Research Square

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# Long-term outcomes of spinal fusion surgery for cervical myelopathy in patients with athetoid cerebral palsy

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## Abstract

# Purpose

Cervical myelopathy in patients with athetoid cerebral palsy (CP) is commonly progressive and intractable due to uncontrolled hyperkinetic cervical spinal motion. This study evaluated the long-term clinical outcomes, complications, and prognoses of patients who underwent cervical fusion.

# Methods

We retrospectively evaluated 224 patients with athetoid CP who underwent cervical fusion between 1983 and 2023. The initial surgical interventions included subaxial front–back fusion (217 cases), posterior fusion for upper cervical lesions (23 cases), and simultaneous combined surgeries for both regions (16 cases). The Barthel Index for activities of daily living, Japanese Orthopaedic Association score for cervical myelopathy (JOA score), radiographic parameters, bony union, and reoperations were investigated over a mean follow-up of 13.0 years.

# Results

At the final follow-up, the mean Barthel Index significantly improved from 51.0 to 64.6 points, and the mean JOA score increased from 5.6 to 8.9 points. Bony union was achieved for 91.2% of subaxial and 78.3% of upper cervical fusions. Early reoperation within 6 months was required in 5.5% after subaxial fusion and 8.7% after upper cervical fusion, and this correlated with the severity of involuntary neck movements. Late reoperations were required for 18.4% of subaxial fusion cases due to adjacent segment disease and upper cervical instability. Severe preoperative focal kyphosis and subsequent correction loss were significant risk factors for late reoperation. The 10-year survival rate was 98.5% with no perioperative deaths.

# Conclusion

Spinal fusion surgery leads to durable improvements in activities of daily living and neurological status of patients with athetoid CP. While intense athetoid movements increased the incidence of early reoperation, late reoperation was required for patients with kyphotic alignment preoperatively.

## Introduction

Athetoid cerebral palsy (CP) is widely known to be caused by non-progressive brain damage that occurs during the fetal or neonatal period [1]. However, patients with this condition often experience degeneration and deformity of the limbs and trunk with age, leading to various secondary disabilities and subsequent decline in daily activities [2]. Among these, cervical myelopathy and radiculopathy

associated with involuntary neck movements are notoriously difficult to treat [3, 4]. This is primarily because the condition is hyperkinetic spinal motion without self-control. The continuous accumulation of excessive stress on the cervical spine from birth leads to severe deformities and multi-segmental lesions. The location and degree of damage vary with the pattern and intensity of the involuntary movements. However, the anterior structures, such as the vertebral bodies and intervertebral discs, are primarily damaged in most cases [5,6]. Once myelopathy or radiculopathy develops, neurological damage often worsens rapidly, and surgical treatment should be considered without delay [7]. We have been actively engaged in the surgical treatment of spinal fusion for over 35 years, and we have summarized the long-term outcomes and challenges in this paper.

Regarding the surgical strategy, intervertebral disc degeneration commonly extends to multiple segments at the mid-lower cervical level. As these pathological lesions are mainly located in the anterior cervical structure, neural decompression and cervical column reconstruction using an anterior approach are desirable. In addition, posterior fixation may provide initial stability to the unstable cervical spine to counteract hyperkinetic conditions. However, anchoring screws to the pedicle or lateral mass can be difficult because of severe deformity or sclerosis of the targeted structures [8]. Therefore, our primary choice for posterior stabilization was interspinous fixation using a pair of wave-shaped rods [9]. Consequently, combined anterior and posterior fusion on the same day (front–back fusion) is the standard protocol for subaxial lesions in patients with athetoid CP (Fig. 1).

For the upper cervical lesions, structures in the cranio-cervical junction are often compromised in cases of severe involuntary movement. The anterior reconstruction of this area is anatomically difficult, and posterior fixation is the primary method. Patients with CP frequently have hypoplasia of the atlas or severe deformation of the lateral atlantoaxial joint and often require fusion spanning from the occipital bone to the C2 level. We preferred to use tapes or wires to reinforce the anchors.

We performed the above-mentioned surgeries for both lesions on the same day when spinal cord compression lesions coexisted in the upper and middle/lower cervical spines. Overall, spinal fusion was the definitive surgical strategy across our cohort.

## Participants and Methods

Between 1983 and 2023, a total of 261 patients with athetoid CP underwent cervical spine fusion in our department. Of these, 224 patients were followed up until the final survey at the end of 2024 (follow-up rate: 85.8%, including 13 patients followed until death). They comprised 150 males and 74 females with an average age of 50.1 years (range, 19–76 years) at the time of initial surgery and an average follow-up of 13.0 years (range, 2–35 years). The initial surgical procedures included front–back fusion for subaxial lesions in 217 patients and posterior fusion above C2 in 23 patients. Sixteen cases involved simultaneous fusion of both regions. Among the upper cervical fusions, 15 involved extended fusion to the occipital bone (O-C fusion). Most patients required multisegmental fusion. (Table 1)

Table 1
Overview of participants

| **Age at surgery** | **Mean 50.1 (19–76) years old** |
|---|---|
| Gender | Male: 150 Female: 74 cases<br>Total 224 cases |
| Surgical procedure:<br>Subaxial front-back fusion | 217 cases |
| Posterior fusion<br>for upper cervical (above C2) | 23 (16 simultaneous subaxial fusion included) |
| Combined both surgeries | 16 |
| Number of fused segment(s): | |
| One | 21 cases |
| Two | 36 |
| Three | 87 |
| Four | 62 |
| Five | 7 |
| Six | 7 |
| Seven | 4 |

The severity of the involuntary neck movements (Athetoid Grade) was classified into five grades based on our original criteria. Grade III or lower movements could be controlled by the examiner's hand, whereas Grade IV or V could not. Nearly half of the patients were classified as having Grade IV or V movements (Table 2).

Table 2
Grade of neck involuntary movement (Athetoid Grade)

| Grade | Severity | Specific intensity of neck involuntary movement | Number |
|---|---|---|---|
| **I** | Slight | Mild involuntary movements are occasionally observed (during speech, etc.) | 0 |
| **II** | Mild | Involuntary muscle contractions can be clearly observed on the neck. | 6 |
| **III** | Moderate | Clear involuntary movements are observed in the neck with deviations of the shoulders and trunk. However, the neck movements can be controlled manually | 94 |
| **IV** | Strong | Strong involuntary movements cannot be restrained by an examiner's hands. | 114 |
| **V** | Strong & Rapid | Strong movements at high speed (moving the entire range of motion rapidly) | 10 |
| (Grade I refers to slight involuntary movements that appear under some stress such as speech. While none were found in the surgical cases investigated in this study, they are sometimes observed in daily clinical practice. There is a clinically significant boundary between grades III and IV.) | | | |

Physical ability and independence in activities of daily living were scored using the Barthel Index [10]. The neurological status was assessed using the Japanese Orthopaedic Association score for cervical myelopathy (JOA score) [11]. Radiographic examinations were used to evaluate the C2–C7 lordosis and focal lordosis angles of the fused segments preoperatively, postoperatively, and at the final follow-up. Instrument failure and bone union were also monitored. Bone union was determined by two spine surgeons (HM, TN) via dynamic radiography using Riew's criteria [12]. The cause, timing, and surgical procedure for reoperation were investigated. In addition, the cause of death and time from surgery to death were recorded for patients who died by the time of the final follow-up.

Statistical analyses were performed using SPSS version 29.0.1.0 (IBM Corp.; Armonk, NY, USA), and statistical significance was set at two-sided $p < 0.05$. The methods for analysis were selected according to the study objectives and included correlation analysis (Spearman’s correlation), group comparisons, multivariate logistic regression analysis, and Kaplan-Meier survival analysis.

Institutional Review Board approval (No. 1-26-5-1) was obtained for this retrospective observational study. Patient consent was obtained via an opt-out process. There were no conflicts of interest regarding this study.

## Results

# Improvement of clinical status

Preoperatively, the distribution of involuntary neck movements (Athetoid Grade) was as follows: Grade I (n = 0), II (n = 6), III (n = 94), IV (n = 114), or V (n = 10). At the final follow-up, 14 cases of Grade IV had

decreased to Grade III, and 6 cases of Grade V had decreased to Grade IV, showing a one-rank improvement each. However, no cases of worsening were observed.

The mean Barthel Index score significantly improved from 51.0 points preoperatively to 64.6 points at the final follow-up. The greatest domain improvement was observed for eating independence (+ 2.8 /10 points), while the least was observed for bathing (+ 0.3/5 points). The Barthel Index correlated with the preoperative Athetoid Grade, with a correlation coefficient of -0.32. The mean JOA score improved from 5.6 points preoperatively to 8.9 points (recovery rate, 29.5%) at the final follow-up (Table 3). The recovery rate was significantly correlated with the preoperative Athetoid Grade (correlation coefficient: -0.35), but no significant differences were found among the surgical site: subaxial fusion alone (28.9%), upper cervical fusion (30.7%), and combined fusion (32.0%).

Table 3
Clinical outcomes by preoperative Athetoid Grade

| | **Barthel Index** | | **JOA score** | | **Reoperation** | |
|---|---|---|---|---|---|---|
| | **Preoperative** | **Follow-up** | **Preoperative** | **Follow-up** | **Early** | **Late** |
| Grade II<br>n = 6 | 78.3 ± 19.7 | 90.0 ± 18.2 | 8.0 ± 2.1 | 11.2 ± 1.9<br>(33.5 ± 8.0%) | 0<br>(0%) | 2<br>(33.3%) |
| III<br>n = 94 | 57.8 ± 28.0 | 71.9 ± 29.1 | 6.2 ± 3.3 | 9.7 ± 3.4<br>(34.6 ± 18.3) | 3<br>(3.2) | 14<br>(14.9) |
| IV<br>n = 114 | 46.9 ± 28.5 | 60.8 ± 31.5 | 5.5 ± 3.4 | 8.4 ± 3.6<br>(26.7 ± 17.8) | 9<br>(7.9) | 22<br>(19.3) |
| V<br>n = 10 | 17.2 ± 9.1 | 20.6 ± 11.0 | 1.8 ± 1.5 | 3.7 ± 1.7<br>(12.5 ± 9.9) | 2<br>(20.0) | 3<br>(30.0) |
| Total | 51.0 ± 29.1 | 64.6 ± 31.4 | 5.6 ± 3.4 | 8.9 ± 3.6<br>(29.5 ± 18.3) | 14<br>P = 0.003 | 41<br>P = 0.277 |

(The number of reoperations represents the combined total of subaxial fusion and upper cervical fusion. The figures in parentheses indicate the JOA score recovery rate and reoperation rate. Comparisons of reoperation rates were performed using Fisher's exact test)

## Changes in radiographic parameters and bone union rate

For subaxial fusion cases, front–back surgery increased the mean focal lordosis angle from − 4.1 to 5.1° (average increase of 9.1°). Consequently, the mean C2–C7 lordosis angle improved from − 3.9° preoperatively to 6.2° postoperatively (average increase of 10.1°). At the final follow-up, the mean focal lordosis angle was − 0.2°, representing an average correction loss of 5.2°. When comparing the correction loss angle by the severity of athetosis, Grade V cases showed the highest mean value at 8.3 ± 6.7°; however, no significant differences were observed among the grades. The mean C2–C7 lordosis angle decreased to 0.6° at the final follow-up, which also showed no significant correlation with the Athetoid Grade. Bone union was achieved for 198 cases of subaxial fusion (union rate, 91.2%). Conversely, upper cervical fusion yielded bone union in 18 of 23 cases (78.3%), with 5 cases resulting in nonunion. Notably, four of the 15 cases (26.7%) involving fixation of the occipital bone resulted in pseudarthrosis at the occipitocervical junction. The inter-observer agreement rate regarding the assessment of bone union across all cases was 98%.

## Early reoperation (relating to instrument failure or infection)

Among the 217 subaxial fusion cases, 4 demonstrated early implant loosening (within 6 months) of the anterior plate or screws. Six patients experienced instrument failure related to posterior interspinous fixation (including two with anterior failure). Three patients developed posterior peri-implant infections. Ultimately, 12 subaxial cases required early reoperation (reoperation rate: 5.5%). For upper cervical fusion, 4 of 23 developed instrument failures (two screw backouts and two rod-plate breakages), with two requiring early reoperation (reoperation rate: 8.7%). Logistic regression analysis of the 14 early reoperations showed no significant correlation with sex, age, preoperative Barthel Index, or JOA scores. However, the early reoperation rate was significantly higher for patients with Athetoid Grade V (20.0%) than the other patients (5.6%). (Fig. 2)

**Late reoperation (relating to adjacent segment disease and/or upper cervical instability)**

Late reoperation (> 6 months postoperatively) was required for 40 patients who underwent subaxial fusion (18.4%). The primary causes were adjacent segment disease (ASD) in 23 cases and upper cervical instability (UCI) in 22 cases, with an overlap of both conditions in 5 cases. In contrast, only one patient who underwent upper cervical fusion (4.3%) required late reoperation due to subaxial instability. Regarding the timing of the late reoperation, the reoperation avoidance rate at 10 years was 67% for ASD and 79% for UCI. The mean postoperative time after initial surgery was 12.1 years for ASD, which was slightly shorter than the 14.8 years observed for UCI (Fig. 3). Patients requiring late reoperation were slightly younger at the time of the initial surgery than those who did not (47.6 vs. 50.6 years old), although this was not statistically significant. No significant correlations were found between late reoperation and sex, Barthel Index, or JOA score by multivariate logistic regression analysis. The association with the Athetoid Grade was also examined, but no correlation was found with the incidence of late reoperation (Fig. 2).

Regarding cervical alignment, patients requiring reoperation due to ASD showed significantly lower preoperative focal lordosis (-11.9°) than the non-reoperation group (-2.9°). This focal kyphosis was corrected to 3.9° postoperatively but reverted to -6.9° before the second surgery. The correction loss (mean, 11.5°) was significantly greater than that of the non-reoperation group (mean, 3.2°). Similarly, the pre-initial surgery and pre-reoperation C2–C7 lordosis angles were significantly lower in cases requiring reoperation due to UCI than for the non-reoperation cases, identifying them as key risk factors (Fig. 4).

## Effects of Athetoid Grade and Prognosis

The Athetoid Grade correlated significantly with early reoperation ($p < 0.05$) but not with late reoperation. Patients with Grade V movement experienced the greatest correction loss (8.3°), although this difference was not statistically significant.

No perioperative deaths occurred. Fifteen patients died during the long-term follow-up (mean age at death: 69.3 ± 13.7 years; mean postoperative time to death: 23.9 ± 10.1 years). The 10-year survival rate was 98.5%. The causes of death included cardiovascular events (n = 5), respiratory failure (n = 2), pneumonia (n = 2), and others. Four deceased patients (26.7%) had undergone prior cervical reoperation; however, no direct impact on the cause of death was noted. There was no correlation between the Athetoid Grade and mortality. At the final follow-up, the average age of the surviving patients was 63.4 years, and 31 patients were aged 75 years or older (including 13 patients aged > 80 years).

## Discussion

Neurological symptoms of cerebral palsy have traditionally been recognized as nonprogressive. However, it has recently become clear that increased medical care and social support are required over the long term because of secondary musculoskeletal or spinal disorders associated with aging and abnormal movement [2, 13]. This highlights the need for healthcare systems that accommodate “lifespan conditions.” Patients have inherent motor disorders, and it is difficult to detect secondary deterioration solely based on motor function. However, athetoid CP primarily involves extrapyramidal symptoms with rare congenital sensory impairments [14], and neurological examinations are crucial to detect early sensory disturbances. Cervical myelopathy in this cohort progresses rapidly, and conservative treatments are rarely effective [15]. Progressive functional decline severely reduces independence and increases the lifelong burden on families and caregivers. We have been actively engaged in the surgical treatment of this intractable disease for more than 35 years. The results of this study confirmed that surgical intervention improves both daily activities and neurological function, even in patients with severe disabilities. (Table 3)

Regarding the surgical strategy, we believe that primary treatment goal is reconstruction of the damaged cervical structures. Several studies have reported the success of laminoplasty with muscle release [16], but we advise extreme caution regarding its indications. Considering the hyperkinesis associated with this disease, it is rational for fusion surgery to become the standard approach. Several reports have

demonstrated good results with posterior fixation using a pedicle screw system [17]; however, accurate placement can be severely compromised by vertebral deformities and facet joint sclerosis [8]. Insufficient initial stability can lead to instrument failure, making salvage surgery even more difficult. We believe that simultaneous front–back fusion is the most reliable surgical procedure [6]. For posterior stabilization, our preferred interspinous fixation using a wave-shaped rod system provides long-term stability without damaging the bony structures [9]. Using this system, cervical realignment from the posterior can be achieved by adjusting the interspinous space(s) and rotational malalignment. This method preserves the osseous structures that provide a graft bed for favorable bone fusion. Anteriorly, segmental decompression and reconstruction are recommended to prevent large correction losses caused by involuntary neck movements (Fig. 1). Recent advances in internal fixation devices (such as intervertebral cages and anterior plates) have improved the success rate of anterior reconstruction [18], [19]. In particular, a dynamic-type or a semi-constrained anterior plate is recommended for this specific disease accompanied with hyperkinesis [20]. We believe that combining this approach with a wave-shaped rod system, which is also a semi-rigid method, reduces the risk of instrument failure. In contrast, the recurrence of myelopathy due to long-term ASD or UCI is strongly influenced by cervical alignment. In patients with severe preoperative kyphosis and strong athetoid movements, rekyphosis gradually advances postoperatively because of persistent mechanical loads on the cervical spine. However, surgery cannot eliminate the lifelong mechanical stress. To mitigate this, continuous stress should be minimized using perioperative medications such as botulinum toxin [21] or specialized multidisciplinary rehabilitation [22].

The life expectancy of patients with athetoid CP has increased due to advanced medical technology and management of secondary complications [23, 24]. In our study, the average age of surviving patients was 63.4 years. Surgical intervention was considered to have contributed to the improvements of ADLs and long-term survival.

The limitations of this study include its retrospective design and lack of a nonsurgical control group. Additionally, clinical outcomes are heavily influenced by systemic comorbidities and non-cervical disabilities [24]. Furthermore, this study evaluated long-term outcomes longitudinally, which may have been affected by temporal changes in surgical techniques, internal fixation devices, and postoperative management. In the statistical analysis, subgroup analyses with small sample sizes (n = 6 for Athetoid Grade II; n = 14 for early reoperation cases) limited statistical power and reliability. Radiographic measurements also represent only an instantaneous state and may not reflect the daily dynamic positioning of the patients. Nevertheless, tracking patient outcomes over a decade provides valuable insights into adjacent segment degeneration and cervical instability in a broader population, particularly given the extraordinarily high mechanical loads placed on the cervical spine in patients with cerebral palsy [25].

## Conclusion

This study evaluated the long-term surgical outcomes of 224 patients who underwent cervical fusion for secondary myelopathy due to athetoid CP. Surgical treatments primarily involving spinal fusion provided satisfactory and durable improvements in daily activities and neurological symptoms. No perioperative deaths were recorded, and the 10-year survival rate reached 98.5%, with many patients surviving until old age. However, late reoperation due to ASD or UCI was required for 40 patients (18.4%) following subaxial fusion surgery. Severe preoperative cervical kyphosis was identified as risk factors for late reoperation.

## Abbreviations

CP — cerebral palsy

ASD — adjacent segment disease

UCI— upper cervical instability

JOA— Japanese orthopaedic association

O-C— occipito-cervical

## Declarations

# Author Contribution

Author Contributions: HM contributed to the study design, evaluation of the results, and drafting of the manuscript. YT contributed to the study methodology and interpretation of the results. TN assisted with data measurement and statistical verification. AS and NK reviewed and verified the results and discussion. All authors read and approved the final manuscript.

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## References

1. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, Jacobsson B, Damiano D (2005) Proposed definition and classification of cerebral palsy. Developmental medicine & child neurology 47-8: 571-6
2. Kumar DS, Perez G, Friel KM (2023) Adults with Cerebral Palsy: Navigating the Complexities of Aging. Brain Sci. 13-9: 1296
3. McCluer S (1982) Cervical spondylosis with myelopathy as a complication of cerebral palsy. Paraplegia 20:308-12

4. Nishihara N, Tanabe G, Nakahara S, Imai T, Murakawa H (1984) Surgical treatment of cervical spondylotic myelopathy complicating athetoid cerebral palsy. JBJS 66-B: 504-8
5. Harada T, Ebara S, Anwar MM, Kenoki K, Yonenobu K, Tokunaga M, Ono K (1996) The cervical spine in athetoid cerebral palsy – A radiological study of 180 patients-. JBJS.78-B: 613-9
6. Onari K, Kondo S, Mihara H, Iwamura Y, Murata A, Niimura T, Toguchi T (2002) Combined anterior-posterior fusion for cervical spondylotic myelopathy in patients with athetoid cerebral palsy. J Neurosurgery (Spine 1) 97: 13-19
7. Imagama S, Ando K, Kobayashi T, Matsumoto Y, Ishiguro H (2022) Surgical outcomes of cervical myelopathy in patients with athetoid cerebral palsy. European Journal of Orthopaedic Surgery & Traumatology 32: 601-9
8. Kato S, Demura S, Yoshioka K, Yokogawa N, Tsuchiya H (2014) Morphological characteristics of cervical spine in patients with athetoid cerebral palsy and the accuracy of pedicle screw placement. Spine 39-8: 508-13
9. Mihara H, Onari K, Hachiya M, Toguchi T, Kondo S, Kaneda K (2001) Biomechanical comparison of posterior cervical fixation. Spine 26-15: 1662-7
10. Mahoney F, Barthel D (1965) Functional evaluation: The Barthel Index. Maryland State Medical Journal 14: 61-65
11. The Committee on the Assessment Criteria for Cervical Myelopathy of the Japanese Orthopaedic Association (1984) Journal of Japanese Orthopaedic Association 68(5): 490-497
12. Song KS, Piyaskulkaew C, Chuntarapas T, Buchowski J.M, Kim HJ, Park MS, Kang H, Riew KD (2014) Dynamic Radiographic Criteria for detecting Pseudarthrosis Following Anterior Cervical Arthrodesis. JBJS Am 96-7: 557-63
13. Murphy KP (2010) The adult with cerebral palsy. Orthop Clin North Am 41-4: 595-605.
14. Collis E, Collis W, Dunham W (1956) The infantile cerebral palsies. William Heinemann Medical Books, London
15. Kim HC, Oh SH, Oh JK, Watanabe K, Lee SH, Shin JH, Kim HJ, Park SM (2022) Surgical strategies and perioperative considerations for cervical deformity with cerebral palsy: A comprehensive review of the literature. Neurospine 19-4: 868-75
16. Ueda Y, Toshikawa T, Koizumi M, Nakao R, Yonenobu K (2005) Cervical laminoplasty combined with muscle release in patients with athetoid cerebral palsy. Spine 30-21: 2420-3
17. Demura S, Kato S, Tsuchiya H (2020) More than 10-year follow-up after laminoplasty and pedicle screw fixation for cervical myelopathy associated with athetoid cerebral palsy. Spine 45-11: 727-34
18. Chou YG, Chen DC, Hsieh WA, Chen WF, Yen PS, Hanold T, Bednar DA (2008) Efficacy of anterior cervical fusion: comparison of titanium cages, polyetheretherketone (PEEK) cages and autogenous bone grafts. J Clin Neurosci. 15-11
19. Stulik J, Pitzen TR, Chrobok J, Ruffing S, Drumm J, Sova L, Kryl J, Hehl J, Steudel WI (2007) Fusion and failure following anterior cervical plating with dynamic or rigid plates: 6-months results of a

multi-centric, prospective, randomized, controlled study. Eur Spine J. 16-10:1689-94

20. Mihara H, Onari K, Hachiya M, Watanabe K, Kondo S (2008) Study on reoperation cases of surgical therapy for cervical spondylotic myelopathy associated with athetoid cerebral palsy. Clinical Orthopaedic Surgery 43-5; 465-72
21. Furuya T, Yamazaki M, Okawa A, Moriya H, Sakamoto T, Matsuyama Y, Hoshino M, Toyone T, Takahashi K (2013) Cervical myelopathy in patients with athetoid cerebral palsy. Spine 38-3: E151-E157
22. Aisen ML, Kerkovich D, Mast J, Mulroy S, Wren TA, Kay RM, Rethlefsen SA (2011) Cerebral palsy: clinical care and neurological rehabilitation. Lancet Neurol 10-9: 844-52
23. Haak P, Lenski M, Hidecker MJC, Paneth N (2009) Cerebral palsy and aging. Dev Med Child Neurol. 40-4: 16-23
24. Blair E, Langdon K, McIntyre S, Lawrence D, Watson L (2019) Survival and mortality in cerebral palsy: observations to the sixth decade from a data linkage study of a total population register and National Death Index. BMC Neurol. 19-1:111
25. Ebara S, Harada T, Hosono N, Inami K, Hamada M, Yonenobu K, Ono K (1989) Unstable cervical spine in athetoid cerebral palsy. Spine 14:1154-59

# Figures

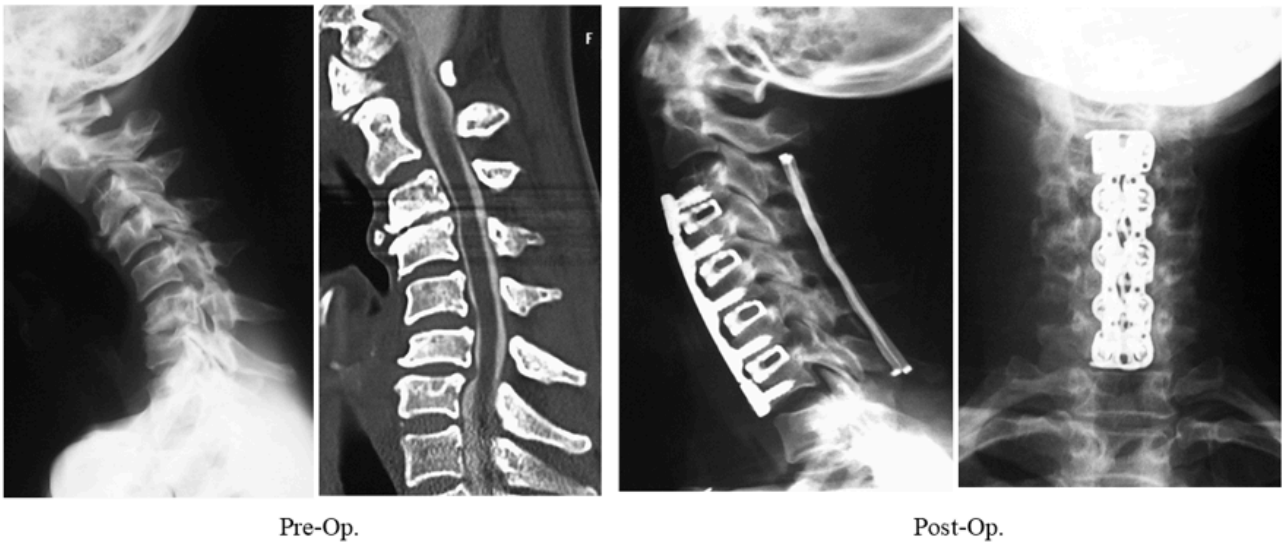



Fig.1 Front-back fusion for subaxial lesion

**Figure 1**

Front-back fusion for subaxial lesion

A representative case: 50-year-old woman with athetoid grade IV, Barthel index 35, and JOA score 8.0.

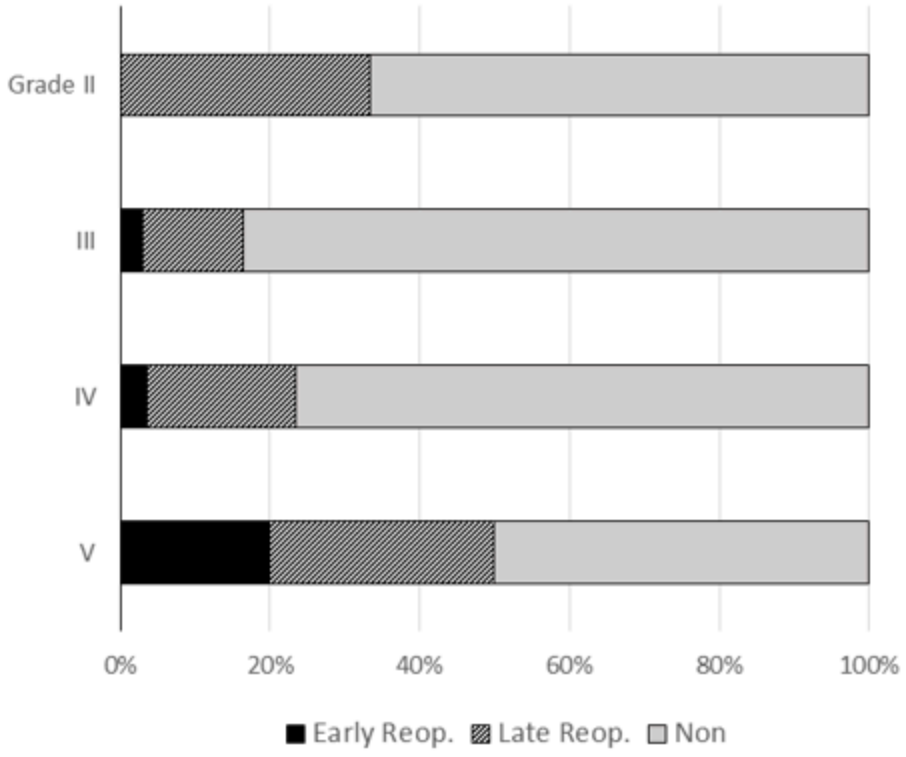



Fig. 2 Reoperation rate by Athetoid Grade

**Figure 2**

See image above for figure legend.

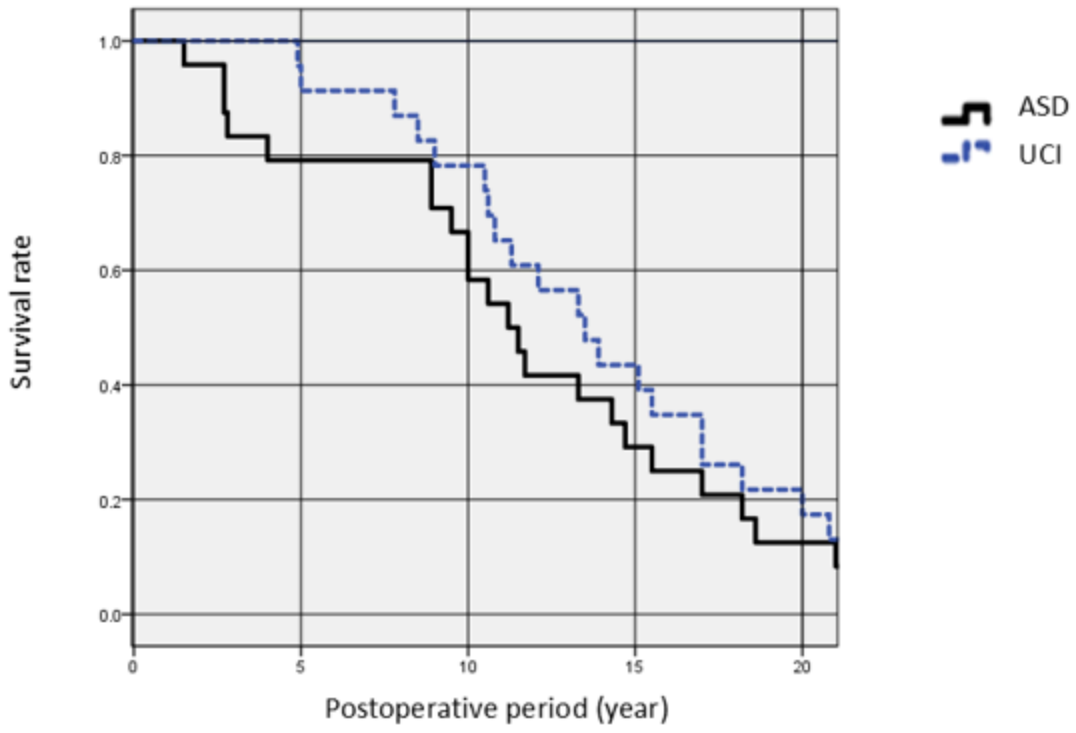



Fig. 3 Reoperation-free survival curve
(Set the event as reoperation due to ASD or UCI)

## Figure 3

See image above for figure legend.

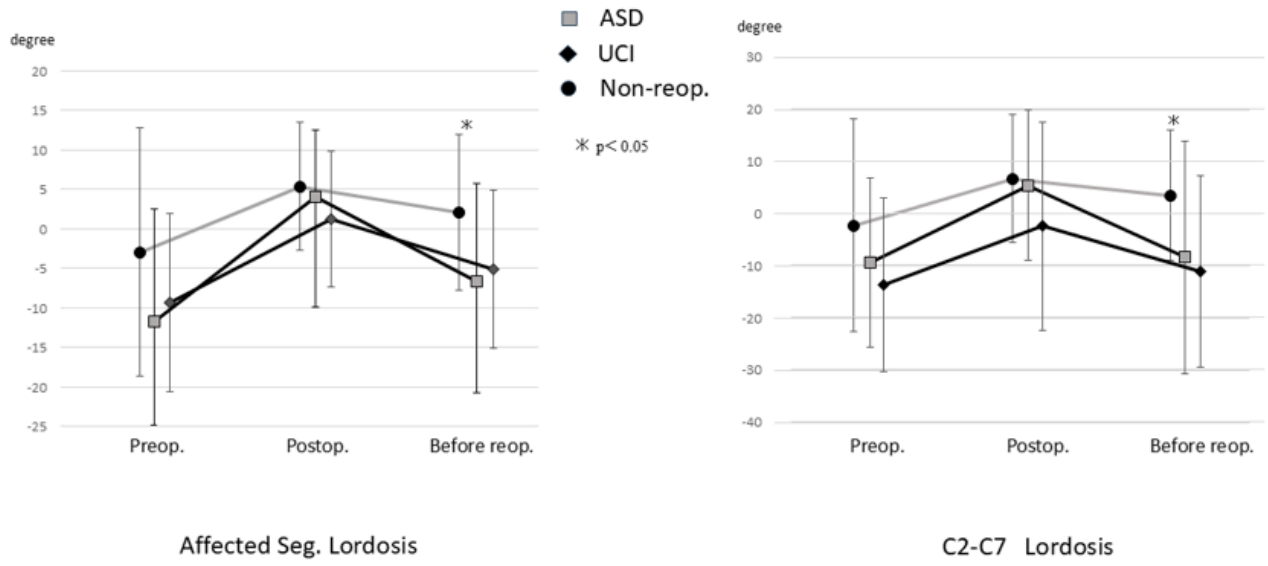



Fig.4 Cervical alignment and reoperation

## Figure 4

See image above for figure legend.