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## The incidence of C5–C6 radiculopathy as a complication of extensive cervical decompression: own results and review of literature

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**Abstract** This retrospective study aims to discuss and compare our results with those previously mentioned in the literature with regard to C5–C6 radiculopathy that occurs after decompression carried out for cervical spondylotic myelopathy. There are few reports in the literature referring to the incidence of the C5–C6 radiculopathy following cervical decompression procedures. Some authors believe that the postoperative cord shift is the most likely cause. From January 1994 to November 2002, 121 patients underwent cervical corpectomies for cervical spondylotic myelopathy. The preoperative and the postoperatively discovered paresis have been assessed according to the criteria of the British Medical Council. The Nurick Scale was used to grade the severity of the myelopathic changes. The follow-up period varied from 4 to 111 months with an average of 50 months. Symptoms of C5 and/or C6 radiculopathy appeared in 10 patients (8.2%) postoperatively. Aggravation of a preoperative C5 and/or C6 radiculopathy was seen in 3 patients, while 7 patients developed a new C5 and/or C6 radiculopathy in the immediate postoperative period. These motor deficits resolved completely in 7 patients within 7 months of surgery, whereas a residual motor weakness remained in the other 3 patients. The postoperative C5 motor deficit is not infrequently associated with partial involvement of the C6 root. The lesions can be either unilateral or bilateral with a statistically average frequency of 8%. The prognosis is generally favorable. Our results did not support the hypothesis that the claimed cord shift phenomenon is a possible aetiology.

**Keywords** Cervical spine · Cervical spondylotic myelopathy · Radiculopathy · Cervical corpectomy · Extensive decompression · Spinal cord shift

### Introduction

On checking our clinical results of cervical corpectomies, we had detected a relevant percentage of patients who developed motor weakness of the muscles supplied with C5 and/or C6 nerve roots postoperatively. There are few reports in the literature referring to the incidence of this neurological deficit following cervical decompression procedures. Some authors reported on the so-called “dissociated motor loss” of the deltoid muscle as a postoperative complication of cervical corpectomies [1, 4, 5, 7, 10, 11–13, 15, 19, 23], laminectomies [3, 20, 23] or laminoplasty [15, 18, 22] done for cervical spondylotic myelopathy (CSM).

The aim of this study is to discuss and compare our results with those previously mentioned in the literature and to shed the light on the underlying causes, risk factors, and possibilities of avoiding this complication.

### Patients and methods

#### Clinical data

From January 1994 to November 2002, 121 patients underwent cervical corpectomies for CSM in our institution. The average age of the patients was 58.6 years. The Nurick-Grade [16] measuring the extent of myelopathy was 1.8 on average. Sixty-seven patients were men and 54 were women. Sixty-five patients (53.7%) underwent one-level corpectomy; whereas multi-level corpectomies were performed in 56 patients (46.3%), among them four-level corpectomy was carried out in 8 patients and three-level in 11 patients. In general, 1.7 level corpectomy was performed per patient on average.

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**Table 1** Summary of ten patients who developed nerve root palsy after cervical corpectomy for cervical spondylotic myelopathy. BMC British Medical Council

Patient number	Age	Sex	Level of corpectomy	Preoperative Nurick score	Nurick score at end of follow-up	Onset of root palsy (days postoperatively)	Palsy grade of affected roots (BMC) preoperatively	Palsy grade of affected roots (BMC) postoperatively	Palsy grade of affected roots at end of follow-up	Time of recovery (months)	Operative revision and findings	Follow-up (months)
1	69	Female	C3-C6	5	3	1	No	C5 M0 unilateral	C5 M4	12	No	70
2	44	Male	C4, C5	1	0	2	No	C5 M3, C6 M4 unilateral	C5 M5, C6 M5	6	No	64
3	65	Male	C3-C6	3	1	1	No	C5 M3, C6M4 unilateral	C5 M4, C6 M4	4	No	62
4	59	Female	C5 C6	1	0	2	No	C5 M3 unilateral	C5 M5	6	No	48
5	65	Male	C3-C5	3	1	2	C5 M4, C6 M4 bilateral	C5 M1, C6 M3 bilateral	C5 M4, C6 M5 bilateral	6	No	46
6	76	Male	C4, C5	2	1	1	C5 M4, C6 M4 unilateral	C5 M3, C6 M4 bilateral	C5 M5, C6 M5 bilateral	12	No	24
7	58	Male	C5	1	0	1	No	C5 M2, C6 M4 unilateral	C5 M5, C6 M5	12	Haematoma	24
8	67	Female	C5	1	0	3	C6 M4 unilateral	C5 M3, C6 M3 bilateral	C5 M5, C6 M5 bilateral	8	No	18
9	59	Male	C5, C6	1	0	2	No	C5 M4, C6 M4 unilateral	C5 M5, C6 M5	2	No	18
10	62	Male	C6	1	0	1	No	C5 M3 unilateral	C5 M5	2	No	12

On the postoperative course, 10 patients developed a C5 (–C6) radiculopathy. All ten patients were subjected to MRI study of their cervical spine immediately after occurrence. The medical charts of these patients were reviewed and the relevant data from the preoperative and postoperative periods were tabulated (Table 1). The preoperatively discovered paresis, if present, and the postoperatively discovered paresis were assessed according to the criteria of the British Medical Council (BMC). The statistical evaluation of the results was carried out using the unpaired *t*-test. The follow-up period varied from 4 to 111 months with an average of 50 months.

### Surgical technique

Two surgical techniques were performed.

#### *One-level corpectomy (fixation with anterior plating)*

Anterior cervical approach was performed according to Cloward's technique [2]. After execution of the anterior corpectomy and spinal canal decompression under the surgical microscope, the defect was reconstructed, either with Harms-titanium (DePuy, Acromed, Raynham, USA), or Königsee-titanium mesh cages (Königsee Instrumente, Königsee, Germany), filled with the cancellous bone chips retrieved from the corpectomized vertebral body. Decortication of the vertebral endplates was carried out in advance using the oscillating burr. Then, mono-segmental anterior cervical plating was carried out (Pilling Weck, Karlstein, Germany; Fig. 1). This surgical technique was applied in 77 patients.

#### *Multi-level corpectomy (fixation with posterior plating)*

No anterior plating was carried out in 44 patients, otherwise the same aforementioned technique of anterior cervical corpectomy and fusion was carried out at two or more levels. At the same sitting, the patient was repositioned and posterior sub-periosteal exposure of the corresponding cervical segments was performed. Then

bilateral posterior cervical plates (Königsee Instrumente, Königsee, Germany) were fixed to the affected segments. The screws were placed in the lateral mass according to Magerl. In this technique, the 25° to 30° lateral and 15° cephalad course of screws parallel to the superior articular process poses less of a risk of facet joint violation [14]. Posterior fusion is then completed by decortication of the laminae and spinous processes and placement of bone chips on the exposed cancellous bony surface (Fig. 2).

### Results

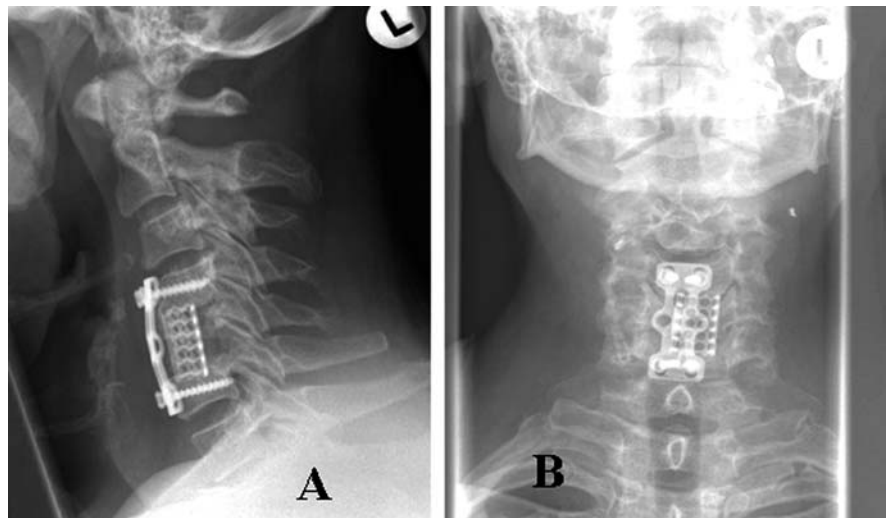
In the postoperative period, symptoms of C5 and/or C6 radiculopathy appeared in 10 (8.2%) patients (Table 1). The average age of these patients was 62.4 years, which was significantly higher than that of the total patients; 58.6 years ( $P < 0.01$ ). The male to female ratio was 7:3.

Three out of the 10 patients underwent one-level corpectomy, 4 underwent two-level corpectomy, only 1 underwent three-level corpectomy, and four-level corpectomy was carried out in 2 patients. So, the average number of corpectomy levels in this subgroup of patients was 2.2 levels per patient, in comparison to 1.7 levels per patient in total ( $P < 0.001$ ).

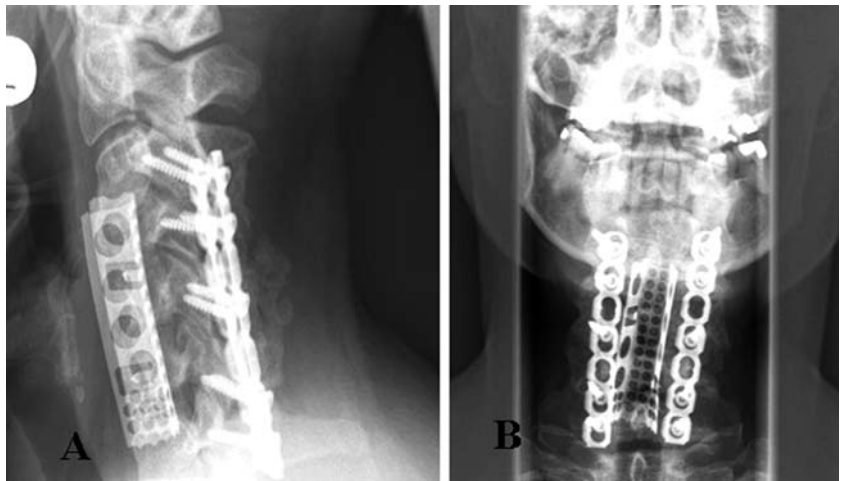
The period of follow-up for those ten patients varied from 12 to 70 months with an average of 38.6 months. The average Nurick score improved from 1.9 in the preoperative period to 0.6 at the end of the follow-up ( $P < 0.001$ ). There was no statistical difference between the preoperative Nurick score of these ten patients affected by postoperative radiculopathy and the remaining patients.

Among the 10 patients affected, 3 had a pre-existing C5 and/or C6 motor weakness (motor grade M4); 2 were unilaterally and 1 was bilaterally affected (Table 1). In those 3 patients, the preoperatively affected motor function deteriorated postoperatively. In the remaining 7 patients, the C5–C6 motor weakness was detected after surgery. These neurological deficits developed within the first 3 postoperative days. Isolated C5 root involvement was

**Fig. 1** One-level corpectomy with anterior plate. **a** Postoperative X-ray lateral view. **b** Postoperative X-ray antero-posterior view.



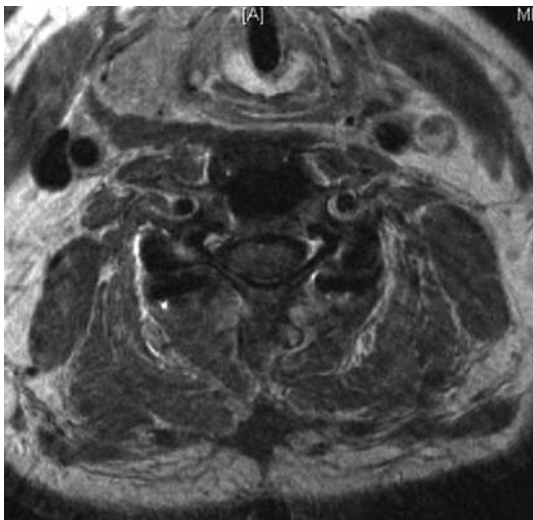
**Fig. 2** Multi-level corpectomy with posterior plating. **a** Postoperative X-ray lateral view. **b** Postoperative X-ray antero-posterior view.



encountered in 3 patients. In the remaining 7 patients both C5 and C6 roots were affected, although the C5 root deteriorated further.

After an average of 7 months postoperatively, the motor deficits improved completely in 7 patients, whereas residual motor weakness of M4 grade remained in the other 3 patients, which was related to the preoperative state. Certainly, there was a non-significant statistical correlation between the preoperatively existing neurological deficit and the residual motor weakness at the final follow-up.

Magnetic resonance imaging of the cervical spine had been carried out in the postoperative period, aimed at finding a possible interpretation of this surprising neurological deficit. Apart from a mild intra-spinal hematoma seen in one patient (patient 7 in Table 1), there were no other significant MRI findings, especially as no spinal cord shift was evident on the MRI studies (Fig. 3). The immediate postoperative revision of this patient (patient 7 in Table 1) confirmed the MRI finding.



**Fig. 3** Early postoperative MRI in a patient with a C5–C6 root lesion, without spinal cord shift.

Cortisone therapy was prescribed for more than 3 days for all patients.

## Discussion

### Summary of the literature

It has been reported in the literature that this neurological complication happens only with CSM. There was no evidence, not only in our patients but also in the literature, of the incidence of this complication with corpectomy performed for fractures or tumors. In the context of cervical spine degenerative disorders, Fan et al. [6] described an incidence of C5 lesions between 0 and 12.9% after cervical laminectomy and 2.5–14.9% after laminoplasty. For one reason or another, this complication has not been adequately addressed in most cervical corpectomy studies. The postoperative C5–C6 radiculopathy rate after corpectomy varied from 2.8 to 13.6%, which has been documented in a few studies [1, 4, 5, 7, 11, 13, 19, 23]. Statistically on average we found an incidence of about 8% C5 nerve root lesions after cervical decompressions. Only two studies reported the involvement of the C6 nerve root [6, 18]. All the neurological deficits were purely motor and showed a gradually improving course mostly after 3 months [4, 7, 11]. How great the improvement was, and whether it was complete or not, have not been mentioned in these studies. However, all the reports in the literature agreed on the involvement of C5, as well as the occurrence of this complication in the early postoperative phase, as common features of the problem.

### Pathogenesis

It is clear from the results of ours and other studies in the literature that the occurrence of C5–C6 radiculopathy is not related to whether the cervical decompressive procedure is carried out anteriorly or posteriorly.

Three possible causes are discussed in the literature:

1. Traction effect on the nerve roots because of spinal cord shift occurring after spinal canal decompression [19, 25]
2. Inadequate foraminal decompression [20]
3. Postoperative instability [20]

The cord shift hypothesis was supported by the results of Saunders [19], who obtained a significant reduction in the C5 radiculopathy from 14.6 to 2.5% by decreasing the width of the central corpectomy from 20 mm to 15 mm.

In our study, where adequate decompression and stabilization were carried out, we failed to find any patients with instability or foraminal stenosis on plain radiographs and MRI studies. Moreover, we did not find any evidence of actual cord shift. The spontaneous recovery of the vast majority of those affected with this complication does not support the cord shift phenomenon. The C6 nerve root was involved in 7 out of 10 patients. Apart from Saunders [19] and Fan et al. [6], who referred to one C6 involvement in their series, all reports talked about C5 lesions. The muscle power grades of the C6 supplied musculature were considerably better than that of the deltoid muscle in our study. This fact and the lack of mention of the C6 nerve root involvement in the literature can be interpreted in the light of considering the nerve supply of the deltoid muscle, which is provided by C5 alone, while the biceps and the hand extensors are provided by an overlapped nerve supply.

#### Risk factors, course, and possibilities of prevention

*Age* In our study, the significantly higher age of the group of patients presenting with postoperative C5 and/or C6 radiculopathy compared with that of the total group of patients seems to be a relevant risk factor. Saunders [19] has emphasized this finding. Also, it agrees more with Frykholm [8] and Payne and Spillane's [17] findings of proportionally increased age-related peri-neural fibrosis. This fibrosis leads to an increased fixation and limited mobilization liability of the nerve root.

*Extent of cervical decompression* The average number of corpectomy levels in patients presenting with this complication (2.2 levels) was significantly higher than the total average of 1.7 levels ( $P < 0.001$ ). We have not found any reference in the literature to the relation between the number of corpectomized levels and the incidence of postoperative C5 lesions. However, in cases of posterior decompression, this complication is clearly correlated with long-segment decompression procedures.

*Pre-existing myelopathy* Saunders [19] found a correlation between the pre-existing myelopathy and the postoperatively developed deltoid muscle weakness in his patients. However, we could not stress this fact in our study. We did not find any significant difference between the preoperative Nurick degree in the total group of patients (1.8) and those presenting with C5 and/or C6 lesions (1.9).

*Neurological course* In our study, the neurological deficits recovered almost completely after an average of 7 months and only three patients had a residual motor paresis of grade M4. Fan et al. [6] reported recovery times ranging from 24 h to 2 years postoperatively. Other authors [4, 5, 7, 11] reported a 3-month recovery period. The course seems to be favorable, taking into consideration the improvement trend of the neurological deficits.

*Prevention* Intraoperative neuromonitoring by the motor-evoked potential elicited from deltoid and biceps muscle by trans-cranial magnetic stimulation facilitates the immediate intraoperative detection of newly developed C5 and/or C6 lesions [6, 9]. However, the use of this method by both Fan et al. [6] and Inoue et al. [9] had until now not showed any proof that the incidence of this postoperative complication could be minimized.

Only decreasing of the width of the corpectomy might help in reducing the incidence of this complication.

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## Conclusion

As described in the literature, postoperative C5 motor deficit is associated with the less serious involvement of the C6 nerve root. The lesions can be either unilateral or bilateral. This neurological deficit occurs with an average frequency of 8% after expansive cervical decompression procedures (corpectomies, laminectomies, laminoplasty). We believe that the pathogenesis of this complication is multifactorial. Risk factors are old age, pre-existing myelopathy, and long-segment decompression procedures. The prognosis is favorable in general. The patients should be informed about the possibility of the occurrence of this complication before surgery.

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## References

1. Banerji D, Acharya R, Behari S (1997) Corpectomy for multi-level cervical spondylosis and ossification of posterior longitudinal ligament. *Neurosurg Rev* 20:25–31
2. Cloward RW (1958) The anterior approach for removal of ruptured cervical discs. *J Neurosurg* 15:602–617
3. Dai L, Ni B, Yuan W (1998) Radiculopathy after laminectomy for cervical compression myelopathy. *J Bone Joint Surg [Br]* 80:846–849
4. Epstein N (2001) Anterior approaches to cervical spondylosis and ossification of posterior longitudinal ligament: review of operative technique and assessment of 65 multilevel circumferential procedures. *Surg Neurol* 6:313–324
5. Epstein N (2001) The value of anterior cervical plating in preventing vertebral fracture and graft extrusion after multilevel anterior cervical corpectomy with posterior wiring and fusion: indications, results and complications. *J Spinal Disord* 13:9–15
6. Fan D, Schwartz DM, Vaccaro AR (2002) Intraoperative neurophysiologic detection of iatrogenic C5 nerve root injury during laminectomy for cervical compression myelopathy. *Spine* 22:2499–2502
7. Fessler RG, Steck JC, Giovanini MA (1998) Anterior cervical corpectomy for cervical spondylotic myelopathy. *Neurosurgery* 43:257–267

8. Frykholm R (1984) Lower cervical nerve roots and their investments. *Acta Chir Scand* 101:457–471
9. Inoue S, Tani T, Taniguchi S (2003) The motor-evoked potentials elicited from the deltoid muscle by trans-cranial magnetic stimulation with a standardized facilitation. *Spine* 28:276–278
10. Keegan JJ (1965) The cause of dissociated motor loss in the upper extremity with cervical spondylosis: a case report. *J Neurosurg* 23:528–536
11. Macdonald RL, Fehlings MG, Tator CH (1997) Multilevel anterior cervical corpectomy and fibular allograft fusion for cervical myelopathy. *J Neurosurg* 86:990–997
12. Matsunaga S, Sakou T, Imamura T, Morimoto N (1993) Dissociated motor loss in the upper extremities: clinical features and pathophysiology. *Spine* 18:1964–1967
13. Mayr MT, Subach BR, Comey CH (2002) Cervical spinal stenosis: outcome after anterior corpectomy, allograft reconstruction and instrumentation. *J Neurosurg* 96:10–16
14. McCullen GM, Garfin SR (2000) Spine update. Cervical spine internal fixation using screw and screw-plate constructs. *Spine* 25:643–652
15. Minoda Y, Nakamura H, Konishi S (2003) Palsy of C5 nerve root after midsagittal splitting laminoplasty of the cervical spine. *Spine* 28:1123–1127
16. Nurick S (1972) The natural history and results of surgical treatment of the spinal cord disorder associated with cervical spondylosis. *Brain* 95:101–108
17. Payne EE, Spillane JD (1960) An anatomico-pathological study of 70 specimens (using a special technique) with particular reference to the problem of cervical spondylosis. *Brain* 80:571–592
18. Satomi K, Nishu Y, Kohno T (1994) Long-term follow-up studies of open-door expansive laminoplasty for cervical stenotic myelopathy. *Spine* 19:507–510
19. Saunders RL (1995) The pathogenesis of radiculopathy complicating multilevel corpectomy. *Neurosurgery* 3:408–412
20. Shinomiya K, Kurosa Y, Fuchioka M (1989) Clinical study of dissociated motor weakness following anterior cervical decompression surgery. *Spine* 14:1211–1214
21. Snow RB, Weiner H (1993) Cervical laminectomy and foraminotomy as surgical treatment of cervical spondylosis: a follow-up study with analysis of failures. *J Spinal Disord* 6:245–250
22. Uematsu Y, Tokuhashi Y, Matsuzaki H (1998) Radiculopathy after laminoplasty of the cervical spine. *Spine* 23:2057–2062
23. Wada E, Suzuki S, Kanazawa A (2001) Subtotal corpectomy versus laminoplasty for multilevel cervical spondylotic myelopathy. *Spine* 26:1443–1448
24. Wiberg J (1986) Effects of surgery on cervical spondylotic myelopathy. *Acta Neurochir* 81:113–117
25. Yonenobu K, Hosono N, Iwasaki M (1991) Neurologic complications of surgery for cervical compression myelopathy. *Spine* 16:1277–1282