Does Anterior Controllable Antidisplacement and Fusion Technique Improve Quality of Life in Revision Treatment for Cervical Ossification of the Posterior Longitudinal Ligament? Three-Year Follow-Up Study

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Research Article

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Abstract

Background: The laminoplasty and laminectomy are two comparatively safe posterior procedures for the treatment of OPLL. The long-term outcomes of posterior surgery seem to be favorable, however it is also criticized for C5 nerve root palsy, progression OPLL and bad cervical lordosis. An additional revision surgery was required for those patients who had the poor clinical improvement after the initial posterior surgery.

Methods: This study was to identify the mid-term clinical results and the health-related quality of life (HRQoL) after anterior controllable antidisplacement and fusion (ACAF) technique for revision treatment of cervical ossification of the posterior longitudinal ligament (OPLL). All the patients were followed up for more than 3 years. The Japanese Orthopaedic Association (JOA) scales, Neck Disability Index (NDI) and Short-Form 36 (SF-36) were recorded to evaluate the health-related quality of life. And the neck and arm pain scale as an expression of visual analog scale (VAS) were also collected. Intraoperative parameters, clinical features, radiological investigations and the surgery-related complications were performed to analysis.

Results: There were 20 patients who underwent ACAF revision surgery between March 2017 and January 2019. Clinical improvements were observed in all outcomes; significant improvements on the NDI, VAS, SF-36, and JOA scores were maintained at 3 years ($P < 0.05$). All the patients showed a better cervical alignment, and the average cervical lordosis was $17 \pm 4.6^\circ$ after revision surgery. There was only one case of cerebrospinal fluid (CSF) leakage, no instance of C5 root platy, postoperative hematoma or esophageal injury occurred. No instrumented failure or pseudarthrosis case was observed during the follow-up.

Conclusions: This study suggested that ACAF is an effective and safe procedure for the revision treatment of cervical OPLL. Such a surgical technique can offer the postoperative improvement on pain levels and health-related quality of life.

Background

Cervical ossification of the posterior longitudinal ligament (OPLL) is a pathologic process of lamellar bone deposition at the site of the posterior longitudinal ligament, which frequently related to cervical myelopathy [1]. In the Asian countries, the incidence of OPLL is similarly reported up to 3% [2].

Asymptomatic patients without severe cord compression can be treated conservatively; however, surgical intervention treatment should be considered for patients with progressive neurological deterioration [3-4]. A variety of surgical approaches have been described utilizing anterior, posterior, and combined anteroposterior approaches, each with unique risks and benefits.

The laminoplasty and laminectomy are two comparatively safe posterior procedures with few complication for the treatment of OPLL [5-6]. They decompress the spinal cord indirectly depending on the backward shift of the cervical spinal cord. The long-term outcomes of posterior surgery seem to be favorable, however it is also criticized for C5 nerve root palsy, progression OPLL and bad cervical lordosis

[7-8]. Owing to the poor cervical alignment, the operative instability and the progressive ossified lesion, the neurological function of the patient will be always deteriorate [5,9]. And a additional revision surgery was required for those patients who had the poor clinical improvement after the initial posterior surgery [10]. The revision surgery was challenging because it maybe was a combination of progressive kyphosis, segmental instability, multi-level progressive OPLL [11].

The anterior controllable antidisplacement and fusion (ACAF) technique was reported for the treatment of multi-levels OPLL with cervical myelopathy [12]. The goal of this novel technique was to achieving direct decompression by make the ossified lesion "controllable floated", the space of cervical spinal canal was much wider with their location unchanged. Our previous study have proved the preliminary feasibility of this novel anterior approach as the revision method for the OPLL [13]. Although health-related quality of life (HRQoL) for anterior cervical disectomy and fusion (ACDF) and cervical disk arthroplasty (CDA) has been largely investigated [14-15], there is fewer studies evaluating the quality of life regarding the revision surgery for cervical OPLL. Accordingly, the purpose of our study was to evaluate current data from a single center regarding revision surgery with ACAF technique for cervical OPLL; we present 3-year follow-up clinical and radiographic data for patients with initially failed posterior surgery.

Materials And Methods

Patient population

We prospectively collected data from a consecutive series of patients underwent ACAF revision surgery due to the OPLL from March 2017 to January 2019. They all had the progressive neurological deterioration after the initial posterior surgery. Patients with severe osteoporosis (criteria of WHO), preexisted spinal deformity, cervical spine trauma, spinal infections, and chronic systemic illnesses were excluded in this study. This study had been approved by Ethics Committee of the authors' affiliated institutions, and all the patients signed informed consent.

Data collection and outcome evaluation

Data including patient demographic, intraoperative details (type of OPLL, surgery time, amount of blood loss, complications), postoperative functional scores, and surgery-related complications were collected. During the follow-up, clinical and radiographic data were collected on the last day of hospital stay, at 1months, 3 months, 6 months, and every year after the surgery. All the patients were included in the clinical and radiographic evaluations at the each follow-up time point. The Japanese Orthopaedic Association Scores (JOA), Visual Analogue Score (VAS), Neck Disability Index (NDI) and the Medical Outcomes Study SF-36 Form Health Survey were used to measure the neck pain, arm pain and the neurological function. Odom grading system (poor, fair, good, or excellent) was used to evaluate patient satisfaction with the surgery.

The cervical lordosis indicates the angle between 2 crossed perpendicular lines that are extended parallel to inferior endplates of C-2 and C-7 on the standing lateral radiograph of the cervical spine. Kyphosis was

defined as C2-7 Cobb $< 0^\circ$. The anteroposterior, lateral and flexion-extension images were taken at before the surgery, 1 month, 6 months, 12 months after the surgery. Pseudarthrosis was defined as interspinous motion of > 1 mm on dynamic flexion-extension images [16].

Surgical technique

All surgical procedures were performed under general anesthesia with endotracheal intubation, with the patients placed in supine position. The somatosensory-evoked potentials (SSEPs) were used to detect the neurological damage during the operation. The exposure was obtained through a Smith-Robinson approach on the right side. Firstly, discectomies of involved levels were carried out. During the decompression of the cephalad and caudal intertebral space, remove the ossified posterior longitudinal ligament. Then, resection of the anterior vertebral bodies of the Vertebrae-OPLL-Complex (VOC) is performed by a high-speed burr; Thirdly, we install the cage with autogenous bone and the anterior static plate. Fourthly, The bilateral osteotomies of the vertebrae along the medial of Luschka joint were made. Finally the VOC was hoisted by gradually tightening with screws. The illustration of the surgical procedures is shown in the Figure 1. Autogenous bone pieces were grafted into the bilateral troughs to obtain further fusion. A hard cervical brace is routinely used postoperatively for 3 months.

Statistical analysis

Statistical analysis was performed using SPSS 16.0. Preoperative and postoperative data such as JOA, VAS, NDI and SF-36 scores were compared using paired t test, while Mann-Whitney U-test for categorical data, and Spearman rank correlation coefficient to investigate relationships. The level of significance was set at $p < 0.05$.

Results

clinical and radiographic results

There were 20 patients with cervical OPLL who underwent ACAF revision surgery in this study. The patient demographic data is shown in Table 1. The mean age was 62.1 ± 8.0 (52-78), and the mean interval between the primary and revision surgery was 78.0 ± 48.2 months (range 5–180 months). The mean operative time in this group was 179.3 ± 41.8 min (range 120-240 min). The mean intraoperative blood loss was 432.5 ± 198.3 ml (range 225-850 ml). All the patients had a minimum of 3 years' follow-up. The imaging of the typical cases were shown in Figure 2-3.

As shown in the Table 2, the preoperative JOA score was 8.7 ± 2.8 , and the postoperative JOA was 13.4 ± 2.4 ($p < 0.05$); Also, The postoperative VAS arm and neck score was 3.9 ± 1.4 , 3.4 ± 1.4 separately, which both decreased significantly ($p < 0.05$). The preoperative NDI score was 24.4 ± 3.0 , and the postoperative NDI was 13.3 ± 2.7 ($p < 0.05$). Similarly, the SF-36 physical and mental subscore presented a similar pattern to the other outcome measures, significantly improved at 6 months post surgery. Using Odom criteria, 90% of patients rated their level of satisfaction with the surgery as excellent or good. The

postoperative cervical lordosis was $17.2 \pm 4.6^\circ$, which was much better than that of preoperative. No patient show neurological deterioration after revision surgery, and all the patients had osseous-fusion at 3-year of follow-up.

During the follow-up, The JOA score demonstrated significant improvement at 3 months after surgery ($P < 0.05$), without significant variations during the later follow-up. The NDI demonstrated significant improvement at 3-year follow-up from a preoperative score ($P < 0.05$), with significant improvements seen by 6 months after surgery ($P < 0.05$) and maintained over time. The largest reduction has been observed at 1-month follow-up both in the VAS arm and VAS neck score ($P < 0.05$), which was slight return of pain over a longer period of observation. With regard to the SF-36, both the physical subscore and mental subscore significantly improving at 6 months post surgery ($P < 0.05$), and then maintained the same trend for the rest of the follow-up. Figure 4 shows the change in clinical outcomes over time.

complication

There was only one case of CSF leakage (5%) happened in our study. In that case, there was severe adhesion between the dural mater and the ossified posterior longitudinal ligament. Fortunately, it was healed by sponge and elastic bandage. There were no occurrences of postoperative hematoma, hoarseness, C5 root platy or instrumented failure.

Discussion

In the present study, we have evaluated HRQoL in a group of revision patients suffering from the cervical OPLL with a prospective design. Our results suggested that HRQoL significantly improve 3 years after discharge ($P < 0.05$). Such findings were consistent with earlier lines of evidence [13,17]. The present study is the first study to investigate the HRQoL of cervical OPLL patients with satisfaction for up 3 years after revision surgery with ACAF technique. It is suggested that VAS, JOA, NDI and SF-36 scores were all significantly improved after ACAF surgery ($P < 0.05$). Great improvement can continued for at least 6 months after the operation. During the follow-up, the greatest reduction in both neck and arm pain was observed at one month, and the pain improvement were no longer significantly at three years, maintaining almost the same score as which in the one year after surgery.

Posterior cervical surgery such as laminoplasty or laminectomy is relatively safe and with low complication rate, they were suggested as the favourite choice for the initial treatment of OPLL [11]. However, owing to the neurological deterioration after posterior surgery, some patients need additional revision surgery [18-19]. The great loss of cervical lordosis and the extensive OPLL progression might be the two main reasons for failure of the operation [20-22]. For posterior procedures, the revision rate after cervical foraminotomy has been reported to range from 2.9% at 7 years to 5% at 31.7 months compared to laminoplasty with a revision rate ranging from 2.1% at 15 years to 13% at 42.3 months, and laminectomy and fusion which has a revision rate ranging from 2% to 27% at 41.3 months [23-25]. Shigematsu et al [26] considered that the reasons for recurrence of symptoms after laminoplasty fall into three categories: technique related, inadequate treatment, and disease progression. Papavero et al [27]

also classified the indications for cervical revision surgery(CRS) into five categories: adjacent segment disease (ASD), infection (INF), implant failure-pseudarthrosis (IFP), non-infectious complication, and deformity.

When the patient had progressive cervical neurological deterioration after initial surgery, a revision surgery should be considered. Papavero et al [27] thought cervical revision surgery required painstaking planning and mastery of a variety of surgical techniques. The results were rewarding in half and satisfactory in a quarter of the patients. The complication rate was lower than expected. It is very difficult to do the decompression surgery with the same posterior procedure. Koerner et al [25] suggested that the approach to revision cervical spine surgery depends on the etiology. In cases of postoperative kyphosis, the operative strategy is to lengthen the anterior column and shorten the posterior column, which is usually performed with anterior–posterior procedures. In cases of ASD without deformity, the approach is dependent on the location of the neural compression. It was reported that multi-level ACCF carries an approximately 22% risk of surgical mortality and morbidity, including deep vein thrombosis, pneumonia and death [28]. Odate et al [11] suggest that the use of anterior decompression revision surgery for OPLL must be limited owing to the high probability of CSF leakage and the low rate in neurological improvement. In their study, the incidence of surgery-related complications was as high as 63%, the main complication being intraoperative CSF leakage (42%), the mean improvement rate of the JOA score was 18% only. To minimize the surgical risk of CSF leakage, hemorrhage and spinal cord injury, Yamaura et al [29] reported the floating method for treatment of cervical myelopathy owing to the OPLL. However, the anterior migration of the ossified ligament in the this method is not controlled by the surgeon, but depending on the pressure of the CSF. There was approximately 14% of the cases with neurological deterioration owing to residual ossified lesion or the postoperative progression of OPLL.

The ACAF technique can restore the spinal canal by isolating and actively antedisplacing the OPLL ventrally, it achieved direct decompression without interference with the spinal cord. Differently from the previous floating technique, we make the antedisplacement of the OPLL through the gradual hoisting force by the anterior plate and screws with immediate feedback. The direct decompression of the spinal cord and nerve roots was the anatomic basis for the clinical effect. However, as a novel technique, the improvement of quality of life and the long-term efficacy remain uncertain. We have previously demonstrated that ACAF is an effective, reliable, and safe procedure for the treatment of OPLL [13]. Wang et al [30] also confirmed that ACAF could improve neurological function significantly for revision treatment after posterior decompression surgery. The present study is the first study to investigate the HRQoL of cervical OPLL patients after revision surgery with ACAF technique. A major strength of this study is that we conducted a face-to-face interview for HRQoL measurements both before and after the treatment with a follow-up spanning 3 years. However, there are some limitations. Small sample size may bias our results; Also, as similar to previous studies, we only recruited participants from a single hospital and the results might not be generalized to other settings or populations, particularly those with distinct socioeconomic or clinical backgrounds.

Conclusions

Our study demonstrate that excellent mid-term clinical outcome can be achieved with the ACAF technique for cervical revision surgery. Such a surgical method has been shown to provide postoperative improvement on pain levels and on health-related quality of life, thus showing it to be a safe alternative to traditional anterior surgical methods. The findings in our study still need to be further confirmed by more investigations with larger sample sizes in external populations.

Declarations

Ethics approval and consent to participate

This study had been approved by Ethics Committee of the authors' affiliated institutions, and the informed consent to participate in the study should be obtained from all the patients.

Consent for publication

All patients provided written informed consent to use their clinical data for publication purposes.

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no conflict of interest.

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Authors' contributions

HDL had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. JKM was highly involved in the planning and execution of this study. The author(s) read and approved the final manuscript.

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Tables

Table 1. Summary of patient demographic and the results of revision ACAF after initial posterior surgery for cervical OPLL

Variable	Value
Sex	
Male	8
Female	12
Age	62.1±8.0 (52-78)
Previous pst op	
Laminectomy	8
Laminoplasty	9
Decompression	3
Mean interval btwn initial op and revision, month	78.0 ± 48.2 (5–180)
Type of the ossification	
Continuous	10
Segmental	2
Mixed	8
k-line	
Minus	11
Plus	9
Mean op time, min	179.3±41.8 (120-240)
Mean blood loss, ml	432.5±198.3 (225-850)
Complications, number of patients	
CSF leakage	1
C5 palsy	0
Postoperative hemotoma	0
Implants complication	0

Pst=posterior; op=operation; btwn=between.

Value are expressed as the mean ±SD (range).

Table 2. Clinical and radiological results of patients.

Item	Value
JOA	
Before surgery	8.7±2.8
After surgery	13.4±2.4 [§]
NDI	
Before surgery	24.4±3.0
After surgery	13.3±2.7 [§]
VAS arm	
Before surgery	7.3±1.3
After surgery	3.9±1.4 [§]
VAS neck	
Before surgery	5.9±2.1
After surgery	3.4±1.4 [§]
SF-36 PCS	
Before surgery	22.3±3.9
After surgery	34.5±2.1 [§]
SF-36 MCS	
Before surgery	29.6±4.8
After surgery	40.4±2.5 [§]
Cervical lordosis °	
Before surgery	3.8±4.3
After surgery	17.0±4.6 [§]

JOA: Japanese orthopaedic association scores; VAS: visual analogue score; NDI: neck disability index; SF-36:Short-Form 36.

Value are expressed as the mean ±SD (range)

[§]P<0.05, compared with the data before surgery.

Figures

Figure 1

Illustration of the procedures of the ACAF technique. A: The bilateral border of the OPLL mass (dash lines); B: Installation of the anterior cervical plate (installation of the "bridge"); C: Bilateral osteotomies of the VOC; D: Controllable antedisplacement of the VOC by the screws.

Figure 2

A case of 59 years old man who needed a revision surgery 5 years after initial posterior decompressing surgery. A: The lateral image showed that the cervical kyphosis occurred after the initial posterior surgery; B-C: The CT scan showed that there was only a window decompressing without fixation in the initial posterior surgery (arrows); D: the MRI showed that the cervical spinal cord of C4-5 was compressed by the OPLL; E-F: the postoperative anterior-posterior and lateral image showed the good device position and still the bad cervical lordosis; G-H: The postoperative CT scan show that the bilateral troughs are created among the widest edge of the OPLL, and we hoisted the VOC by the screws (arrows). We usually used a 2-mm high-speed cutting burr and a 1 mm Kerrison rongeurs to remove the posterior vertebral wall on the bottom of the troughs.

Figure 3

A case of 61 years old man who needed a revision surgery 12 months after initial posterior laminectomy. A-B: The anterior-posterior and lateral image showed the loss of cervical lordosis after the initial laminectomy; C-D: The CT scan showed that there was a continuous type of OPLL, and only a semi-laminectomy with one-side lateral mass fixation was done in the initial surgery; E: The intraoperative photo showed that after installation of the intervertebral cages and anterior cervical plate, we used a 1 mm Kerrison rongeurs to remove the posterior vertebral wall on the bottom of the troughs for isolation of the VOC (arrows); F-G: The postoperative anterior-posterior and lateral image showed the good internal fixation position and the improved cervical lordosis; H: The CT scan show that the VOC was hoisted forward, and the cervical spinal canal was obviously wider than before.

Figure 4

Graphs showing changes in clinical outcomes over time (mean value). (A) Japanese Orthopedic Association score. (B) Neck Disability Index. (C) Visual analog scale (VAS) arm. (D) VAS neck. (E) Short-form 36-item (SF-36) mental subscores. (F) SF-36 physical subscores.