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ORTHOPAEDIC SURGERY

Anterior corpectomy and reconstruction with titanium mesh cage and dynamic cervical plate for cervical spondylotic myelopathy in elderly osteoporosis patients

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Abstract
Objective This retrospective study was to evaluate the relationship between osteoporosis and dynamic cervical plates in screw–plate or screw–bone interface of elderly cervical spondylotic myelopathy (CSM) patients.
Methods Retrospective study was conducted on elderly CSM patients, treated by anterior corpectomy and reconstruction with titanium mesh cages (TMC) and dynamic cervical plate between July 2004 and June 2007. All patients underwent bone mineral density (BMD) assessment in preoperation, and according to the osteoporosis degree they have been divided into two groups: moderate osteoporosis degree group and severe osteoporosis degree group. The clinical outcome [Japanese Orthopaedic Association score (JOA) and Visual Analogue Scale (VAS)], bone fusion assessment (CT mielogram), the change of titanium mesh cages and plate of cephalic screw-plate-angle (SPA) and cephalic endplate-plate-angle (EPA) of plain X-ray films were measured.
Results The mean JOA score and recovery rate were not different between the two groups ($P > 0.05$). There was no loss of sagittal alignment after surgery in any patient, and no significant difference between both groups on lordosis measurements ($P > 0.05$). Although there was a significant difference of the cage subsidence rate between the two groups ($P < 0.001$), all patients had favorable bone union and none required additional treatment. The average changes of SPA were greater in A group patients than in B group patients, while the variation of EPA was higher in B group patients than in A group patients ($P < 0.001$).
Conclusions Despite the fact that there is a significant difference of the cage subsidence rate between the two groups no clinical outcome, nor sagittal alignment or fusion rate differences among groups was observed in elderly CSM patients.

Keywords Cervical spondylotic myelopathy · Osteoporosis · Corpectomy · Titanium mesh cage · Dynamic cervical plate

Introduction

Cervical spondylotic myelopathy (CSM) is a neurological disorder caused by the narrowing of the spinal canal as a result of degenerative changes in the cervical spine with the advancing age in the population [18, 26, 30]. Various pathologic processes in the cervical spine may cause mechanical compression of the spinal cord and yield to degenerative cervical myelopathy [21, 23]. When the clinical symptoms are severe and progressive, or when conservative treatment is not effective, surgical intervention is indicated [28]. Anterior corpectomy may be the most appropriate procedure to decompress the spinal cord in patients with severe canal stenosis and anterior pathologies [7, 15]. Stabilization after corpectomy is achieved with instrumentation using

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tricortical autogenous iliac bone graft, autogenous or allogenous fibular graft, and recently titanium mesh cage (TMC) [1, 4, 11, 20, 32].

Cervical corpectomy removes almost all pathology causing spinal cord compressions such as osteophytes, discs, and ossified posterior longitudinal ligament (PLL) [7, 19], and the anterior column support after corpectomy may be restored using structural auto- or allografts and titanium mesh cage [10]. However, Fernyhough et al. [6] reported that autogenous or allogeneous fibular strut grafts may show subsidence into the vertebral bodies, especially in osteoporosis patients, and this increases stress concentration on the implants and sometimes failure of anterior plate or instrumentation. The spinal cord may be compressed for the strut grafts subsidence into the vertebral bodies [30, 32]. Kanayama et al. [13] showed that the anterior plate fixation provides a more rigid construct and results in rapid solid fusion with less risk of graft-related complications. Anterior plates provide stability following decompression and fusion of the cervical spine, and the locking plate includes an integrated lock mechanism, which is designed to prevent migration of the bone screws. Dynamic cervical plate allows for better load sharing while providing overall resistance to motion, address perceived biomechanical deficiencies of rigid cervical plate.

Several clinical studies showed that advanced age, prolonged symptoms prior to surgery, severe preoperative neurologic dysfunction, and a greater degree of cord compression adversely impact the results of anterior surgery [22, 24, 29, 30]. Not only the autogenous or allogeneous fibular strut grafts, but also the TMC may show subsidence into the vertebral bodies, especially in osteoporosis patients, and this causes stress concentration on the implants and sometimes failure of anterior plate or instrumentation [6, 10]. Few data exist on the outcome of dynamic cervical plate in elderly CSM patients of osteoporosis. This retrospective study was to evaluate the relationship between the osteoporosis and dynamic cervical plates in screw–plate or screw–bone interface of elderly CSM patients.

Patients and methods

A retrospective study was conducted on elderly patients, surgically treated for CSM between July 2004 and June 2007. The inclusion criteria were elderly CSM patients in whom only one level needs corpectomy have clinical symptoms and no improvement for at least 6 weeks of conservative therapy (i.e., physical therapy together with use of anti-inflammatory medications and muscle relaxants at the manufacturer's recommended therapeutic dose). The defined "elderly" patients were older than 65 years, and the patients had osteoporosis. Exclusion criteria included posterior longitudinal ligament (PLL) ossification in addition to spondyloarthritis, patients less than 65 years, and patients without osteoporosis. Preoperative radiologic evaluation in each patient consisted of anteroposterior, lateral, and bilateral oblique radiographs and also flexion–extension films for detecting instability. Magnetic resonance imaging (MRI) was routinely performed. Indications for surgical treatment were progressive myelopathy and spinal cord compression documented by MRI studies, persistent and progressive pain, and impaired neurologic functions.

All patients underwent bone mineral density (BMD) assessment using the peripheral dual-energy X-ray absorptiometry scanner (FR DMS Corp, Challenger) before operation. The bone mineral density of the lumbar spine (L_2–L_4, in g/cm^2) was assessed, T score to justify whether osteoporosis and $T \leq -2.5$ SD is osteoporosis. According the osteoporosis degree [14], they were divided into two groups: moderate osteoporosis (A group,$T \leq -2.5$ SD, 41 cases) and severe osteoporosis (B group, $T \leq -2.5$ SD and had one or more fragility fractures in medical history before operation, 45 cases). Eighty-six patients initially fulfilled the study criteria, and 11 patients were lost to follow-up. Of the remaining 75 patients available for analysis, 36 belong to group A (included 19 men and 17 women with an average age of 72.73 ± 5.61 years), and 39 belong to group B (included 20 men and 19 women with an average age of 73.51 ± 6.32 years). Two groups had similar age and sex distribution, level of pain, and the pain history (Table 1).

Surgical procedures

Anterior corpectomy and decompression procedure was similar to the procedure described by Saunders et al. [28]. TMC was given in proper length and contour according to the angle of proximal and distal endplates before filling with cancellous auto grafts. Bone obtained after corpectomy was used as the autogenous bone graft to fill the mesh

Table 1 Patients' general data (means ± SD)

There were no significant differences between the two groups ($p > 0.05$)

Group	Sex		Age (years)	Corpectomy level		History (years)
	Male	Female		C5	C6	
A (36)	19	17	72.73 ± 5.61	11	25	5.16 ± 1.02
B (39)	20	19	73.51 ± 6.32	13	36	5.30 ± 1.08

Table 2 The clinical outcomes (means ± SD)

Groups	VAS			JOA			
	Pre-OP	Post-OP	Follow-up	Pre-OP	Post-OP	Follow-up	Recovery rate
A (36)	7.25 ± 2.59	2.84 ± 1.16	1.53 ± 0.62	8.9 ± 2.3	15.6 ± 1.1	15.4 ± 1.2	82.3 ± 10.2
B (39)	7.18 ± 2.46	2.78 ± 1.35	1.48 ± 0.71	8.2 ± 2.4	15.4 ± 1.3	15.3 ± 1.4	81.8 ± 11.6

cages. Anterior cervical locking plate system (Zephir plate) was used in all patients for further stabilization. All patients were mobilized immediately after the surgery with a hard cervical collar that the patients wore continuously the first 6 weeks after surgery.

Critical of clinical outcome

Before surgery and at the 2-year follow-up, neck pain (Visual Analogue Scale, VAS) and neurologic function (Japanese Orthopaedic Association score, JOA) were quantified. Surgical outcome was represented by the recovery ratio, calculated using the formula: Recovery ratio = (postoperative JOA score−preoperative JOA score)/(17 points−preoperative JOA score)×100%.

Plain X-rays of the cervical spine were obtained, as well as lateral views in flexion and extension. Should any segment show 5° or more angulation and 2 mm or more displacement at lateral flexion and extension radiographs, the segment was considered unstable. The Canvas 9.01 software (Deneba Systems, Scientific Imagine Edition, Miami, FL, USA) was used to measure the cephalic screw-plate-angle (SPA) and cephalic endplate-plate-angle (EPA) of plain X-ray films on personal computer. The SPA was defined as the angle between the axis shaft line of screw and plate, and the EPA as the angle between the line of cephalic endplate posterior marginal to the joint of screw contact plate and the line of plate axis. Take the plate as the point of reference under gravity and linear motion, the SPA response the change of screw, and the EPA response the adjustment of the vertebrae.

CT myelograms were also obtained for all patients. The focus was to evaluate three radiographic characteristics at follow-up: the cervical alignment of C2–C7 curvature, cage position, and fusion rate. The criteria for fusion were continuity of trabecular pattern, and the fusion rate assessed using Computed tomography (CT) scan. Criteria described by Bridwell et al. [3] were used to evaluate fusion through the mesh cages.

Statistical analysis

Statistical analyses were performed independently by a non-clinical research assistant and an outside party to ensure objectivity, using SPSS Version 16.0 software. Student's *t* test was used and results were considered statistically significant if the *P* value was equal to or less than 0.05 for continuous variables.

Results

There was no intraoperative death in our study. Eighty-six patients were included in this study at initially and 75 cases had follow-up at least 24 months. Eleven patients were lost for the follow up time was less than 24 months, and the follow-up rate was 87.8% (36/41) in the A group and 86.7% (39/45) in the B group. The followed time was from 24 to 32 months (average 28 month), and average 28.15 ± 3.24 months on A group and 27.86 ± 2.68 months on B group ($P > 0.05$). There was no patient with neurologic deterioration after the surgical treatment. All patients had neurologic recovery compared with their preoperative neurologic status, and at the last follow up, they were all able to walk and perform daily activities without any assistance.

There were four patients (11.1%) in A group and five patients (12.8%) in B group noted sometimes with slight neck pain, but none reported mild or severe axial neck pain. The pain index improved from 7.25 ± 2.59 to 2.84 ± 1.16 ($P < 0.001$) in A group patients and improved from 7.18 ± 2.46 to 2.78 ± 1.35 ($P < 0.001$) in B group patients (Table 2). At the final follow-up, the pain index of VAS was 1.53 ± 0.62 in A group patients and 1.48 ± 0.71 in B group patients, and there was no significant difference ($P > 0.05$).

The mean JOA score was 8.9 ± 2.3 preoperatively, 15.6 ± 1.1 on the initial postoperatively, and 15.24 ± 1.2 on the final follow-up in A group patients. Compared to A group, the average JOA score was 8.3 ± 2.4 preoperatively, 15.4 ± 1.3 on the initial postoperatively, and 15.3 ± 1.4 on the final follow-up in B group patients (Table 2). The recovery rates of JOA score were 82.3 ± 10.2 in A group and 81.8 ± 11.6 in B group ($P > 0.05$).

Postoperative sagittal cervical alignment was within the normal range in all patients. There was no loss of sagittal alignment after surgery in any patients. The average of lordosis between C2 and C7 was 14.5 ± 6.9 degrees at preoperatively, 12.4 ± 5.6° at post-3 months and 12.7 ± 4.1° at

Table 3 The cervical lordosis, cage subsidence and screw–plate or screw–bone angle change (mean ± SD)

Groups	Cervical lordosis			Cage subsidence (mm)	SPA°	EPA°
	Pre-OP	Post-OP	Follow-up			
A (36)	14.5 ± 6.9	12.4 ± 5.6°	12.7 ± 4.1	2.8 ± 1.1	10.27 ± 4.59	2.93 ± 1.86
B (39)	14.7 ± 6.3	13.1 ± 6.2	12.2 ± 5.6	4.2 ± 2.1	2.69 ± 1.75	4.81 ± 2.73

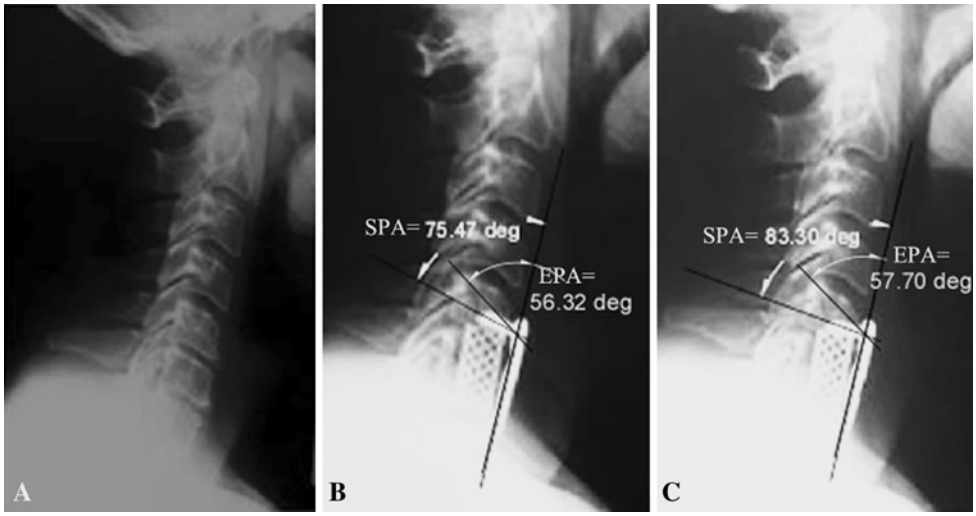

Fig. 1 Moderate osteoporotic of CSM patient. **a** Preoperative lateral radiographs of 73-year-old man with cervical spondylotic myelopathy. **b** Postoperative lateral cervical radiograph reveals anterior corpectomy and fusion of C5–6–7 with titanium curve mesh cage packed with autogenous bone graft and anterior cervical plate fixation. **c** Lateral radiography obtained 12 months after surgery

last follow up in A group. Compared to A group, the mean lordosis was 14.7 ± 6.3° at preoperatively, 13.1 ± 6.2° at post-3 months and 12.2 ± 5.6° at last follow up in B group. The difference in lordosis measurements at preoperative, at post-3 months and at last follow up was not significant ($P > 0.05$). There was also no significant difference between both groups ($P > 0.05$).

There was no anterior implant failure. Spinal fusion was noted in all patients between the mesh cage and adjacent upper and lower endplates on dynamic X-rays of the cervical spine at 11 months. None of the patients had evidence of pseudarthrosis. There were no cases of cage extrusion, migration, or collapse. Three cases (8.3%) of loss of corpectomy level height between the initial and final postoperative X-rays suggestive of cage subsidence (average 2.8 ± 1.1 mm; range 2–4 mm) over time in A group (Table 3). However, an average cage subsidence of 4.2 ± 2.1 mm (range 3–6 mm) was seen on the postoperative radiograph in 12 patients (30.8%) in B group. Although there was significant difference of the cage subsidence rate between two groups ($P < 0.001$), all patients had favorable bone union and none required additional treatment.

The fact of osteoporosis in patients should be taken into account when the dynamic cervical plate was put to use in elderly CSM patients, for the movement at the screw–plate or screw–bone interface was different on the degree of osteoporosis (Table 3, Figs. 1, 2). The average change of SPA was greater in A group patients than B group patients (10.27 ± 4.59 deg versus 2.69 ± 1.75 deg, $P < 0.001$), and the variation of EPA were higher in B group patients than A group patients (4.81 ± 2.73 deg versus 2.93 ± 1.86 deg, $P < 0.001$).

Discussion

Cervical spondylotic myelopathy is the most common reason of spinal cord dysfunction in patients over 50 years of age [15, 23]. Their history usually involves an indolent course, and neurologic status is usually good in the early period. However, there is no sign or method to understand when neurologic deterioration will occur. Several clinical studies show that advanced age, prolonged symptoms prior to surgery, severe preoperative neurologic dysfunction, and a greater degree of cord compression adversely impact the results of surgery [2, 8, 18, 28, 31]. Major neurologic recovery occurs in the first 6 months in these cases. The mean JOA score was better than preoperational and maintained to final follow up. Postoperative sagittal cervical alignment was within the normal range in all patients. A period of neurologic recovery after anterior corpectomy varies in the literature. Majd et al. [20] reported a surgical treatment for cervical spondylotic myelopathy patients, most of neurologic recovery occurs gradually in the first 6 months. Kirkpatrick [16] and Orr [25] studies suggested that it may take up to 2 years. Fessler et al. [7] reported

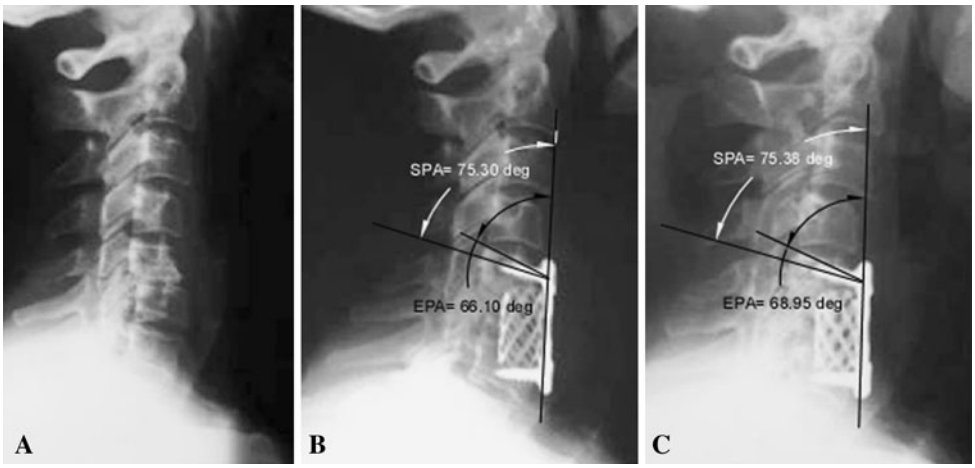

Fig. 2 Severe osteoporosis of CSM patient. **a** Lateral roentgenogram of 72-year-old man with cervical spondylotic myelopathy. **b** Postoperative lateral cervical radiograph reveals anterior corpectomy and fusion of C5–6–7 with a mesh cage packed with autogenous bone graft and anterior cervical plate. **c** lateral radiography obtained 12 months after surgery

92% improved neurologic status in their series. In the current study, four patients (11.1%) in moderate osteoporosis group and five patients (12.8%) in severe osteoporosis group were sometimes noted with slight neck pain post operation, but none reported mild or severe axial neck pain. The pain index got better than preoperational and maintained to final follow up, and there were no significant differences between the two groups.

Cervical corpectomy removes almost all pathology which causing spinal cord compression [7, 19], and the anterior column support may be restored using TMC after corpectomy. TMC, used with variable diameter and height and can be filled with autogeneous cancellous bone graft, has many advantages when used for anterior column support [10, 12]. Primary stability is improved with the spikes, which penetrate into the adjacent upper and lower endplates. Also, precontoured cages help to achieve better sagittal alignment, especially when more than 2-level corpectomy is performed. TMC filled with autogenous iliac cancellous bone graft helps in early fusion [4]. There were no cases of cage extrusion, migration, or collapse in this study. The difference in lordosis measurements at preoperative, at post three month and at last follow up was not significant. There was no loss of sagittal alignment after surgery in any patient. Thus, stability is improved and sagittal alignment is preserved. However, the cage subsidences were not only in moderate osteoporosis group patients, but also in the severe osteoporosis group patients. There was no anterior implant failure in this series. Spinal fusion was noted in all patients between the mesh cage and adjacent upper and lower end plates on dynamic X-rays of the cervical spine.

Cervical plates offer the advantages of improved initial stability in the post-operative period, which decreases the need for wearing a cervical collar and results in a faster return to normal activities [9, 17]. Anterior cervical plate has become widely accepted when single and multi-level anterior cervical fusion surgery is performed, and several important features have been added to the newer generation of plates for increasing the rate of graft fusion. Dynamic cervical plate, which was designed in a way to increase the load on the graft and allow for better load sharing allows axial translation and rotation at the plate–screw interface so that, theoretically, fusion rates would increase and time to fusion would diminish [5, 27]. The movement at the screw–plate interface was different on the degree of osteoporosis in this study (Table 3, Figs. 1, 2). For the elderly patients, frequently having a variety of osteoporosis, the movements at the screw–plate interface were bigger in moderate than severe osteoporotic patients. On the contrary, there were more movements at the screw–bone interface in severe osteoporotic patients than moderate. For this reason, the facts osteoporosis in patients should be take into account when the dynamic cervical plates was put to use in elderly cervical spondylotic myelopathy patients.

The major shortcoming of this study is that the results are not compared with a control series of non osteoporotic patients and the limitations of this study are the nature of this analysis was retrospective which may be associated with biases. Further studies are required to avoid selection bias, and long-term prospective and randomized studies will be necessary to provide optimal clinical data to determine the associations between the osteoporosis and dynamic cervical plates in elderly CSM patients.

Conclusion

Despite the fact that there is a significant difference of the cage subsidence rate between the two groups no clinical outcome, nor sagittal alignment or fusion rate differences among groups was observed in elderly CSM patients.

Conflict of interest There are no competing interests in this study.

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