One-stage internal fixation and anterior fusion in complex cervical spinal disorders

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The authors describe their experience with the Morscher titanium cervical plate with cancellous locking screws in the management of complex cervical spine disorders. Fifty patients (32 males and 18 females) with a mean age of 54 years (range 10 to 84 years) underwent anterior spinal fixation that extended two to five vertebral bodies, using a titanium cervical plate and autogenous bone graft. Surgeries were performed for a variety of reasons: one for a congenital lesion, five for spinal neoplasms, nine for trauma, and 35 for degenerative arthritides. Ten patients had symptomatic kyphoses due to previous laminectomy, failed anterior surgery, or trauma. Satisfactory fixation and fusion with no neurological deterioration was obtained in all but two cases. Specific complications included six cases of dysphagia, one of sepsis, one of Horner’s syndrome, and one case in which the patient had a fatal myocardial infarction the night after surgery. At the end of the follow-up period, fusion was found to have occurred in all remaining cases with no outstanding implant-related problems.

KEY WORDS • anterior cervical fusion • internal fixation • kyphus • spinal plate

INCE the introduction of the anterior approach to the cervical spine in 1955 by Robinson and Smith and its subsequent popularization by Cloward, such approaches have become commonplace in the modern neurosurgical treatment of both radicular and myelopathic syndromes secondary to cervical spondylolisthesis. In the treatment of single-level disease, anterior cervical surgery has been particularly successful in terms of its high fusion (74% to 98%) and low graft displacement rates (2.1% to 4.6%). However, when multiple levels are involved, the rate of pseudarthrosis rises steeply (33% in one series).24

In consideration of more complex cervical spinal pathology, such as the management of kyphotic deformity or spinal reconstruction after tumor surgery, anterior approaches to fusion cannot be successful unless they are combined with a major orthotic fixation device to counteract grossly disordered spinal biomechanics and stability. It would appear that a brace or halo vest would be needed in these situations, but both are poorly tolerated and provide their own complications. The advent of cervical internal fixation allowed synchronous decompression and stabilization with excellent fusion (96% to 100%) and graft displacement (0%) rates. However, there has been considerable reluctance to use such devices despite their obvious advantages. Major stumbling blocks have been the need for penetration of the posterior cortex of cervical vertebrae with its potential for neurological injury as well as a relatively complex set of instrumentation and difficulty in placing plates low in the cervical spine.

Morscher developed a low profile, titanium magnetic resonance (MR) imaging–compatible plate with a locking cancellous screw system that has overcome many disadvantages. In this paper we present our experience using such a device in a series of complex spinal pathologies in which one-stage decompression and fusion was the goal.

Clinical Material and Methods

Instrumentation

The cervical spine locking plate* was designed specifically to stabilize the spine in one stage with decompressive surgery to obtain maximum construct rigidity using relatively simple instrumentation. The plates are composed of pure titanium low in profile (2 mm thick), and available in 15 lengths ranging from 16 mm to 55 mm. New prototype plates up to 90 mm in length have been made available to us for evaluation in the management of

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* Locking plate manufactured by Stratec Medical, Waldenburg, Switzerland.
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multisegmental pathology. The plates have a pair of cranial and caudal holes to accommodate cancellous anchor screws and a varying number of intermediate holes through which additional screws may be placed to anchor the graft. The holes are, in fact, slightly convergent "wells," machined to be perpendicular to the plate in all situations with the exception of one end (designated with an arrow) at which the angle is set at 12˚ to allow easy access for the instrumentation when working on either the high cervical spine or the upper thoracic spine if the plate is reversed. The drill guide fits into the plates' wells, which only allows drilling at the predetermined angle. The 3-mm drill bit is provided with a stop at 14 mm, thus the posterior cortex cannot be penetrated in the adult; the tap is fitted with a sleeve that inhibits tapping beyond 14 mm. The large cruciform screwdriver is used to place anchor screws, which come in either a solid or fenestrated form. Solid screws are used in situations in which plate removal may be anticipated, and fenestrated screws when plate removal is considered undesirable, for example, in tumor surgery or under conditions where osteosynthesis might be impaired. The anchor screws are 14 mm in length, 4 mm in diameter and bear expansion heads. When the small 1.8 mm locking screws are inserted into the heads of the anchor screws thereby expanding the latter, the anchor screw is locked onto the plate and "backing out" of the screw is not possible. Originally, we employed the fenestrated bone screws but, on the advice of the more experienced (F Magerl, personal communication, 1993), we have shifted toward using the solid ones. A plate positioning device allows a no-touch technique. A universal handle (to be used in conjunction with the tap, screwdriver, and plate positioning device) and power drill complete the instrumentation.

Surgical Technique

Surgery was performed with the patient supine and the head on a horseshoe head ring, except in cases in which spinal stability was already compromised or could become so by the decompressive surgery, or in cases of kyphotic deformity in which Gardner–Wells traction was employed. If two levels were to be fused a transverse incision sufficed; for longer fixations, we preferred a longitudinal incision along the anterior border of the sternocleidomastoid muscle, in the interval between the carotid sheath laterally and the pharynx medially. Great care was taken to avoid damaging structures passing from the carotid sheath to the pharynx (such as the pharyngeal branch of the vagus at C-3, superior laryngeal nerve at C-5) to avoid postoperative dysphagia or hoarseness. We have learned by experience that to expose above the level of C-4, it is best to enter the prevertebral plane lower down at C-5, then retract the pharynx anteromedially.

After decompressive surgery, an appropriately shaped wedge, dowel, or strut of tricortical autologous iliac crest was harvested and positioned using an impactor so as to be flush with the anterior aspect of the cervical spine after removal of all osteophytes and vertebral irregularities in the area directly subjacent to the plate. Due to the posterior or cranial–anterior caudal slope of the cervical vertebrae, it was important that screws were placed toward the cranial aspect of a vertebral body, which was confirmed either by radiological examination or more easily by probing with a needle for the adjacent disc space. After selecting a plate of the appropriate length and confirming its flush fit, an anchor hole was drilled and an anchor screw loosely inserted. To maintain cervical lordosis, the plate was gently curved, taking care not to distort the screw holes. After a further check that the plate was in satisfactory position, an anchor hole was drilled diagonally opposite the plate followed by the other two holes. All anchor screws were inserted, fully tightened, locked onto the plate by insertion of the locking screws, and a final radiographic check was performed. Although perioperative radiology was useful, it was not essential in all cases as the technique and instrumentation were very user-friendly.

**Patient Population and Management**

We employed the cervical locking plate in treating 50 patients with a mean age of 54 years (range 10 to 84 years). There were 32 males and 18 females.

The etiological indications for fusion were diverse: one patient underwent fusion for a congenital lesion, five for spinal reconstruction following ablative cervical tumor surgery, nine for traumatic lesions, and 35 for a range of degenerative arthritides that included failed anterior surgery or laminectomy. The indications for fusion according to surgical pathology were equally diverse including single- or multilevel disc disease, canal stenosis, fixed subluxation, mobile subluxation, kyphotic deformity, and direct cord or root compression (Table 1).

<table>
<thead>
<tr>
<th>Etiology</th>
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<th>CS</th>
<th>SLDD</th>
<th>MLDD</th>
<th>Fixed Sub</th>
<th>Mobile Sub</th>
<th>KD</th>
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<td>6</td>
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<tr>
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<td>17</td>
<td>2</td>
<td>10</td>
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* CS = canal stenosis; SLDD = single-level degenerative disease; MLDD = multiple-level degenerative disease; Sub = subluxation; KD = kyphotic deformity; CRC = cord/root compression.
tions were treated by a Smith–Robinson procedure with a large graft to distract the disc space and reduce the sub-luxation, followed by plating to ensure union. Kyphotic deformities were treated by appropriate corpectomies combined, on most occasions, with drilling the joints of Luschka to reduce the deformity prior to graft and plate placement.

It is in the field of cervical vertebral excisional tumor surgery that we have been particularly pleased with the locking plate system. Five patients presenting with cervical tumors had radical excision and reconstruction. Four of these patients had extradural tumors of bone, and all required decompression followed by stabilization. This was performed either as a single-staged operation with bone grafting and plate stabilization or, in one case, as a staged procedure. Two of these four patients had incipient cord compression and destruction of the body of C-3 (plasmacytoma one, aneurysmal bone cyst one). A standard anterior approach with tumor corpectomy followed by autologous iliac crest bone grafting and plating was used for the patient presenting with purely anterior disease due to plasmacytoma. This patient progressed to sound bone fusion 3 months postoperatively. The second patient had destruction and expansion of the whole of the vertebral body including, in particular, the lamina on the left posterior of C-3, which initially required a posterolateral approach with tumor decompression and elective sacrifice of the vertebral artery, followed by intertransverse strut grafting between C-2 and C-4. At a second procedure, a corpectomy arch of C-3 and the anterior bone cyst was performed with grafting and plating as before. Due to the three-column instability in this patient, he was immobilized postoperatively in a halo vest and progressed to sound bone fusion.

The remaining two patients with vertebral neoplasms presented with a high cervical myelopathy (recurrent chordoma) and with a cervical myelopathy combined with radiculopathy (chondrosarcoma), respectively. In the first case, the patient with a recurrent chordoma had had two anterior operations, the first via an extended Smith–Robinson approach and the second by a single-level vertebrectomy and apparently complete excision of the tumor. The neoplasm recurred 12 months after the second operation. This patient was returned to an ambulatory state after a two-level vertebrectomy and apparently complete excision of the anterior extradural tumor; stability was restored with autologous bone grafting and plating. In the second case, the patient with a chondrosarcoma presented with a mild cervical myelopathy and multiple root involvement of the upper and middle cord of the brachial plexus. Reversal of her myelopathy was effected via C-5, C-6, and C-7 hemivertebrectomies with dural decompression and nerve root neurolysis with grafting and plating to restore spinal stability. As a result of the procedure, the patient’s myelopathy was completely reversed and hand function was considerably improved.

The last patient, we believe, is unique in undergoing a two-level corpectomy to achieve access to an anteriorly placed intradural lesion. This patient had undergone three previous posterior operations for an anteriorly placed meningioma in the lower cervical region and after each operation was rendered paraparetic. After an elective vertebrectomy of C-6 and C-7, the dura was opened and meningioma excision easily performed. The dural defect was repaired with Tisseal and fat grafts subjacent to an autologous iliac crest graft stabilized with the plate. The patient was ambulatory immediately postoperatively and said that his walking had, in fact, improved.

The five cases reported show the wide range of pathology and disordered spinal biomechanics that can be rendered stable using the plate.

Forty-eight patients were immobilized postoperatively in a hard collar, one in a brace (a patient with a choreoathetoid movement disorder) and one in a halo vest (the anterior surgery being part of a combined anterior and posterior total vertebrectomy for aneurysmal bone cyst).

Operative Results

The mean operative time was 120 minutes (range 65 to 300 minutes) and the mean blood loss was 240 ml (range 50 to 1800 ml, the higher blood losses associated with tumor surgery). There were no major accidents in this series in terms of vertebral artery, spinal cord, or root syndromes.

Early postoperative complications for the cohort of 50 patients included six cases of dysphagia greater than 5 days, of which two required gastrostomy for 2 months; one case of sepsis requiring plate removal; two cases of early construct detachment; and one case of Horner’s syndrome. One patient (2%) had a fatal myocardial infarction on the 1st postoperative night.

Satisfactory fixation was obtained in all 50 patients immediately postoperatively; the two early construct detachments occurred secondary to emergency reintubation, in one case for the patient who had a postoperative myocardial infarction and in the other case for a patient with a choreoathetoid movement disorder who experienced respiratory difficulties due to abnormal glottic movements. This latter patient accounted for our one case of sepsis requiring plate removal because she needed early tracheostomy to manage her airway.

Of the 50 surgical patients, 32 were followed for 3 months or longer (mean 9.6 months, range 3 to 16 months). With regard to radiological criteria, all operations in 32 patients achieved fusion by 3 to 6 months postoperatively (mean 4.1 months). Late mechanical complications consisted of two cases of isolated fracture of a lower cancellous screw, but with firm bone union in flexion and extension radiographs. No patient showed other implant-related complications (screw migration, screw-bone lucency, graft displacement, mal- or nonunion). A clinical follow-up evaluation was performed at the same time and yielded the following information. Although not an indication for surgery in itself, of the 28 patients who complained of neck pain preoperatively, only seven reported pain postoperatively. All four patients with brachalgia were relieved of their pain and the three patients complaining of Lhermittes phenomenon with mobile subluxation no longer experienced symptoms.

Twenty-seven of the 32 patients reviewed originally presented with myelopathic symptoms or signs; 7 had had mild spastic paraparesis with or without numb clum-
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TABLE 2
Prevalence of preoperative and postoperative symptomatology in 32 patients

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Preop</th>
<th>Postop*</th>
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<tbody>
<tr>
<td>neck pain</td>
<td>28</td>
<td>7</td>
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<tr>
<td>brachalgia</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Lhermittes</td>
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<td>0</td>
</tr>
<tr>
<td>myelopathy</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>numb hands/mild paraparesis</td>
<td>4</td>
<td>2</td>
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<tr>
<td>ambulatory with aid</td>
<td>6</td>
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</table>

* Postoperative follow-up examinations were performed at 3 months or later.

Discussion

Osteosynthetic plating and grafting of the cervical spine using low-profile plates was first reported by Orozco and Llovet13 in 1970 for the management of cervical fractures. Since that time, other authors have used anterior cervical plating and osteosynthesis, predominantly for cervical trauma.1,2,9,17,22 Caspar14 contributed significantly to anterior or cervical stabilization by creating instrumentation whereby an osteosynthetic anterior plate could be applied to the cervical spine. However, we consider that the Caspar system has some drawbacks: although elegant, the instrumentation is somewhat complex; the use of fluoroscopy is mandatory to avoid neurological injury because the screws employ bicortical fixation and the mandatory nature of fluoroscopy implies difficulty in placing plates low in the cervical spine. A recent study by Maiman10 has, nevertheless, questioned the necessity of posterior cortical penetration with the Caspar system, showing that an osteosynthetic anterior plate could be applied to the cervical spine. However, we consider that the Caspar system has some drawbacks: although elegant, the instrumentation is somewhat complex; the use of fluoroscopy is mandatory to avoid neurological injury because the screws employ bicortical fixation and the mandatory nature of fluoroscopy implies difficulty in placing plates low in the cervical spine. A recent study by Maiman10 has, nevertheless, questioned the necessity of posterior cortical penetration with the Caspar system, showing that the pull-out forces are not significantly different, whether bicortical penetration is achieved or not.

Morscher, et al.,13 have developed a low-profile titanium MR imaging–compatible plate that uses a cancellous screw system, obviating the need for posterior cortical penetration with the risk of neurological injury, and thus x-ray films at lower cervical levels are not necessary to assess penetration. To prevent screws from loosening, the locking system represents a considerable advance. In addition, the plate may be gently contoured to maintain normal cervical lordosis, and similar to the previous bicortical screw fixation plates, allows the patient to be mobilized early, reducing hospital stay. The surgeon, however, should remain wary of becoming predisposed to plate fracture with either the Caspar or the Morscher system, which is more common in the context of intraoperative contouring. It should be noted that the Morscher system has some limitations due to lack of flexibility in screw placement and angulation, which we have encountered in several cases, and this is not the case with the Caspar system. The advent of a slotted screw system may represent a suitable union between the advantages and disadvantages of the Caspar and Morscher systems. The use of fenestrated screws in the latter system is presently not recommended as there have been many cases of screw fracture and the company has withdrawn them from the market.

Biomechanically, anterior plate fixation of the cervical spine is not ideal in posterior element traumatic models. Although the benefits of spinal fixation are known, one must not lose sight of the fact that they are an adjunct to and not a substitute for bone fusion. All implants will fail unless sound bone union takes place. Biomechanical studies of traumatic cervical spine motion segments stabilized with an anterior plate have shown that the control of torsion as well as flexion forces needs to be supplemented with a Philadelphia collar until sound fusion has occurred.6,11,23 Notwithstanding these biomechanical considerations, however, a recent study of the titanium cancellous screw plate showed 100% fusion in 13 patients, with only one patient having a malunion due to a technically faulty plating in which a pair of screws was placed in disc rather than bone.21

The series of 50 patients presented shows an acceptable complication rate. The mortality rate was 2% from a medical cause unrelated to the plating procedure. Sepsis occurred in 2% and was related to an early tracheostomy that needed to be performed in a patient with a choreoathetoid movement disorder. These two patients also accounted for our two early prosthetic detachments (4%) as they both required emergency intubation, and, on radiological review, one patient had imperfect plating because the lower screws had been placed mainly in disc, just catching the lower edge of the vertebral body. This highlights the need for accurately localizing the disc space and placing the screws in the cranial part of the vertebral body. There were six cases (12%) of dysphagia, four of which were transient, lasting up to 10 days, two of which required gastrostomy with symptoms persisting for 2 months. The cause of this dysphagia was not related to prevertebral sepsis, but seemed to occur in patients with high plating procedures and was perhaps related to damage to the pharyngeal branch of the vagus. The incidence of dysphagia has reduced with increasing experience and the avoidance of direct dissection high in relation to the pharyngeal sheath. We now use the technique of entering the prevertebral space lower down the spine and mobilizing the pharyngeal structures by traction. In cases of failed anterior surgery, we believe it is paramount that an approach be made on the same side as the previous surgery because bilateral damage to the pharyngeal plexus may well prove disastrous. Our dysphagia rate is higher than reported in other series (VKH Sonntag, unpublished data),18,20 but in many series, dysphagia is not mentioned specifically and our rate may be related to the relatively large number of fused levels. One patient had transient hoarseness and one had postoperative Horner’s syndrome, a rare complication due to extensive anterior surgery, which has been described by others.18,20

Despite the obvious advantages of anterior cervical osteosynthesis using spinal plating techniques, relatively few surgeons have employed them for dealing with neoplastic conditions.8,14,20 With increasing experience, we
have found that the reconstruction of multiple corpectomy defects, due to excisional anterior surgery of vertebral body neoplasms, is highly efficacious and, as long as uninvolved bone is reached and bridged with a suitable graft, the patient can be mobilized without a halo vest, as may be required in a fibula strut keystone technique described by Saunders, et al. It is, of course, essential to ensure adequate immobilization in such patients where osteointegration may be impaired by providing a rigid Philadelphia collar in the context of two-column, or a halo vest in the context of three-column, instability.

This cohort of patients, drawn from an extensive cervical spinal practice with diverse spinal pathologies, has shown the AO locking plate to be highly efficacious in managing a wide range of complex spinal pathology. The complications described are equivalent to those in other series and the fusion rates are identical to these series. Neurological results are akin to anterior surgery for spondylosis disease. In addition, the technique offers a surgical prosthesis that is easy to apply to obtain the desired results.

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References