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Original Article

Effect of anterior and posterior operations on surgical parameters and postoperative complications in patients with ossification of the posterior longitudinal ligament

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Abstract: Objective: This study aimed to explore and analyze the effect of anterior and posterior operations for the surgical parameters and postoperative complications in patients with ossification of the posterior cervical ligament. Methods: A total of 78 patients with ossification of the posterior cervical ligament who received treatment in our hospital from January 2019 to October 2019 were selected as the study subjects and divided into the front group (n = 40) and back group (n = 38) according to differences in their selection. The treatment effects, operation time, blood loss and incision length were compared between the two groups. The postoperative Japanese Orthopaedic Association score (JOA), preoperative overall curvature, immediate postoperative curvature and follow-up curvature were compared between the two groups. The incidence rate of postoperative complications was also compared between the two groups. Results: The operation time, blood loss and incision length in the back group were lower than those in the front group ($P < 0.05$). The JOA scores of the front group were higher than those in the back group at 4 time points of postoperative follow-up ($P < 0.05$). The overall curvature immediately after operation and during follow-up in the front group was greater than those in the back group ($P < 0.05$). The incidence rate of axial neck symptoms was 45.00% (18/40) in the front group and 23.68% (9/38) in the back group, with a statistically significant difference ($P < 0.05$). Conclusion: Compared with a posterior operation, an anterior operation has better efficacy and long-term effect in the treatment of patients with ossification of the posterior longitudinal ligament. An anterior operation can better maintain the curvature of decompression, but the incidence rate of postoperative axial symptoms is slightly higher.

Keywords: Ossification of the posterior longitudinal ligament, anterior operation, posterior operation, surgical indicators, postoperative complications

Introduction

With the increase of living pressure and work intensity of Chinese residents in recent years, the prevalence rate of various cervical vertebrae diseases has been increasing annually. Ossification of the posterior longitudinal ligament (OPLL) is a type of disease in which abnormal proliferation of the posterior longitudinal ligament of the cervical spine and heterotopic ossification occur, leading to space-occupying stenosis in the spinal canal, and finally causing a series of clinical symptoms due to compression of the spinal cord and nerve roots in individuals [1, 2]. The disease was discovered by Japanese scholars in an autopsy in 1960 for the first time and was officially confirmed in 1964, and it has now become an independent clinical disease.

The early clinical symptoms of patients with OPLL are not obvious, and most patients only have limited head and neck extension or neck pain and soreness. However, as the disease progresses, patients may have diminished limb muscle strength, urethral sphincter dysfunction, and radicular-related symptoms and some severe patients may present with progressive quadriplegia [3, 4]. Epidemiological survey data shows a high incidence of OPLL in population groups aged 50-60 years, and worldwide statistics show that the incidence of this disease in Asia is higher overall than that in Europe and the United States, with a prevalence of about

1.9%-4.3% in the population aged over 30 years in Japan and about 1.6%-1.8% in China [5, 6]. Although the disease has been under investigation for more than 50 years, the exact cause of the disease remains under speculation and theory. At present, the clinically recognized etiology is mainly caused by genetic factors and various pathogenic factors (mechanical stimulation, cervical disc degeneration, metabolic factors), leading to osteogenic differentiation of cervical posterior longitudinal ligament fibroblasts, followed by pathological changes [7, 8].

Currently, the clinical treatment of OPLL is more accurate, and patients with asymptomatic or mild early symptoms can be treated conservatively and actively monitored for disease. If the patients have symptoms of spinal cord compression, surgical intervention is required. Most studies have shown that delaying the operation time does not improve the actual compression of the spinal cord in patients, but may lead to irreversible changes in the spinal cord, thus requiring active surgical intervention [9, 10]. The controversy points of the study on the disease are also focused on the choice of advantages and disadvantages. Some studies have indicated that an anterior operation can relieve compression symptoms more significantly, and the long-term follow-up effect is excellent. Some studies have shown that a posterior operation is simpler and safer, and can increase the stability of the cervical spine [11, 12]. The purpose of this study was to explore the differences in various indicators between an anterior operation and posterior operation in patients with OPLL through group intervention, and compare the incidence of postoperative complications between the two groups, so as to provide a theoretical basis for the clinical treatment of patients with OPLL.

Materials and methods

General information

A total of 78 patients with ossification of the posterior cervical ligament who received treatment in our hospital from January 2019 to October 2019 were selected as the study subjects and divided into a front group (n = 40) and a back group (n = 38) according to the difference in their surgical selection.

Inclusion criteria (1) Clinical diagnosis of OPLL and head and neck extension limitation, limb muscle weakness and other corresponding clinical symptoms [13]; (2) All patients needed to be treated with surgery; (3) Clinical data were complete and detailed; (4) Consciousness was clear and patients were able to cooperate with the investigation; (5) This investigation was approved by the hospital ethics committee; (6) Patients signed an informed consent form.

Exclusion criteria: (1) Patients aged ≥ 80 years old; (2) Pregnant or lactating women; (3) Patients with malignant tumors; (4) Patients with severe cardiovascular and cerebrovascular diseases and hematopoietic system diseases; (5) Patients with poor treatment compliance; (6) Patients with intraspinal tumors; (7) Patients with other diseases affecting the survey results.

Additional exclusion criteria: (1) those who voluntarily requested to withdraw during the investigation; (2) those who lost their visitors during the investigation; or (3) those who died during the investigation.

Intervention

After admission, the patients underwent cervical anteroposterior and lateral position, cervical CT and cervical MRI examination. The cervical lesions of the patients were recorded in detail; the patients were trained with bed urination and bed defecation to promote the development of nursing work in the later stages and to make active preoperative preparations; and the patients were given general anesthesia during the operation. The patients in the front group were placed in the supine position, with head and both shoulders slightly deviated to the left, the neck slightly extended, the cervical vertebra fully exposed. A transverse incision was made on the right side of the anterior cervical approach. The lesion site was exposed between the cervical visceral sheath and the carotid sheath. After fluoroscopic positioning using a C-arm machine, a retractor was placed in the upper and lower vertebral bodies of the lesion and the intervertebral space were distracted. Discectomy or subtotal vertebrectomy for decompression, fusion and internal fixation were performed. The bone grafts used during the operation were autologous bone or artificial bone. The decompression and bone graft seg-

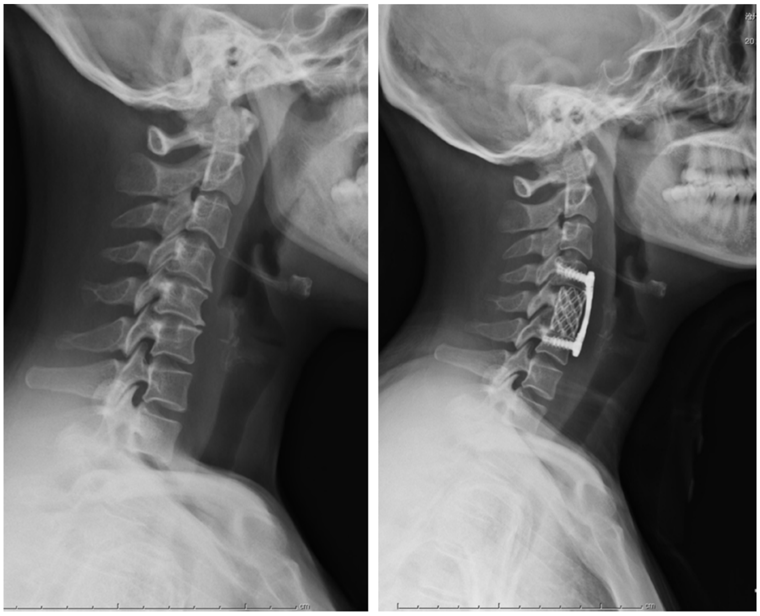

Figure 1. Preoperative and postoperative cervical imaging of patients. Left: Preoperative cervical imaging; Right: Postoperative cervical imaging.

ments were internally fixed with a plate after fusion. The incision was sutured layer by layer after saline irrigation, and antibacterial therapy was routinely performed after the operation (**Figure 1**). In the back group, the patient was placed in the prone position. An incision was made in the posterior midline of the patient to fully expose the spinous process and vertebral plate. The screw was placed according to the Magerl technical standard, and then the titanium rod with the adjusted curvature was placed and fixed, and total laminectomy or fusion of the facet joint was performed for the lesion, which was consistent with the front group, and antibacterial therapy was also performed after operation.

Observation indicators and evaluation criteria

Treatment efficiency

The treatment effects of the two groups were evaluated at 12 months after operation. The treatment effects were divided into three categories: markedly effective, effective and invalid. The specific effects were distinguished according to the following criteria: markedly effective refers to that the JOA score increased by more than 50% after treatment compared with that before treatment; effective refers to that the JOA score increased by 25% to 49% after treatment compared with that before treatment; invalid refers to that the JOA score increased by less than 25% after treatment compared with that before treatment. The overall response rate = (markedly effective number + effective number)/total number of cases × 100%.

Comparison of general surgical conditions between the two groups

The operation time, intraoperative blood loss and incision length of the two groups were recorded by medical staff, and the differences between the two groups were compared.

Comparison of JOA scores at different time points after operation

The patients in the two groups were given JOA scale scores before operation, and also at 1, 3, 6 and 12 months after operation. The JOA scale includes four dimensions: upper limb motor function (0-4 points), lower limb motor function (0-4 points), sensation (upper and lower limbs and trunk are respectively scored 2 points, 6 points in total) and bladder function (0-3 points). The total score of the scale is the sum of the scores of the four dimensions, with a total score of 17 points. The score represents that the subject has better function. This scale is mainly used for the assessment of human functional disorders, which has good reliability and validity [14].

Comparison of postoperative cervical spine imaging

Radiographic examination was performed in the two groups of patients before operation, immediately after operation and 12 months after operation, and the changes in the overall curvature and the differences between the two groups at the three time points were analyzed. The overall curvature was the angle between the extension line of the lower edge of C2 vertebral body and C7 vertebral body, which is also clinically known as the Cobb angle.

Table 1. Comparison of general clinical data between the two groups (Fig. $\overline{x} \pm s$)/[n (%)]

General clinical data		Front group (n = 40)	Back group (n = 38)	T/X^2	P
Gender	M	21	20	0.0	0.991
	F	19	18		
Age distribution (years)	35-45	5	5	0.231	0.878
	46-55	13	13		
	56-65	14	13		
	66-79	8	7		
Disease duration distribution (years)	< 1	8	7	0.332	0.471
	1 ≤ Disease duration < 2	11	10		
	2 < disease duration ≤ 5	12	13		
	> 5	9	8		
Education	Illiteracy	2	2	0.256	0.873
	Primary school	5	4		
	Junior Middle School	13	12		
	High school and above	20	20		
Marital status	Married	38	37	0.296	0.587
	Non-marital	2	1		
Monthly income (RMB)	< 5000	31	30	0.554	0.341
	5000-9999	5	5		
	> 10000	4	3		

Incidence rate of postoperative complications

The incidence of complications such as wound infection, vertebral artery injury, internal fixation prolapse or breakage, and cervical axial symptoms at 12 months after operation in the two groups were statistically analyzed, and the differences were compared.

Statistical analysis

SPSS 20.0 software was used for statistical analysis of the collected data. Measurement data were expressed as ($\overline{x} \pm s$). Student's t test was adopted for the intergroup comparison. The measurement data were expressed in the form of [n (%)]. Chi-square test was used to compare the differences between groups. Graphpad Prism 8.0 was used for illustration of experimental results. $P < 0.05$ was considered statistically significant [15].

Results

Comparison of general clinical data between the two groups

After statistical analysis and comparison of differences, it was found that there was no significant difference in general clinical data such as gender, age distribution, disease course distribution, marital status and education level between the two groups ($P > 0.05$), which were comparable (**Table 1**).

Comparison of overall response rate between the two groups

Comparison of pre- and post-assessment showed that in the front group, there were 25 markedly effective cases, 5 effective cases and 10 invalid cases, with an overall response rate of 75.00% (30/40). In the back group, there were 20 markedly effective cases, 10 effective cases and 8 invalid cases, with an overall response rate of 78.95% (30/38) (**Table 2**).

Comparison of general surgical conditions between the two groups

Through intraoperative statistical comparison, it was found that the operation time of patients in the back group was lower than that of the front group. The intraoperative blood loss of patients in the back group was less than that in the front group, and the incision length of patients in the front group was also increased.

Table 2. Comparison of overall response rate between the two groups [n (%)]

Group	Number of cases	Markedly effective	Effective	Invalid	ORR
Front group	40	25 (62.50)	5 (12.50)	10 (25.00)	30 (75.00)
Back group	38	20 (52.63)	10 (26.32)	8 (21.05)	30 (78.95)
X^2	-	-	-	-	0.171
P	-	-	-	-	0.679

Table 3. Comparison of general surgical conditions between the two groups ($\bar{x} \pm s$)

Group	Number of cases	Operative time (min)	Intraoperative blood loss (ml)	Incision length (mm)
Back group	40	173.19 ± 20.13	310.27 ± 19.28	40.28 ± 3.33
Front group	38	203.81 ± 18.28	354.17 ± 20.33	46.38 ± 4.23
T	-	7.021	9.788	7.096
P	-	< 0.001	< 0.001	< 0.001

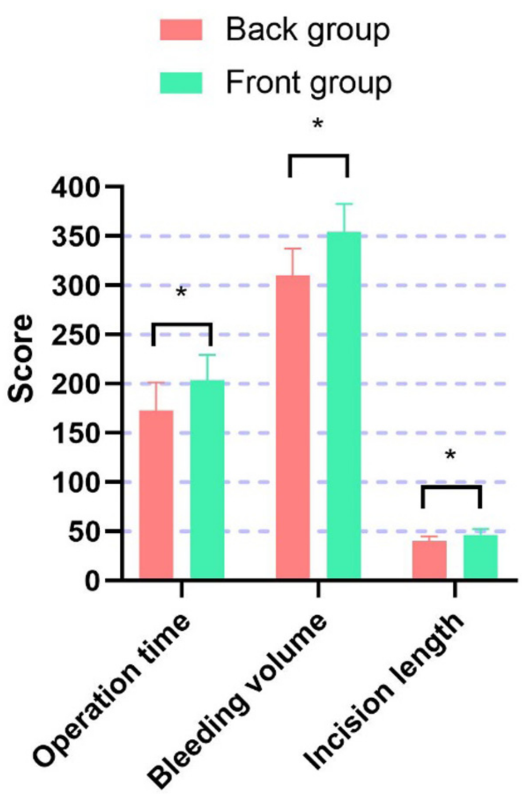

Figure 2. Comparison of general surgical conditions between the two groups. The comparison showed that the operation time of patients in front group was longer than that in back group, the intraoperative blood loss was greater than that in back group, and the incision length was also longer than that in back group, and the difference had statistical significance ($P < 0.05$); * indicated that the difference in the same index had statistical significance.

The difference analysis of the three indicators showed statistical significance ($P < 0.05$) (**Table 3**; **Figure 2**).

Comparison of JOA scores at different time points after operation

The follow-up evaluation results at 1, 3, 6 and 12 months after operation showed that the postoperative JOA scores of patients in the front group were better than those in the back group, revealing a statistically significant difference ($P < 0.05$). The comparison of scores before and after operation showed that the postoperative JOA scores of patients in both groups were better than their preoperative scores ($P < 0.05$) (**Table 4**; **Figure 3**).

Comparison of postoperative cervical spine imaging

The overall curvature of the two groups immediately after operation was significantly increased, showing statistical significance ($P < 0.05$). The overall curvature of the front group was higher than that of the back group ($P < 0.05$). The follow-up results at 12 months after operation also showed that the overall curvature of the front group was higher than that of the back group ($P < 0.05$) (**Table 5**; **Figure 4**).

Comparison of incidence rate of postoperative complications between the two groups

Through follow-up visit and other means, it was found that 1 patient (incidence rate 2.50%) had postoperative wound infection, and recovered after active antibacterial therapy and 18 patients (incidence rate 45.00%) had cervical axial symptoms in front group. In the back group, 2 patients (incidence rate 5.26%) had postoperative wound infection and recovered

Table 4. Comparison of JOA scores between the two groups at different time points after operation ($\overline{x} \pm s$)

Group	Number of cases	Preoperative	1 month after operation	3 months after operation	6 months after operation	12 months after operation
Front group	40	6.01 ± 1.29	14.87 ± 2.31*	15.03 ± 2.41*	14.35 ± 1.98*	14.30 ± 1.87*
Back group	38	5.99 ± 1.31	12.98 ± 2.44*	13.76 ± 2.33*	13.21 ± 1.37*	13.18 ± 1.22*
T	-	0.068	3.514	2.364	2.942	3.115
P	-	0.946	0.001	0.021	0.004	0.003

Note: Compared with that before operation, *$P < 0.05$.

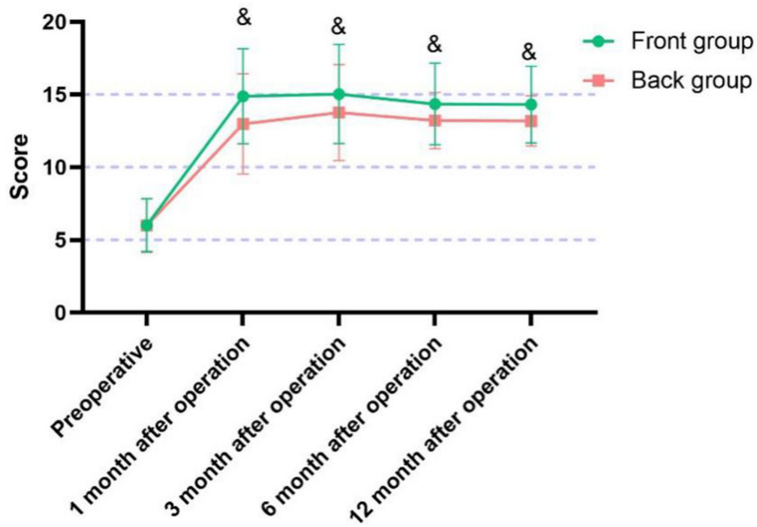

Figure 3. Comparison of JOA scores at different time points after operation between the two groups. The difference in the preoperative JOA score between the anterior and back groups had no statistical significance ($P > 0.05$). The comparison from 1 month after operation to 12 months of follow-up showed that the JOA scores of patients in the front group were significantly higher than those of patients in the back group ($P < 0.05$); the difference in the same indicator at the same time had statistical significance.

after active antibacterial therapy and 9 patients (incidence rate 23.68%) had cervical axial symptoms. There was a statistically significant difference in the incidence rate of cervical axial symptoms between the two groups ($P < 0.05$) (**Table 6**).

Discussion

Cervical spondylotic myelopathy is one of the more common types of lesions in cervical spondylosis. The main pathological change process is that the degeneration of cervical intervertebral disc leads to secondary changes in the surrounding bone and soft tissue, which in turns into compression and stimulation of the spinal cord, ultimately affecting the spinal cord; so that the patients have a series of clinical symptoms such as sensory, motor, reflex, urination and defecation abnormalities. The elderly are in the high-risk group of this kind of disease, which seriously affects the normal life, and also brings a greater burden to their families and the society [16, 17]. OPLL of cervical vertebra is a kind of cervical spondylotic myelopathy, which is a pathological disease with complicated pathology and unknown pathogenesis. Specifically, under the combined action of multiple factors, OPLL of cervical vertebra occurs, which in turn leads to cervical spinal stenosis and compression of cervical spinal cord and nerve root, resulting in limb sensorimotor disorder, visceral autonomic dysfunction and other related clinical symptoms [18]. Epidemiological surveys have shown that the overall prevalence of OPLL is mainly in Asia and Japan. The prevalence of OPLL is about 1.9% to 3.4% in Japanese over 30 years old. Relevant studies have indicated that the peak age of OPLL prevalence is around 60 years old. The prevalence of OPLL is about 3% in other areas in Asia, such as Taiwan and South Korea. A survey in China has shown that the prevalence of OPLL is about 0.44% to 8.92% in northern China, with an average prevalence of 3.08%. However, in recent years, with the increase of work pressure of residents and the continuous of aging society, the prevalence of OPLL may be further increased [19].

At present, the exact mechanism of OPLL is still unknown, and it is still under speculation and in

Table 5. Comparison of postoperative cervical spine imaging between the two groups ($\overline{x} \pm s$)

Group	Number of cases	Pre-operative overall curvature	Immediate postoperative global curvature	Overall curvature 12 months post procedure
Front group	40	10.28 ± 2.31	16.28 ± 3.23	17.01 ± 3.21
Back group	38	10.31 ± 2.28	14.27 ± 2.39	14.82 ± 3.02
T	-	0.058	3.111	3.1
P	-	0.954	0.003	0.003

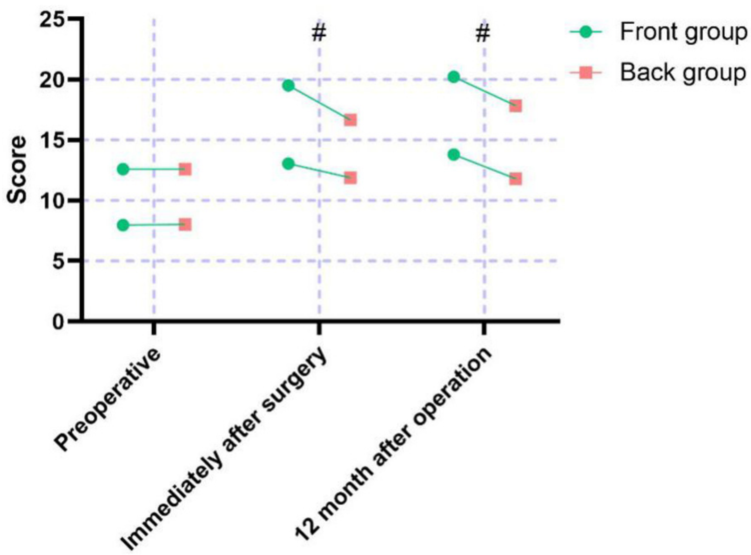

Figure 4. Comparison of postoperative cervical spine imaging between the two groups. Preoperative comparison showed that there was no significant difference in the overall curvature of patients in the anterior back group ($P > 0.05$). The comparison immediately after operation and at 12 months after operation showed that the overall curvature of the front group was significantly higher than that of the back group, and the difference was significant ($P < 0.05$); # indicated that there was a statistically significant difference in the same index at the same time point.

the hypothesis stage. The main views regarding the disease in recent years include the following points: (1) the theory of disc degeneration, advocating that the annulus fibrosus site protrudes posteriorly after disc degeneration, resulting in increased tension of the posterior longitudinal ligament, and the surrounding tissues of the diseased disc lead to the proliferation and calcium salt deposition of the posterior longitudinal ligament during the continuous attempt to repair the disc process, and finally ossification. (2) The theory of systemic bone hypertrophy, which is more biased to genetic factors that the hypertrophic changes of the bone and joint lead to the OPLL. (3) The theory of mechanical injury, advocating that long-term head down posture will lead to changes in spinal load, excessive stimulation of the surrounding tissues and then lead to ossification after posterior longitudinal ligament injury. (4) The theory of glucose metabolism disorder, of which the clinical data show that about 12.6% of OPLL patients have diabetes, so it is speculated that glucose metabolism disorder induces the ossification process of the posterior longitudinal ligament [20, 21]. Although there are many studies on the etiology of OPLL, there is no uniform conclusion on the specific etiology of OPLL. Therefore, some studies advocate starting from the pathological characteristics of patients with OPLL. Abnormal ossification will lead to the formation of adhesions in the dura mater of the posterior longitudinal ligament, thus accelerating the ossification process of the dura mater [22].

From the above findings, it can be seen that the OPLL of the cervical vertebra will cause serious damage to the normal physiological function of patients, and the degree of damage will be further aggravated with the progression of lesions. It has been indicated that the ossification foci of posterior longitudinal ligament will grow into the spinal canal horizontally and longitudinally at an average rate of 0.4 mm/year to 0.67 mm/year, so it is recommended to implement aggressive therapeutic interventions to improve the prognosis of patients with OPLL in clinical practice [23]. Non-surgical treatment is mainly applicable to elderly patients with mild symptoms or those with difficulty adapting to surgery. The main means include revealing traction, bed rest, neck collar fixation, drug intervention, traditional Chinese medicine

Table 6. Comparison of incidence rate of postoperative complications between the two groups [n (%)]

Group	Number of cases	Wound infection	Vertebral artery injury	Instrumentation pullout or breakage	Axial symptoms of neck	Total incidence
Front group	40	1 (2.50)	0 (0.00)	0 (0.00)	18 (45.00)	19 (47.50)
Back group	38	2 (5.26)	0 (0.00)	0 (0.00)	9 (23.68)	11 (28.95)
X^2	-	0.402	-	-	3.912	2.834
P	-	0.526	-	-	0.048	0.092

treatment, *etc*. Although non-surgical treatment has a slow onset, it has the advantage of being relatively mild. In this paper, patients with OPLL were divided into groups to analyze the therapeutic effect and the influence of complications after an anterior operation or a posterior operation. The results showed that in terms of overall response rate in the front group, there were 25 markedly effective cases and 5 effective cases, with the overall response rate of 75.00%; in the back group, there were 20 markedly effective cases and 10 effective cases, with the overall response rate of 78.95%. There was no significant difference between the two groups. It has been pointed out that the advantages of an anterior operation for OPLL are that it can directly remove the compression, directly decompress the spinal cord, and effectively restore the physiological curvature of the cervical spine if the vertebral body height is distracted during surgery, providing conditions to improve the neurological function of patients with OPLL [24]. Other scholars' study results showed that compared with a posterior operation, an anterior operation has certain advantages in both short-term and long-term neurological recovery in patients with OPLL, and the long-term follow-up results showed that the postoperative neurosurgical function score (NCSS) of patients undergoing an anterior operation was improved, and the score of patients undergoing a posterior operation was decreased to some extent [25]. The authors believed that the location of ossification focus, the degree and extent of spinal stenosis and other factors should be fully considered in the selection of surgical position. Although the anterior operation had good decompression effect, it needed high technical requirements and was complicated and difficult to perform. In addition, the intraoperative visual field was limited and the patients suffered trauma. Therefore, the authors believed that anterior operation should be the first choice for patients with well-tolerated, multilevel disease and kyphotic deformity of the cervical spine. For the OLPP patients with poor tolerance, multilevel disease and cervical lordosis, the posterior operation may be preferred.

Regarding the comparison of postoperative JOA scores, we concluded that the back group surgery is often performed by indirect decompression of the cervical spine through the "bowstring effect", but the compression still exists, and even the condition shows a slow progressive state and poor long-term follow-up results. While in the front group surgery, although it is invasive, it can completely solve the actual compression and relieve the current situation of spinal cord compression, so the effect is better in the long-term. A survey of 75 patients who underwent surgery for OPLL showed that 48 patients who underwent anterior operation had a mean improvement rate of 78% at postoperative follow-up, compared with only 46.1% in the back group, and long-term follow-up confirmed that the anterior operation had a better effect. It has also been pointed out that the posterior operation alone often fails to solve the fundamental problem of compression, and even posterior decompression surgery will provide some space for the growth of ossification foci, with the possibility of accelerating the progression of ossification foci. This argument is also supported by the fact that the follow-up of patients in the front group was superior to that in the back group in both JOA score and overall curvature.

Finally, in the comparison of complications, it was mentioned above that the front operation was more difficult to perform, complicated and more invasive, so the incidence rate of postoperative complications was also higher. A study on 14 cases of anterior operation and 13 cases of posterior operation showed that the incidence rate of postoperative complications in the front group was significantly higher than that in the back group. There were 2 cases of cerebrospinal fluid leakage in the front group, and no cerebrospinal fluid leakage was found in the back group. The analysis showed that the ossification site of OPLL in patients adhered to or ossified the bursa, which was caused by the damage of the bursa during the intraoperative separation of compression material. In addition, axial symptoms are also common postoperative complications in patients with OPLL. The causes were analyzed. The excessive distraction of intervertebral space was related to the injury of paravertebral muscles. In order to better restore the cervical curvature, the intervertebral space was distracted in the front group, which inevitably increased the incidence rate of postoperative complications.

In conclusion, compared with a posterior operation, an anterior operation has better efficacy and long-term effect in the treatment of patients with OPLL, which can better maintain the curvature of decompression, but it has a slightly higher incidence rate of postoperative axial symptoms. The shortcomings of this study are as follows: (1) the included sample size is small, resulting in a lack of comprehensiveness in the results; (2) there are some differences in the conditions of the included samples, and the investigation should be focused on the same lesion type as far as possible, which can relatively improve the pertinence of the investigation; (3) there is a lack of follow-up of the neurological function of the included samples. In view of the above deficiencies, the next step is to conduct a longer and detailed investigation to provide more accurate and detailed theoretical support for the selection of surgical treatment for patients with OPLL.

Disclosure of conflict of interest

None.

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