Surgical results of anterior corpectomy in the aged patients with cervical myelopathy

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Abstract Retrospective study on the results of anterior corpectomy for the treatment of cervical myelopathy in patients over 70 years old. To evaluate the surgical results of anterior corpectomy in aged patients with multilevel cervical myelopathy and to investigate the probable pathomechanism by radiographic study. There are few data focused on the surgical results and post-operative complications of anterior corpectomy in aged patients with cervical myelopathy. Twenty patients 70 years of age or older who underwent anterior corpectomy, titanium mesh cage (TMC) reconstruction and anterior plate fixation for the treatment of compressive cervical myelopathy were reviewed. The average age at the time of operation was 75 years. Neurologic deficits before and after surgery were assessed using a scoring system proposed by the Japanese Orthopedic Association (JOA Score). Clinical results and post-operative complications were compared with those of patients 69 years old or younger as a control. Pre-operative Radiologic evaluation of every patient consisted of anterior–posterior, lateral, bilateral oblique, flexion, and extension radiographs, computed tomography and magnetic resonance imaging of the cervical spine. Any factor causing spinal cord compression and the sign of cervical instability were recorded. Surgical-related complications occurred in seven patients in the aged group. The incidence of complications was 35% in the aged patient group

and 9.7% in the control group respectively. Although the difference was striking, no statistical significance was found between the two groups. One patient died of respiratory failure resulting from pulmonary infection. The mortality rate was 5%. The pre-operative mean JOA score was 9.3 (from 3 to 14) in the aged patient group. Nineteen patients were followed at least 2 years and the mean JOA score was 13.4 (from 8 to 17). 68.4% of the aged patients achieved a good or excellent result. There was no statistical difference in the recovery rate of JOA score between the aged group (58.1%) and control group (67.0%). In the pre-operative radiographs, the incidence of cervical instability was much higher in the control group (32%) than in the aged group (5%) and multilevel cord compression caused by posterior disc space osteophytes was more common in the aged group. Anterior corpectomy combined with TMC fusion and plate fixation provides favorable neurologic recovery even in the patients over 70 years old. However, the incidence of surgical related complications shows a conspicuous increasing in the aged patients. Overcompensation mechanism for cervical instability is the probable cause of degenerative cervical spondylotic myelopathy in aged patients.

Keywords Cervical Myelopathy · Aged · Anterior Corpectomy · Clinical Results · Complications

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Introduction

Cervical myelopathy commonly develops in patients over the age of 50 years old. As the population of the world ages, the surgical treatment of the cervical myelopathy in the aged patients has become a great challenge [1]. It is difficult to perform a spinal surgery on an aged patient,

because of the complicated pathological changes of the spine and the increased presence of comorbidities. Recently anterior cervical corpectomy, titanium mesh cage (TMC) supporting and anterior cervical plate fixation has become a widely used surgical procedure for the treatment of multilevel cervical spondylotic myelopathy [2–4]. It has also been regarded as a safe procedure even in the elderly population [4]. However, to date, there have been few reports on the pathomechanism of cervical myelopathy in aged patients. Further, the post-operative complications and the surgical results of anterior corpectomy have not been fully evaluated in aged patients. The purpose of this retrospective study was to evaluate surgical results of anterior corpectomy in patients 70 years of age or older in comparison with those 69 years of age or younger, and the pathomechanism of cervical myelopathy in elderly patients was also investigated by radiographic study.

Materials and methods

From January 2001 through December 2003, 51 patients were surgically treated with anterior corpectomy for multilevel degenerative cervical myelopathy at our university hospital. Clinical diagnosis was made by physical examination, plain radiography (including anterior–posterior, lateral, bilateral oblique, flexion, and extension radiographs), computed tomography (CT), and magnetic resonance imaging (MRI). Indications for surgical treatment were persistent and progressive radicular pain, and impaired neurologic function and spinal cord compression documented by CT and MRI studies. Anterior corpectomy and decompression was similar to the procedure described by Saunders et al. [5]. After corpectomy, titanium mesh cage filled with local autogeneous bone was used for structural anterior column support in our series. In most condition, the local decompressed cancellous bone is enough to fill the TMC and thus avoid the donor site morbidity. To maintain the sagittal alignment of the cervical spine, a suitable height of the TMC should be chosen during the operation. The details of the procedure have been reported previously [6]. Further more, a lordotic pre-curved TMC can help achieve better cervical alignment, especially when more than two-level corpectomy is performed. General anaesthesia was used in all these patients during the operation. For the post-operative course, most of the patients were required to stay in bed for the first three days after surgery. A cervical collar was used full-time to prevent excessive cervical spine motion until fusion was obtained. Clinical and X-ray film (including anterior–posterior, lateral, flexion, and extension radiographs) follow-up was routinely done at 8 weeks and 3, 6 and

12 months after surgery. Less than 5° angulation between the vertebral levels adjacent to the mesh cage at lateral flexion and extension radiographs was considered to be the findings for fusion.

The patients were divided into two groups according to the age at the time of operation. The aged patients group (70 years old or older at the time of surgery) included 20 patients. The control group consisted of 31 patients who were 69 years old or younger at the time of surgery. The pre-operative associated medical problems, the incidence of cervical instability, the pre- and post-operative JOA score and the post-operative complications were compared between the aged patients group and the control group. The average length of follow-up was 35.3 months (range 24–55 months) in all the patients.

Clinical data of the patients

The aged patients group consisted of 15 men and five women, with an average age of 75 years (range 70–86 years). The neurologic dysfunction was characterized by upper extremity paresis, walking difficulty and balance problems. Eight patients had upper extremity pain unresponsive to analgesics. The time between the onset of the initial symptoms and the operation was from 3 months to more than 20 years. Six patients were unable to walk, even with the use of a walking aid. Difficulty in urination was common in male patients mainly resulting from a benign prostatic hypertrophy. The control group consisted of 15 men and 16 women, with an average age of 52 years (range 37–68 years). Progressive myelopathy resulted from spinal cord compression was the main symptom in this group and only two patients had persistent radicular pain. The pre-operative duration of symptoms was from 1 month to 5 years.

Pre-operative associated medical problem

A variety of pre-operative associated medical problems were recorded in the aged patients group. There were 11 patients with hypertension, 5 patients with prostatic hypertrophy, 4 patients with coronary artery disease, 4 patients with diabetes, 1 patient with chronic bronchitis and 1 patient with gallstone. They were treated conservatively by medication. Four patients had a history of treatment for cerebral infarction, one patient had a history of gastrectomy for gastric cancer, and one patient had a history of pulmonary lobectomy for early lung cancer. Several patients had other orthopedic problems including osteoarthritis of the knee joints in two patients and

degenerative lumbar spinal stenosis in four patients. Twelve patients (60%) had two or more than two kinds of associated medical problems. Nine different pre-operative diseases, including hypertension ($n = 2$), diabetes ($n = 2$), cerebral infarction ($n = 2$), degenerative lumbar disease ($n = 2$) and coronary artery disease ($n = 1$) were found in five patients in the control group. All of these patients were referred to specialists for evaluation of their disease before surgery.

Radiologic evaluation

Sagittal magnetic resonance images (MRI) showed two-level spinal cord compression in 14 patients and three-level spinal cord compression in 6 patients in the aged group. And in the control group, there were 23 two-level diseases and 8 three-level diseases. The commonest diseased segments were C4-C5 and C5-C6. A high-intensity signal from the sagittal T2-weighted MRI in the spinal cord at the level of maximum compression was found in six patients in the aged group and in three patients in the control group. Anterior-posterior and lateral radiographs with neutral and flexion-extension stress views were obtained pre- and post-surgery. The Cobb angle between the line passing through the lower margin of the C2 vertebral body and C6 at the lateral radiograph in the neutral position was measured to describe the postural alignment of the cervical spine. The lordotic angle was represented as a positive value and the kyphotic angle as a negative value. Ten degrees or more angulation and 3 mm or more displacement at lateral flexion and extension radiographs were considered to be the findings for cervical instability.

Methods of assessment

Neurologic function was assessed using a scoring system proposed by the Japanese Orthopaedic Association (JOA score) before and after surgery in each patient. Functional improvement was expressed by the recovery rate [7] and the results were classified into the following five groups: excellent, from 75 to 100%; good, from 50 to 74%; fair, from 25 to 49%; unchanged, from 0 to 24%; and worse, less than 0%.

Subjective evaluation of the surgical results was performed by a telephone questionnaire at the final follow-up. The symptom improvements were classified into the following four groups: obvious improvement; moderate improvement; no improvement and aggravation. The daily activity and self-care ability of the patient were also reported by the patient's family members.

Statistical analysis

The Student *t* test was used for statistical analysis of the difference in the mean values of pre- and post-operative JOA scores and recovery rates between the aged group and the control group. The same statistical analysis was used in the comparison of pre- and post-operative alignment of the cervical spine. The χ^2 test was used in the comparison of the incidence of surgical related complications between the two groups. Statistical significance was set up at $P < 0.05$.

Results

Operative related complications

Seven surgical related complications occurred in the aged patient group including pulmonary infection in three patients, delirium in one patient, vertebral artery injury in one patient, C5 radicular syndrome in one patient, leakage of cerebrospinal fluid in one patient. A 76-year-old male died of respiratory failure resulted from pulmonary infection nine days after surgery. The mortality rate was 5%. Another two patients with pulmonary infection were successfully treated by anti-infectious therapy. The main clinical manifestation of the patient with delirium was delusion of persecution that lasted 2 weeks after the operation. We ligatured the injured vertebral artery to stop bleeding during the operation, and the patient felt well after blood transfusion therapy. The patient with C5 root symptom responded well to analgesic and recovered within 2 months after surgery. The leakage of cerebrospinal fluid stopped spontaneously and resulted in delayed wound healing that was managed by dressing changes. A transient muscle weakness or dyskinesia was found in three patients post-operatively which recovered quickly.

The early complications in the control group consisted of delirium in one patient, hoarseness in one patient and C5 root symptom in one patient. For these patients, conservative treatment was needed before these symptoms recovered. Although there was no statistical difference in the incidence of complications between the two groups, the incidence of complication in the control group was 9.7% that was much lower than that in aged group (35%). No implant related complication was found and no additional surgery was needed in either group.

Clinical results

The pre- and post-operative JOA score and the recovery rate in the aged group and the control group are shown in Table 1. In each group, the post-operative JOA score was

Table 1 Comparison of pre- and post-operative JOA scores and recovery rate between the aged patient group and the control group

	Aged group	Control group	<i>P</i> value
Pre-operative JOA score	9.3 ± 2.7	11.0 ± 1.7	0.005
Post-operative JOA score	13.4 ± 2.8	14.8 ± 2.0	0.021
Recovery rate (%)	58.1 ± 26.4	67.0 ± 28.6	0.138

JOA Japanese Orthopedic Association

significantly improved at the last follow-up compared with the pre-operative score ($P < 0.001$ in either group). Either the pre-operative or the post-operative JOA score in the aged group was significantly lower than those in the control group. No statistical difference was observed in the recovery rate between the two groups. There are six excellent, seven good, four fair and two unchanged results in the aged group. The excellent and good rate was 68.4% in the aged group and 71.0% (16 excellent, six good, six fair and three unchanged results) in the control group. No statistical difference was found in the excellent and good rate between the two groups.

At the final telephone questionnaire, 15 patients (78.9%) demonstrated that their symptoms were improved after the operations. Nine (47.4%) patients selected “obvious improvement” and only one patient selected “aggravated symptoms” post-operatively. About two thirds of the aged patients’ daily activity and self-care ability was improved after the surgery and this was conformed by their families.

Radiologic evaluation

In the pre-operative radiographs, only one patient (5%) in the aged group was defined as having cervical instability. On the other hand, ten patients (32%) in the control group had instability of the cervical spine. The incidence of cervical instability in the aged group was much lower than that in the control group. Most of the patients in the aged group had multiple-segment disc narrowing especially at the diseased level (Fig. 1a). Pre-operative MRI revealed that the anterior factors were the main cause of spinal cord compression in both groups (Fig. 1b). And in the aged patient group, posterior disc space osteophytes were the most common factor to cause central narrowing of the cervical spinal canal (Fig. 1c). The pre- and post-operative Cobb angle of the cervical spine in the aged group and the control group are shown in Table 2. In both groups the average Cobb angle was slightly increased after the surgery without statistical differences. Solid fusion could be achieved in all patients within 6 months in spite of slight (less than 1 mm) end plate collapse usually occurring during this period. There was no mesh cage migration and no anterior plate failure.

Fig. 1 A 75-year-old man presented with gait difficulties and monoparesia on left upper extremity and dizziness. **a** Multiple-segment disc narrowing was found from the pre-operative lateral radiographs without cervical spine instability. **b** A sagittal T2-weighted image showed anterior spinal cord compression at C3-6 level. **c** A two-dimensional computed tomography (2D-CT) showed wide hyperostosis up and down the disc space. **d** Post-operative 2D-CT showed enlarged spinal canal and the posterior bony spurs were removed. **e** A lateral X-ray film after the surgery showed perfect lordotic curvature maintained by pre-bending of the mesh

Discussion

To date, there have been few reports regarding the pathomechanism of cervical myelopathy in aged patients. Kawaguchi et al. [8] found that the incidence of either retrolisthesis or anterolisthesis in the elderly patients (≥ 70 years old) was significantly higher than that in the younger patients from the pre-operative radiographs. The incidence of cervical instability was 70% in the elderly patients and 14% in the younger patients, respectively. They presumed that retrolisthesis and anterolisthesis resulting from intervertebral disc degeneration was the cause of spinal cord compression in elderly patients. In our study contrary result was obtained. The incidence of cervical instability was 5% in the aged group and 32% in the

Fig. 1 continued

Table 2 Comparison of pre- and post-operative cervical alignment between the aged patient group and the control group

	Aged group	Control group
Pre-operative Cobb angle (°)	18.8 ± 6.6	21.5 ± 5.7
Post-operative Cobb angle (°)	19.4 ± 4.5	22.1 ± 5.0
<i>P</i> value	0.370	0.297

Cobb angle = the angle between the line passing through the lower margin of the C2 vertebral body and C6 at the lateral radiograph in the neutral position

control group. Although the difference has no statistical significance, the incidence of cervical instability is relatively higher in the younger patients. Dia [9] has demonstrated that cervical instability is more likely to happen in the early phase of disc degeneration. However, tractive bony spurs around disc caused by excessive motion will increase the contact surface and rebuild the stability. Three different clinical results may occur during the self-regulatory mechanism for cervical instability. First is full-compensation, in which the stability of cervical spine is rebuilt by hyperostosis and the symptoms in this kind of patients disappear spontaneously. Second is decompensation, in which the hyperostosis fails to compensate the cervical instability that will cause progressive aggravation of neurological function. This usually occurs in younger patients and requires early surgical intervention. Third is hyper-compensation, in which the stability of cervical spine is rebuilt but the new compressive symptoms are caused by the excessive hyperostosis. In the present study, posterior disc space osteophytes intrusion into the cervical spinal canal is the main cause of spinal cord compression in the aged patients group and cervical instability is rare. We presume that the hyper-compensative mechanism for cervical instability is the probable cause of degenerative spondylotic myelopathy in aged patients.

It remains controversial whether anterior or posterior decompression should be chosen for the surgical treatment of aged patients with cervical myelopathy [10]. The most common surgical procedure for the treatment of degenerative cervical myelopathy has been laminectomy. It is a safe and easy procedure with little blood loss, but there are some disadvantages like potential cervical kyphosis, formation of hematoma, axial neck pain. Another posterior surgical option is laminoplasty. Compared with laminectomy it involves less complication but axial neck pain remains a problem. Previous studies have showed satisfactory neurological improvement and low medical morbidity when this procedure was performed in aged patients [8, 11]. In these studies, the posterior procedure was indicated because the posterior factor such as hypertrophic ligamentum flavum is the main cause of spinal cord compression in elderly patients. In the present study,

however we found the anterior factors such as disc and osteophyte are the main cause of spinal cord compression. Multilevel anterior discectomy and fusion is an alternative surgical method but it may be hard and dangerous when the disc height is greatly reduced. Recently anterior cervical corpectomy has been introduced for the treatment of patients with multilevel degenerative cervical myelopathy [2, 3]. Several studies reported that anterior cervical corpectomy and fusion was an effective procedure with a more favorable neurological improvement when compared to posterior decompressive laminectomy or laminoplasty [4, 12]. It also seems to be a safe procedure even in the elderly population [4]. We prefer the anterior corpectomy and fusion as a first-line procedure in the aged patients because it can remove almost all pathology causing spinal cord compression like osteophytes, discs, and ossified PLL (Fig. 1d). However, to avoid iatrogenic spinal cord injury in the patients with severe canal stenosis caused by OPLL, posterior decompression would be recommended firstly. Further study is needed to clarify whether anterior decompression is superior to posterior decompression or vice versa in the treatment of cervical myelopathy in the aged patients.

Anterior column support after corpectomy may be restored by autogenous or allogeneous fibular strut grafts. However, when three or more level corpectomy is performed a fibular strut graft is hard to maintain the lordotic position of the cervical spine because it has no curvature and it is usually placed anteriorly not to cause spinal cord compression that results in decreased primary graft stability. Recently, TMC has become a popular choice for structural anterior column support. It can be used with variable diameter and height, and it can be filled with autogenous cancellous bone graft. In most cases of our series, the local decompressed cancellous bone is enough to fill the TMC and thus avoid the donor site morbidity. To maintain the sagittal alignment of the cervical spine, a suitable height of TMC should be chosen during the operation. Also, pre-curved cages help achieve better cervical alignment, especially when more than two-level corpectomy is performed (Fig. 1e). In the present study, an anterior cervical plate was used for stabilization in all the patients. It is reported anterior plate fixation provides a more rigid construct and results in rapid solid fusion with less risk of graft-related complications [13].

Although the mean recovery rate of neurological function in the aged patients group in our series is 58.1%, which is better than that reported by Kawaguchi et al. [8] (45%) where laminoplasty was performed. As the mean pre-operative JOA score (6.0) in their study is lower than ours (9.3), we can not determine that anterior corpectomy is superior to posterior laminoplasty in the treatment for cervical myelopathy in aged patients. However, post-

operative kyphotic changes of the cervical spine after laminoplasty did not occur in our series. Some symptoms such as chronic neck pain and dizziness that may trouble the patient greatly can be successfully released after the surgery. As these symptoms are not involved in the JOA scoring system. Subjective reports provide more information than objective clinical evaluation along. Regarding the post-operative status, there was no statistical difference in the recovery rate of the JOA score between the aged patients group and the control group. For most aged patients, improvement of daily activity and self-care ability were observed post-operatively, which was thought to be the most essential goal of surgery for aged patients [1]. Thus, we believe that anterior corpectomy achieves the improvement in the quality of life even in aged patients with multilevel spondylotic myelopathy.

In the present study, surgery related complications are problematic when anterior corpectomy is considered for the treatment of myelopathy in the aged patients. The incidence of surgical related complications in the aged group was strikingly higher than that in the control group yet the difference is not significant. This may simply be due to the small numbers and the fact that the groups were not matched in other factors. The most common complication was pulmonary infection and this was also the main cause of death. The high incidence of pulmonary infection in the aged patients may due to the presence of comorbid pulmonary disease, the effect of tracheal intubation and insufficient respiratory tract care. Therefore, we have added as a part of our protocol, to monitor the patients more than 70 years old in the intensive-care unit for the first 24 h following surgery. The spinal dura mater is more likely to be injured in the aged patients as the posterior longitudinal ligament always adheres to the membrane. Vertebral artery injury is a seldom complication, however, it should be carefully avoided during the operation. If it does occur it is difficult to repair. Fortunately, no severe results were observed when one side vertebral artery was ligatured in the case of our series. It has been reported that microsurgery techniques can successfully prevent these iatrogenic injuries [14]. The precise mechanisms of delirium and C5 radiculopathy after surgery are not fully understood. However, they were not permanent problems, as the symptoms of these complications recovered spontaneously in all cases.

In conclusion, anterior corpectomy seem to be an effective surgical procedure for the treatment of multilevel

cervical myelopathy to achieve good neurologic recovery and quality of life even in patients 70 years of age or older. Special consideration based on the potential risks and benefits from surgical treatment is required before an anterior corpectomy is suggested to an aged patient because of the high frequency of pre-operative medical problems and pos-operative complications.

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