



Clinical Results of Odontoid Fractures according to a Modified, Treatment-Oriented Classification

Eui-Jin Cho,
Se-Hoon Kim,
Won-Hyung Kim,
Sung-Won Jin,
Seung-Hwan Lee,
Bum-Joon Kim,
Sung-Gon Ha,
Sang-Dae Kim,
Dong-Jun Lim

Department of Neurosurgery, Korea University Ansan Hospital, Korea University College of Medicine, Ansan, Korea

Corresponding Author:

Se-Hoon Kim

Department of Neurosurgery, Korea University Ansan Hospital, Korea University Medical Center, 123 Jeokgeum-ro, Danwon-gu, Ansan 15355, Korea

Tel: +82-31-412-5050

Fax: +82-31-412-5054

E-mail: sehoonkim.2016@gmail.com

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Objective: Odontoid fracture is common in cervical injury, representing about 20% of total cervical fractures. Classic odontoid fracture classification focused on anatomy of fracture site has no treatment recommendation and a modified treatment-oriented classification of odontoid fracture was suggested in 2005. We reviewed our odontoid fracture patients to assess the feasibility and efficacy of Grauer's classification.

Methods: Between October 2000 and September 2015, we collected data from patients who came to our institute for odontoid fracture. Demographic data of patients was reviewed, and neck visual analog scale (VAS) score and fusion rate were assessed by reviewing electronic medical records retrospectively.

Results: Sixty-nine patients out of a total of eighty two odontoid fracture patients were reviewed according to Grauer's classification. Neck VAS of all subtypes in odontoid fracture classification were decreased at last follow-up ($p=0.001$). Overall fusion rate was 88.4% at last follow-up. Concordance rate between Grauer's recommendation and our treatment was 69.9%, especially in type II with the concordance higher than 80%. Complication was minimal representing 7.2%, only in types I and III.

Conclusion: In this study, there were statistically significant improvement in all subtypes in terms of neck VAS at the last follow up, especially in types II and III. Grauer's classification appears to be meaningful to decide treatment plan for odontoid fractures, especially type II odontoid fracture.

Key Words: Odontoid fracture, Treatment, Classification

INTRODUCTION

In spinal injury population, over 60% is related in cervical injury¹². About 20% of cervical spine fractures are odontoid fractures¹⁰. In younger patients, these fractures are usually made by high-velocity accidents, whereas falls in elderly patients⁸. There are variable treatment options from collar immobilization (including collar, halo-vest) to anterior screw fixation or posterior fusion. Anderson and D'Alonzo² proposed a classification of odontoid fractures and their classification has been still used till today. But classification of Anderson and D'Alonzo has no treatment guideline, and the treatments of odontoid fracture are controversial. In 2005, Grauer et al.⁸ proposed a modified, treatment-oriented classification of odontoid fractures. This classification divided odontoid fractures into 3 groups, especially type II fractures into three subgroups (subclass A, B, and C). We reviewed odontoid fracture patients treated in our institute to assess the feasibility and efficacy of the Grauer's classification.

MATERIALS AND METHODS

1. Patients

Between October 2000 and September 2015, we reviewed patients who were diagnosed with odontoid fracture in Korea University Medical Center. We excluded any patients refused recommended treatments or, were transferred to other hospitals. We checked all patients regarding neck visual analogue scale (VAS) score at initial or preoperative and postoperative or final follow-up. Orthotopic, lateral, and open mouth X-rays, Occipitocervical computed tomography (CT) or 3-dimensional reconstruction CT (3D-CT) were evaluated at pretreatment and post-treatment states in all patients. Cervical magnetic resonance imaging (MRI) was evaluated at pretreatment state in all patients, and for patients with spinal cord injury patients, follow-up cervical MRI was also performed at posttreatment state. More than 1-year follow-up was done in all patients and mean follow-up period was 25.52 months (range, 12–60 months). Simple

& dynamic cervical spine X-ray, 3D-CT follow-up for instability and fusion assessment were done at 1-year follow-up.

2. External Fixation or Surgical Treatment

In 30 patients, immobilization was performed with cervical Halter traction or skull traction for 2 weeks, and then Halo-vest for 3 months. Some patients who were not able to do Halo-vest, external immobilization was done with Philadelphia brace for the same duration.

Anterior cervical stabilization was done via anterior odontoid screw fixation using a odontoid screw in 21 patients. UCSS (Medtronic Inc., Minneapolis, MN, USA) anterior cannulated odontoid lag screw 3.5 mm in diameter was implanted in all cases. All patients wore Philadelphia brace for three months.

Posterior stabilization was done with C1 lateral mass—C2 pedicle screws in 18 patients. The 3.5-mm diameter and 22- to 26-mm length atlanto-axial lateral mass/pedicle screws were placed at both intersection 2 mm above the lower edge of posterior arch and medial clination of 5–10 degree. All patients wore Philadelphia brace for 3 months.

3. Statistics Analysis

Statistical analysis was performed with SPSS ver. 13.0 (SPSS Inc., Chicago, IL, USA). A p-value of <0.05 was considered statistically significant. Paired Student t-test was used for comparing pre- and posttreatment VAS score.

RESULTS

We reviewed 82 odontoid fracture patients who came to our institute from October 2000 to September 2015. Thirteen patients were excluded due to refusal of treatment or transfer to other hospitals. Finally, 69 patients were reviewed according to

Table 1. The demographics of patients with odontoid fracture at presentation (n=69)

Variable	Value
Age (yr)	49.8±19.6
Sex	
Male	50
Female	19
Trauma mechanism	
Fall	43
Motor vehicle accident	20
Others	6
Additional cervical fracture	11
Associated spinal cord injury	2
VAS score	6.17±1.83
Follow-up period (mo)	25.5±12.1

Values are presented as mean±standard deviation or number. VAS, visual analog scale.

Grauer's classification and we compared our treatment with recommended treatment by Grauer's classification and reviewed efficacy of Grauer's classification.

Fifty male and nineteen female patients were reviewed. Average of patient age was 49.8 years old and standard deviation was 19.6 years. Most of the patients (43 patients, 62.3%) were injured by fall down, 20 (29.0%) by vehicle accident, 6 by others such as fighting and so on. 11 patients were found to have other cervical spine fracture in addition to odontoid fracture. Two patients had cord injury and weakness, quadriplegia. Initial VAS pain score was 6.17±1.83 (Table 1).

According to Grauer's classification, 3 patients were in type I fracture, 4 in type IIA, 16 in type IIB, 8 in type IIC, and 38 in type III. In type I, external immobilization is recommended treatment by Grauer's et al.⁸⁾. Concurrence of treatment in type I fracture was 1 patient of total 3 patients (33.33%). One patient was treated with anterior odontoid screw fixation, the other was treated with posterior screw fixation. In type IIA, all were corresponded with recommend treatment of Grauer's classification, external immobilization. In type IIB, 13 of 16 patients (81.25%) underwent anterior screw fixation, 2 treated with external fixation, and 1 was treated with posterior screw fixation. In type IIC, 7 of 8 (87.5%) were treated with posterior screw fixation, the other with external immobilization. In type III, 23 of 38 (60.5%) were treated with external immobilization, but 8 with anterior screw fixation, 7 with posterior screw fixation.

In all subtypes of odontoid fracture, VAS pain score was decreased after treatment (p<0.05 in subtypes IIB, IIC, and III) (Table 2). Fusion rate was higher than 87% in all subgroups except type I (66.6%) which might be because of small number

Table 2. Analysis of neck VAS according to Grauer's classification

Type	Pre VAS	Post VAS	p-value
I (n=3)	4.67±2.87	2.33±0.94	0.180
IIA (n=4)	7.25±0.83	4.75±0.43	0.062
IIB (n=16)	6.50±2.03	3.19±1.18	0.001
IIC (n=8)	6.25±1.48	3.75±1.85	0.016
III (n=38)	6.03±1.68	3.05±1.52	0.001
Total (n=69)	6.17±1.83	4.70±1.51	0.001

Values are presented as mean±standard deviation.

VAS, visual analog scale; Pre, pretreatment; Post, posttreatment.

Table 3. Analysis of treatment results of 69 odontoid fractures according to Grauer's classification

Type	Concordance	Fusion rate	Complications
I (n=3)	1 (33.3)	2 (66.6)	1 (33.3)
IIA (n=4)	4 (100)	4 (100)	0 (0)
IIB (n=16)	13 (81.3)	15 (88.2)	0 (0)
IIC (n=8)	7 (87.5)	7 (87.5)	0 (0)
III (n=38)	23 (60.5)	34 (91.9)	4 (10.5)
Total (n=69)	48 (69.9)	61 (88.4)	5 (7.2)

of patients. Complications such as uncontrolled pain, instability were found only in type I, III patients treated with external immobilization, not surgical treatment (Table 3). According to Grauer's classification, concurrence of actual treatment was highly related in type II fractures.

DISCUSSION

In traumatic cervical spinal injury, odontoid fracture is a common injury. There are several classifications of odontoid fractures. Schatzker's classification divided odontoid fracture into 2 groups; fracture at below and above attachment of accessory ligaments¹⁵. Mourgue's classification proposed 2 groups as fracture at base (union rate 100%) and neck (union rate less than 50%)⁶. Althoff's classification proposed 4 types of odontoid fractures; first type with fracture above the neck have a pseudoarthrosis rate about 64%, second type fracture is through the neck and have pseudoarthrosis rate around 55%, third type in which the fracture includes lateral mass have 50% union rate, fourth type concerns fractures at body of vertebral axis and have high rate of union about 93%¹. Commonly applied odontoid fracture classification, Anderson and D'Alonzo classification, and Grauer's classification have no difference in types I and III. In types I and III odontoid fracture, fracture line was usually in cancellous bone, so healing rate of both fracture groups are relatively high⁵. Therefore, external immobilization (including traction, halo-vest fixation, brace immobilization, and so on) was used commonly in types I and III odontoid fractures. Type II odontoid fracture is on connection of odontoid and vertebral body, and it makes injury in blood vessel commonly^{7,16}. It makes fracture healing poor, so external immobilization is not proper to treat type II odontoid fracture. So, Grauer et al.⁸ suggested new classification in 2005, that distributed type II fracture to 3 subtypes, IIA, IIB, and IIC. Type IIA odontoid fracture is transverse fracture without comminution and displacement is less than 1 mm. Type IIB is fracture that fracture line is anterosuperior to posteroinferior direction or displacement is over than 1 mm. Type IIC is fracture that fracture line is anteroinferior to posterosuperior direction or has significant comminution (Fig. 1). Each types have different treatment recommendation as Table 4⁸.

There is controversy about proper treatment in odontoid fractures³. We treated odontoid fracture patients (1 in type I, 4 in type IIA, and 23 in type III) with immobilization as Grauer's

classification recommendation. In our cases, union rate is relatively higher (over than 85%) although several papers have high nonunion rate (13%–72%) with immobilization^{13,14}. Generally,

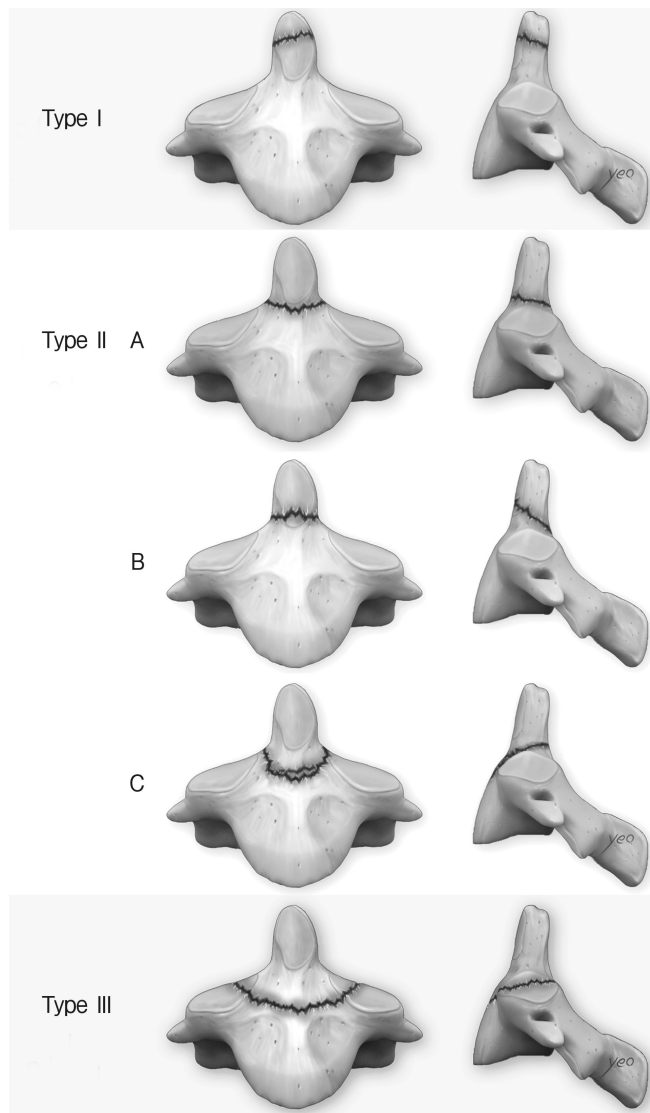


Fig. 1. Proposed subclassification of type II odontoid fracture by Grauer et al.⁸.

Table 4. Proposed classification and treatment algorithm of Odontoid fractures by Grauer et al.⁸

Subtype	Description	Treatment guideline
Type I	Above inferior aspect of C1 anterior arch	External immobilization*
Type II	Between types I and II fractures	
Type IIA	Nondisplaced fracture	External immobilization
Type IIB	Anterior superior to posterior inferior and displaced transverse fractures	Anterior screw fixation
Type IIC	Anterior inferior to posterior superior or comminuted fractures	Posterior atlantoaxial fusion
Type III	Including at least one of the superior articular facets of C2	External immobilization

*Halo-vest fixation or Philadelphia brace.

external immobilization is contraindicated because of low bone density, decreased blood supply, etc.⁷. So, we treated old age patients by anterior or posterior screw fixation although they are in type I, III odontoid fracture. Complication such as uncontrolled neck pain, instability was seen in several cases, but overall complication rate was low. We can consider external immobilization as primary treatment in type I, III patients without any contraindications.

Anterior odontoid screw fixation has clinical effect about high fusion rate and preservation of cervical rotation⁹. Thirteen patients of type IIB, some patients in other types were treated with anterior odontoid screw fixation (Fig. 2). There was no complication such as pain aggravation, displacement and so on. All 13 patients treated with anterior odontoid screw in type IIB fracture were recovered with bone union. Eight patients in type III fracture were also treated with anterior screw fixation. There was no complication and successful recovery in almost patients. All patients who were treated with anterior odontoid screw fixation

had no or minimal limitation of neck rotation. As this result, anterior screw fixation can be a good treatment option in type IIB odontoid fracture if operation is available and avoid excessive neck exercise after operation.

Posterior atlanto-axial pedicle screw fixation and wiring were considered as preferred treatment options in type II odontoid fractures, previously^{4,11}. It was done in 7 patients with type IIC. Some patients who had severe displacement, were not profit to Halo-vest fixation were also treated with posterior screw fixation. Bone union rate was high (87.5% in type IIC) and complication rate was very low (only 1 case in type III, broken screw by secondary trauma). All patients suffered from limitation of neck rotation. Over all fusion rate was higher than 90% in cases of posterior atlanto-axial screw fixation. Posterior atlanto-axial screw fixation can be a good option for type III or severe displacement odontoid fracture patients. In cases of difficult placement of C2 pedicle screw from narrow pedicle or high-riding vertebral



Fig. 2. An illustrative case of type IIB patient treated by anterior odontoid screw fixation. A 15-year-old male patient had odontoid fracture, type IIB by Grauer's classification from a vehicle accident trauma. Initial X-ray (A) and CT (B) were evaluated. Anterior screw fixation was done and follow-up X-ray (C) and CT (D) were evaluated at postoperative 12 months, which demonstrated bone union at the fracture site.

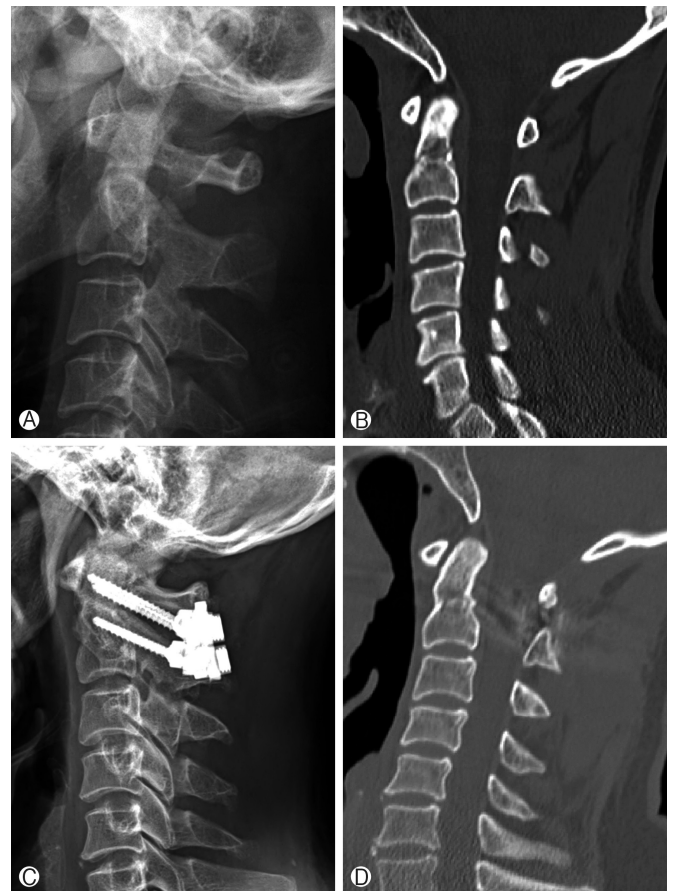


Fig. 3. An illustrative case of type IIC patient treated by posterior atlanto-axial translaminar screw fixation. A 40-year-old male patient was diagnosed of odontoid fracture, type IIC by Grauer's classification from a fall down trauma. Initial X-ray (A) and CT (B) were evaluated. Posterior screw fixation was done at C1 lateral mass and C2 pedicle and follow-up X-ray (C) and CT (D) were evaluated at postoperative 12 months.

Table 5. Analysis of treatment discordance cases with Grauer’s classification

Sex/age (yr)	Recommendation (type)	Treatment	Reasons
M/60	Immobilization (I)	Posterior fixation	Lamina fracture
M/66	Immobilization (I)	Posterior fixation	Lamina fracture
M/74	Anterior fixation (IIb)	Posterior fixation	Pedicle fracture
F/91	Anterior fixation (IIb)	External immobilization	Poor general condition
F/51	Anterior fixation (IIb)	Posterior fixation	Lamina fracture
F/54	Posterior fixation (IIc)	External immobilization	Poor general condition
M/13	External immobilization (III)	Anterior fixation	Dislocation
M/41	External immobilization (III)	Posterior fixation	Lamina fracture
M/32	External immobilization (III)	Posterior fixation	Pedicle fracture
F/64	External immobilization (III)	Anterior fixation	Low BMD*
F/47	External immobilization (III)	Anterior fixation	Low BMD*
F/59	External immobilization (III)	Anterior fixation	Low BMD*
F/64	External immobilization (III)	Anterior fixation	Low BMD*
F/74	External immobilization (III)	Anterior fixation	Low BMD*
M/77	External immobilization (III)	Posterior fixation	Lamina fracture
M/42	External immobilization (III)	Posterior fixation	Pedicle fracture
M/52	External immobilization (III)	Posterior fixation	Pedicle fracture
F/51	External immobilization (III)	Anterior fixation	Low BMD*
M/43	External immobilization (III)	Posterior fixation	Lamina fracture
F/62	External immobilization (III)	Anterior fixation	Low BMD*
M/54	External immobilization (III)	Posterior fixation	Pedicle fracture

BMD, bone marrow density.

*Low BMD means lower than -2.5.

artery, C2 translaminar screw fixation can be safely performed (Fig. 3).

There were some cases that were discordant with treatment recommendation of Grauer’s classification. When we decided treatment plan, we considered patients condition, instability, bone marrow density. So, we did other treatments in 21 patients, that anterior or posterior fixation in types I and III, posterior fixation or external immobilization in type IIb, external immobilization in type III as Table 5.

There are some limitations in this study such as small sample size, short-term period, retrospective study, only single center study. It needs to study in larger sample size with multicenter study, long-term follow-up, prospective study.

CONCLUSION

Odontoid fractures could be treated with various procedures including external immobilization, anterior screw fixation, posterior atlanto-axial fusion. Although other factor such as instability, bone density and patients conditions are important, type of odontoid fracture seems to be the most important factor that decides treatment plan in odontoid fracture patients. As followed Grauer’s classification, types I, IIA, III of odontoid fracture is treated with external immobilization using Halo-vest fixation or Philadelphia brace. Anterior screw fixation in type IIB, posterior atlanto-axial fusion in type IIC are usually recom-

mended for treatment.

We refer the proposed treatment-oriented classification by Grauer et al.⁸⁾ is recommendable when making a treatment plan in odontoid fracture patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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