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Microscope Enhanced the Efficacy and Safety of Anterior Cervical Surgery for Managing Cervical Ossification of the Posterior Longitudinal Ligament

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Background: We aimed to compare microscope-assisted anterior cervical surgery with traditional open-base surgery for treating cervical ossification of the posterior longitudinal ligament (OPLL).

Material/Methods: Patients were grouped into microscope-assisted anterior cervical surgery group (case group, n=30) and conventional anterior cervical surgery group (control group, n=30). Baseline characteristics, intraoperative and post-operative indexes including operation time, blood loss amount, duration of hospitalization, visual analogue scale (VAS), and complication rate were recorded. The neurological functions of patients were assessed using the Japanese Orthopaedic Association (JOA) score. Furthermore, the corresponding rate of improved JOA score (RIS) in each group was also calculated to evaluate surgery outcomes.

Results: The average blood loss amount and hospital stay duration in the case group were lower than in the control group ($p<0.05$). The post-operative VAS scores of both groups were decreased significantly. Particularly the post-operative VAS score in the case group was significantly lower than that in the control group ($p<0.05$). While the improvement rate of JOA scores in the case group was significantly higher than that in control group after cervical spine surgery. A significantly higher RIS rate was observed in the case group ($p<0.05$). Furthermore, post-operative complications of patients in the case group were lower than those in the control group ($p<0.05$).

Conclusions: Compared to conventional anterior cervical surgery, surgeries operated with microscope exhibit higher efficacy and safety including less bleeding amount, shorter operation time, released pain degree, improved neurological functions, and fewer incidences of complications.

MeSH Keywords: Electron Microscope Tomography • Neck Pain • Ossification of Posterior Longitudinal Ligament

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2695 6 — 37

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Background

Cervical ossification of the posterior longitudinal ligament (OPLL) occurs when the posterior longitudinal ligament is pathologically replaced by ectopic new bone formation [1]. Cervical OPLL mainly occurs in East Asian populations before 2012 [2], but nowadays, it has been identified as an etiology of spondylopathy regardless of ethnicity [3]. Its symptom is the gradual heterotopic coalescence of the centers of ossification and chondrification. The ossified mass caused by cervical OPLL may be adherent to the dura mater, and can therefore lead to surgery-related complications and a high rate of iatrogenic neurological deterioration [4]. Cervical OPLL may often result in a narrow spinal canal, and it has been reported as one of the causes for spinal cord compression, which can lead to progressive radiculomyelopathy [5,6]. Apart from that, cervical OPLL may trigger radiculopathy or cervical myelopathy [7,8], thereby affecting the spinal centrum 5 (C5) [9]. OPLL usually requires surgical treatment in cases of symptomatic progressive myelopathy. There is a variety of surgical approaches for cervical OPLL, but the optimal surgical option has been controversial, because surgery for cervical OPLL is complicated and may be accompanied by some unexpected complications [10]. Recently, many techniques aimed at decreasing the risk of post-operative complications have been reported, such as laser-assisted corpectomy [11], a specialized microdissector [12], and micromanipulations [7]. Despite the controversies, achieving decompression of the spinal cord is the fundamental principle for managing cervical OPLL [13]. Two surgical decompression approaches, including anterior decompressive surgery and posterior decompressive surgery, are often carried out in cervical OPLL patients [14].

Anterior decompression and posterior decompression are used to treat OPLL via discectomy/corpectomy and laminectomy/laminoplasty, respectively [15]. Anterior decompression has been reported to yield better outcomes compared to the posterior approach for cervical OPLL [16]. However, an anterior approach also has some disadvantages, such as high rates of pseudarthrosis. Besides, it may also be accompanied by some post-operative complications. These post-operative complications may significantly decrease the well-being of patients who may subject to additional surgeries after the first operation.

As a result of this, selecting an appropriate surgical management approach for cervical OPLL is a key to avoid the aforementioned issues and special care should be paid during the surgical removal of the posterior longitudinal ligament mass. It has been reported that microscope-assisted anterior procedures may provide crucial imaging information which may result in a reduced risk of neurologic complications [17]. Researchers also found that combined use of a microscope and CO_2 laser with posterior foraminotomy is an effective surgical procedure for cervical radiculopathy. There is significant improvement in clinical outcomes when the use of a microscope is introduced into surgical procedures [18]. Therefore, anterior microscopic decompressive surgery may be considered as a surgical option for cervical OPLL. This study was designed to compare the efficacy and safety of microscope-assisted anterior procedures and conventional open surgeries for cervical OPLL.

Material and Methods

Patients

A total of 60 consecutive OPLL patients admitted to Yantai YEDA Hospital from March 2014 to May 2016 were recruited into the present study. Baseline characteristics, clinical and follow-up data of the included patients were respectively recorded to complete the retrospective analysis. Thirty patients who underwent microscope-assisted anterior cervical surgery were classified as the case group (mean age of 55.2±11.1 years, 18 males and 12 females) while the other 30 patients were allocated to the traditional anterior cervical surgery as the control group (mean age of 54.8±10.7 years, 21 males and 9 females). All the patients provided written informed consent and were followed up for 12 months [19]. Approval of the study was obtained from the ethics committee of Yantai YEDA Hospital.

Inclusion, classification and exclusion criteria

All the patients were diagnosed with cervical OPLL according to imaging studies, including x-ray (lateral cervical spine and cervical flexion and extension position), computed tomography (CT) (combination of three-dimensional reconstruction) and magnetic resonance imaging (MRI). OPLL patients were diagnosed and classified based on the cervical spine radiographs and CT sagittal reconstruction of two-dimensional sheet, in combination with Japanese Orthopaedic Association (JOA) scores [20]. The segmental ossification focus was located in the back of each vertebral body and appeared in a single type and was not connected between the up and the down side. Moreover, there was a gap between the ossification sheet and the vertebral body; continuous ossification focus appeared like a ribbon or streak, spanning two or more segments; hybrid ossification focus exhibited the characteristics of both segmental type and continuous type as mentioned earlier; localized ossification focus was confined to the deep ligament of the trailing edge of the posterior disc, leading to the formation of isolated ossification focus with local block carina. The spinal stenosis rate was calculated based on CT images. Spinal stenosis rate=maximum thickness/the corresponding planar sagittal diameter ×100%.

Patients with cervical or thoracic yellow ligament hypertrophy or ossification, vertebral OPLL, brain or spinal cord disease, and a history of spinal trauma were excluded.

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Surgical procedures

For the case group, under the condition of general anesthesia or cervical plexus block anesthesia, the oblique incision was exposed after routine anterior cervical surgery. Then taking the bending point in the lateral anterior hook, which was projected to the continuation in the front edge of the vertebral body as the safety limit for decompression of the vertebral body in the anterior half part, we resected the intervertebral disc of lesions under the naked eye, and microscope-decompression was performed as follows. The eyepiece was adjusted to the appropriate working distance in order to optimize the endoscopic operation. The posterior longitudinal ligament was resected completely under a microscope.

For the control group, the intervertebral discs of lesion areas were handled under the naked eye with the same method described in the case group. Longitudinal ligament hook was inserted into ligaments through the fiber direction at a relatively normal part (or at normal ligament junction part), rotated and lifted up carefully. Then the dagger was incised and gently dissected into the posterior longitudinal ligament from the epidural space. Furthermore, ultrathin gun forceps were employed to bite and excise the ossification part of the posterior longitudinal ligament gradually [21].

Observation indexes

We recorded the operation time, blood loss, length of hospital stay, post-operative complications and image assessment of patients in each group. We also used visual analogue score (VAS) in order to evaluate the various degrees of pain: 0 stands for painless; 3 points or less indicate that there is a slight but tolerable pain; 4–6 points indicates pain which can affect the sleep of patients; 7–10 points indicates intensive pain which affect both the appetite and sleep of patients. The JOA score was used to evaluate the neurological functions of patients before and after their operation. Rate of improved JOA score (RIS) = (post-operative score–pre-operative score)/(17 – pre-operative score) ×100%. According to the improvement rate, curative effect was assessed as following: RIS >75% means excellent, 50%< RIS ≤75% means good, 25%< RIS ≤50% means moderate, RIS ≤25% means poor. Excellent rate=(excellent cases + good cases)/total cases ×100%. The corresponding rate between the two groups was compared to determine whether the results were significantly different [22,23].

Statistical analysis

All data analyses were performed with GraphPad Prism 6.0. Count data was analyzed using the chi-square test and measurement data were depicted by mean value ± standard deviation ($\bar{\chi}\pm s$). Measurement data between the two groups were compared using the *t*-test if the normality assumption was fulfilled; otherwise, the rank sum test (Mann-Whitney test) was performed. A $p<0.05$ was considered as statistically significant.

Results

Baseline characteristics of the case and control groups

Patients in the case group underwent microscope auxiliary anterior surgery while patients in the control group underwent conventional anterior surgery. The baseline characteristics included gender, age, course of disease, pre-operative JOA score, spinal canal stenosis rate, and diagnosis were compared between the two groups. The difference did not appear to be statistically significant ($p>0.05$), as shown in Table 1.

Comparative surgical status in two surgical procedures

The average operation time showed no statistical significance ($p>0.05$) between the two groups; patients with conventional anterior surgery (the control group) had higher intraoperative blood loss amount than those with microscope-assisted anterior surgery (the case group), and the corresponding difference was statistically significant ($p<0.001$). The average hospitalization day in the case group was significantly less than that of the control group ($p<0.05$), as shown in Table 2.

Improvement of pain release

VAS scores in the case group before and after treatment were 7.8±1.5, and 3.1±0.5, respectively. For the control group, VAS scores before and after treatments were 7.5±1.9 and 4.8±1.1, respectively. Therefore, the average VAS scores after treatment in both the control and case group were significantly decreased compared to scores before treatment. Decline in the average VAS score in the case group was more significant compared to that in the control group as shown in Table 3.

Comparison of neurological functions and improvement rate

JOA score was used to assess patients' neurological functions and then we calculated the corresponding improvement rate of post-operative neurological functions in each group. The case group exhibited an average pre-operative JOA score of 9.27±1.81 and its 12-month average post-operative JOA score was 15.77±1.08. Therefore, the average post-operative JOA score was significantly higher than that prior to the operation in the case group ($p<0.001$). In the control group, the average pre-operative score of 9.12±1.48 and the 12-month average post-operative JOA score with an average of 14.37±1.71, indicating that the average post-operative JOA score was also

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Table 1. Baseline characteristics of patients included in the case group and control group.

	Case group	Control group	*P*-value
Sample size	30	30	
Gender (Male/Female)	18/12	21/9	0.417#
Age (years)	55.2±11.1	54.8±10.7	0.980*
Course of disease (month)	27.9±20.7	28.7±18.2	0.823*
Preoperative JOA score	9.27±1.81	9.12±1.48	0.599*
OPLL society of Japan			
Localized type	3	4	0.697#
Continuous type	11	10	
Segmental type	9	12	
Mixed type	7	4	
Spinal stenosis rate (%)	42.1±10.5	42.6±11.3	0.968#

* Using the rank sum test (Mann-Whitney test); # using chi square test. JOA – Japanese Orthopaedic Association; JOA – Japanese Orthopaedic Association; OPLL – ossification of posterior longitudinal ligament; OPLL – ossification of posterior longitudinal ligament.

Table 2. Comparative operation status between the case group and control group.

	Case group	Control group	*P*-value
Operative time (min)	133.1±19.0	137.8±28.2	0.465*
Intraoperative blood loss amount (ml)	94.4±12.6	112.8±15.5	<0.001*
Hospitalization days (day)	6.7±1.2	7.5±1.7	0.029*

* Using the rank sum test (Mann-Whitney test).

Table 3. Improvement of pain release in the case group and control group.

	Pre-operative VAS score	Post-operative VAS score	P-value[b]
Case group	7.8±1.5	3.1±0.5	<0.001*
Control group	7.5±1.9	4.8±1.1	<0.001*
P-value[a]	0.738*	<0.001*	

* Using the rank sum test (Mann-Whitney test); [a] comparisons of the VAS score in the case group and the control group; [b] comparisons of the preoperative VAS score and the postoperative VAS score in the two groups.

Table 4. The improvement of neurological functions in the case group and control group.

	Pre-operative JOA score	Post-operative JOA score	Improvement rate (%)	P[b]
Case group	9.27±1.81	15.77±1.08	80.35±12.05	<0.001*
Control group	9.12±1.48	14.37±1.71	65.43±22.16	<0.001*
P-value[a]	0.599*	0.012*	0.013*	

* Use the rank sum test (Mann-Whitney test); [a] comparisons of the JOA score in the case group and the control group; [b] comparisons of the preoperative JOA score and the postoperative 12-month JOA score.

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Table 5. Evaluation of curative effectiveness in the case group and control group.

	Evaluation of outcomes				Rate of excellent and good (%)
	Excellent	Good	Moderate	Poor	
Case group	22	7	1	0	96.67
Control group	10	10	9	1	66.67
P-value	0.002*	0.390*	0.006*	0.313*	0.003*

* Using chi square test.

Table 6. Post-operative complications in the case group and control group.

	Cerebrospinal fluid leakage	Recurrent laryngeal nerve injury	Postoperative wound infection	Total complications
Case group	0	1	2	3
Control group	2	3	8	13
P-value	0.150*	0.301*	0.038*	0.004*

* Using chi square test.

significantly higher than that prior to the operation in the control group ($p<0.001$), as shown in Table 4.

The average improvement rate of neurological functions in the case group was 80.35±12.05%; however, this figure was 65.43±22.16% in the control group. Hence, the improvement rate of neurological functions in the case group was significantly higher than that in the control group ($p=0.013$), as shown in Table 4. According to the improvement rate, we evaluated the efficacy of different surgical approaches for each patient and calculated the corresponding rate of excellent and good cases. The rate of excellent and good cases was 96.67% in the case group, while it was only 66.67% in the control group. Therefore, the rate of excellent and good cases in the case group was significantly higher than that in the control group ($p=0.003$), as shown in Table 5.

Post-operative complications

In the case group, there was one case of post-operative recurrent laryngeal nerve (RLN) injury which was recovered after two weeks, and two cases of post-operative wound infection without other complications. In the control group, there were two cases of complication with cerebrospinal fluid leakage and the two patients were managed by gelatin sponge pack and local injection with biological protein glue. These patients healed after one week. In addition, there were three cases with recurrent laryngeal nerve injury with spontaneously recovered in two weeks without any special treatment, and eight cases of post-operative wound infection. In summary, the total number of complications in the case group was significantly lower than that in the control group ($p<0.01$), as shown in Table 6. Therefore, the operation safety and prevention of complications can be achieved by implementing the use of a microscope during surgical procedures.

Discussion

OPLL is a common cause of both cervical myelopathy and radiculopathy in Asian populations [22]. Although there have been extended debates over its surgical procedures, including anterior and posterior cervical decompression, accumulated evidence still suggests that anterior cervical decompression can achieve more satisfactory clinical outcomes particularly for severe multilevel OPLL [16,22,24–26]. Many techniques for decreasing the risk of complications associated with the anterior cervical decompression have been demonstrated in several research studies, and they generally include the floating method, the use of microscopes, diamond-tip burrs, and laser-assisted corpectomy [17,26]. The use of a microscope provides compelling clinical outcomes since it reduces the risk of complications and minimizes the damage of pre-vertebral soft tissues [17,27].

We conducted a retrospective case-control study which involved the corresponding clinical data of 60 OPLL patients in order to compare the efficacy and safety between microscope-assisted anterior cervical decompression and conventional anterior cervical decompression. With the use of a microscope, the average intra-operative hemorrhage volume, hospitalization duration, and post-operative VAS score decreased significantly,

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while the corresponding post-operative cervical JOA score, the improvement rate and the RIS excellence rate increased dramatically. Meanwhile, lower incidence of post-operative complications in the case group further exhibited the high efficacy and safety of anterior cervical surgery with a microscope in managing OPLL.

Previous studies have revealed that outstanding outcomes can be obtained from anterior cervical decompression. Mizuno and Nakagawa published their investigation of 107 OPLL patients with a 6-month follow-up period and these patients were treated by either anterior cervical decompression or direct removal of the ossified mass [28]. They discovered that 104 patients developed myelopathy and three patients who developed radiculopathy were alleviated [29]. Odate et al. found that the average recovery rate of JOA score in 68 OPLL patients with an average follow-up period of 29.6 months was 63.0±32.3% after anterior cervical decompression and fusion (ACF) combined with an anterior cervical plate [26]. Kojima et al. also reported that 87% of their patients with multiple spondylosis and OPLL were alleviated neurologically after ACF [30] and Eleraky et al. found that 86.5% of their patients displayed neurological improvements after the use of anterior cervical decompression [31]. Compared with other studies, our study had one distinct advantage: patients were followed for at least 12 months and our study design may provide more information with respect to the long-term effects of anterior cervical decompression on OPLL patients. Introducing a microscope into anterior cervical surgery allows improvements in hospitalization duration, hemorrhage volume, post-operative VAS score (pain), JOA score (neurological function) and the excellent rate (curative effect) in OPLL patients.

Among all potential complications associated with anterior cervical decompression, neurological iatrogenic deterioration appears to be very common in OPLL patients [32,33]. Several studies showed an amelioration of neurological deterioration in different operative techniques including microscope, diamond-tip burrs, and laser-assisted equipment [11,34]. Relevant studies also indicated that OPLL patients who were conducted with anterior cervical decompression and fusion had no significant neurological complications and a neurological deterioration rate of 0–7% might be observed in MOPLL patients who were conducted with anterior cervical decompression [22,27,35]. In our study, introducing a microscope into anterior cervical surgery among OPLL patients is able to reduce the risk of post-operative complications such as neurological deterioration.

As mentioned earlier, surgical outcomes that result from anterior cervical decompression may not be favorable and adverse events may be triggered as a result of the anterior cervical decompression. Several factors including age, sex, ossification type, duration of preoperative symptoms, diabetes, pre-operative neurologic score, and interrelated imaging parameters may be considered as predictive factors [25,28,36]. For instance, Choi et al. indicated that the use of anterior cervical decompression in OPLL patients is only associated with the risk of diabetes [28]. Apart from that, Chen et al. indicated that anterior cervical decompression is particularly effective for OPLL patients with respect to the post-operative JOA score, recovery rate and risk of complications. As suggested by their statistical analysis, the number of anterior cervical decompressions and the pre-operative JOA score was associated with the overall effectiveness of the operation [37].

However, there were still some limitations in the present study that need to be improved in the future. There were only 60 patients included in our study and such a small sample size is not persuasive enough. Besides, overall conclusions may be biased due to the lack of randomization or control of confounding factors. Therefore, further research needs to be done to verify our conclusions in larger extent.

Conclusions

Our retrospective case-control study suggested that incorporating a microscope into anterior cervical surgery, such as cervical anterior decompression, appeared to be more effective and safer than conventional cervical anterior surgery since the average intra-operative hemorrhage volume, hospitalization duration, the post-operative VAS score, post-operative JOA score, the improvement rate, the excellent rate, and the incidence of post-operative complications were reduced. Therefore, a microscope may play a significant role in anterior cervical surgeries since it may enhance the effectiveness and the safety of spine surgeries.

Conflict of interest

The authors declare that they have no conflict of interest.

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