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Surgical management of cervical myelopathy dealing with the cervical–thoracic junction

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Abstract

BACKGROUND CONTEXT: The treatment of compressive cervical myelopathy is, in general, a surgical endeavor. Surgery involves decompression, often with an accompanying fusion with stabilization. The length of the fusion can vary and the decision regarding length of fusion is not always clear.

PURPOSE: This study explores the fundamental principles regarding the length of fusion at the cervicothoracic junction.

STUDY DESIGN/SETTING: A review of the literature regarding the anatomy and biomechanics of the cervicothoracic region is provided. Surgical approaches and indications for cervicothoracic junction region fusions are discussed. Fundamental guidelines for the decision-making process are provided.

CONCLUSION: The cervicothoracic region is a biomechanically complex region. Although there is little biomechanical data indicating the appropriate length of fusion, several fundamental guidelines may be followed to reduce the incidence of construct failure. A long fusion should not end at an apical vertebra nor at the cervicothoracic junction. Long cervical fusions should be extended to traverse the cervicothoracic junction to a neutral vertebra.

Keywords: Cervical myelopathy; Fusion; Cervicothoracic junction; Length of fusion; Cervicothoracic fusion; Cervical laminectomy

1. Introduction

The management of cervical myelopathy requires decompression of the spinal cord either ventrally, dorsally, or both, depending on the pathology, geometry, and spinal alignment. Cervical laminectomy is valuable for the management of congenital or acquired cervical spinal stenosis at multiple levels. The decision to fuse or not depends on factors such as the patient's age, preoperative sagittal alignment, underlying diagnosis, as well as the length of the decompression required. The true incidence of postlaminectomy kyphosis is difficult to ascertain from the literature because of the heterogeneous patient population and inconsistent reporting. When multilevel anterior procedures are performed, grafting and plating is essential. Fusion rates are increased and the incidence of iatrogenic deformity is decreased [1–4].

Surgery at or near the cervicothoracic junction poses a particular challenge owing to the anatomical challenges associated with the surgical approach and the complex nature of the regional biomechanics. There exists very little literature assessing the appropriate length of fusion in the cervical spine. Length of fusion depends on factors such as age of the patient, underlying pathology, length of laminectomy, and quality of the bone. There are some general guidelines, however, that may reduce the incidence of construct failure. These are based on sound anatomical and biomechanical principles.

2. Anatomy

The vertebrae of the subaxial cervical spine are fairly uniform and are aligned in a slightly lordotic posture. The components of the cervical vertebrae include the body, superior and inferior articular processes, pedicles, lamina, and a spinous process. The vertebral bodies are the axial load-bearing elements of the spine. The pedicle of the

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subaxial cervical spine connects the body with lateral masses. They are small and medially oriented. The lateral masses of the subaxial cervical spine consist of superior and inferior articulating processes that form the bony confines of the facet joint. The orientation of the facet joints is in the coronal plane. This limits spinal movement in extension. The cervical laminae are thin, and the spinous processes of the midcervical spine are small and often bifid.

The anatomy of the thoracic spine contrasts significantly with that of the cervical spine in large part because of complex osteo-ligamentous articulation with the thoracic rib cage. An understanding of the complex relationship between transverse process, the pedicle, the neuroforamen, the rib head articulation with the vertebral body, and disc is essential for proper and safe surgery in this region. Physiologic kyphosis of the thoracic spine results from a relatively greater height of the dorsal vertebral wall compared with the ventral vertebral wall. Pedicle orientation and dimensions vary significantly over the levels of the thoracic spine [5,6]. Facet orientation in the thoracic spine is primarily in the coronal plane, which permits rotational motion. The lamina increases in width and thickness from the upper to the lower thoracic spine. As is evident from a perusal of Table 1, the range of motion in the spine depends on the level [7].

The anatomy and biomechanics of the cervicothoracic junction are distinctive. There is a transition from cervical lordosis to kyphosis in the thoracic region [5,6]. The cervical spine has very mobile vertebral elements, whereas the thoracic spine is characterized by its stabilizing facet and rib architecture (Table 1). This abrupt change from mobility to stability predisposes this region of the spine to trauma and degeneration. Special care must be taken when operating near the cervicothoracic junction. A higher incidence of postoperative kyphotic deformity exists in this region. Inoue et al. reported 36 patients whose spinal cord tumors were resected either via laminectomy, laminoplasty, or hemilaminectomy [8]. Patients who underwent C7 laminectomy developed kyphosis localized at the cervicothoracic junction and marked compensatory lordosis of the cervical region, whereas patients who underwent laminoplasty developed significantly less deformity. Steinmetz et al. retrospectively reviewed all operations involving the cervicothoracic junction in the Department of Neurosurgery at the Cleveland Clinic Foundation for a 5-year period [9]. Out of 593 total cases there were 14 failures. An extensive search for factors associated with failure established two surgical procedures with poor outcome. These include uninstrumented laminectomy and ventral multilevel corpectomies across the cervicothoracic junction. Laminectomy across the cervicothoracic junction without instrumentation was strongly associated with failure (38% of cases).

Table 1
Range of motion of intact cervicothoracic spine in three modes of motion

	Combined flexion/extension	One side lateral bending	One side axial rotation
	Degrees		
C0–C1	25	5	4
C1–C2	20	5	40
C2–C3	10	10	3
C3–C4	15	12	7
C4–C5	20	12	7
C5–C6	20	10	7
C6–C7	15	10	5
C7–T1	10	5	1
T1–T2	5	5	9
T2–T3	5	5	8
T3–T4	5	5	8

Adapted from White and Punjabi [7].

Note how upper thoracic spine provides some motion between its levels.

3. Surgical approach

Multiple procedures allow access to the cervicothoracic junction. The nature of the pathology guides the choice of surgical approach. The ventral approach to the cervical spine has been effectively used for 50 years [10,11]. This approach provides direct access for spinal cord and nerve root decompression secondary to herniated intervertebral discs, dorsal vertebral body osteophytes, ossified posterior longitudinal ligament, and uncovertebral joint hypertrophy. Another important benefit of the ventral approach is the ability to correct kyphotic deformity, through discectomy or corpectomy [9]. Ventral approaches afford significant opportunities for deformity correction that are not possible with dorsal approaches. Ventral decompression options include discectomy and corpectomy, either single or multiple levels, or a combination of both. Arthrodesis can be accomplished by using autograft or allograft bone, or a combination of cages. Typically, cages are packed with autograft or allograft bone to facilitate fusion. All of these options can be used with or without a ventral cervical plating system. The primary advantage of a ventral approach relates to the facilitation of ventral pathology resection. Often, however, the approach is difficult, especially in the face of multiple level pathology, reoperation, or cervicothoracic junction involvement. Finally, a ventral approach nearly always obligates a simultaneous fusion procedure.

Generally, dorsal approaches are reserved for patients with multilevel, predominantly dorsal or circumferential compression, in the presence of a straight or lordotic cervical alignment. This surgical option appears to be surgeon-dependent more than scientifically based. Absolute contraindication to laminectomy is preoperative kyphosis. Laminectomy may be considered in cases of cervical lordosis and often in patients with a straightened spine.

Laminoplasty is an alternate to multilevel laminectomy. The goal of a laminoplasty procedure is the expansion of the spinal canal cross-sectional dimensions, a sparing of spinal stability, and the preservation of lamina integrity.