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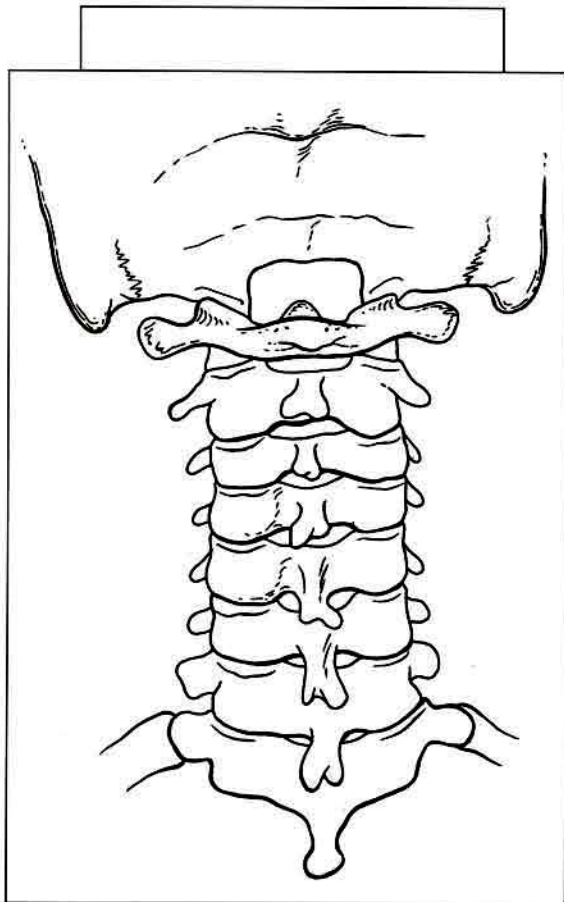
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Surgery of the Cervical Spine



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9 Anterior surgical procedures for cervical disc disease

Jeffrey Fischgrund and Harry N. Herkowitz

Degenerative changes within the cervical spine represent ubiquitous radiographic and pathoanatomic findings. Production of clinical symptomatology, however, is less frequent, and generally self-limited. Symptoms may include neck pain with referred pain patterns, radiculopathy, myelopathy, or myeloradiculopathy. Most patients presenting with symptoms that result from degenerative disc disease improve adequately with time or conservative measures, but patients with progressive myelopathy or those with radicular pain refractory to conservative measures become candidates for surgery.

There are always surgical options for any neurocompressive lesion. Anterior, posterior, or combined antero-posterior approaches can be used, depending on the pathoanatomy and evidence of cervical deformity or instability; anterior surgical approaches currently represent the most commonly used approaches. The natural history of cervical disc disease, the indications for surgery, and anterior surgical techniques are reviewed in some detail.

NATURAL HISTORY

Before discussing the surgical treatment of cervical radiculopathy and myelopathy, the natural history of the disease process must be understood. Several authors^{1,2,23,41,43,44,48} have reviewed this subject retrospectively. The results of surgical intervention should be compared to the natural history of the disease before definitive treatment is recommended.

Lees and Turner⁴¹ reported on 95 patients with cervical spondylosis: 51 presented with symptoms of a cervical radiculopathy without evidence of myelopathy. During long-term follow-up (2–19 years), no patient developed myelopathy if it had been absent at initial consultation. Forty-five percent of the study group with radicular pain had only a single episode of pain with no recurrence, 30% continued to have mild symptoms, and 25% had persistent or worsening symptoms. The authors concluded that the symptoms were often relieved by wearing a collar, but that the same final result could be obtained with any or no treatment.

Forty-four of Lees and Turner's patients had radiographic and objective evidence of myelopathy.⁴¹ All patients with a follow-up of more than 10 years had exacerbation of symptoms for at least 1 year followed by either a static period or mild improvement. Patients with myelopathy were graded using Lees and Turner's myelopathy classification as either mild, moderate, or severe.

- Mild: hand and arm symptoms producing some incapacity but not preventing ordinary everyday activities.
- Moderate: considerable difficulty in using hands or legs, sufficient to affect the performance of everyday tasks.
- Severe: ambulatory aids needed for walking, patient often confined to bed, chair, or house.

Those patients with mild disability at initial presentation had the best prognosis with no significant progression during the study period. Of the 15 patients who initially presented with severe disability secondary to myelopathy, 14 remained moderately or severely disabled after 10–20 years of follow-up. Lees and Turner concluded that the course of cervical spondylotic myelopathy may be prolonged and that long periods of non-progressive disability are the rule, with rare instances of progressive deterioration.

Nurick⁴⁸ developed his own classification of cervical spondylotic myelopathy based on ambulatory function and reported on 36 patients treated conservatively. Nurick's classification⁴⁴ breaks down as:

- No difficulty in walking.
- Slight difficulty in walking, but does not prevent full-time employment.
- Difficulty in walking that prevents full-time employment or ability to do all housework, but not so severe as to require someone else's help to walk.

body with a right-angled burr. Care is taken not to disrupt or penetrate the anterior or posterior cortices as this will compromise stability of the construct and may lead to neurologic impingement. In the inferior vertebral body, an 'L-shaped trough' is created using both straight and right-angled burrs. The anterior cortex is obviously violated, although the posterior cortex is left intact. After careful measurement, a tricortical graft is harvested from the anterior iliac crest. The iliac crest fits well with the contours of the cervical spine. The portion of the graft to be inserted superiorly is rounded with a burr into a matching 'peg', whereas the inferior portion is carefully sculpted to fit into the anteroposterior portion of the L-shaped trough. The superior portion of the graft is placed first and cranial tong traction applied. The inferior portion of the graft is then tapped into position and rotated, securely locking the graft into position. Traction is then released. The tricortical iliac crest graft provides more cancellous elements and may facilitate an earlier successful arthrodesis when compared to the fibular strut. However, the fibular strut does provide a more rigid strut when fitted properly.

Boni et al⁷ described a technique known as multiple subtotal somatectomy for the anterior decompression of cervical stenosis of three or more levels. He drilled tunnels in the intervertebral spaces using the Cloward¹⁰ technique. The tunnel is deepened (anterior to posterior) until the posterior longitudinal ligament is decompressed by removal of the posterior wall of the vertebral body. The bone bridges linking the tunnels are then removed with bone forceps. The final trench should be 15 mm wide with its height including all the vertebral bodies involved in the arthrodesis. Boni recommended a tricortical iliac crest graft for fusion and found that convexity of the graft adapted well to the normal cervical lordosis. Patients were immobilized after the operation in either a Minerva cast or a SOMI brace.

When using any of these techniques, if the anterior construct is thought to provide insufficient stability, additional stabilization procedures should be considered. Under the circumstances two options exist, including application of a halo device or a concomitant posterior arthrodesis. Many factors need to be considered by the surgeon, including stability of the construct, quality and strength of the patient's bone, the patient's general medical condition, and patient reliability.

RESULTS

The first large series of patients treated with anterior interbody fusion for cervical degenerative disc disease was reported by Robinson et al⁵² in 1962. Disc removal and anterior interbody fusion was performed on 107 inter-

spaces in 55 patients. The criteria used by Robinson for rating the results are as follows:

- Excellent: all preoperative symptoms relieved, abnormal findings unchanged or improved.
- Good: minimum residual of the preoperative symptoms, not requiring medication or limiting activity, and abnormal findings unchanged or improved.
- Fair: definite relief of some preoperative symptoms with others remaining unchanged or only slightly improved.
- Poor: symptoms and signs unchanged from preoperative status.

Follow-up ranged from 2 to 73 months. Overall, 46% of the patients were rated as excellent, 27% good, 22% fair, and 6% poor. Patients who had multi-level fusions had worse results than those who had single-level disease. Seventeen of 18 patients who had a significant degenerative disc at a single level had an excellent or good result after fusion, whereas only 8 of 16 patients with three or more involved spaces had an excellent or good result. The poorer results in multiple level fusions may result from the greater severity of disease in those patients with multi-level degenerative disc.

Robinson et al⁵² found that there was no clear correlation after operation between the absence of fusion and the clinical results. In all, 13 of the 107 interspaces grafted did not fuse. However, of the nine patients with non-unions, only four continued to have complaints that could possibly have resulted from lack of union. All four patients underwent reoperation. Only one of the 46 patients who had a solid fusion needed additional cervical spine surgery. The value of preserving the subchondral bone plate above and below the graft was also assessed.⁵² Of 38 interspaces successfully fused without plate preservation, 26 maintained and 12 lost height. Of the 47 fused with end-plate preserved, 41 maintained and 6 lost space. These findings led Robinson et al to conclude that, by preserving the subchondral bone, a load-bearing surface for the graft remains, preserving the restored height of the intervertebral space during healing.

Connolly et al¹³ reported 63 patients who underwent anterior cervical fusion. Follow-up ranged from 7 to 70 months. He used a procedure similar to the standard Smith–Robinson anterior operation, but in most of his cases neuroforamen decompressions were also done. Overall, approximately two-thirds of his patients improved after the operation, with a non-union rate of 21%. Fifteen percent of his one- and two-level decompressions, but 40% of his three-level decompressions, developed a non-union. The results of Connolly et al also showed that the adequacy of the fusion bore no constant relationship to the final clinical result. DePalma and Rothman¹⁶ reported on a large series of anterior interbody fusions for cervical degenerative disc disease. A total of 442 disc levels were fused with the Robinson

technique in 229 patients. Follow-up was 13–105 months (mean 57 months). At final follow-up, 63% of the patients were considered to have satisfactory results, rated as excellent or good. There was no tendency for the results to deteriorate or improve as the length of follow-up increased. Follow-up radiographs demonstrated further disc degeneration at adjacent levels (usually below the fusion mass) in 81% of the patients. After the operation, two-thirds of the osteophytes (at 211 levels that fused) had resolved. Pseudoarthrosis occurred in 12% of the patients, although the effect of pseudoarthroses on the quality of the result was of no statistical significance. Lack of correlation between a successful fusion and patient outcome can be explained by the fact that even though bone union does not occur, a stable fibrous union does. In addition, removal of the degenerative disc alleviates mechanical pressure on the nerve root, thus relieving most symptoms. Finally, distraction of the disc space and neuroforamen may still occur, even though much of the initial height of the interspace gained by the bone graft is lost.³¹

Additional factors influencing the late results of anterior interbody fusion were reported by Williams et al.⁶³ They found that relief of symptoms at long-term follow-up was not as satisfactory as the initial short-term evaluation indicated. Sixty patients with a follow-up of 2–9 years (average 55 months) were reviewed. Preoperative indications for surgery included either radicular or non-radicular (occipital headache, non-radiating, neck, or intracapsular) pain. Seventy-three percent of patients with radicular complaints had a good or excellent result whereas only 26% of those patients with non-radicular pain had good or excellent results. Additionally, the late operative results correlated with the adequacy of decompression. Ten of 13 patients had excellent or good results when the discs removed corresponded to the levels of the preoperative myelographic defect. When several myelographic defects were present before the operation, but discectomy was not done at all levels of compression, only 6 of 11 patients had excellent or good results.

A literature review of series of multiple interbody fusions has shown satisfactory results for the treatment of cervical disc disease, with rates of over 90% in many.^{16,22,51,56,61,62,63} As a rule, however, the results tend to deteriorate as the number of levels fused increases. In addition, the success or failure of fusion does not appear to influence the long-term results.

Surgical treatment of myelopathy by an anterior cervical approach was described by Bohlman⁵ in 1977. Seventeen patients were treated with a Smith–Robinson anterior cervical discectomy and fusion at one or more levels (Fig. 9.9). Two out of three patients who were bedridden before the operation were ambulatory after surgery. The 14 patients who required walking aids before operation all

recovered from their myelopathy and were able to walk independently. Fourteen patients had increased strength in the upper extremities after the operation. In two patients, with severe loss of position and vibratory sense, no recovery occurred. Evidence of posterior column spinal cord dysfunction probably represents a more extensive form of cord compression with a less favorable response to decompression. These excellent results occurred in spite of the fact that Bohlman made no attempt to remove either the lateral or posterior osteophytes. He postulated that the introduction of instruments into a narrow spinal canal could compromise the already compressed spinal cord and produce further deficit. Two patients in his series had repeat myelograms following anterior discectomy and fusion which demonstrated resorption of the posterior osteophytes.

A more radical anterior decompression was described by Boni et al.⁷ They performed multiple subtotal somatectomies on 29 patients with spondylotic myelopathy and myeloradiculopathy. The number of levels decompressed ranged from three to six. Good results were reported in 53% of the patients with moderate results reported in 47%. Successful fusion of the iliac crest graft occurred 60–90 days after the operation in all patients. Boni et al advocated this procedure because it allows a full anterior decompression which can be checked visually.

Bernard and Whitecloud⁴ performed anterior decompression and stabilization with autogenous fibular graft in 21 patients with either cervical spondylomyelopathy or cervical spondylomyeloradiculopathy (Fig. 9.10). Myelopathy was the dominant feature in all cases. Two to four levels were decompressed in all patients. Before operation, all patients were graded according to Nurck's classification. At follow-up evaluation, 16 of 21 patients had improved one functional grade. Bernard and Whitecloud recommended this approach because it surgically addresses the bony and soft tissue abnormalities responsible for spinal cord and nerve root compression. They suggested that surgical decompression by this method favorably alters the natural history of cervical spondylotic myelopathy and cervical spondylotic myeloradiculopathy. The series of Hanaï et al²⁵ consisted of 30 patients with cervical spondylotic myelopathy who underwent subtotal vertebrectomy and fusion. Three-level vertebrectomies were performed in 18 patients and four-level vertebrectomies were performed in 12 patients. The patients were evaluated by the Japanese Orthopaedic Association (JOA) score before and after the operation. The JOA score consisted of an evaluation of motor, sensory, and bladder functions, with a score of 17 indicating no neurologic deficit. The preoperative score was in the range 5–14 points (mean 8.9). All patients showed postoperative improvement and were satisfied with the surgery. The postoperative score was in the range 9–16 (mean 13.9).

COMPLICATIONS

Complications of anterior surgery for cervical disc disease can be divided into those occurring at the graft site and those occurring in the neck. The initial report of Robinson et al⁵² described no complication in 48 of 56 patients. Four patients had a temporary unilateral paralysis of the vocal folds, two patients had marked dysphagia, and two patients had a transient Horner's syndrome. In the large series of De Palma et al,¹⁶ the most common complication occurred at the graft donor site. Hematomas developed in 9% of the patients, and 36% had persistent donor site pain 1 year after surgery.

Flynn¹⁹ compiled the replies of 704 neurosurgeons describing 36 657 anterior cervical interbody fusions. The single largest neurologic complication was recurrent laryngeal nerve palsy, which occurred in 52 cases, and this compromised almost 17% of all neurologic complications. The risk to the recurrent laryngeal nerve can be decreased by using a left-sided approach because, on the left, the nerve enters the thorax within the carotid sheath which then loops under the aortic arch and ascends into the neck beside the trachea and esophagus. On the right side it may leave the carotid sheath at a higher level, and of course anteriorly behind the thyroid, thus leaving itself more susceptible to injury (Fig. 9.11).

The most dangerous neurologic complication is that of spinal cord injury. Flynn¹⁹ reported that there were 100 cases of significant permanent myelopathy or myelodradiculopathy in his large series; 75% of these patients had an immediate postoperative deficit, whereas 25% of the patients developed a neurologic deficit during the postoperative recovery period. Analysis of the data led Flynn to conclude that, regardless of the etiology of the myelopathy, reoperation had little effect on the ultimate status of the neurologic deficit. In addition, most surgeons were unable to determine the etiology of the neurologic deterioration.

The most common problems seen after the operation include a transient sore throat and difficulty in swallowing.^{29,60} Certainly, the vast majority of these complaints are minor and resolve within a few days or weeks. More severe, penetrating injuries to the esophagus and trachea may occur, although the risk of such injury may be decreased by using dull retractors. Perforating injuries to the esophagus are rarely reported, but can be life threatening. Newhouse et al⁴⁷ reported an incidence of perforation of 0.25% in over 10 000 cases of anterior cervical surgery. One-third of the perforations occurred at the time of surgery, and were related to sharp or motonized instruments. Late perforation was usually related to the use of anterior plates and screws, often used for fracture stability.

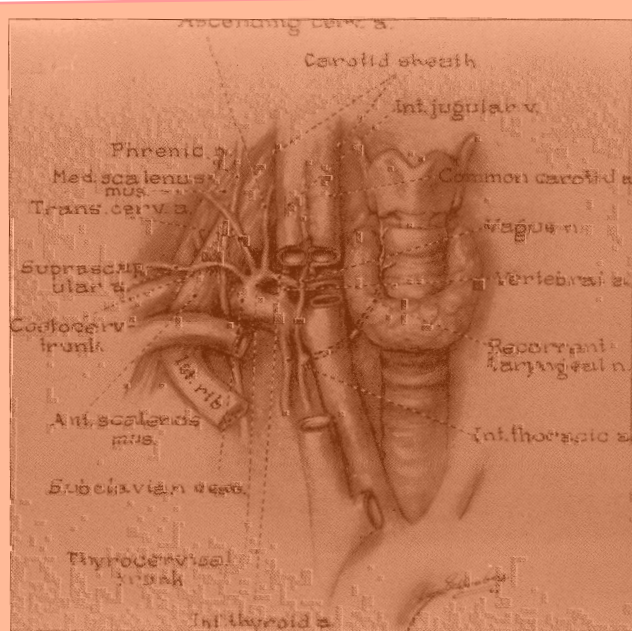


Figure 9.11

Arteries and nerves at the base of the neck on the right side. The right recurrent laryngeal nerve arises from the vagus nerve at the level of the subclavian artery, loops beneath it, and ascends between the trachea and esophagus. The nerve can recur above the level of the subclavian artery and be injured in an approach to the middle cervical spine from the right side. (From Rothman RH, Simeone FA. *The Spine*. 3rd ed Philadelphia, WB Saunders, 1992. with permission)

ANTERIOR DISCECTOMY WITHOUT FUSION

Anterior discectomy without fusion developed as an alternative to cervical fusion based on the premise that, if successful results of anterior fusions occur with pseudoarthroses, then discectomy can be performed without fusion. Several papers have advocated anterior cervical discectomy without fusion, reporting success rates similar to those with fusion.^{46,49,53}

Murphy and Gado⁴⁶ reported on 26 patients who underwent one- or two-level anterior cervical discectomy for 'radiculitis' secondary to a herniated cervical disc without concomitant fusion. Good results (improvement of neurologic deficit, alleviation of pain, and patient able to return to normal activities) were reported in 24 of 26 patients. The two patients with poor results required reoperation within 2 weeks of the initial procedure. Seventy-two percent of patients developed a spontaneous fusion at the discectomy level. Twenty patients developed some degree of postoperative kyphosis.

O'Laoire and Thomas⁴⁹ also performed anterior discectomy without fusion in 26 patients. All patients had a myelopathy secondary to cervical disc protrusion. He reported that all patients improved after the operation with 100% excellent to good results. Results were graded only according to neurologic recovery. The minimum follow-up in this study was only 1 year.

The studies of both Murphy and Gado⁴⁶ and O'Laoire and Thomas⁴⁹ neglected specific mention of the postoperative incidence of neck pain. Transient, but severe, neck pain after anterior cervical discectomy has been reported by several authors.^{37,64} Although 82% of patients in one series³⁶ noted symptomatic relief after anterior cervical discectomy, 12% reported the development of cervical pain after an average follow-up of 3.5 years.

Yamamoto et al⁶⁵ reported on 55 patients who underwent anterior cervical discectomy without fusion for either an acute soft disc herniation or spondylosis. At 3 months follow-up, all but one patient with spondylosis had improved. However, a final follow-up, 2–3 years after surgery, showed that only 47% had actually improved. An overall satisfactory result was present in 82% of the patients who had surgery for an initial diagnosis of soft disc herniation. In the experience of Yamamoto et al, the incidence of cervical and/or intracapsular pain, not present preoperatively, was 49% within 1 month of anterior cervical discectomy. One year after surgery, 9% of the patients with soft disc herniations and 34% of the spondylotic patients continued to have neck or scapular pain.

Anterior cervical discectomy without fusion defeats many of the principles of anterior cervical fusion, which includes distraction of the neuroforamen and stretching of the buckled ligamentum flavum. In addition, by its very nature,

this surgery is designed to create a pseudoarthrosis, which may lead to a less satisfactory result. Although results of surgery for soft disc herniation are better than those with spondylosis, there is a relatively high rate of persistent postoperative neck pain. Most series, to date, have limited clinical and radiographic follow-up needed to determine the development of instability or kyphotic angulation. This procedure cannot be recommended until better long-term follow-up studies are available.³¹

AUTOGRAFT VERSUS ALLOGRAFT

In an attempt to eliminate donor site problems while maintaining acceptable fusion rates, many surgeons have substituted allograft for autogenous bone in anterior cervical fusions.^{8,11,18,26} Allograft eliminates the necessity for additional surgery to obtain the bone graft, thereby decreasing operative time, morbidity, and pain at the donor site.

One of the first studies comparing allograft versus autograft bone for anterior cervical fusion was reported by Brown et al⁸ in 1976. He reported no difference in fusion rates between the two types of graft. However, a difference in graft collapse was noted. Twenty-eight percent of patients receiving allografts had collapse of the graft compared to 16% of the patients receiving autograft. This trend was only true for multi-level fusions. Brown found no difference in collapse rate for one-level cervical fusions.

Fernyhough et al¹⁸ retrospectively reviewed 126 patients who underwent autogenous or allograft fibular strut grafting (Fig. 9.12) after decompression for multi-level cervical spondylosis. The combined non-union rate for both groups ranged from 21% for a two-level fusion up to 50% for a four-level fusion. Overall, the allograft group had a statistically significant higher rate of non-union (41%) than the autograft group (27%). However, no correlation between the clinical results and the rate of union was presented in this study.

Zdeblick and Ducker⁶⁷ reviewed 88 consecutive patients who underwent a Smith–Robinson anterior cervical fusion: 60 patients had autologous iliac crest graft placed, whereas freeze-dried iliac crest grafts were inserted in 27 patients. The delayed union and non-union rate was significantly higher in the allograft group compared to the autograft group. However, when one-level fusions were considered, the non-union rates at 1 year were similar. In two-level fusions the union rate was dramatically lower with allograft (38% versus 83%). In addition, the freeze-dried allograft bone collapsed more frequently during the healing process. The clinical results for the two patient groups were similar. The authors concluded that the use of freeze-dried iliac crest allograft bone in Smith–Robinson cervical fusions is

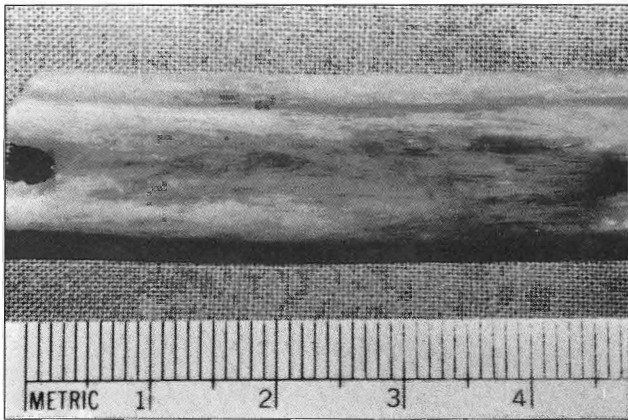


Figure 9.12

Contoured fibular strut graft reconstituted after freeze-drying (From Rothman RH, Simeone FA. *The Spine*, 3rd ed. Philadelphia, WB Saunders, 1992, with permission)

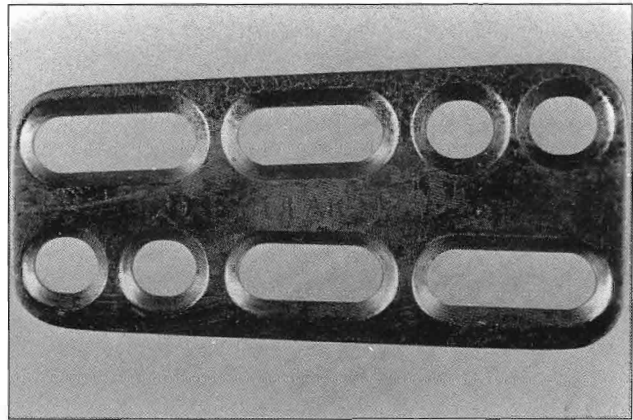


Figure 9.13

The Caspar anterior cervical plate

not recommended in multi-level fusions; when used for one-level fusions, radiographic collapse or lucency may persist despite clinical success.⁷

ANTERIOR CERVICAL INSTRUMENTATION

In an attempt to increase the success rate in anterior cervical fusions, several authors^{21,45,54,58} have advocated the use of anterior cervical instrumentation. The anterior cervical plate theoretically provides increased postoperative stability after anterior decompression. In addition, the plate can act as a buttress to prevent graft extrusion in the immediate postoperative period, before bone fusion occurs.

Gassman and Seligson²¹ used an anterior cervical plate for 13 anterior cervical fusions in adults undergoing surgery for traumatic and degenerative lesions. All patients showed radiographic evidence of progressive or complete fusion at 1 year follow-up. One patient required plate and screw removal approximately 2 months after the initial surgery because of screw loosening that caused dysphagia. Both this report and that of Tippets and Apfelbaum⁵⁸ used a plating system which requires penetration of the posterior cortex of the vertebral body for adequate screw fixation. Although no new neurologic deficits were reported in either study, penetration of the screws into the spinal cord carries the potential for neurologic injury.

Seifert and Stolke⁵⁴ combined spondylectomy, microsurgical decompression, and osteosynthesis using the Caspar plate (Fig. 9.13) in 22 patients with multi-segmental cervical spondylosis. In all patients, satisfactory bony fusion was achieved. Because of the immediate stability provided by the osteosynthesis, Seifert and Stolke felt that the application of a halo vest was not necessary, and immobilized their patients in either a hard or soft cervical collar. Recently, Morscher et al⁴⁵ developed a titanium plate system that is MRI compatible and does not rely on posterior vertebral body cortical penetration for stability. Currently, there are no long-term studies available to evaluate this system or the plate of Lesoin et al⁴² which affords some medial-lateral and cephalocaudal variability in screw placement. Until prospective studies are available which use anterior plating systems, it is difficult to state the indications for their use in degenerative cervical spine disease.

In summary, as clinical information on cervical degenerative disorders becomes increasingly available, it is clear that the anterior approach represents the procedure of choice in many cases. Familiarity of the surgical anatomy, adequate decompression through discectomy or vertebrectomy, followed by solid arthrodesis, are essential for success. Adherence to basic spinal surgery principles of anterior cervical techniques, as outlined in this chapter, will lead to success in most patients while minimizing the potential of complication.