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Degenerative spondylolisthesis of the cervical spine – symptoms and surgical strategies depending on disease progress

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Abstract *Background.* Degenerative spondylolisthesis of the cervical spine is rare. Patients show signs of progressive myelopathy, radiculopathy and pain. Treatment strategies include ventral, dorsal and combined fusion techniques with or without repositioning and decompression.

Methods. In this study, we present 16 patients with degenerative cervical spondylolisthesis. The leading symptom was severe myelopathy in 8 patients, radiculomyelopathy in 5 patients and neck pain in 3 patients. However, neck pain was the initial symptom in all the patients and decreased when neurological symptoms became more evident. Radiographic examinations included plain radiography, MRI, CT, myelography and lateral tomography.

Results. Spondylolisthesis was located five times at level C3/4, C4/5 and C5/6. In three cases spondylolisthesis was located at level C7/T1.

There were two patients with spondylolisthesis on two levels. Instability could be demonstrated by flexion/extension radiography in five cases. Patients were divided into three groups according to a newly introduced classification system. The surgical approach corresponded to this classification. In ten patients the spondylolisthesis could be corrected by extension and positioning, so discectomy and fusion on one or two levels with cage, plate and screws was sufficient. In five cases a corpectomy was necessary due to severe spondylolisthesis. In one case a combined approach with dorsal decompression and release followed by ventral fusion was applied due to additional dorsal spinal cord compression. The follow-up period was 6–52 months. After surgery, none of the patients showed any signs of neurological deterioration. In all cases, a stable fusion was achieved with no signs of instability on flexion/extension radiographs. Neurological improvement was seen in 6 of 8 patients with myelopathy and 4 of 5 patients with radiculomyelopathy. The others showed stable disease. Pain relief was seen in all patients who complained of pain preoperatively.

Conclusion. The aims of treatment for cervical spondylolisthesis are spinal cord decompression (ventral, dorsal or both), correction and fusion. The used procedure should depend on the severity of the cervical deformity, degree and side of the spinal cord compression, and the possibility of correction by extension and positioning.

Keywords Spondylolisthesis · Cervical spine · Myelopathy · Degenerative instability · Fusion

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Introduction

Degenerative spondylolisthesis of the lumbar spine is a common disease. The main causes are arthrosis of the facet joints and disc degeneration. These changes may occur at single or multiple motion segments. Kirkaldy-Willis et al. (1978) described the phases of the degenerative process as dysfunction, instability, and stabilization [8].

Progressive degeneration and/or disc herniation leads to collapse of the disc space. The facet joints may override, thus stretching the adjacent capsular and ligamentous structures. Over time, instability results in hypertrophic changes at the annular attachments, formation of traction osteophytes and hypertrophy of the facets, which generates a stenosis of the spinal canal and neural foramina. Persistent unisegmental or multisegmental instability patterns produce rotational and translational subluxation, resulting in degenerative spondylolisthesis or scoliosis [8]. The mechanisms of spinal restabilization, as described above, may prevent progression of the disease [12].

Spondylolisthesis is rarely seen in the cervical spine and only few publications are dedicated to this topic. The first reports described anomalies of the pedicles and defects in the posterior arch reflecting a spondylolytic cervical spondylolisthesis. However, more recent publications have focused on the degenerative aspects of cervical spondylolisthesis formation. In 1986, Lee et al. studied the radiographic differences between degenerative and traumatic slippage of the cervical spine [9]. In 2003, Tani et al. described the functional importance of degenerative spondylolisthesis in cervical spondylotic myelopathy. The authors emphasized that cervical degenerative spondylolisthesis received insufficient attention in contrast to lumbar spondylolisthesis [14].

The mechanisms for the formation of cervical spondylolisthesis seem to be analogous to the lumbar spine, with hypertrophic degeneration of the facet joints resulting in altered cervical mechanics and secondary subluxation [2]. In order to better understand this progression process of cervical spondylolisthesis, we studied 16 patients with radiologically verified spondylolisthesis.

Material and methods

We reviewed 16 patients (7 women and 9 men) with degenerative cervical spondylolisthesis. Trauma, infection and neoplasms were excluded. The mean age was 67.6 years (range 50–75). The leading symptom was severe myelopathy in 8 patients, radiculomyelopathy in 5 patients and neck pain in 3 patients. Radiographic examinations included plain radiography, MRI, CT, myelography and lateral tomography. In correspondence to previous definitions, spondylolisthesis was assumed when the slippage of one vertebra over the other was 2 mm or more [9, 14].

If spondylolisthesis could be radiologically proven, patients were divided into three groups according to additional radiographic findings: group 1 – spondylolisthesis with degeneration of the facet joints; group 2 – spondylolisthesis with degeneration of the facet joints and vertebral bodies; group 3 – spondylolisthesis with severe cervical spine deformity.

Clinical symptoms and surgical proceedings depended on the classification of the spondylolisthesis. The follow-up period was 6–52 months. Radiographic and clinical examinations were performed every 3 months in the first year after surgery. Fusion was evaluated by flexion/extension radiography after 6 and 12 months. The operative segment was deemed to be fused if there was less than 2° of segmental movement and no more than 50% radiolucency covering the implant's outer surface.

Since different fusion techniques were used (mostly titanium cages, but also PEEK cages and iliac crest bone), trabeculation between the adjacent segments could not be assessed in the majority of our patients. The above described criteria have also been applied in other analyses of fusion using cervical fusion cages [6]. However, in the cases where PEEK cages or iliac bone crest were used trabecular formations were assessed.

For evaluation of instability, angular range of motion and sagittal translation were measured in flexion and extension radiographs. Increased range of motion in the involved segment was considered as instability [7, 11]. Since the study was a retrospective study, the postoperative evaluation of patients was based on clinical data, subjective impressions of the patient and Odom's criteria [10].

Results

Spondylolisthesis in our patients was located at level C3/4 in 5 cases, level C4/5 in a further 5 cases, and level C5/6 in yet another 5 cases. In three cases spondylolisthesis was located at level C7/T1. There were two patients with listhesis on two levels (one at level C4/5 and C5/6, and one at level C3/4 and C4/5). The mean slippage was 2.9 ± 0.9 mm

Table 1 Staging system for classification of cervical spondylolisthesis depending on clinical symptoms, morphological characteristics and suggested surgical procedures

Stage	Number of patients	Leading symptoms	Morphological characterisation	Radiological instability	Surgical procedure
1	3	Pain	Degeneration of the facet joints	Present	Discectomy at 1 level, repositioning and fusion ^a
2	8	Radiculomyelopathy or myelopathy	Degeneration of the facet joints and vertebral bodies	Infrequent	Discectomy at 1 or 2 levels, repositioning and fusion
3	5	Severe myelopathy	Severe spine deformity	Not present	Corpectomy, vertebral body replacement and fusion

^aA dorsal decompression and release was necessary in one patient due to severe spondylarthrosis

(range 2–6 mm) in neutral position. Instability could be demonstrated by flexion/extension radiography in five cases (two times at level C3/4, two times at level C4/5 and one time at level C5/6).

According to our classification we included 3 patients in group 1, 8 patients in group 2 and 5 patients in group 3 (Table 1). There were no significant differences in the degree of slippage between the groups. In group 1 the leading symptom was pain and all patients showed mobility on flexion and extension radiographs. The spondylolisthesis could be corrected by extension and positioning in two cases, so discectomy and fusion at one level was sufficient.

One case exhibited severe spondylarthrosis, so additional dorsal decompression and release was necessary (Fig. 1).

Patients in group 2 presented with myelopathy or radiculomyelopathy as the leading symptom. Two patients had spondylolisthesis on two levels. The spondylolisthesis could be corrected by extension and positioning in 5 of 8 patients. In three cases discectomy at the adjacent level was necessary to achieve adequate decompression and repositioning (Fig. 1).

In group 3 all patients presented with severe myelopathy. Radiological examinations revealed severe deformities of the cervical spine with absolute spinal canal stenosis and myelocompression. In these patients a corpectomy

Fig. 1 *Top:* showing MRI (left) and radiographs of the cervical spine before (middle) and after (right) surgery. This patient was classified as stage 1 cervical spondylolisthesis. The radiographs demonstrate a slippage of C3 over C4 without any signs of spondylosis. Pain was the leading symptom. The surgical procedure was dorsal release, ventral discectomy, repositioning and fusion using a SOLIS cage and an alpha-plate (Stryker, Cestas, France). *Middle:* showing MRI (left) and radiographs of the cervical spine before (middle) and after (right) surgery. This patient was classified as stage 2 cervical spondylolisthesis. The radiographs demonstrate a slippage of C4 over C5 with additional spondylosis at level C5/6. Radiculomyelopathy was the leading symptom. The surgical procedure was ventral discectomy at two levels, repositioning and fusion using iliac crest bone graft and an ABC-plate (Aesculap, Tuttlingen, Germany). *Bottom:* showing MRI (left) and radiographs of the cervical spine before (middle) and after (right) surgery. This patient was classified as stage 3 cervical spondylolisthesis. The radiographs demonstrate a slippage of C3 over C4 with additional severe spondylosis and spinal canal stenosis. Myelopathy was the leading symptom. The surgical procedure was ventral corpectomy and fusion using an anterior distraction device (ADD, Ulrich, Ulm, Germany) and an alpha-plate (Stryker, Cestas, France)

with vertebral body replacement was necessary (Fig. 1). Moreover, neck pain was the initial symptom in all patients and decreased when neurological symptoms became more evident.

After surgery, none of the patients showed any signs of neurological deterioration. In all cases, a solid fusion was achieved with no signs of instability on flexion/extension radiographs 6 and 12 months after surgery, respectively and no signs of radiolucency around the implants. In cases with PEEK cages (3) and iliac bone crest (1), trabecular formation could be demonstrated. Neurological improvement was seen in 6 of 8 patients with myelopathy and 4 of 5 patients with radiculomyelopathy. The others showed stable disease. Pain relief was seen in all patients who complained of pain preoperatively. According to Odom's criteria, 4 patients (25%) had an excellent outcome, 6 patients (37%) had a good outcome, 3 patients (19%) had a satisfactory outcome and 3 patients (19%) had a poor outcome.

Discussion

In contrast to spondylolisthesis of the lumbar spine, cervical spine spondylolisthesis is very rare and only few cases are described in the literature [1, 2, 5, 9, 14]. Moreover, cervical spondylolisthesis is often associated with other pathologies like aneurysmal bone cyst, neurofibromatosis or skeletal fluorosis [4, 5, 13]. The main causes of degenerative cervical spondylolisthesis are arthrosis of the facet joints and disc degeneration. Since disc degeneration leads to collapse of the disc space, the facet joints may override. Increased stress with flexion and extension may stretch the disc and ligaments, allowing slippage to occur [9]. The mechanisms of degenerative spinal restabilization may prevent progression of the disease and lead to various forms of deformity [12].

However, degenerative spondylolisthesis of the cervical spine has still not been extensively described. An explanation for this fact could be that many patients are diagnosed late with severe cervical spine deformities. When a deformity occurs one does not necessarily think that a spondylolisthesis was the primary cause. Tani et al. (2003) described the importance of degenerative spondylolisthe-

sis in cervical spondylotic myelopathy in the elderly. The authors emphasized that degenerative spondylolisthesis may be more common than previously thought [14].

This study presents a classification system which is oriented towards clinical and morphological data. Our concept is based on the assumption that degeneration of the disc and the facet joints firstly occurs in association with instability and neck pain. Neck pain was consistently the initial symptom in all of our patients. At this stage, degeneration of the vertebral bodies and discs may only be mild. If instability proceeds faster than restoration, spondylolisthesis may become visible on radiographs at this early stage. However, this seems to be very rare in the cervical spine, in contrast to the lumbar spine. We saw only three cases of this in our series of 16 patients. Facet joint degeneration is more frequently accompanied by spondylolysis and discopathy, leading to restabilization and spinal canal stenosis.

In our experience, the surgical approach corresponds well to our classification system. Discectomy at one or two levels may be sufficient in the early stages. If the facet joints show severe degeneration, dorsal decompression and release can sometimes facilitate repositioning. In the case of severe spinal canal stenosis, corpectomy and fusion can be used to improve neurological deficits. This concept allowed us to achieve good results, especially regarding neck pain (100% success rate). Furthermore, 75% of our patients showed improvement of myelopathy and 80% showed improvement of radiculomyelopathy. This is lower than the rate reported for general cervical spinal canal stenosis and may be due to the specificity of cervical spondylolisthesis formation with additional traction on the spinal cord [3].

Since cervical spondylolisthesis may only present with neck pain in the early stages, we would recommend flexion/extension radiography in patients with prolonged neck pain. In the case of radiologically proven cervical spondylolisthesis with instability or spinal cord compression we would suggest surgery. The surgical approach should depend on the stage of spondylolisthesis, the side and degree of spinal cord compression, and the possibility of correction by extension and positioning in order to restore a balanced spine.

References

1. Boulos AS, Lovely TJ (1996) Degenerative cervical spondylolisthesis: diagnosis and management in five cases. *J Spinal Disord* 9:241-245
2. Deburge A, Mazda K, Guigui P (1995) Unstable degenerative spondylolisthesis of the cervical spine. *J Bone Joint Surg Br* 77:122-125
3. Eleraky MA, Llanos C, Sonntag VK (1999) Cervical corpectomy: report of 185 cases and review of the literature. *J Neurosurg* 90:35-41
4. Fujimura Y, Nishi Y, Chiba K, Kobayashi K (1995) Prognosis of neurological deficits associated with upper cervical spine injuries. *Paraplegia* 33: 195-202
5. Goffin J, Grob D (1999) Spondylolysis of the cervical spine in neurofibromatosis. A case report. *Spine* 24:587-590
6. Hacker RJ, Cauthen JC, Gilbert TJ, Griffith SL (2000) A prospective randomized multicenter clinical evaluation of an anterior cervical fusion cage. *Spine* 25:2646-2654

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7. Holmes A, Wang C, Han ZH, Dang GT (1994) The range and nature of flexion-extension motion in the cervical spine. *Spine* 19:2505–2510
 8. Kirkaldy-Willis WH, Wedge JH, Yong-Hing K, Reilly J (1978) Pathology and pathogenesis of lumbar spondylosis and stenosis. *Spine* 3:319–328
 9. Lee C, Woodring JH, Rogers LF, Kim KS (1986) The radiographic distinction of degenerative slippage (spondylolisthesis and retrolisthesis) from traumatic slippage of the cervical spine. *Skeletal Radiol* 15:439–443
 10. Odom GL, Finney W, Woodhall B, Durham NC (1958) Cervical disc lesions. *JAMA* 166:23–28
 11. Penning L (1978) Normal movements of the cervical spine. *AJR Am J Roentgenol* 130:317–326
 12. Postacchini F, Perugia D (1991) Degenerative lumbar spondylolisthesis. Part I: etiology, pathogenesis, pathomorphology, and clinical features. *Ital J Orthop Traumatol* 17:165–173
 13. Sy MH, Marouf OC, Sene P, Diouf S, Seye SI (1998) [Cervical spondylolisthesis in skeletal fluorosis. A case report]. *Int Orthop* 22:407–409
 14. Tani T, Kawasaki M, Taniguchi S, Ushida T (2003) Functional importance of degenerative spondylolisthesis in cervical spondylotic myelopathy in the elderly. *Spine* 28:1128–1134