Comparison of ventral corpectomy and plate-screw-instrumented fusion with dorsal laminectomy and rod-screw-instrumented fusion for treatment of at least two vertebral-level spondylotic cervical myelopathy

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Abstract The objective of the article is to verify the hypothesis that the dorsal multilevel laminectomy and rod-screw-instrumented fusion (DLF) for multilevel spondylotic cervical myelopathy (MSCM) is less strenuous for patients, and less prone to perioperative complications, than ventral multilevel corpectomy and plate-screw-instrumented fusion (VCF), while clinical outcome is comparable. One hundred and three successive patients were treated for at least two vertebral-level MSCM, 42 of them by VCF and 61 by DLF. The two patients groups were retrospectively compared. VCF patients were slightly younger than DLF patients (62.5 ± 10.61 years versus 66 ± 12.4 years, $P = 0.012$). In VCF patients, a median of 2 (2–3) corpectomies and in DLF patients a median of 3 (2–5) laminectomies were performed. In VCF patients, surgery lasted longer than in DLF patients (229 ± 60 min versus 183 ± 46 min, $P \leq 0.001$). Between the VCF and the DLF patients groups, no significant difference was

found in perioperative complications (e.g. hardware failure rates of 16.7% in VCF and of 6.6% in the DLF patients) and mortality rates. The postoperative outcome, as assessed by the postoperative change of the Nurick scores, the change of neck pain, the patients' satisfaction, and the change of the subaxial Cobb angle of the spine did not differ between the two patients groups. However, when comparing the postoperative Nurick scores directly, VCF patients fared somewhat better than DLF patients [median of 2 (0–5) versus 3 (1–5), $P = 0.003$]. The hypothesized advantages of DLF over VCF in the surgical treatment of at least two vertebral-level MSCM could not be confirmed in this retrospective study. A prospective randomized study is warranted to clarify this issue.

Keywords Spondylotic · Cervical · Myelopathy · Corpectomy · Laminectomy · Fusion

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Introduction

Ventral multilevel corpectomy and plate-screw-instrumented fusion (VCF) for the treatment of multilevel spondylotic cervical myelopathy (MSCM) may be associated with high perioperative morbidity, including hardware failure [7, 13, 24, 26]. This was also the case in our own series of 84 patients (unpublished data) with spondylotic cervical myelopathy: While in patients with single level corpectomies hardware failure occurred in 9.5% ($n = 8$) of cases, in multilevel corpectomies it occurred in 16.7% ($n = 14$). Although this difference was not statistically significant ($P = 0.525$), in patients with MSCM an alternative surgical approach by dorsal multilevel laminectomy seemed to be warranted. The long-term outcome of this posterior approach may decline due to post-laminectomy

kyphosis and instability [7–9, 11, 17]. However, modern dorsal rod-screw-fixation devices will help to avoid these late complications [10, 20, 21].

Thus, since 2003, we abandoned VCF in favor of dorsal multilevel laminectomy and rod-screw-instrumented fusion (DLF) in patients where VCF as well as DLF seemed feasible for the surgical treatment of their at least two vertebral-level MSCM. The hypothesis was that DLF is less strenuous for patients, and that it has a lower perioperative morbidity, including less hardware failure than VCF, while the clinical outcome is the same. After we collected a sufficient number of patients with both of these treatment modalities, we thought to test our initial hypothesis.

Patients and methods

All patients operated for MSCM by spinal canal decompression and instrumented fusion, using either a modern dynamic plate-screw-system (VCF) or a modern rod-screw-system (DLF), were identified from the electronic surgical log-book of the department.

Corpectomy was performed by an anterolateral approach and always included the resection of the dorsal longitudinal ligament to ensure adequate decompression of the spinal canal. Autologous iliac crest was used as fusion material. The plate-screw-fixation extended from the adjacent intact superior to the adjacent intact inferior vertebral body. Either the ACP Codman System (Ethicon Inc., Norderstedt, Germany) or the ACP Atlantis System (Medtronic Inc., Duesseldorf, Germany) dynamic locking plate-screw-systems was used. Postoperatively, all patients' cervical spines were immobilized in semi-rigid collars (Miami J; Ossur Europe, Pulheim, Germany, or Aspen Medical Products Inc., Irvine, CA, USA) for 12 weeks. Routine follow-up took place at 6 weeks, 3 months, 9 months, and 2 years postoperatively, and included clinical assessment and plain anterior-posterior and lateral radiographs of the cervical spine. Flexion-extension radiographs as well as computed tomographies or magnetic resonance images of the cervical spine were done when considered necessary.

Laminectomy was performed by a dorsal approach from pedicle to pedicle, to ensure adequate decompression of the spinal canal. The autologous bone obtained from the laminectomy was used for posterolateral fusion. Rod-screw-fixation (Neon, Ulrich Medical, Ulm, Germany) extended from the lateral masses of the intact adjacent superior to the lateral masses of the intact adjacent inferior vertebra. In between, the lateral masses of every second laminectomized vertebra were included in the rod-screw-fixation. Pedicle screws were used if lateral mass screws failed. The follow-up of DLF patients was identical with that of VCF patients.

In the VCF as well as in the DLF patients groups, ventral compression of the spinal canal by osteophytes prevailed over dorsal compression by ligamentous hypertrophy in all patients. Before 2003, all patients were surgically treated by VCF. Since 2003, we abandoned VCF in favor of DLF in patients where VCF as well as DLF seemed feasible for the surgical treatment of their at least two vertebral-level MSCM. However, VCF was still occasionally used in combination with DLF: If the spondylotic segments of the MSCM were considered to produce a focally extreme stenosis ventrally (either by osteophytes or by kyphotic deformity), which was not adequately treatable by laminectomy, in an initial step, the extreme ventral stenosis was locally decompressed by ventral discectomy or corpectomy with plate-screw-instrumented fusion, followed by a second step of extended DLF, addressing all other stenotic segments. Patients operated by combined VCF and DLF were excluded from this study.

The following data were extracted retrospectively from the patients charts: age, gender, substantial musculoskeletal comorbidities (defined as morbidities requiring surgery or chronic medication), ASA class, BMI, duration of myelopathy history, number of corpectomized/laminectomized vertebrae, duration of surgery, blood loss, blood transfusions performed, complications and their treatment, including hardware failure (defined as screw-pull-out with loss or impending loss of stability, whether clinically symptomatic or not). The Cobb angle of the subaxial cervical spine (cover plate of C3 to base of C7) was measured on preoperative and most recent radiographies. The following data have been collected by structured telephone interviews, using a pre-designed interview protocol: preoperative and current Nurick grade [15], preoperative and current neck pain [assessed by visual analog scale (VAS)] [5], and satisfaction with the treatment results (if patients were not sure about this, they were considered as not satisfied). In three patients, who had died in the meantime, data were collected from their relatives. The data were collected by one of the authors not involved in the operative treatment of the patients.

The Chi-square test, the non-parametric Mann–Whitney test, and multiple logistic regression analysis were used for statistical analysis of data. Results were considered significant at $P < 0.05$ level. The analyses were performed using SPSS 14.

Results

The study period extended from April 1999 to October 2007 and comprised 103 patients with at least two ventral-level MSCM. Forty-two patients underwent VCF and 61

underwent DLF. Another 10 patients underwent combined VCF and DLF and were excluded from this study. Another 25 patients with ossification of the posterior longitudinal ligament and patients operated for posttraumatic myelopathy (central cord syndrome) due to degenerative cervical stenosis were also excluded from the study.

The preoperative findings of the two patients groups are shown in Table 1. All variables, except age, were well balanced. Patients with VCF were slightly younger than patients with DLF (62.5 ± 10.61 years versus 66 ± 12.4 years, $P = 0.012$).

The operative findings are summarized in Table 2. VCF lasted on average 45 min longer than DLF (183 ± 46 min versus 229 ± 60 min, $P \leq 0.001$), while there was no significant difference in blood loss or transfusion rates.

The complications that occurred are summarized in Table 3. Apart from two cases of transient hoarseness and one case of transient dysphagia, typical for the ventral approach, there were no statistically significant differences between type and incidence of complications in the two patients groups. In particular, incidence of postoperative new onset of, or worsened radiculopathies (11.9% in VCF and 19.6% in DLF, $P = 0.23$) and incidence of hardware failure (16.7% in VCF and 6.5% in DLF, $P = 0.108$) did not differ significantly between the two patient groups. All patients with hardware failure have undergone revision surgery.

In the VCF group, the irreversible complications were represented by two cases of wound infection leading to sepsis and death of the patients. In the DLF group, the irreversible complications were represented by four cases of new onset or worsened radiculopathies not completely

reversible during the available follow-up. Again, there was no significant difference found between the two patient groups.

Also, mortality did not differ significantly between the two patients groups. In the VCF group, two patients died due to septic complications following wound infections. In the DLF group, one patient died during postoperative rehabilitation therapy. In this case, the immediate cause of death remains unclear.

The postoperative outcome, as assessed by the postoperative change of Nurick scores, the postoperative change of neck pain, patients' satisfaction, as well as by the postoperative change of the Cobb angle C3–C7, are summarized in Table 4. No statistically significant difference was found between the two patients groups. However, when assessing clinical outcome by comparing the patients' current postoperative Nurick scores (and not the Δ Nurick score of Table 4), patients with VCF fared somewhat better than those with DLF [median of 2 (0–5) versus 3 (1–5), $P = 0.003$]. In an attempt to exclude a possible bias caused by the inevitably shorter follow-up in DLF-patients, comparison of the postoperative Nurick scores of the two patients groups was redone, this time only considering DLF patients with a follow-up of >1 year. Again, VCF patients tended to fare somewhat better than DLF patients [median of 2 (0–5) versus 2.5 (1–5), $P = 0.055$]. However, in terms of neck pain (1.0 [–8 –9]) in VCF patients versus (0.50 [–8 –8]) in DLF patients, $P = 0.948$ and satisfaction (79% satisfied VCF patients versus 91% satisfied DLF patients, $P = 0.12$), the difference between the two patient groups remained not significant.

Table 1 Preoperative findings

Variable	VCF ($n = 42$)	DLF ($n = 61$)	P
Age [median (range)]	62.50 [39;85]	66.0 [34;85]	0.012
Gender [male (%)]	31 [73.8%]	46 [75.4%]	0.852
Musculoskeletal comorbidities [n (%)]	16 [38.1%]	27 [44.3%]	0.535
ASA [median (range)]	2 [1;4]	2 [1;4]	0.321
BMI [median (range)]	24.5 [17.3;34.3]	26 [15;41]	0.147
Duration of myelopathy history in month [median (range)]	12 [0.5;192]	7 [1;120]	0.591
Preoperative Nurick score [median (range)]	3 [0;5]	3 [1;5]	0.236
Preoperative neck pain on VAS [median (range)]	4 [0;10]	3.54 [0;8]	0.757
Cobb angle C3–C7 [median (range)]	10 [–11;41]	5.03 [–20;38]	0.096

VAS visual analog scale

Table 2 Intraoperative data

Variable	VCF ($n = 42$)	DLF ($n = 61$)	P
Number of operated cervical levels [median (range)]	2 (2–3) corpectomies	3 (1–5) laminectomies	–
Duration of surgery [mean $\pm$ SD (min)]	229.24 $\pm$ 60.1	183.84 $\pm$ 46.62	<0.001
Blood loss [mean $\pm$ SD (ml)]	743.33 $\pm$ 748.9	839.83 $\pm$ 876.6	0.37
Transfusion rate (%)	2.9	11.4	0.15

Table 3 Complications (multiple nominations possible)

Variable	VCF (<i>n</i> = 42)	DLF (<i>n</i> = 61)	<i>P</i>
Overall complications (%)	40.4	36.0	0.654
Surgical complications (%)	38	32.7	0.507
Radiculopathy (%)	11.9	19.6	0.232
Hoarseness, dysphagia (%)	7.1	–	–
Wound infection (%)	2.3	6.5	0.331
Hardware failure (%)	16.6	6.5	0.108
Medical complications (%)	7.1	7.1	1.02
Pneumonia (%)	2.3	4.7	0.797
Renal failure (%)	0	2.3	–
Sepsis (%)	4.7	0	–
Irreversible complications (%)	4.7	6.5	0.74
Radiculopathy (%)	0	6.5	–
Sepsis (%)	4.7	0	–
Operative mortality (%)	4.7	1.6	0.667

The influence of age, ASA, musculoskeletal comorbidities, BMI, number of operated cervical levels, occurrence of postoperative complications and postoperative change of the Cobb angle C3–C7 upon the postoperative outcome parameters (i.e. postoperative change of Nurick scores, postoperative change of neck pain and patients satisfaction) was assessed by logistic regression analysis for the VCF as well as for the DLF patient groups. In the VCF group, patients without perioperative complications were significantly ($P = 0.038$) more satisfied than those patients with perioperative complications, also patients with fewer musculoskeletal comorbidities had significant better postoperative neck pain relief ($P = 0.018$) than patients with many musculoskeletal comorbidities.

The remaining variables showed no significant influence upon above postoperative clinical outcome parameters.

Discussion

Both VCF and DLF are established surgical modalities for the treatment of MSCM. Their differential indications and

limitations are not yet definitively clear. Generally, a dorsal approach is recommended in MSCM because in VCF the incidence of complications is known to considerably increase with the number of corpectomies performed [7, 13, 18, 24]. This study retrospectively compared intraoperative data, complications and clinical results of VCF with DLF in the to-date largest series of patients with MSCM. It was hypothesized that DLF is less strenuous for the patients, that it is associated with less perioperative morbidity and that it results in a clinical outcome comparable to VCF in the treatment of at least two vertebral-level MSCM.

In this study, DLF for at least two vertebral-level MSCM was found to be significantly shorter, by about 45 min on average, than VCF. In the only other study that compared the operative times for VCF with laminoplasty for MSCM in smaller groups of 13 patients each, operative times were not found to differ significantly [4]. As found in other studies, the amount of blood loss did not differ between the two patients groups [4, 25].

In this study, the incidence of postoperative complications did not significantly differ between VCF and DLF. In the literature, complications are generally thought to occur more often following VCF (3–60%) than after posterior procedures (6.8–16%) [1, 4, 6, 7, 9, 10, 13, 14, 23–25, 27]. Complications following VCF are most often associated with the graft and include hardware failure and pseudarthrosis [7]. Complications following DLF and laminoplasties are mainly represented by decompression radiculopathies [7, 9].

The two main complications in both patient groups of the present study were post-decompression radiculopathies and hardware failure. Postoperative radiculopathies were slightly, but not significantly, more frequent following DLF and were reversible in the majority of cases. This is in accordance with the literature, where postoperative radiculopathies are described to occur in 2–15% of the patients, following more often dorsal than ventral approaches [3, 7, 9, 17–20]. Their genesis and potential treatment are not yet clarified. These radiculopathies are usually reversible within months to a few years [3, 9, 12].

Table 4 Postoperative outcome

Variable	VCF (<i>n</i> = 42)	DLF (<i>n</i> = 61)	<i>P</i>
Δ Nurick score [median (range)]	0 [–2;3]	0 [–2;2]	0.50
Δ Neck pain [median (range)]	1.0 [–8;9]	0.50 [–8;8]	0.948
Δ Cobb angle C3–C7 [median (range)]	0 [–21;35]	0 [–15;28]	0.761
Satisfied patients (%)	79.3	91.4	0.123
Duration of follow up [median ± SD (months)]	196.56 ± 212.0	66.53 ± 34.21	–

Δ Nurick score = postoperative Nurick score – preoperative Nurick score

Δ Neck pain = postoperative Neck pain – preoperative Neck pain

Δ Cobb angle = postoperative Cobb angle – preoperative Cobb angle

In the present series, hardware failure was more frequent following VCF than DLF. However, the difference was statistically not significant. The incidence of hardware failure with graft dislodgement is known to increase with the number of corpectomies: 1–4% in one level, 5–13% in two levels and 16–71% in three or more level corpectomies [13, 18, 24, 26]. This is one of the main reasons for recommending the dorsal approach in the treatment of MSCM [7, 9, 24].

Today, isolated laminectomy for the treatment of MSCM is generally abandoned in favor of laminoplasties or laminectomies followed by instrumented fusion. Although not yet proven, laminoplasties are thought to lower the incidence of post-laminectomy kyphosis and instability, as well as post-laminectomy scar membranes, which are thought to cause late neurological deteriorations following simple laminectomy in up to 30% of patients [7–9, 11, 17]. However, laminoplasties do not reliably prevent late postoperative kyphotic deformity and preserved cervical motion in laminoplasties is not necessarily associated with good clinical results [16, 17, 22, 25]. As confirmed by the present study, laminectomy and instrumented fusion will prevent kyphotic deformities of the cervical spine and neck pain, while they are associated with a low but not nil incidence of hardware failure and with potential adjacent segment degeneration [7, 10, 20]. However, it is not clear whether laminoplasties or laminectomies with instrumented fusion provide better results in the treatment of MSCM. We chose to use DLF over laminoplasties mainly because the surgical technique of dorsal rod-screw-fixation was already established at our institution for other surgical indications, e.g. cervical spine trauma and tumors.

In this study, the clinical outcome, as measured by the Nurick scale, was possibly marginally better for VCF patients than for DLF patients. However, when clinical outcome was assessed by the presence of neck pain and patients satisfaction, there was no difference between VCF and DLF patients. Thus, these results are in accordance with the literature, where the clinical outcome of the two treatment modalities is considered to be comparable [2, 4, 19, 25, 27]. Notably, in the long-term follow-up, laminoplasties are thought to be more often associated with axial pain than VCF [7, 13, 25]. This finding was not confirmed in our DLF patient group. Because of the instrumented fusion performed, progredient kyphotic deformity as a possible cause of axial pain was avoided.

The limitations of this study result from its retrospective character. It cannot be definitively confirmed that the extent of stenosis (number of motion segments involved) was perfectly matched in the two patient groups. However, the probability to be so is high since referral practice, patients population and indications for surgery remained unchanged in the study period. The higher median number

of laminectomized segments in DLF patients as compared to the lower median number of corpectomized segments in VDF patients can be explained by the tendency to expand the dorsal laminectomy further than the ventral corpectomies in order to achieve the same amount of spinal cord decompression from a mainly ventral osteophytic compression [9]. Another limitation of the study is that it was not possible to test the hypotheses of the study for the subgroup of patients with at least three vertebral-level MSCM because of insufficient patient numbers. In spite of its limitations, this study is the largest one to date comparing VCF with DLF in at least two vertebral-level MSCM.

Conclusions

The hypothesis that initiated this study could not be confirmed. No obvious advantages of DLF over VCF in the treatment of at least two vertebral-level MSCM were found: duration of surgery was somewhat shorter in DLF; the less often occurring hardware failure in the DLF group did not attain statistical significance, while the outcome according to Nurick grade is possibly marginally better after VCF. However, outcome reflected by the presence of neck pain and patients satisfaction is similar. These findings have to be verified by a prospective randomized study. Also, the present study cannot exclude that advantages of DLF over VCF may become obvious in the treatment of at least three vertebral-level MSCM, as has been suggested, but not proven in the literature [4, 7, 9, 10, 24, 25, 27]. A prospective randomized study is required to address this issue.

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