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# The Treatment of Traumatic Atlantoaxial Rotatory Subluxation (Fielding Type I) and the Correlation between the Clinical Progress and Radiological Reduction Parameter

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**Study Design:** This is a retrospective study.
**Objectives:** We will discuss clinical outcomes of adult traumatic atlantoaxial rotatory subluxation (Fielding type I) and verify the correlation between the clinical outcomes and radiological reduction rate.
**Summary of Literature Review:** Atlantoaxial rotatory subluxation which usually occur in children by non-traumatic sources or minor trauma has been discussed persistently. However, studies of atlantoaxial rotatory subluxation which occur in adults over 20 years old, especially by traumatic injury is rare.
**Materials and Methods:** From October 2004 to April 2011, thirty patients diagnosed of traumatic atlantoaxial rotatory subluxation with 6 months follow-up period were enrolled in the study. After diagnosis, we started treating Halter traction with 5 lbs. We discontinued traction when the patient recovered over 90% of ROM and applied Philadelphia collar to the patient. We measured visual analogue scale (VAS) for cervical pain and ROM. We measured atlanto-dens interval (ADI) and lateral mass-dens interval (LDI) difference using three-dimensional computed tomography (3D-CT) to validate radiological reduction rate.
**Results:** At the end of follow-up, none of the patients complained over pain and all recovered to full ROM. ADI was in normal range during the whole treatment period. LDI difference gradually decreased during treatment period, however, only 8 cases (26.7%) came back to normal range.
**Conclusions:** In traumatic atlantoaxial rotatory subluxation (Fielding type I), satisfactory clinical outcomes such as pain relief or ROM improvement using traction and the radiological reduction rate was also improved but it failed to achieve a complete reduction of LDI difference in radiography.

**Key Words:** Adult, Atlantoaxial subluxation, Fielding type I , three dimensional computed tomography

## INTRODUCTION

Clinical presentations of atlantoaxial rotatory subluxation are limited painful ROM and cock-robin posture being rotated to the one side and tilted to the other side. There is an asymmetrical rotation in atlanto-dens interval (ADI) and lateral mass-dens interval on radiological examination.[1] Fielding et al classified atlantoaxial rotatory subluxation into 4 types according to the atlanto-dens interval and the forms of anterio-posterior rotation.[2] Among these, type 1 is the only one that has intact transverse ligament with normal atlanto-dens interval.[2, 3]

There are a number of studies about pediatric atlantoaxial rotatory subluxation from type 1 to type 4 (Fielding classification) to date. The causes for this are known to be the

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본 논문의 요지는 2007년도 대한척추외과학회 추계학술대회에서 발표되었음.

genetic disorders and mild injuries such as upper respiratory tract infection, head and neck operation, Down syndrome and Morquio's syndrome.[3,4] On the other hand the cause of atlantoaxial rotatory subluxation of patient older than 20 years old is thought to be due to severe trauma[5] and much discussion about this haven't been taken placed apart from only several case reports. Therefore, the continuous studies regarding whether applying established management methods of pediatric atlantoaxial rotatory subluxation to the adult traumatic atlantoaxial rotatory subluxation is required.

For this reason, the authors aimed to discuss the correlation between the treatment results, radiological reduction rate and clinical outcomes in adult traumatic atlantoaxial rotatory subluxation (Fielding type 1) which the authors experienced.

## RESEARCH SUBJECTS AND METHODS

The subjects were 30 patients who were older than 20 years old and were diagnosed with traumatic atlantoaxial rotatory subluxation between October 2004 and April 2011 and had follow-up period of at least 6 months. The observation period was between 6 months and 18 months and the mean observation period was 7.7 months. The mean age was 23.6 years old and there were 29 male patients and 1 female patient. In terms of the mechanisms of the trauma, the 15 cases had hyperflexion injuries caused by the cervical area being pulled by someone else, 2 cases had traffic accidents, 11 cases had head and cervical injuries caused by collapse on the floor and 2 cases were injured by violence. The direction of atlantoaxial rotatory subluxation was right in 14 cases and left in the 16 cases.

All 30 cases started Halter traction with 5 lbs. when the diagnosis was made and the pain and the recovery of ROM were observed periodically. Visual Analogue Scale (VAS) was used to measure the degree of pain. The traction was removed and Philadelphia collar was applied to support activities of daily living when ROM was recovered (more than 90% of normal range was achieved-40 degree of flexion, 40 degree of extension, 70 degree of left and right rotation). The patients were advised to keep Philadelphia collar for 8 weeks. The first hospital attendance, the time of pain relief, the time of ROM recovery and VAS for cervical pain and ROM range (flexion, extension and rotation to the right and the left) in 2 weeks, 4 weeks and 8 weeks after application of Philadelphia collar were measured to evaluate the clinical outcomes.

Cervical spine 3D CT was performed at each time and atlanto-dens interval (ADI) and lateral mass-dens interval (LDI) (Fig. 1.) were measured independently by 4 orthopedic specialists to observe the radiological reduction rate.

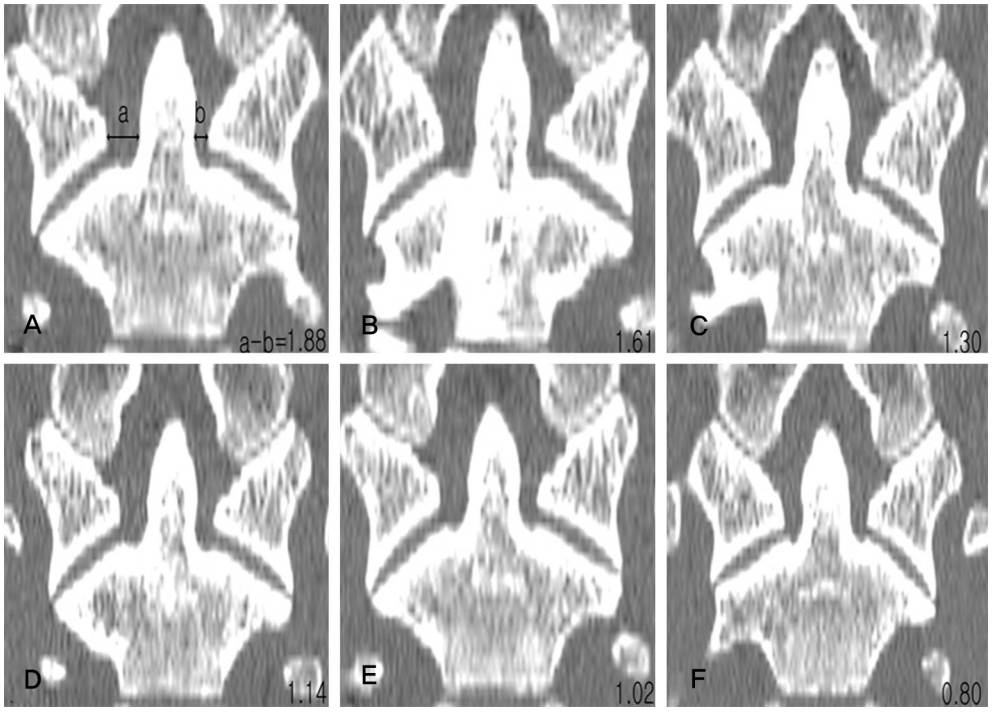


**Fig. 1.** The following 3D-CT coronal images are in the order as following; **(A)** initial, **(B)** pain relief, **(C)** full ROM recovery and **(D)** 2 weeks, **(E)** 4 weeks, **(F)** 8 weeks after applying a brace. Lateral mass-Dens Interval (LDI) difference is calculated by subtracting b from a.

**Table 1.** VAS, ROM and LDI difference

| The point of | VAS* | ROM† | | | LDI‡ difference |
|---|---|---|---|---|---|
| | | Flexion | Extension | Rotation to subluxated direction /Rotation to opposite direction | |
| Diagnosis | 8.0±0.7 | 21.5±7.6 | 19.3±10.1 | 47.0±10.2/33.0±9.2 | 1.9±1.0 |
| Pain relief | 1.3±0.5 | 34.2±6.2 | 29.8±8.4 | 64.3±7.2/57.0±7.9 | 1.6±0.7 |
| ROM recovery | 0.3±0.5 | 45 | 45 | 80/80 | 1.5±0.8 |
| brace for 2 weeks | 0 | 45 | 45 | 80/80 | 1.4±0.7 |
| brace for 4 weeks | 0 | 45 | 45 | 80/80 | 1.0±0.5 |
| brace for 8 weeks | 0 | 45 | 45 | 80/80 | 0.9±0.5 |

*VAS; visual analogue scale, †ROM; range of motion, ‡LDI; Lateral mass-dens interval

Intraclass correlation coefficient was used to test the reliability of each specialist as a statistical analysis.

Wilcoxon signed rank test was used to analyze the correlation between clinical outcomes and lateral mass-dens interval from the initial hospital attendance to the time of ROM recovery and Friedman test was used to analyze the correlation between clinical outcome and lateral mass-dens interval throughout the whole follow-up period.

## RESULTS

None of the 30 patients complained of cervical pain during the final follow-up and there was no limited ROM observed. The time of diagnosis and the initial treatment was 2.8±2.6 days after the trauma and the pain started to ease 3.8±1.3 days after and the ROM started to recover 9.2±1.8 days after the commencement of the treatment and VAS was significantly improved from 8.0±0.7 (at the time of the initial diagnosis) to 1.3 ±0.5 (at the time of pain relief) and it was persistently reduced and reached down to 0.3±0.5 when ROM was recovered. None of the patients complained of pain from 2 weeks after the application of Philadelphia collar to the final follow-up (Table 1). The ROM at the time of initial diagnosis were 21.5±7.6° of flexion, 19.3±10.2° of extension, 47.0±10.2° of rotation towards the subluxation and 33.0±9.2° of rotation towards the opposite direction of the subluxation. These were improved to 34.2±6.2° of flexion, 29.8±8.4° of flexion, 64.3±7.2° of rotation towards the subluxation and 57.0±7.9° of rotation towards the opposite direction of the subluxation when the pain started to ease. The maximum ROM was possible at the time of ROM recovery (Table 1) and cock-robin posture was disappeared in all the patients.

**Table 2.** Data analysis using Wilcoxon test

| | The point of diagnosing a disease ~ ROM recovery |
|---|---|
| Z | -3.261(a) |
| Two-tailed p-value | 0.01> |

**Table 3.** Data analysis using Friedman test

| The point of | Average of the ranks |
|---|---|
| Diagnosis | 3.73 |
| Applying brace for 2 weeks | 3.02 |
| Applying brace for 4 weeks | 2.07 |
| Applying brace for 8 weeks | 1.18 |
| N | 30 |
| Chi-square | 66.993 |
| Degree of freedom | 3 |
| p-value | 0.01> |

The atlanto-dens interval during the follow- up was all less than 3mm on 3D CT scan. The lateral mass-dens interval at the time of initial diagnosis was 1.9±1.0mm, 1.6±0.7mm at the time of pain relief, 1.5±0.8mm at the time of ROM recovery, which shows correlation between radiologic findings and clinical ($p<0.01$) (Table 2). The lateral mass-dens interval at the 2nd week, 4th week and 8th week after the application of Philadelphia collar was 1.3±0.7mm, 1.0±0.5mm and 0.9± 0.5mm respectively (Fig. 2.) showing a significant reduction as the clinical outcome was improved ($p<0.01$) (Table 3). However, the lateral mass-dens interval was still in abnormal range even at the final follow-up in most of the cases (73.3%) (Table 1). The recovery to the normal range was observed in only 8 cases (26.7%)

## DISCUSSION

Simple X-ray or CT is used for the diagnosis of atlantoaxial rotatory subluxation. However, it is difficult to reach correct diagnosis with X-ray because the patient usually has severely bended head and stiff neck in many cases. Moreover, the proximal bone structures such as mandibular bone or occipital bone can be overlapped which makes it difficult for diagnosis. CT scan minimizes these problems but it has its own limitations.[3, 6] The author also experienced difficulties to reach a correct diagnosis with X-ray due to the patients' abnormal postures in many cases and 3D CT provided accurate diagnostic image of atlantoaxial relation in these cases.

Philadelphia collar and retraction are commonly used to treat pediatric atlantoaxial rotatory subluxation and the suggested criteria to decide the treatment method and the time of the treatment are alleviation of pain, recovery to normal ROM range and the correction of deformity.[7] Among criteria, the correction of deformity has been thought to be the most important criteria.

Among the suggested management methods of pediatric atlantoaxial rotatory subluxation, Fielding et al [2] suggested skull traction (starting with 3.2~3.6kgs in children, 6.8kgs in adults and increase 0.5~0.9kg every 3-4 days up to 6.8kgs in children and 9.1kgs in adults until the deformity is corrected) should be started initially and the reducted condition had to be maintained for 3 months by using various forms of cervical immobilization methods when the deformity was corrected. Subach et al.[4] recommended observing for 2 weeks after rigid immobilization using cervical collar and additional closed reduction with cervical traction should be followed if the deformity is not corrected and additional 6 weeks immobilization should be followed if the deformity is reducted.

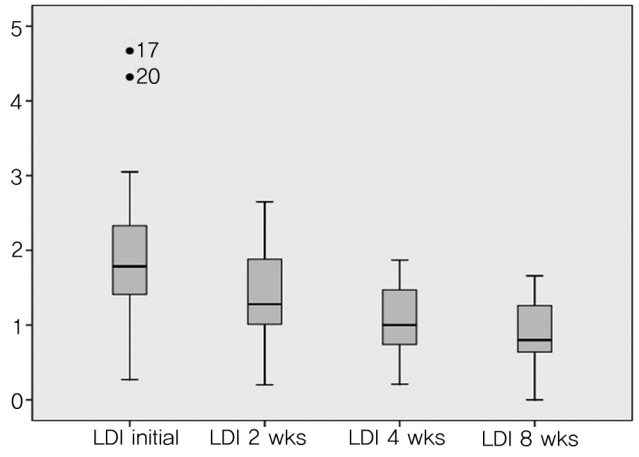


**Fig. 2.** The following graph shows Lateral mass-Dens Interval(LDI) difference at diagnosing point, 2 weeks, 4 weeks, 8 weeks after applying a brace.

Since then, various management methods have been suggested by a number of different authors but most of them have agreed on that it can be observed administering anti-inflammatory and immobilization with soft cervical collar for 1-2 weeks and that cervical traction is the most appropriate treatment for injuries within 3 months. If the injury onset was longer than 3 months, the satisfactory outcome can be expected by an operation. [1,8-10]

It is known that the early diagnosis is essential for the successful non-invasive reduction in adult atlantoaxial rotatory subluxation and the need for the invasive reduction increases when the reduction is delayed for several months[5,11] like the pediatric atlantoaxial rotatory subluxation. However, there aren't enough systemic studies regarding adult atlantoaxial rotatory subluxation based on Fielding type 1, 2 and 3, and only there are several reports of bilateral atlantoaxial rotatory subluxation cases caused by trauma to date.[11-17] All the known treatment principle is that less than 3mm of atlantoaxial interval indicates no damage in transverse ligament [14,18-21] and conservative management is recommended in this case.[22] The suggested treatments are either 3 weeks SOMI collar followed by 6 weeks Halo retraction[16] or simple 3 months Halo retraction.[20] There weren't clear management methods suggested in some literature.[15]

The authors established the management plan referencing to all the suggested treatment methods in literature for both pediatric and adult atlantoaxial rotatory subluxation to date under the principle of adult traumatic atlantoaxial rotatory subluxation. The time for the retraction removal and the time for the additional collar were consulted to the principle of pediatric atlantoaxial rotatory subluxation.[7] It was decided to focus on clinical progression as long as there was a clinical improvement although the correction of the deformity wasn't proportioned to the other two clinical signs of improvement based on the evidence that radiological reduction was not completed in some pediatric cases despite the improvement on symptoms and the deformity. [4, 23, 24]

The 30 cases that the authors experienced were type 1 Fielding with the normal range of atlanto-dens interval. All the cases were diagnosed within a week after the trauma and they all received conservative management. There was a significant

persistent increase in the level of radiological reduction as the clinical outcomes improved based on radiological index up to the final follow-up. Nevertheless, only 26.7% (8 cases) of them succeeded in reduction to the normal range and the rest of them were fail to reach to the complete reduction. Despite this, none of the patients complained of recurrent cervical pain or worsening ROM until the final follow-up. In other words, the clinical outcome such as relief of pain and recovery of ROM should be valued when type 1 Fielding adult traumatic atlantoaxial rotatory subluxation is treated as it does in pediatric atlantoaxial rotatory subluxation and the principle being focused on the deformity reduction might be inappropriate.

Unfortunately, the researches were limited to the type 1 Fielding adult traumatic atlantoaxial rotatory subluxation. Hence, further research on other types of traumatic atlantoaxial rotatory subluxation will be required in the future.

## CONCLUSION

It is judged that the traction treatment for Fielding type 1 adult traumatic atlantoaxial rotatory subluxation is required only until the ROM is recovered. The satisfactory clinical outcome was obtained although complete radiological reduction was not obtained. The clinical outcomes such as relief of pain or ROM recovery to the normal range are thought to be a vital data to predict the prognosis and the complete radiological reduction might not be the feasible treatment purpose.

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## 성인에서 발생한 외상성 환축추 회전성 아탈구(Fielding 제 1형)의 치료 및 임상경과와 방사선상 정복 지표 간의 관계

김성완 • 안영준 • 양보규 • 이승림 • 김석진
국립경찰병원 정형외과

**연구 계획:** 후향적 연구
**목적:** 성인에서 발생한 Fielding 분류 제 1형의 외상성 환축추 회전성 아탈구 환자들의 치료 결과 및 방사선상 정복 정도와 임상경과 사이의 관계를 고찰하였다.
**선행문헌의 요약:** 보통 소아에서 비외상성 또는 가벼운 외상에 의해 발생하는 환축추 회전성 아탈구에 대한 논의는 지속적으로 있어 왔으나, 20세 이상의 성인에서 특히 외상에 의해 발생한 경우에 대한 논의는 부족한 실정이다.
**대상 및 방법:** 2004년 10월부터 2011년 4월까지 20세 이상으로 외상성 환축추 회전성 아탈구로 진단받고 최소 6개월 이상 추시가 가능했던 30예를 대상으로 하였다. 진단된 시점부터 Halter 견인을 5 lbs 로 시작하였다. 90% 이상의 관절운동범위 회복 시점에서 견인을 해제하고 보조기(Philadelphia collar)를 착용 하였다. 경부통에 대한 Visual Analogue Scale(VAS), 관절운동범위를 측정하였다. 방사선상 정복 정도를 추시하기 위하여 경추부 3차원 재구성 전산화 단층촬영을 시행하여 환추-치돌기 간격, 외측괴-치돌기 간격차를 측정하였다.
**결과:** 최종 추시 상 30예 모두에서 경부통의 호소는 없었고, 관절운동범위의 제한은 관찰되지 않았다. 환추-치돌기 간격은 치료 기간 내내 정상 범위였다. 외측괴-치돌기 간격차는 치료기간 동안 점차 감소하였으나 최종 추시 시점에 정상 범위로 정복된 경우는 단 8예(26.7%)였다.
**결론:** Fielding 분류 제 1형의 외상성 환축추 회전성 아탈구 환자에서 견인을 통해 임상적으로 만족스러운 통증의 경감과 관절운동범위의 회복을 얻었고 방사선학적 정복 지표도 향상되었지만 외측괴-치돌기 간격차의 완벽한 정복을 보이진 않았다.

**색인 단어: 성인, 환축추 회전성 아탈구, Fielding 분류 제 1형, 3차원 재구성 전산화 단층촬영**
**약칭 제목: Fielding 1형 환축추 회전성 아탈구의 치료**