72 Management of Soft Cervical Disc Herniation: Controversies and Complication Avoidance

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SUMMARY OF KEY POINTS

- Commonly accepted indications for surgery differ, depending on whether a pure soft disc herniation causes radiculopathy without deficit or whether there are neurologic deficits due to nerve root compression or signs of spinal cord compression.
- Radiologic evaluation is crucial in decision making. When the abnormality is central, broad based, and dorsal, a ventral procedure is more likely to achieve decompression.
- Clinical outcome in terms of a visual analog scale of neck and arm pain and physical and mental score improvement seem comparable with autograft with plate, cage with plate, or stand-alone cage.
- The debate regarding disc arthroplasty versus cervical discectomy with fusion (ACDF) in the surgical treatment of soft disc herniations will probably continue until sufficient long-term results prove whether or not disc arthroplasty prevents acceleration of adjacent segment degeneration, as often seen after ACDF, while at the same time limiting the number of surgeries for adjacent level disease.
- The use of rhBMP is declining following published safety concerns as well as investigational conflicts of interest.
- Meticulous knowledge of potential ACDF-related complications is of paramount importance in order to avoid them whenever possible, as well as to successfully and safely manage them when they happen.
- Two years after surgery for cervical radiculopathy caused by soft cervical disc herniation (without myelopathy), 75% of patients have substantial pain relief from radicular symptoms (pain, numbness, and weakness). Overall improvement of myelopathy symptoms may take longer than recovery from radicular symptoms.

About 450 years ago, Vesalius described the intervertebral disc.[1] It was not until 1928 that Stookey described a number of clinical syndromes resulting from cervical disc protrusions. These protrusions were thought to be neoplasms of notochordal origin and were incorrectly identified as chondromas.[2] During this same era, other investigators provided a more precise understanding of the pathophysiology of intervertebral disc herniation.[3-5]

Both soft and hard cervical disc herniations can lead to nerve root compression (radiculopathy) or compression of the spinal cord (myelopathy). Hard cervical disc herniation is a condition in which osteophytosis is involved. This chapter focuses on pure soft disc herniation, which causes radiculopathy more frequently than myelopathy (Figs. 72-1 through 72-4).

Population-based data from Rochester, Minnesota, indicate that cervical radiculopathy has an annual incidence rate of 107.3 per 100,000 for men and 63.5 per 100,000 for women, with a peak at 50 to 54 years of age. A history of physical exertion or trauma preceded the onset of symptoms in only 15% of cases. A study from Sicily reported a prevalence of 3.5 cases per 1000 population.[6]

Generally, the most common cause of cervical radiculopathy (in 70% to 75% of cases) is foraminal encroachment of the spinal nerve due to a combination of factors, including decreased disc height and degenerative changes of the uncovertebral joints anteriorly and zygapophyseal joints posteriorly (i.e., cervical spondylosis). In contrast to disorders of the lumbar spine, pure herniation of the nucleus pulposus (soft disc herniation) is responsible for only 20% to 25% of cases,[7] although the relative proportion of disc herniation in younger people is significantly higher.[8] Overall though, in many cases there is a combination of some spondylosis with a soft disc herniation. Other causes, including tumors of the cervical spine and spinal infections, are infrequent.[6]

This chapter provides a concise strategy for treating soft cervical disc herniations (SCDHs), based on former knowledge and new insights. Controversies are discussed, including when one operates and, if so, how one does it. Second, an overview of possible complications and how to avoid them is provided.

CONTROVERSIES

Surgical Indications

Commonly accepted indications for surgery differ, depending on whether a pure soft disc herniation causes radiculopathy without deficit or whether there are neurologic deficits due to nerve root compression or signs of spinal cord compression.

Data on the natural history of cervical radiculopathy are limited. In the population-based study from Rochester, Minnesota, 26% of 561 patients with cervical radiculopathy underwent surgery within 3 months of diagnosis (typically for the combination of radicular pain, sensory loss, and muscle weakness), whereas the remainder were treated medically.[6] The natural course of spondylotic and discogenic cervical radiculopathy is generally favorable. Especially pure soft disc herniations often resolve spontaneously.[8]

The main objectives of treatment are to relieve pain, to improve neurologic function, and to prevent recurrences. None of the commonly recommended nonsurgical therapies for cervical radiculopathy have been tested in randomized, placebo-controlled trials. Therefore, recommendations are derived largely from case series and anecdotal experiences. The patient's preferences should be taken into account in the decision-making process. Analgesic agents, including opioids and nonsteroidal anti-inflammatory drugs, are often used as first-line therapy. Retrospective and prospective cohort studies reported favorable results with interlaminar and

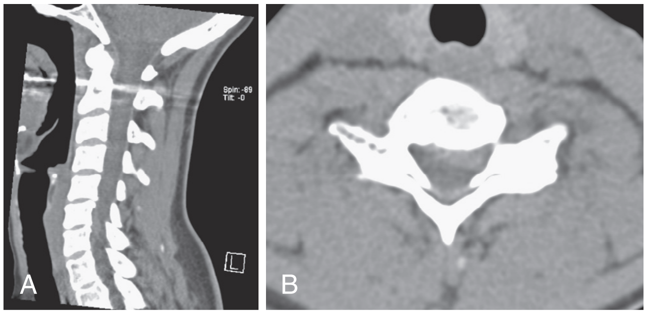

Figure 72-1. A and **B,** CT images of C6-7 soft cervical disc herniation.

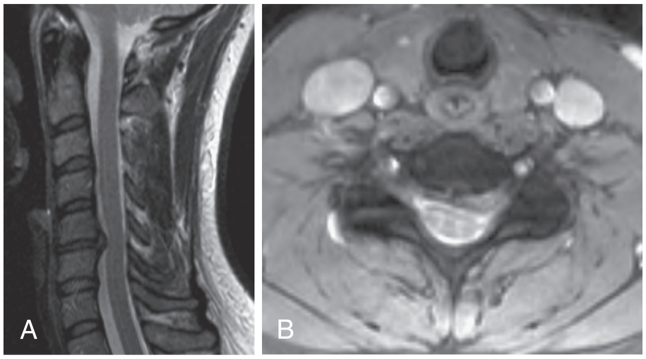

Figure 72-2. A and **B,** Magnetic resonance images of C5-6 soft cervical disc herniation.

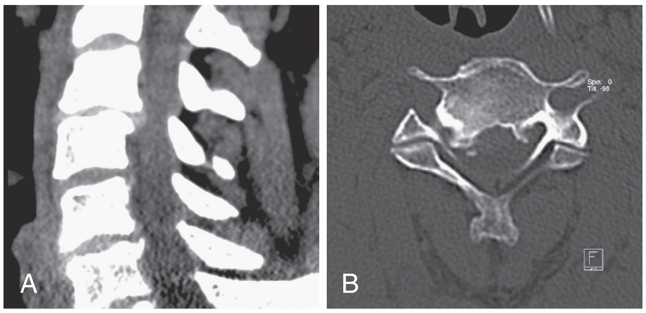

Figure 72-3. CT images of C3-4 hard cervical disc herniation.

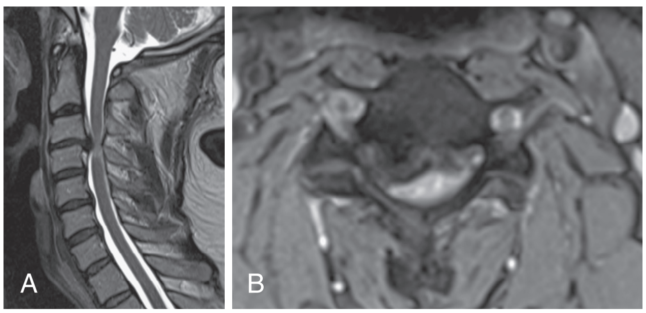

Figure 72-4. Magnetic resonance images of C3-4 hard cervical disc herniation.

transforaminal epidural injections of corticosteroids, with up to 60% of patients experiencing long-term relief of radicular and neck pain and a return to usual activities. However, complications from these injections, although rare, can be serious and include severe neurologic sequelae from spinal cord or brain stem lesions. Given the potential for harm, placebo-controlled trials are needed to assess both the safety and the efficacy of cervical epidural injections. Some investigators advocate the use of short-term immobilization (less than 2 weeks) with either a hard or a soft collar (either continuously or only at night) to aid in pain control. Cervical traction consists of administering a distracting force to the neck in order to separate the cervical segments and relieve compression of nerve roots by intervertebral discs. Especially in absence of nightly pain, traction therapy may be considered to alleviate pain. Various techniques and durations have been recommended. However, a systematic review stated that no conclusions could be drawn about the efficacy of cervical traction. The same is true for exercise therapy.[6]

Therefore, in appropriate patients, surgery may effectively relieve otherwise intractable symptoms and signs related to cervical radiculopathy, although there are no data to guide the optimal timing of this intervention. For cervical radiculopathy without evidence of myelopathy, surgery is typically recommended when cervical root compression is visualized on magnetic resonance imaging (MRI) or computed tomography (CT) myelography with concordant symptoms and signs of cervical root-related dysfunction, and when the pain does not disappear despite nonsurgical treatment for at least 6 to 12 weeks. A progressive, functionally important motor deficit represents a more urgent surgical indication. Surgery is definitely recommended in cases in which imaging shows cervical compression of the spinal cord in combination with clinical evidence of moderate to severe myelopathy.[6]

As summarized in a Cochrane review,[9] there are only a limited number of good-quality studies comparing surgical and nonsurgical treatments for cervical radiculopathy. In one randomized trial comparing surgical and nonsurgical therapies among 81 patients with radiculopathy alone, the patients in the surgical group had a significantly greater reduction in pain at 3 months than the patients who were assigned to receive physiotherapy or who underwent immobilization in a hard collar. However, at 1 year, there was no difference among the three treatment groups in any of the outcomes measured, including pain, function, and mood.[9]

Comparing cervical with lumbar (soft) disc herniations, Peul[10] pointed out that in absence of alarming symptoms related to lumbar disc herniations, surgery is optional, depending on the patient's preference. However, in contrast with lumbar disc herniation, cervical soft disc herniations more frequently justify surgical treatment when refractory radiculopathy is concerned.

Surgical Approach

Multiple surgical approaches to the cervical spinal canal or neural foramina are possible, with associated advantages and disadvantages. Ventral and dorsal options have been described.[11]

The dorsal exposures have three possible advantages in comparison to the ventral approach: (1) less surgical effort is required in exposing or decompressing multiple levels; (2) additional fusion with or without instrumentation is often not required; and (3) the procedure does not necessarily stiffen the motion segments involved and therefore does not accelerate spondylotic degeneration at adjacent levels, as is thought to occur after (ventral) fusion procedures. Partial hemilaminectomy, with or without foraminotomy as described by Frykholm,[12] has become a standard dorsal exposure for laterally located cervical disc herniation.[11] Central disc herniations, however, should be approached ventrally.

Techniqually,[11] the dorsal approach begins with a small partial hemilaminectomy above and below the level of expected pathology. Removing the caudal margin of the rostral lamina laterally and the attached ligamentum flavum allows for identification of the lateral dural margin and the nerve root origin. Although the major exposure is caudal, it is desirable to also expose the rostral border of the nerve root to allow for its complete identification and achieve some space for the minimal mobilization of the nerve root. Often, there is a small amount of space caudal to the nerve root. This space can be enlarged with a curette or a high-speed drill. Venous bleeding is most common with this approach and should be adequately addressed during exposition of the neural structures. Care must also be taken to ensure one has enough of the nerve root exposed so that the motor root is not confused with extruded disc material.

After sufficient exposure of the nerve, the surgeon starts to explore for a disc extrusion, from above or beneath the nerve root. If there is a soft disc extrusion, the posterior longitudinal ligament can be incised with a knife, and a bit of pressure on the above posterior longitudinal ligament occasionally causes the fragment to be milked outward beneath the elevated root. Following this step, there is often some additional space so that the foramen can be better explored and enlarged, if necessary. If only a small, hard bony ridge beneath the nerve root is present, it might not be necessary to remove it. Often, a simple but thorough decompression of the nerve root dorsally into the foramen provides adequate relief of symptoms. After removal of an extruded cervical disc, it is not necessary or advisable to enter the cervical disc space to remove additional degenerated disc material from behind. Usually, visualizing the interspace would require significant root and spinal cord retraction, which in itself could result in nerve root or spinal cord injury. On the other hand, such additional discectomy is not necessary, as the recurrence rate for a cervical disc herniation without entering the disc space is less than 1% in most series.

More than half a century has elapsed since the initial description of ventral cervical discectomy by Bailey and Badgley.[13] Modifications of this technique were described by Robinson and Smith in 1955[14] and by Cloward and the group of Dereymaeker and Mulier, both in 1958.[15,16] Robinson and Smith described an operation for removal of cervical disc material with replacement by a rectangular bone graft, obtained from the iliac crest, to allow for the development of a cervical fusion.[14] With Cloward's method, the discectomy and fusion were performed by a dowel technique. Although numerous modifications have been developed since the 1950s, the great majority of spine surgeons nowadays use either the Cloward or the Smith-Robinson technique, primarily for herniations that are located on the midline or mediolaterally.[17-26]

Technically, the ventral approach begins with optimal positioning of the patient with the head in slight (hyper-)extension. The side of the incision has been given excessive emphasis because of potential harm to the laryngeal nerve. However, more practical concerns such as previous surgery (and thus potential subclinical vocal cord problems) and the side of the radicular symptoms (as it appears that owing to the surgeon's oblique perspective, contralateral decompression is favored) should dictate the side of incision. After a right- or left-sided approach has been chosen, a transverse skin incision is made. An avascular dissection plane is developed between the esophagus/trachea medially and the sternocleidomastoid/carotid sheath laterally. Handheld retractors might be utilized to provide initial exposure of the anterior vertebral column and the adjacent longus colli muscles. Final orthostatic retraction is placed, after confirmation of the target level. After removal of the disc and preparation of the end plates according to the technique used (different fusion techniques versus disc replacement; see the discussion presented later), the posterior longitudinal ligament is opened and the disc extrusion is removed. When myelopathy is present, the authors advise starting to open the ligament laterally, without exerting (additional) pressure on the spinal cord. Finalization of the procedure follows according to the technique.

Radiologic evaluation is crucial in decision making. When the abnormality is central, broad based, and dorsal, a ventral procedure is more likely to achieve decompression. On the other hand, with lateral or foraminal nerve root compression, the simpler dorsal keyhole laminoforaminotomy works well. One may consider that the possible additional decompressive effect due to (slight) distraction of vertebrae (and thus opening of the neuroforamina) in ventral fusion is not obtained via a dorsal approach. Physicians who advocate either procedure exclusively may not always provide the "best" approach.[27]

Ventral Approach: Cervical Discectomy without or with Fusion Versus Prosthesis

Cervical discectomy with fusion (ACDF), as has been described by Cloward[15] and Robinson and Smith,[14] has become a routine surgical procedure. Nevertheless, when autografts from the iliac crest are used, the technique has been associated with donor site morbidity such as pain, infection, hematomas, nerve injury, and iliac crest deformity. Graft and fusion problems at the fusion bed may occur, such as nonunion, graft collapse or dislodgement.[28] In attempts to overcome the graft-related problems, anterior cervical discectomy without bone fusion (ACD) was introduced in 1960 by Hirsch.[29] However, ACD has usually been associated with postoperative neck pain, cervical curve deformity (kyphosis), and lower fusion rates (up to 60%). One can consider that the actual aim of ACD is even to avoid fusion. Hospital stay is an important consideration in this era of cost consciousness. In some countries, the debate between advocates of ACDF and those of ACD is ongoing. Abd-Alrahman and colleagues[28] concluded that the controversial issue in the management of patients undergoing anterior cervical discectomy will continue regarding the choice between ACD and ACDF. Proponents of interbody grafting claim that with ACD, the disc height and the area of the neural foramina at that level will decrease postoperatively, with the potential for persistent symptoms or the development of a radiculopathy, and that the kyphosis rate is high. With ACDF, the fusion rate is high, the neck pain is less, and the distraction of disc space stretches the ligamentum flavum and reduces its buckling, diminishing the risk for postoperative ongoing or recurrent nerve root compression. Nowadays ACDF in various graft fashions is much more frequently performed than is ACD. ACD should furthermore be limited to patients with a single soft disc without spondylosis.

Disc arthroplasty became popular in Europe during the first decade of the 21st century, but it is less frequently used nowadays due to uncertainty about its long-term benefit in comparison to ACDF, the complexity of the surgical technique, and the high price of many of the devices. From a theoretic viewpoint, cervical disc arthroplasty or total intervertebral disc replacement (TDR) seems to be a promising nonfusion alternative for the treatment of degenerative disc disease, especially in cases of pure soft disc herniation. TDR is designed to preserve motion, avoid limitations of fusion, and allow patients to quickly return to routine activities. The primary goal of the procedure in the cervical spine is to maintain segmental motion after removing the local pathology, and by doing so to prevent later adjacent level degeneration,[29-32] as is sometimes seen after ACDF due to increased motion stress at those adjacent levels. TDR also avoids the morbidity of bone graft harvest, pseudarthrosis, issues caused by ventral cervical plating, and cervical immobilization side effects.[31] The Frenchay (Bristol) prosthesis[33] and the Bryan intervertebral disc prosthesis were the first of these devices to be clinically assessed in Europe. The first cervical disc arthroplasty clinical trial in the United States was the Bryan disc study initiated in May 2002 after a European prospective human clinical trial began in 2000.[34] The results of the European clinical trial with the Bryan disc prosthesis (Fig. 72-5), though neither randomized nor controlled, validated the stability, biocompatibility, and functionality predicted by clinical testing. McAfee and colleagues[35] published a meta-analysis of four prospective randomized controlled Food and Drug Administration (FDA) investigational device exemption (IDE) clinical trials: these findings suggest that TDR is superior to ACDF in overall success, neurologic success, and survivorship outcomes at 24 months postoperatively. Upadhyaya and coworkers[36] reported similar findings, in slight favor of TDR, based on trials with the Bryan, Prestige, and ProDisc C devices.[37-39] A Cochrane review unequivocally stated that there is high-quality evidence that the goal of preservation of segmental mobility in arthroplasty was met.[40] At the 6-year follow-up, TDR using the Bryan prosthesis displayed satisfactory clinical and radiographic outcomes.[41] However, a statistically significant effect on the incidence of secondary symptoms at adjacent levels, the primary goal of arthroplasty over fusion, was not found at 1 to 2 years.[40] A systematic review by Verma and associates of IDE and non-IDE trials showed no difference in the rate of adjacent segment disease for ACDF versus TDR.[42] The debate about disc arthroplasty versus ACDF in the surgical treatment of soft

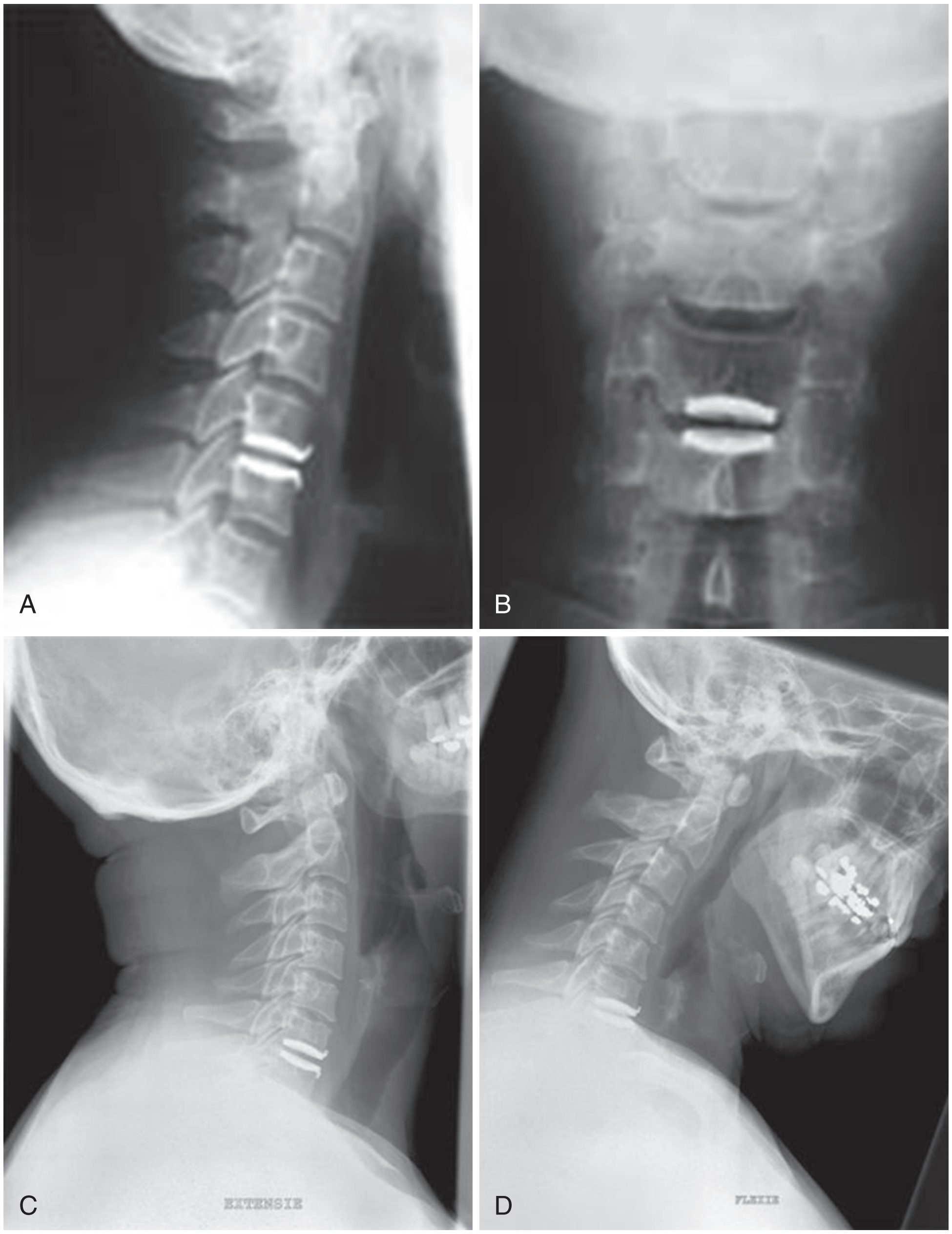

Figure 72-5. A–D, Radiographs of Bryan prosthesis with dynamic (flexion-extension) images.

disc herniations will probably continue until sufficient long-term results prove whether or not disc arthroplasty prevents acceleration of adjacent segment degeneration, as often seen after ACDF, while at the same time limiting the number of surgeries for adjacent level disease.

Yi and colleagues[43] reported that anterior cervical foraminotomy can be a valid alternative treatment for unilateral cervical radiculopathy, sharing the same goal as arthroplasty—namely, preservation of segmental motion and avoidance of adjacent segment degeneration.

Cervical Discectomy with Bone Fusion Strategies

Several techniques for ACDF are currently performed, mostly depending on the choice of the surgeon. However, there may be differences in perioperative morbidity and short- and long-term outcome. The study by Bhadra and associates[44] analyzed the cost-effectiveness of three techniques, in comparison to each other and to arthroplasty. Besides a group of arthroplasty patients, they defined three groups of 15 patients each: (1) plate and tricortical autograft; (2) plate, cage, and bone substitute; and (3) cage only. They found that the clinical outcome in terms of a visual analog scale of neck and arm pain and physical and mental score improvement were comparable with all three techniques. The radiologic fusion rate was comparable to currently available data. Because the hospital stay was longer in the plate and autograft group, the total cost was a maximum with this group. Using a cage alone was the most cost-effective technique in the author's hands.

Autograft

Some surgeons still consider autograft to be the gold standard for achieving radiographic fusion in one-level anterior cervical discectomy and fusion. Autogenous bone has osteoinductive, osteoconductive, and osteogenic properties.[45] The capacity for rapid regeneration comes mostly from fresh cancellous bone, which contains bone matrix proteins and mineral collagen. An ideal autograft includes strong cortical bone to provide structural support and cancellous bone for augmented incorporation and fusion characteristics. Revascularization of cancellous bone is completed within 2 weeks, whereas it takes 2 months for cortical bone. An additional advantage of autogenous bone graft is that is does not carry transmissible diseases to the host. Cortical and cancellous graft material is generally obtained from the iliac crest.

As was mentioned by Bhadra and colleagues,[44] autograft as a gold standard is challenged. Seemingly, when rigid instrumentation is used, the inferior fusion rates with allograft can be overcome. Samartzis and coworkers[46] found that when autograft (without plate) was compared with allograft with rigid ventral plate fixation in one-level anterior cervical discectomy and fusion, the two methods resulted in statistically equivalently high fusion rates with excellent and good clinical outcomes. The radiographic fusion rate was even higher in the allograft group. They stated also that the use of allograft eliminates the complications and pitfalls associated with autologous donor site harvesting. On the other hand, autograft was considered safer in terms of preventing infection. The specific complication rates related to the plating itself were not addressed. Additionally, the same authors showed in another study[44] that when considering autograft in one-level cervical fusion with or without rigid plate fixation, the two methods gave similar results.

Allograft

Allografts are tissues obtained from cadavers or living donors.[45] They are associated with delayed vascularization and delayed incorporation, perhaps because of antigenic recognition. Allografts have osteoinductive and osteoconductive properties. However, they have lost their osteogenic property.

To overcome the relatively high collapse rate of allogeneic iliac crest, Martin and associates conducted a study on the efficacy of allogeneic fibula graft[48] on the cervical fusion rate. They found that allogeneic fibula is an effective substrate for use in achieving fusion after cervical discectomy. Maximal results were achieved with its use at one level. As a secondary outcome, cigarette smoking appeared to decrease the fusion rates, but not by a statistically significant amount.

As mentioned earlier, when rigid instrumentation is used, ventral cervical fusions at one level with autograft or allograft seem to have comparable fusion rates, the latter being widely adopted in the United States.

Cage

Cage fusion technology originated in 1979 from Bagby's work on horses and was first used in humans in around 1990.[49] The principle of distraction-compression, the basic principle of stand-alone intervertebral cage fusion, was introduced. Interbody cages provide initial segmental stability by tensioning the ligamental apparatus, which anchors a cage's top and bottom areas to the adjacent end plates. They can be threaded or not.

Titanium cage-assisted ACDF provides long-term stability, increasing lordosis, segmental height, and foraminal height. Polyetheretherketone (PEEK) is a semicrystalline polyaromatic linear polymer that provides a good combination of strength, stiffness, toughness, and environmental resistance. The elastic modulus of the PEEK cage is close to that of bone, which helps to decrease stress shielding and increase bony fusion. The PEEK cage has a deleterious influence on cell attachment and growth and inhibits a stimulatory effect on the protein content of osteoblasts.[50] Trabecular metal™ is a porous tantalum biomaterial with structure and mechanical properties similar to that of trabecular bone and with proved osteoconductivity[51] (Fig. 72-6).

Studies by Cho and colleagues[52] and by Chou and colleagues[50] consistently showed the equivalence of PEEK cages and autografts in ACDF, in terms of fusion rates, clinical improvement, and complication rate. The low fusion and high complication rates associated with titanium cages may mean that these should no longer be used in clinical practice. Löfgren and associates published a study in which TM showed a lower fusion rate than the Smith-Robinson technique with autograft after single-level anterior/ventral cervical fusion without plating. No difference was though seen in clinical outcomes between the groups. The operative time was shorter with TM implants.[51]

A more recent systematic review found minimal evidence for a better clinical and radiographic outcome for PEEK cages compared with bone grafts. No differences were found among PEEK, titanium, and carbon fiber cages.[53] Although subsidence is more frequently seen in stand-alone cage ACDF, it appears to be of no clinical significance.[54,55]

The issue of postoperative image distortion (on CT or MRI) is rarely addressed in the literature, though it should be taken into account when appreciating cage fusions.

To Plate or Not to Plate?

Plating is theoretically designed to improve fusion rates, based on the impending risk of pseudarthrosis in uninstrumented cases. The essential question is twofold: does instrumentation improve fusion rates, and, more basically, is pseudarthrosis in uninstrumented cases a significant problem? Furthermore, if pseudarthrosis occurs or is radiographically documented, is it

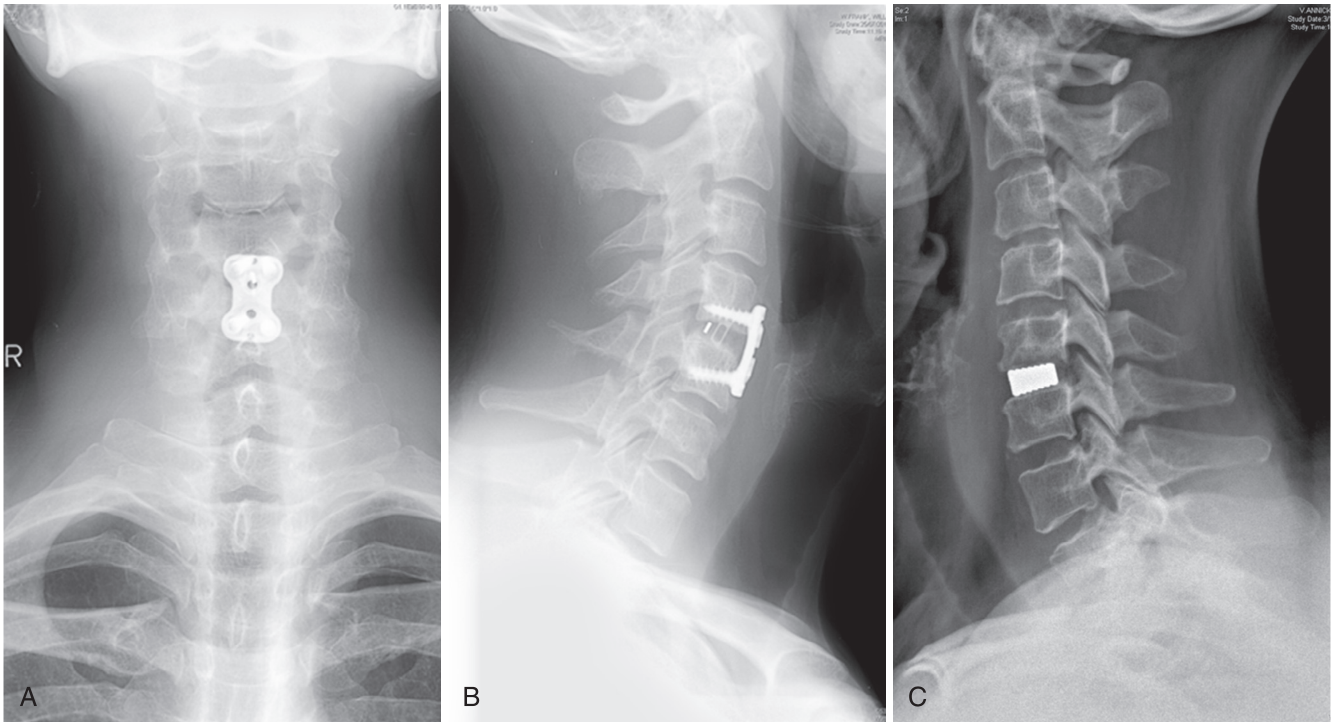

Figure 72-6. Trabecular metal is a porous tantalum biomaterial with structure and mechanical properties similar to that of trabecular bone and with proved osteoconductivity.

of any clinical relevance? Additionally, focusing on the previously mentioned higher fusion rates in autograft versus allograft, can plating compensate for this difference?

The first question is answered by a lot of studies showing higher fusion rates in instrumented autologous and allogeneic grafts, compared with cases without plating, even at one level.[56,57] Second, despite the differences in the reported fusion rates of these procedures, they seem to be similar in their effectiveness of symptomatic relief.[56,58] The proposal that surgical fusion is unnecessary is controversial.

Bhadra coworkers[44] tended to answer the final question. Seemingly, plating can compensate for lower fusion rates in allografts, in comparison to autografts. The clinical relevance again can be questioned.

As a general appraisal we state that plating is mostly associated with multilevel pathology, which is rare in pure soft disc herniation cases. In the latter, plating seems only issued when allograft is considered. The need for additional plating in cage ACDF remains unclear and mostly depends on surgeon's routine and personal experience.[59]

Bone Morphogenetic Protein (BMP)?

Because of the potential risk of pseudarthrosis (0 to 40%) and late-term destabilization of anterior cervical fusion, means to improve the rate and speed of bone healing were developed. At one time recombinant human (rh)BMP seemed promising and still has not been completely abandoned.[60] Nowadays, however, the use of rhBMP is declining following published safety concerns as well as investigational conflicts of interest. In both lumbar and cervical fusion procedures, unreported complications were highlighted: infection, subsidence, ectopic bone formation, osteolysis, and the like were reported to an extent of a 40% greater risk of adverse events with rhBMP in cervical fusion in the early postoperative period, including life-threatening events.[61,62]

COMPLICATION AVOIDANCE

Of utmost importance in avoiding complications with any operation for soft cervical disc herniations is to perform the appropriate operation on the appropriate patient. Correlating the clinical picture with the imaging abnormalities is crucial.[63] It is known that ACDF is one of the most commonly performed spinal procedures. Its outcome is satisfactory in the majority of cases. However, occasional complications can become troublesome and even, in rare circumstances, catastrophic. Although there are several case reports describing such complications, their rate of occurrence is generally underreported, and data regarding their exact incidence in large clinical series are lacking. Meticulous knowledge of potential ACDF-related complications is of paramount importance in order to avoid them whenever possible, as well as to successfully and safely manage them when they happen.[64]

Complications Related to the Dorsal Approach

Because the dorsal approach is worth considering, especially in (lateral) soft cervical disc herniation, some potential problems are worth mentioning. First, one should confirm the correct level to operate. Further, proper visualization of the interlaminar space must be obtained. A high-speed drill can be effective, but it can damage the spinal cord or exiting nerve, as the amount of ligamentum flavum is occasionally sparse. Venous bleeding most commonly occurs and must be dealt with sufficiently for obvious physiologic reasons, as well the minimization of interference with adequate visualization of neural structures. The nerve itself should finally be exposed in both its sensory and motor component since the latter can be mistaken for the (soft) herniation and thus may be cut. The authors occasionally choose to insert a drain before closure, although hematomas are rarely reported. Postoperative neck pain is seen more often than after ventral cervical disc surgery.

Complications Related to Cervical Disc Arthroplasty

Besides the intraoperative risks and possible complications that are, for the most part, the same as those seen with ventral discectomy and fusion techniques,[65,66] one can specifically distinguish immediate (e.g., malpositioning of the prosthesis), early (e.g., migration), intermediate (e.g., subsidence) and late (e.g., wear debris formation with osteolysis) postoperative complications. The impact of a cervical disc prosthesis and its complications in the long run have to be elucidated. These complications can be minimized while providing optimal function by limiting this type of surgery to patients with appropriate indications.

Complications Related to ACDF

Preoperative Period

In patients with a significant neurologic deficit, the preoperative use of corticosteroids may be considered. However, there are no convincing reports in the literature to support the efficacy of the routine use of corticosteroids in patients undergoing elective decompressive operation.[63] As has been shown for trauma patients,[67] corticosteroids are more likely to induce additional problems, especially in elderly patients, than they are to effectively diminish the risk of spinal cord or nerve injury.

In patients with spinal cord compression, hyperextension of the neck during intubation or preoperative positioning should be avoided. In pure soft disc herniation problems, this situation of risk for spinal cord compression is rarely encountered. However, whenever it is, the patient should be intubated fiberoptically.

Intraoperative Period[63]

Injury to the Laryngeal Nerve(s): Approach Related? On the left side, the recurrent laryngeal nerve loops under the arch of the aorta and is protected in the left tracheoesophageal groove. On the right side, however, it travels around the subclavian artery, passing dorsomedially to the side of the trachea and esophagus. The nerve is vulnerable as it passes from the subclavian artery to the right tracheoesophageal groove. Minor hoarseness after a ventral cervical operation is common and has been reported in up to one half of patients. In most cases, it resolves spontaneously and is generally due to edema from tracheal intubation or from severe retraction of the larynx. However, permanent laryngeal dysfunction due to injury of the laryngeal nerves may also be the cause of postoperative hoarseness and is estimated to occur in about 1% of cases.

The higher risk of injury to the recurrent laryngeal nerve associated with a right-sided approach, especially in the lower cervical spine (which, though, has never been confirmed in the literature), however, is in the estimation of some surgeons balanced by the convenience of the position for right-handed surgeons. As stated earlier, more practical concerns should dictate the side of the incision: previous surgery (vocal cord testing should be performed before operating on the opposite side), the side of the radicular symptoms, and the surgeon's routine.

Injury to the Oesophagus and Pharynx.[68-70] Likewise, dysphagia due to edema from pressure by retraction blades is common after ventral cervical surgery. In certain cases, however, it may persist as long as several weeks and, in rare cases, it may be permanent. Elderly patients who have had extensive mobilization of the upper esophagus or hypopharynx are more prone to this consequence.

Esophageal or pharyngeal perforation can occur, either as a result of sharp dissection or from the sharp teeth of self-retaining retractors. This complication occurs more frequently in the upper cervical region, in which the wall of the hypopharynx is thinner. If the laceration of the esophagus is recognized intraoperatively, it should be repaired primarily. In the majority of cases, the injury to the esophagus is not recognized during surgery and presents later as a local infection, fistula, sepsis, or mediastinitis.

To avoid injury to the esophagus, dissection below the level of the superficial cervical fascia should be performed with utmost care in a sharp or blunt way. In addition, the longus colli muscles should be freed enough from the ventrolateral side of the superior and inferior vertebral bodies in order to have the sharp teeth of the self-retaining retractors placed safely under them without risk of dislodgement during the procedure.

The esophagus and other soft tissue structures should be hidden by the retractors to avoid injury by drills during bone removal.

Injury to the Structures in the Carotid Sheath. The carotid artery, the internal jugular vein, and the vagus nerve are at risk of damage in the lateral part of the operative field. Laceration of these structures is caused by the sharp teeth of retractor blades or during the dissection with sharp instruments. For this reason, blunt dissection could be advisable. In most cases, carotid artery lacerations can be repaired primarily. Bleeding from the jugular vein should be controlled by repairing the laceration. In an ultimate case, ligation of the jugular vein should be considered. Injury to the vagus nerve is an unusual complication, but if transsection is observed intraoperatively, primary anastomosis should be attempted.

Injury to the Inferior Thyroid Artery.[71] Because the inferior thyroid artery most frequently crosses the C6-7 interspace obliquely, the course of the inferior thyroid artery may complicate a ventral procedure. Serious bleeding may occur and necessitate vessel clips. In the avascular plain between the visceral structures and the carotid sheath, meticulous dissection is required to approach the linea alba.

Injury to the Vertebral Artery. Far lateral bone removal can damage the vertebral artery and is most likely to occur on the opposite side of the approach. An aggressive dissection of the longus colli muscles can also injure the artery between the transverse processes. Third, an anatomic variation with a midline loop of the vertebral artery into the vertebral body or intervertebral disc can cause problems. Commonly, bleeding can be controlled with gentle compression using a muscle pledget, hemostatic gelatin (Gelfoam), or oxidized cellulose (Surgicel). The risk of neurologic deficit after a unilateral vertebral artery occlusion is low, but this can be encountered if there is a congenital anomaly with an absence of anastomosis between the left and the right vertebral arteries.[71] Cases of Wallenberg syndrome were described in such situations. To avoid this injury, one should identify the midline carefully and proceed with drilling accordingly.

Horner Syndrome. The cervical sympathetic chain is located ventral to the transverse process and ventrolateral to the longus colli muscle. Injury results in a Horner syndrome, which can result from either transsection or retraction of the sympathetic chain. The incidence of permanent injury is less than 1%. To avoid this injury during a ventral approach, the soft tissue dissection should be limited to the medial aspect of the longus colli muscle.[72,73]

Increased Neurologic Deficit. Increased neurologic deficit is uncommon after ventral cervical surgery, but it can comprise both the spinal cord and the nerve roots. If neurologic problems are seen immediately after the surgery, the most likely causes are (1) problems related to positioning or manipulation of the neck during intubation, (2) direct surgical trauma to the neural elements, and (3) intraoperative displacement of a graft or cage or severe epidural hematoma. During intraoperative localization, the fluoroscopic localization needle in the disc space can be bent at the tip to avoid inadvertent advancement of the needle into the spinal canal. Nerve root injuries are less common than spinal cord injuries, but for unclear reasons, the C5 nerve root is sensitive to trauma. Traction caused by decompression in combination with the specific rectangular root entry zone is one of the possible explanations.

If a neurologic deficit is not present immediately after the patient awakens but becomes clear within hours, an epidural hematoma and displacement of the graft are the most frequent possibilities. Using a graft or cage that does not occlude the disc space in its full width allows epidural blood to evacuate ventrally and therefore may limit the risk for epidural hematoma formation. If neurologic worsening occurs within days after the operation, an epidural abscess must be considered in the differential diagnosis.

In an attempt to decrease the potential additional neurologic deficit, one can consider monitoring neurologic function with intraoperative somatosensory evoked potentials. By doing this, spinal cord injury as well as nerve root injury may diminish.[74] Because spinal cord compression is not common in pure soft cervical disc herniations, the advantage of this neurophysiologic backup is rather theoretic in this particular indication.

Dural Laceration and Cerebrospinal Fluid Fistula. Dura mater laceration and cerebrospinal fluid leakage may occur during removal of the posterior longitudinal ligament or during drilling. Direct repair is usually not feasible. A piece of Gelfoam with fibrin sealant should be placed over the dural effect, and lumbar subarachnoid drainage should be performed for 4 to 5 days. Attention should be paid when the dorsal cortex or the slope of the uncovertebral joints is encountered. The surgeon must also be aware that the nerve roots are more ventrally located than the spinal cord.

Postoperative Period[63]

Soft Tissue Hematomas and Respiratory Problems. To prevent prevertebral cervical soft tissue hematomas after a ventral cervical operation, the authors advocate inserting a drain in the prevertebral space before closure, which should be left in place for 12 to 24 hours. The possibility of a large and compressive hematoma obviously warrants careful monitoring of the patient in the recovery room after the operative procedure. This may be an argument not to discharge a patient too early from the ward. Even days after the operation, soft tissue hematomas may rarely occur but still postulate urgent reoperation.

Postoperative Infection. Both superficial and deep infectious processes rarely occur after a ventral cervical operation. Superficial infections external to the platysma muscle can be treated by simply opening the incision, followed by dressing changes and the administration of appropriate antibiotics and secondary closure. Cellulitis or abscess in the deeper tissues, however, requires a more thorough evaluation.

Graft removal in the presence of infection is a complex issue. One option is leaving the graft in place, treating with antibiotics, and following the status of the graft with cervical spine films. Once the graft appears to collapse, removal and replacement with autograft would be indicated. In most cases, bone healing will take place.

Although one can speculate that with cages or plates (and TDR) the infection rates are relatively higher, data in the literature are scarce. Exceptional case reports are described.[75,76]

Finally, rare infectious complications concern epidural abscesses and meningitis. If a patient has delayed progressive postoperative spinal cord dysfunction, with or without evidence of osteomyelitis or systemic signs of sepsis, epidural abscess should always be considered in the differential diagnosis.

Graft or Cage Complications. Bone graft complications enclose graft collapse, displacement (and subsidence), and nonunion (pseudarthrosis). Elderly patients with osteoporotic bone are most prone to display graft collapse. If there is doubt about the structural integrity of autologous bone, an allograft should be used. However, in younger patients, autologous graft is stronger than allograft in resisting axial compression. Most patients with graft collapse are asymptomatic and do not require reoperation.

Graft Displacement and Subsidence. Graft displacement may require reoperation and has in general been reported to occur in as many as 8% of the patients who undergo surgery for disc herniation. A well-fitting graft and placement with compression may reduce this complication.

Subsidence (vertical displacement) is a radiologic finding that most of the time does not cause clinical problems. If subsidence occurs, it mostly does so in the ventral part of the cervical column, not where the width of the neuroforamina can be affected; as such, kyphosis may develop.

Stand-alone cage subsidence appears to occur more frequently, but, as stated earlier, it does not seem to have significant clinical repercussions.[77] Plating is reported to avoid subsidence, but this has not been shown via clinical studies.[78]

Nonunion. Graft nonunion or pseudarthrosis—which by definition is present when there is radiolucency at the fusion level or more than 2 mm of motion at the fusion site—has been reported in 5% of patients who undergo single-level fusion (and in 15% of multilevel fusions). Despite radiographic nonunion, the majority of these patients are clinically asymptomatic, and reoperation is not indicated. However, persistent neck pain, progressive angulation, and subluxation may mandate graft revision.

Biomechanics: Focus on Kyphosis. Kyphosis after ACD is classic and tends to become greater if the operation is performed on two levels rather than on one level. This could be explained by the fact that after discectomy the disc space systematically collapses. Collapse occurs ventrally more than dorsally, owing to the dorsal structures of the vertebra (facet joints), which do not collapse, and because of the wedge shape of the cervical disc. This results in a reversal of lordosis or straightening of the cervical curve. Additional fusion (ACDF) is performed to overcome this problem.

Kyphosis is not always uneventful. Neck pain can be associated in a certain number of patients. Furthermore, adjacent level degeneration (ALD) seems to be influenced or increased by this formation.

Long-Term Benefit

Data from prospective observational studies indicate that 2 years after surgery for cervical radiculopathy caused by soft cervical disc herniation (without myelopathy), 75% of patients have substantial relief from radicular symptoms (pain, numbness, and weakness).[79,80] Overall improvement of myelopathy symptoms may take longer than recovery from radicular symptoms.[63]

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