International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

An Overview on Anterior Cervical Discectomy and Fusion

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Abstract

Cervical disc prolapse is a common cause of neck pain and neurological deficits, resulting from compression of neural structures by herniated disc material or osteophytes. Anterior cervical discectomy and fusion (ACDF) is considered the gold standard surgical approach for management, offering effective decompression and stabilization. The introduction of interbody cages has significantly improved surgical outcomes by enhancing fusion rates and minimizing graft-related complications. However, cage-related complications such as subsidence, migration, and non-union remain concerns that may affect long-term outcomes.

Keywords: Cervical disc prolapse, ACDF, cervical cage, fusion, complications

Introduction:

Cervical disc prolapse is a common spinal disorder that can lead to neck pain, radiculopathy, and myelopathy due to compression of neural elements by herniated disc material or associated degenerative changes **(1).**

Surgical intervention is indicated in cases with persistent symptoms or neurological deficits, with anterior cervical discectomy and fusion (ACDF) being the most widely accepted surgical technique. This approach allows direct decompression of neural structures while maintaining spinal stability and restoring disc height **(2).**

The evolution of interbody fusion techniques led to the introduction of cervical cages, which were developed to overcome complications associated with autologous bone grafts such as donor site morbidity. Early designs, such as the Bagby cage, paved the way for modern cage systems used in ACDF procedures **(3).**

Various materials have been used in cage manufacturing, including titanium, carbon fiber, and polyetheretherketone (PEEK), each with specific advantages and limitations. PEEK cages, in particular, have gained popularity due to their favorable biomechanical properties, radiolucency, and reduced risk of imaging artifacts **(4).**

Despite their advantages, the use of cervical cages is associated with potential complications such as subsidence, migration, and non-union, which may impact surgical outcomes. Understanding these complications and their contributing factors is essential for optimizing patient outcomes **(5).**

The goal of surgery is to remove any elements which are compressing the neural elements; these include soft disc material, bony osteophytes and spondylotic ridges. Anterior cervical discectomy permits the removal of a compressive soft disc herniation, along with spondylotic osteophytes and ridges. The benefits of ACDF include the prevention of further osteophyte formation, regression of existing osteophytic spurs, disc space distraction which reduces ligamentum flavum buckling and enlargement of the neural foramina with consequent nerve root decompression **(2)**.

Fusion using cages

Bagby was responsible for the early development of the interbody fusion cages. He found that the Cloward technique, which requires obtaining bone from the iliac crest, resulted in unacceptable morbidity. Bagby then developed a novel device, the first interbody stainless-steel basket. During a standard anterior cervical decompression and reaming procedure, cancellous bone chips were removed from the posterior aspects of the cervical vertebrae then packed inside the basket to promote anterior interbody cervical fusion **(3)**.

Classification of cages

There are two basic types of cages, threaded hollow cylindrical cages (Cloward type procedure) and rectangular cages (Smith-Robinson type procedure). The threaded cages are introduced and screwed through the endplates of the vertebral bodies, whereas the rectangular cages mimic the intervertebral space dimensions and in accordance with the anatomy of the endplates **(6)**.

Titanium, carbon fiber, and Polyetheretherketone (PEEK) are most commonly used material for cage production. The use of a titanium cage may lead to vertebral body collapse if the end plate is over degraded during discectomy. In addition, radiological metallic artifacts may complicate imaging compared to the radiotransparent Carbon fiber cages. Subsidence, migration, and structure failure are well-recognized complications with the use of titanium and carbon fiber cages resulting in disc height collapse and kyphotic deformity **(5)**.

On the other hand, PEEK is a semicrystalline polyaromatic linear polymer that provides a good combination of strength, stiffness, toughness, and environmental resistance with biocompatible, non-absorbable, and corrosion-resistant abilities. Furthermore, the cage structure (two titanium spikes on the upper and bottom frame, in addition to the retention teeth on the surface of the upper and bottom frame offers a fixation mechanism, which is similar to the functions of a plate and screws. In addition, the PEEK cage is radiolucent and does not produce artifacts, it is easy to evaluate fusion status on radiographs and CT scans **(4)**.

Usually, cages used in ACDF are packed with bone grafts, demineralized bone matrix (DBM), bone morphogenetic protein or acrylate to reach early and solid fusion. If the autologous bone graft is obtained not from the operation site, donor-site complications are still unavoidable. To minimize the extent of surgery, and to avoid donor-site complications, packing the cages with DBM mixed with autologous blood is preferred **(7)**.

Figure 1. Composite Ti/PEEK Cage. Combo ® cage (A-SPINE Asia, Taiwan) demonstrating ridged titanium endplates on a PEEK interbody spacer. **(8)**

Advantages of Cage Utilization in anterior cervical fixation (9)

1. Avoidance of graft related complications as:

a. Graft extrusion as sharp serration in the upper and lower borders of the cage makes extrusion of the cage almost impossible.

b. Graft collapse due to the hard structure of the cage and its nature resorption does not occur.

c. Pseudoarthrosis and non-fusion as if proper technique is used, fusion is noticed in almost all cases.

2. Avoidance of graft donor site complications.

3. Easiness of the procedure.

4. An interface with the esophagus that is common to all plate devices is not seen with the cervical cage which is recessed below the vertebral surface.

5. Opening of the intervertebral spaces and correction of the kyphotic deformity with subsequent opening of the intervertebral foramina due to the physiological design of the cage being broader anteriorly than posteriorly.

Complications of Anterior Surgical Approach (10)

- Cerebrospinal fluid leak
- RLN injury
- Dysphagia
- Horner's syndrome
- Cervical nerve root injury
- Hematoma
- Paraparesis
- Death
- Infection
- Esophageal perforations
- Non-union (dependent on technique)
- Graft dislodgement/collapse (dependent on technique)
- Instrumentation failure (dependent on technique)
- Vascular injury (carotid artery, vertebral artery or venous)

Dysphagia: It is a quite frequent symptom after anterior cervical surgery and can be encountered in up to 50% of cases in the immediate postoperative period. Dysphagia is dependent on the number of levels treated. At 12 months post- operatively, however, the rate of moderate to severe dysphagia decreases to about 13%. The etiology of this complication is not fully understood. An injury to the superior laryngeal nerve has been suggested as a potential cause. Papavero et al. have reported that no correlation exists between the pharynx/esophagus retraction and postoperative swallowing disturbances **(11)**.

Recurrent laryngeal nerve (RLN) palsy: It has been reported in 2–11%. In contrast to common belief, the injury rate does not appear to be related to the side of the approach. Postoperative laryngoscopy revealed that the true incidence of initial and persisting RLN palsy after anterior cervical spine surgery was much higher than anticipated. Gokaslan et al. reported that the postoperative rate of clinically symptomatic RLN palsy was 8.3%, and the incidence of RLN palsy not associated with hoarseness (i.e., clinically unapparent without laryngoscopy) was 15.9%. At 3 months postoperatively, these rates decrease to 2.5% and 10.8%, respectively **(12)**.

Superior laryngeal nerve lesion: Caution is extremely important if the contralateral side was operated on for thyroid surgery or neck surgery, or was irradiated. A bilateral lesion interrupts the afferent part of the cough reflex and can cause life-threatening aspiration. A unilateral lesion causes slight hoarseness, voice fatigue, loss of high tonalities, and decrease in voice volume. Therefore, prudence is particularly indicated in singers, teachers and professional speakers. Caution is necessary in any cervical spine operation rostral to C4 **(13)**.

Horner's syndrome: Injury to the sympathetic trunk occurs when dissection extends lateral to the longus coli muscles and is usually temporary or of little clinical significance **(14)**.

Cerebrospinal fluid fistula: It is usually related to laceration of the dura and arachnoid over the nerve root by the high-speed air drill. Also, the curette may tear the dura and must be used with extreme caution in removing the posterior disc fragment **(15)**.

Postoperative hematoma: Although an uncommon complication after anterior cervical spine surgery, retropharyngeal hematoma with associated airway compromise has potentially catastrophic consequences. After completion of the surgical procedure all retracting devices should be removed, as increased tissue pressures will tamponade bleeding sites. A handheld retractor (such as a cloward retractor) should be introduced into the wound and manipulated appropriately for visualization. Bipolar electrocautery and thrombin-soaked gelfoam should be readily available on an as needed basis. Once complete hemostasis is assured, a drain is placed at the discretion of the surgeon and the wound is closed in standard fashion **(16)**.

Nerve and spinal cord injury: Serious neurological sequelae are rare and the risk of spinal cord injury is less than 1%. The practical and real risk of spinal cord injury is between 0.2 and 0.5%. Most spinal cord or nerve root injuries are associated with technical mishaps. Plunging into the spinal cord has been reported with many of the various anterior cervical procedures. Bone graft insertion is also associated with direct spinal cord injury. Vascular compromise of the spinal cord is associated with significant morbidity **(17)**.

Esophageal injury: Uncommon but potentially devastating complication that may present anytime from the early postoperative period to years later. Delayed injuries are the result of erosion of the posterior wall of the esophagus by the graft and/or the instrumentation affecting the posterior wall of the esophagus **(18)**.

Pseudoarthrosis: Patients with persistent or recurrent neck pain after ACDF should be evaluated for pseudarthrosis. Patients may also endorse persistent radicular symptoms. Radiographs and advanced imaging should be ordered; however, the only gold standard is surgical exploration. Radiographic markers that suggest pseudarthrosis include a radiolucent strip at the vertebral body-graft interface, increasing kyphosis, loosening of hardware, and more than 2 mm change in the interspinous process distance during flexion-extension .CT is the preferred method of visualizing the fusion mass and local anatomy, although metal artifact from instrumentation may obscure the images **(19)**.

Complications of the cervical cages

Reports have voiced concern that development of cage subsidence and loss of lordosis occur when cages are used without plate fixation. Reduced contact surface between the cartilage end plates and cages leads to increased instability and related problems **(20)**.

Factors that increase the possibility of subsidence include (5)

- Aggressive removal of the bony end-plate, the best is to remove parts of the end plate to promote fusion and to leave other parts intact to minimize subsidence.
- The placement of cages in more than one level, the incidence of subsidence is higher especially in the cages placed in the disc space above and below which other cages are used.
- Age of the patient, the older the patient; the incidence of subsidence is higher due to osteoporosis of the bone.
- Size of the cage, proper size of the cage should be used as a larger cage size will increase the possibility of subsidence.

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