved cranially and caudally to facilitate movement.

FIG. 6. Sheets are removed from under the patient’s head as each osteotomy is performed, with the surgical team pressing on the head to facilitate lordosis.
Posterior Operation Steps (Video 1, 5:53–7:01)

1) After the patient is turned prone on the Jackson table, a midline incision is made. The midline raphe is found meticulously, taking great care to stay in the avascular midline plane. Some surgeons are under the mistaken impression that the dissection should be done on either side of the spinous processes, preserving the midline soft tissues, which is presumed to be the nuchal ligament and the interspinous ligament. This is a mistake. All soft tissues that remain in the middle are devascularized by cutting the left and right sides and will necrose. If the soft tissues are divided in the middle, they will remain viable. Additionally, there is no interspinous ligament in the cervical spine. Instead, it is the interspinales muscle (Video 1, 5:53–6:00).

2) Once the spinous processes are found, the surgeon and assistant both dissect with the electrocautery directly on the spine. Any soft tissue between the spinous processes is divided down the middle and preserved with the muscles on either side, such that all soft tissue is removed from the bone. Minimal bleeding is encountered. The electrocautery is used as a knife, rather than an instrument to scrape on the bone (Video 1, 5:53–6:00).

3) Prior to instrumentation, a posterior osteotomy is performed at C7–T1. An osteotome is placed into the C7–T1 facet joint to start the posterior osteotomy, facilitate movement, and provide additional lordosis (Fig. 7A and Video 1, 6:00–6:14). The burr is used in addition to the osteotome to remove any remaining bone from the midline, between the inferior C7 lamina and superior T1 lamina. Movement between the C7 and T1 spinous processes is confirmed with a reducer (Video 1, 6:14–6:34).

4) Instrumentation is placed, with C2 pars screws, C3–6 lateral mass screws, and T1 pedicle screws. Although C2 pedicle screws are longer and more biomechanically favorable, they require a more lateral and cranial dissection, which adds morbidity and time. When the upper instrumented vertebra is C2, pedicle screws are the preferred option.

5) To further provide lordosis, a wire is placed around the C7 and T1 spinous processes and tightened to provide further lordosis and stabilization (Fig. 7B and Video 1, 6:34). Recall that a plate was placed anteriorly at this level, yet additional movement can still be achieved.

In the final step (step 18), the wound is closed in a standard fashion.

Discussion

Surgical intervention to correct cervical sagittal plane deformities is complex, carries significant risks, and should only be performed by experienced surgeons. In patients with severe chin-on-chest deformity due to AS, complication rates range between 26% and 87% (mostly classified as minor) with a 3% mortality rate. Postoperative neurological deficits have been reported in 23% of patients, of which 82% were transient C8 radiculopathies, with 4% of deficits remaining permanent. High complication rates in cervical deformity surgery have also been observed. In a prospective, multicenter study of 78 patients who underwent cervical deformity surgery, Smith et al. reported a 43% minor complication rate and 24% major complication rate. Specifically, complications were dysphagia in 11% of patients, deep wound infection in 6%, postoperative C5 deficit in 6%, respiratory failure in 5%, and mortality in 1%. Stratified by approach, early complications occurred in 27% of patients who underwent anterior surgery, 68% who underwent posterior surgery, and 79% who underwent combined approaches. Of note, AS-associated cervical deformities were rare and only seen in 2 patients (3%). The anterior osteotomy for correction of cervical deformities has been described previously by our group. In the earliest series, 38 patients who underwent anterior cervical osteotomies were presented; 17 patients (45%) had anterior-only osteotomies and 21 (55%) underwent combined anterior and posterior osteotomies. The same anterior osteotomy technique was described, with some small modifications. Caspar pins can be placed divergently, meaning the tips of the Caspar pins are positioned away from each other and the posts are convergent, to facilitate lordosis.
addition, after a Penfield 2 or 4 is used to identify the lateral border of the uncinate, a small cottonoid can be placed lateral to the uncinate to protect the vertebral artery. The anterior osteotomy—only group had a shorter surgery duration and less estimated blood loss than the combined anterior-posterior osteotomy cohort. The anterior osteotomy—only group also had less angular correction and less mean translation correction, yet both groups had significant improvements in Neck Disability Index (NDI) scores. In a similar analysis, anterior osteotomies in 31 patients were compared with pedicle subtraction osteotomies (PSOs) in 4 patients. Both groups had significantly improved angular and translational correction, along with improved NDI scores, yet the PSO group had more angular correction (48.8° vs 27.7°) and translational correction (2.8 cm vs 1.8 cm). Importantly, the PSO group had significantly more blood loss (775 ml vs 216 ml). It must be noted that, although in the current report an anterior-posterior approach was used, a posterior-or-anterior-posterior three-stage approach could have also been used, known as a “back-front-back” approach. First, posterior facet resection and osteotomies can be done with placement of screws only, followed by a multilevel anterior cervical disectomy and fusion without a plate, followed by posterior instrumentation with rods and compression for lordosis at the levels of interest. Overall, although these prior studies have highlighted the anterior osteotomy nicely,13–15 discussion of patients with AS undergoing such procedures is rare.

Specific to the surgical treatment of AS-related severe cervical kyphosis, Etame et al. reviewed 6 retrospective studies comprising 227 patients, and the most common indication for surgery was loss of the horizontal gaze.1 Objective change in horizontal gaze was evaluated in patients with AS in one of the reported studies by McMasters.16 Among 15 patients, the authors reported a mean total correction of 54° with a subsequent loss of correction of 6° during follow-up (the mean follow-up was 18 months).16 Similarly, in 2 other studies evaluating mostly patients with AS, significant improvements in cervical kyphosis were observed after surgery.17,18 These prior descriptions of AS are an excellent source of information; however, an in-depth description of surgical correction of an AS cervical deformity appears to be lacking, especially one with detailed intraoperative pictures and videos which are of most use to surgeons.

In addition to usual risk mitigation measures, extreme care is required with intubation and positioning of patients with a fixed, severe cervical kyphotic deformity. Traditionally, these patients underwent awake surgery in a sitting position to allow for continuous monitoring of neurological function.19 Advancements in fiber-optic intubation techniques and neuroradiology allow for safe intubation and the ability to rapidly respond to signal changes in somatosensory evoked potentials and motor evoked potentials.20 In a cohort of 16 patients with AS who underwent a C7 osteotomy, Langeloo et al. reported that 9 of those patients had a concerning motor evoked potential signal decrease intraoperatively, of whom 6 patients demonstrated signal recovery as a result of changes made intraoperatively.21 Of the 3 patients with a postoperative neurological deficit, 2 had postoperative recovery and 1 had a permanent deficit.

A narrated video (Video 1) is provided to demonstrate the in-depth procedural steps described above.

Conclusions

Fixed, cervical kyphotic deformities are commonly seen in patients with AS, and surgical intervention is technically challenging to any spine surgeon. The current technical report provides detailed surgical steps, representative photographs, and a narrated operative video describing multilevel anterior cervical osteotomies, uncinatectomies, and a posterior osteotomy for the correction of a fixed cervical deformity secondary to AS. It is our hope that this report can help spine surgeons tackle these demanding operations.

References


Disclosures
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Author Contributions
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Supplemental Information
Videos

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