Anterior cervicothoracic junction corpectomy and plate fixation without sternotomy

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Object. Exposure of the lower cervical and upper thoracic spinal regions through a cervical incision without sternotomy has been described in cases of anterior decompression and methylmethacrylate vertebral body reconstruction. The use of anterior instrumentation and structural bone grafts in this procedure has not been well described.

Methods. Twenty-one patients underwent anterior cervicothoracic decompression, fusion, and fixation via a low cervical approach. Eight of these patients underwent lower cervical or upper thoracic corpectomy (C7–T4) through the cervical incision. The decompressive procedure was followed by placement of an allograft bone strut and an anterior locking plate system.

No patient developed new neurological deficit related to the spinal cord or exiting nerve roots. Three of four patients with preoperative neurological deficits improved dramatically. Two patients developed recurrent laryngeal nerve palsy, of which one was permanent. There was one case of instrumentation-related failure, and two patients developed a superficial wound infection related to a posterior incision made as part of a 360° fusion. Patients were followed for a mean of 18.5 months (range 2–30 months). Two patients died (of metastatic cancer, and a motor vehicle accident, respectively) during the follow-up period.

Conclusions. Anterior decompression, fusion, and fixation is feasible via a cervical incision. This procedural approach spares the patient the morbidity associated with sternotomy or the lateral extracavitary approach. A thorough preoperative assessment of mediastinal anatomy is essential for the safe execution of these procedures.

Key Words • anterior cervical fusion • cervical spine • thoracic spine • vertebrectomy

Exposure of the anterior aspect of the cervicothoracic junction may be obtained via a low cervical approach with or without the creation of a manubrial window. This approach obviates the need for a thoracotomy or sternotomy and thus avoids their attendant morbidity. Several authors have described the use of such an approach for the decompression of the spinal cord and placement of anterior strut grafts. In particular, the use of methylmethacrylate, with or without supplemental Steinmann pins, has been advocated for the reconstruction of the spine, particularly in patients with cancer. Although some authors have stated that this approach would likely not permit the provision of anterior plate fixation, isolated reports of this procedure exist.

In this series the author describes eight patients in whom anterior cervicothoracic corpectomy and fusion were performed using a low cervical approach, allograft bone, and an anterior cervical plate. The use of such a construct confers some degree of immediate rigidity to the spine and allows for the possibility of bone fusion. Clinical results and several technical caveats are presented.

Abbreviations used in this paper: CT = computerized tomography; MR = magnetic resonance; MVA = motor vehicle accident; RLN = recurrent laryngeal nerve; VB = vertebral body.

CLINICAL MATERIAL AND METHODS

Patient Population

Over a 3-year period, 21 patients underwent fixation of the cervicothoracic junction for a variety of indications. Eight of these patients underwent anterior corpectomy of C-7, T-1, T-2, or T-3 and subsequent anterior cervicothoracic fusion and fixation. These eight cases serve as the basis for this report. Surgery was performed in three patients following trauma, in two patients for tumor (one primary lymphoma and one Pancoast tumor with direct spread), in two patients for osteomyelitis, and in one patient for degenerative disease. In five patients significant neurological deficits related to spinal cord or nerve root compression were present preoperatively. Data are summarized in Table 1.

Surgical Procedure

All patients underwent preoperative MR imaging and CT studies. The position of the manubrium and the great vessels relative to the level of the pathological entity was assessed in each patient. In two patients, both of whom underwent a C-7 corpectomy, a standard horizontal cervical incision was used. The other six patients underwent surgery via an extended cervical approach, which required
that an incision be made along the medial border of the sternocleidomastoid muscle, ending at the manubrium. In two patients, the incision was continued caudally in the midline to allow for resection of the rostral third of the manubrium. A left-sided incision was used in seven patients; the anatomical position of one tumor necessitated the use of a right-sided incision in a single case. A left-sided incision was preferred because of the course of the RLN. A standard cervical dissection along the medial border of the sternocleidomastoid muscle, medial to the carotid sheath, was performed to expose the anterior surface of the lower cervical spine. The dissection was extended caudally, angling beneath the manubrium or accompanied by a partial resection of the manubrium. When required, up to 3 cm of the manubrium was resected using a Leksell rongeur. Although resection of the head of the clavicle was not necessary in this series, it has been described and may increase exposure as well.13,14 A table-mounted self-retaining retractor system, used in all cases, proved to be very helpful in retracting mediastinal contents. The thoracic duct may be ligated and divided if it cannot be retracted out of the field. A narrow, malleable blade was used for caudal retraction. The use of corpectomy, in contrast to discectomy, allowed for visualization of the thecal sac following bone removal. A nearly “end on” view of the caudal VB may be obtained. Following decompression of the spinal cord and nerve roots, a fibular allograft was used as a load-bearing strut. In all cases an anterior cervical plate was implanted to provide immediate rigidity to the construct. The use of variable-angle screws was helpful for the placement of the plates caudally. The angle required for screw placement often required contouring of the plate in addition to the use of variable-angle screws. Four of the eight patients also underwent posterior stabilization procedures for the treatment of gross instability. Postoperative immobilization therapy consisted of a rigid cervical collar in six patients and a Minerva brace in two. The duration of immobilization therapy was 6 weeks in all patients.

RESULTS

Corpectomies were performed at C-7 (five cases), T-1 (two cases), T-2 (three cases), and T-3 (one case). A partial corpectomy of T-4 was performed in one patient. Instrumentation was placed as far caudal as the rostral endplate of T-5. Patients were followed for a mean of 18.5 months (range 2–30 months). The patient who harbored the Pancoast tumor died 2 months following surgery of metastatic disease. This patient’s tumor had been stable in size for 12 months following radiotherapy, and her oncologist had declared that she was free of systemic disease prior to operation. The operation was performed to treat a progressive painful spinal deformity caused by erosion of T-1 and T-2. A second patient was killed in a MVA (restrained passenger) 18 months postoperatively. Recurrent multiple myeloma was diagnosed in a third patient 6 months following surgery for spinal osteomyelitis. This patient was lost to follow up thereafter. Data including follow-up periods are summarized in Table 1.

Three patients with neurological deficits caused by spinal cord compression improved significantly. One patient with radicular symptoms also improved significantly. The patient harboring the Pancoast tumor suffered neurological deficits secondary to nerve root involvement. Deficits in this case did not improve. No patient suffered a new surgery-related neurological deficit referable to the spinal cord or nerve roots. Approach- and instrumentation-related complications included one temporary and one permanent recurrent RLN palsy. The permanent RLN palsy

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Diagnosis</th>
<th>Anterior Procedure</th>
<th>Posterior Fixation</th>
<th>Follow Up (mos)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pancoast tumor invading T-1 &amp; T-2 w/ spinal instability, pain &amp; root related deficits</td>
<td>T-1 &amp; T-2 corpectomies; C7–T3 arthrodesis</td>
<td>yes</td>
<td>2</td>
<td>no change in neurological deficits; died 2 mos postop of progressive systemic disease</td>
</tr>
<tr>
<td>2</td>
<td>osteomyelitis w/ epidural abscess &amp; spinal cord compression causing incomplete SCI</td>
<td>C-6 &amp; C-7 corpectomies; C5–T1 arthrodesis</td>
<td>no</td>
<td>4</td>
<td>improved neurological function; infection resolved</td>
</tr>
<tr>
<td>3</td>
<td>osteomyelitis w/ gross spinal instability, near-complete SCI</td>
<td>T-2, T-3, &amp; partial T-4 corpectomies; T1–T4 arthrodesis</td>
<td>yes</td>
<td>6</td>
<td>marked neurological improvement; posterior wound revision for superficial dehiscence; diagnosed w/ recurrent myeloma 6 mos postop, lost to follow up; instrumentation failure at last follow up; no revision contemplated</td>
</tr>
<tr>
<td>4</td>
<td>trauma, C7–T1 fracture dislocation, ankylosing spondylitis; neurologically intact</td>
<td>T-1 corpectomy; C7–T2 arthrodesis</td>
<td>yes</td>
<td>18</td>
<td>neurologically intact at discharge; killed in MVA (passenger) 18 mos postop</td>
</tr>
<tr>
<td>5</td>
<td>lymphoma, spinal instability, mild paraparesis</td>
<td>T-2 corpectomy; T1–T3 arthrodesis</td>
<td>no</td>
<td>30</td>
<td>RLN palsy; otherwise no deficits; in remission following adjuvant treatment</td>
</tr>
<tr>
<td>6</td>
<td>C7–T1 fracture dislocation, severe incomplete SCI</td>
<td>C-7 corpectomy; C6–T1 arthrodesis</td>
<td>yes</td>
<td>27</td>
<td>marked neurological recovery; no complications</td>
</tr>
<tr>
<td>7</td>
<td>C6–7 &amp; C7–T1 degenerative disease w/ radiculomyelopathy</td>
<td>C-7 corpectomy; C6–T1 arthrodesis</td>
<td>no</td>
<td>12</td>
<td>radicular symptoms resolved; myelopathy unchanged; no complications</td>
</tr>
<tr>
<td>8</td>
<td>C-7 burst fracture; neurologically intact</td>
<td>C-7 corpectomy; C6–T1 arthrodesis</td>
<td>no</td>
<td>12</td>
<td>neurologically intact; no complications</td>
</tr>
</tbody>
</table>

* SCI = spinal cord injury.
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occurred in a woman with a T-2 lymphoma in whom the tumor anatomy necessitated a right-sided approach. There was one case of instrumentation failure (screw backout in one case of osteomyelitis). In two of the four patients who underwent concomitant posterior fixation posterior wound dehiscence developed. One of these patients required a wound revision, and the other was treated with dressing changes and an oral course of antibiotic medication. Reoperation was not required in the case of instrumentation failure. Outcome data are summarized in Table 1.

ILLUSTRATIVE CASES

Case 6

The patient in Case 6 is (now) a 70-year-old man who was involved in a MVA in 1999. Findings on plain radiographs obtained at an outside emergency room were interpreted as normal; however, the patient was maintained in a cervical collar because of persistent complaints of neck pain. Eventually he was transferred to a rehabilitation unit where he became progressively weaker. A neurosurgeon diagnosed a Brown–Séguard syndrome, and CT scanning and subsequent MR imaging were performed. These studies demonstrated a fracture dislocation of C7–T1 and a hematoma behind the VB of C-7 (Fig. 1). He was then transferred for definitive care. On arrival, examination demonstrated pinprick sensory loss below the collar on the right. He had 3 to 4/5 strength in his right leg and 5/5 strength in the left leg. Severe weakness (1/5) in the triceps and hand intrinsics was present bilaterally, as was 4/5 strength in the right biceps. A Foley catheter had been in place for 2 weeks.

The patient was positioned supine on a Jackson table with a roll between the shoulders and his head placed on a donut cushion to encourage reduction of the deformity. Ten pounds of traction was applied to stabilize the spine during deformity reduction and fixation. An incision was made along the medial border of the left sternocleidomastoid muscle and was extended to the midline at the suprasternal notch. Caudal exposure was aided using a narrow table-mounted retractor blade placed on the manubrium and angled caudally. The level of the lesion was easily identified through the prevertebral fascia. Incision of the fascia resulted in the expression of hematoma and bone fragments. The caudal portion of C-7 and the rostral portion of T-1 were resected to visualize the thecal sac because of concerns of a potential anterior compressive mass. The subluxation was reduced without difficulty, and a fibula strut graft was placed. An anterior plate was fixed to the spine with multiple points of fixation (Fig. 2). The plate was bent into a slight kyphotic angle caudally to accommodate the curvature of the upper thoracic spine. Variable-angle screws were used to secure the plate. The wound was closed and the patient underwent an immediate posterior decompression and fixation procedure.

The patient remained intubated and sedated overnight. The next day, without difficulty, he was extubated. He was immobilized in a hard cervical collar for 6 weeks after surgery. His postoperative course included a prolonged period of convalescence in the rehabilitation unit but was otherwise uncomplicated. Two years and three months following surgery he is ambulatory and continent. Significant bilateral hand dysfunction is present (left worse than right) but he is able to feed himself with assistive devices and is living at home with his wife, who is able to care for him.

Case 5

This 67-year-old woman presented with a 2-month history of intrascapular back pain and a paraparesis that had progressed over the 2 weeks prior to admission. Examination revealed diffusely decreased lower-extremity strength (4/5), a sensory level in the middle thoracic region, and hyperreflexia in the lower extremity. An MR image (Fig. 3) demonstrated a pathological fracture of T-2, cord compression, and kyphosis. A metastatic workup and routine laboratory tests did not allow for identification of the nature of the pathological entity, and the patient was offered surgery to establish a diagnosis, decompress the spinal cord, and stabilize her spine.

A low cervical approach was undertaken. In this case, the incision was continued caudally in the midline to expose the rostral portion of the manubrium. A rongeur was used to remove the rostral 3 cm of the manubrium and a narrow table-mounted retractor blade was used for exposure. The VB of T-2 was identified and was markedly abnormal. A standard corpectomy was performed. Specimens sent for pathological investigation were determined to be B-cell lymphoma. The spine was reconstructed using fibula allograft and an anterior cervical plate with variable-angle screws placed at the caudal end on the construct. Vocal cord paralysis was noted several days after the procedure. This was treated successfully by Teflon injection into the cord. The patient underwent postoperative chemotherapy and is in remission, neurologically intact, and free of back pain 30 months after surgery. A postoperative radiograph and CT scan are shown in Fig. 4.
DISCUSSION

Decompression and fixation of the cervicothoracic junction is often difficult. A posterolateral (lateral extracavitary) approach may allow for anterior decompression and placement of a strut graft; however, fixation may require extension of the fusion mass over multiple levels to obtain adequate fixation. This approach, always technically challenging, may be more difficult to perform in the upper thoracic region because of limitations imposed by the scapula. Furthermore, pulmonary-related complications are common following this approach. Anterior approaches are limited by the position the sternum and of the great vessels, as well as by the curvature of the spine. Despite these limitations, the authors of several small case series have described a suprasternal approach to the upper thoracic spine. The anatomical constraints of this exposure have been elegantly described in studies by Gieger, et al., and Comey, et al. These authors emphasized the importance of thorough knowledge of the regional anatomy,
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especially of the recurrent laryngeal nerves and thoracic ducts. Therefore a left-sided approach was preferentially used whenever possible. Although the course of the RLN is more consistent on the right, its course is consistent across the operative field. Although other authors have reported success with the use of right-sided approaches, the one case of permanent vocal cord paralysis in this series occurred in the only patient in whom surgery was performed via a right-sided approach. The thoracic duct is vulnerable to injury as it crosses from behind the esophagus to the left carotid sheath. Fortunately, ligation of the duct is well tolerated, and no duct-related problems were noted in this series.

Geiger, et al., and Comey, et al., have discussed the need to review preoperative imaging studies to determine the feasibility of the approach. Sharan and colleagues conducted a review of 103 patients who underwent MR imaging of the cervicothoracic junction. They found that in 63 patients, the T1–2 intervertebral disc space was the lowest disc level that could be directly approached via a supraclavicular route; in only 15 of 103 patients was an approach to the T2–3 disc space possible. Exposure, however, could be achieved as far caudal as the T-3 VB in the majority of patients if a corpectomy was undertaken. The performance of a corpectomy allows for visualization of the thecal sac along a more rostral–caudal trajectory. Therefore, although upper thoracic discectomy is not possible in the majority of patients, exposure for corpectomy down to the level of T-3 could be achieved for most patients. This restriction of the angle of approach has led some authors to the conclusion that anterior fixation of this region is not feasible.

Pointillart and colleagues have recently presented two cases in which anterior fixation of the upper thoracic spine was performed by placing instrumentation via a low cervical approach. The description was presented in abstract form, however, and details are not currently available. Boockvar, et al., have also reported the use of a low cervical approach to the cervicothoracic junction. They placed instrumentation following corpectomy down to the level of T-1 or T-2 in seven cases. These patients were part of a larger series of patients who underwent anterior plate fixation of the lower cervical spine and upper thoracic spine for a variety of indications. These authors focused on surgery-related and structural complications of anterior fusion and did not provide detailed discussion of operative technique or imaging considerations.

In the current study the feasibility of anterior decompression, arthrodesis, and fixation is demonstrated in a selected group of patients. Those selected for this procedure underwent a thorough preoperative assessment of upper mediastinal anatomy to determine their suitability for this approach. One of these patients (in whom a C-7 corpectomy was performed for degenerative disease [Case 6]) may have received adequate treatment via a posterior approach; however, the other seven patients suffered from significant anterior column incompetence and/or anterior compression of the spinal cord. Possible alternative approaches for decompression would have included cervical fixation, a lateral extracavitary approach, or, in one case, thoracotomy. Sternotomy and thoracotomy breach additional body cavities and are associated with nontrivial morbidity. Transpedicular approaches as well as lateral extracavitary approaches have been described in this region and are useful in selected cases, particularly when there is a lateral component to the lesion or when anterior procedures are untenable due to patient’s anatomy. Making “windows” in the manubrium or sternum has also been described; these allow access to the upper thoracic spine with a limited sternotomy. Sundaresan and colleagues performed a limited resection of the sternum and distal clavicle and then used the clavicle as a strut graft in a series of seven patients in whom good results were achieved.

The morbidity rate in the present series is not trivial, but it compares favorably with a series in which patients have been treated using a variety of approaches for similar problems. In a series of 36 patients, the majority of whom (58%) underwent surgery via posterior approaches alone, there were three postoperative deaths (two cases of sternotomy and one case of anterior C-7 corpectomy). Other reported complications in this series included a C6–7 subluxation after C7–T2 fusion, pseudomeningocele, vocal cord paralysis, dysphagia, and Horner syndrome. Other medical complications included wound infection, urinary tract infection, decubitus ulcers, deep vein thrombosis, pneumonia, and tumor recurrence. Boockvar, et al., described three surgery-related complications (RLN palsy, Horner syndrome, and respiratory arrest) and five graft-related complications (migration, fracture, and pseudarthrosis) in their series of 14 patients treated with anterior decompression and fusion of the lower cervical spine and cervicothoracic junction. Therefore, it is clear that no easy and risk-free way exists to access and stabilize this region of the spine. The absence of graft-related complications in the present series, in comparison with that reported by Boockvar, et al., may be a result of technical factors related to graft choice and handling (in particular, the screw fixation of the graft used by Boockvar, et al.), and the frequent (50%) use of supplementary posterior instrumentation in this series.

The ability to place anterior cervical locking plates allowed for single-incision decompression, arthrodesis, and fixation in half of these patients. The others were believed to have three-column instability and required anterior decompression as well as restoration of load-bearing support. These patients underwent posterior fixation in addition to the anterior fixation. Although it may be argued that anterior fixation was not needed after restoration of load-bearing support in these patients, the addition of the cervical plate did not result in any clinically appreciable morbidity and did secure the graft and provided additional rigidity in these patients with gross spinal instability.

Important technical considerations relevant to this procedure include a thorough preoperative radiological evaluation. The standard sagittal MR image must be reviewed with particular attention to the sternum and great vessels. This surgical procedure should only be attempted if a clear avenue of approach can be appreciated. Visualization for corpectomy and reconstruction is aided by the use of a table-mounted retractor system (Fig. 5). Plate fixation may require some plate bending to accommodate the kyphotic posture of the upper thoracic spine. Finally, the use of a plate that can accommodate variable-angled screws is very helpful, particularly at the caudal end of the construct, where placement of a drill guide for the standard
screw trajectory may be impossible. Finally, the potential approach-morbidity is significant. Patients must be made aware of the risks of RLN palsy (including the possibility of tracheostomy and gastrostomy), pulmonary injury, and injury to the great vessels in addition to the usual risks of anterior spinal surgery.

References