

# Combined Fractures Involving the Odontoid and Unilateral Superior Articular Processes of the Axis: A Report of Three Cases and Literature Review

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## Learning Point for this Article:

The combined fractures involving the odontoid and unilateral superior articular processes of the axis may be considered as Type III odontoid fractures when diagnosed only by X-rays. To avoid neck pain, limitations in the ROM of the neck, and torticollis, surgery is recommended for the treatment of these fractures when observing a great dislocation, the presence of comminuted fractures or torticollis of the odontoid on X-ray and CT images.

## Abstract

**Introduction:** A treatment strategy has not yet been established for combined fractures involving the odontoid and unilateral superior articular processes of the axis. Such injuries are rare, with only 17 reported cases in the literature. A lateral flexion force with a rotated position of the atlas on the axis is considered to be the mechanism of injury.

**Case Report:** Herein, we present three cases (two female; 1 male; and age range 65–87 years) of combined fractures involving the odontoid and unilateral superior articular processes of the axis, with a mean follow-up period of 17 months. Two patients were treated surgically, while one patient was treated non-surgically. In the present cases, two new findings were obtained regarding the mechanism of injury. First, both clockwise and counterclockwise rotated positions result in such fractures. Second, a comminuted-type fracture of the superior articular process of the axis was observed. Neck pain, limitations in the range of motion of the neck, and torticollis remained after treatment in non-surgical cases, while there were no such symptoms in surgical cases.

**Conclusion:** Of importance, the combined fractures shown in the current study may be considered as Type III odontoid fractures when diagnosed only by X-rays. Therefore, when observing a great dislocation, the presence of comminuted fractures or torticollis of the odontoid should be ascertained on X-ray and computed tomography images (especially coronal images). To avoid lingering symptoms in the neck, surgery is recommended for the treatment of these fractures.

**Keywords:** Combined fracture of the axis, odontoid fracture, superior articular process fracture, surgical treatment, conservative treatment, case report.

## Introduction

Combined fractures involving the odontoid and unilateral superior articular processes of the axis are rare, and a treatment strategy has not yet been established. To our knowledge, only 17 such cases have been reported [1, 2, 3, 4, 5, 6]. Herein, we report three cases of combined fractures involving the odontoid and unilateral superior articular processes of the axis, with a

literature review. In addition, we provide novel information regarding the mechanism of injury and fracture forms, and propose treatment strategies for such uncommon fractures.

## Case Report

### Case 1

A 65-year-old man was involved in a motor vehicle accident (a

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### Author's Photo Gallery



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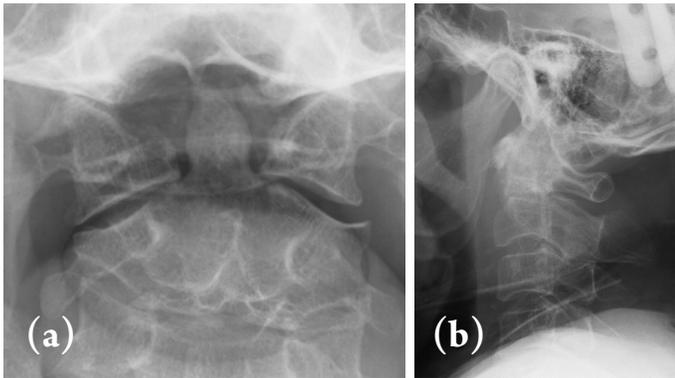
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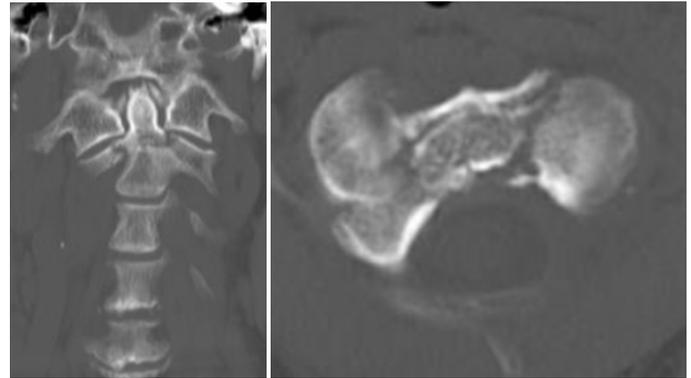




**Figure 1:** Pre-operative X-rays in Case 1. A radiographic open mouth view shows a Type III odontoid fracture, a greater inclination of the right superior articular process of the axis compared to that of the left, and a left-sided facet joint opening of C1-C2 in Case 1 (a). A lateral view shows a 2-mm anterior displacement of the odontoid process in Case 1 (b).

car collided into the passenger's side of his car). His head was thrown out of a fully-opened driver-side window while he was seated; thus, his neck was forced to bend to the right side. He experienced sudden severe neck pain. No loss of consciousness occurred, and no abnormal vital signs were observed. He had a hematoma from the posterior cervical region to both sides of the head on initial examination. No neurological deficits were observed. He suffered from severe pain in his posterior neck and was guarded against head movement. Torticollis was observed in the neck. A radiographic open mouth view showed a Type III odontoid fracture (Anderson and D'Alonzo classification system [7]) and a lateral subluxation between the atlas and axis (Fig. 1a). A lateral view showed displacement of the odontoid process (Fig. 1b). A right-sided lateral mass fracture of the axis and rotational dislocation were observed on computed tomography (CT) (Fig. 2a and b). A right-sided hyper lateral flexion with clockwise rotational position was observed on CT.

Due to a diagnosis of bilateral pulmonary injury and hemothorax, halo fixation was applied, and surgical treatment was performed 9 days after the injury. After manual reduction with a Mayfield fixator, fusion surgery (in the prone position and under general anesthesia) was performed with lateral mass



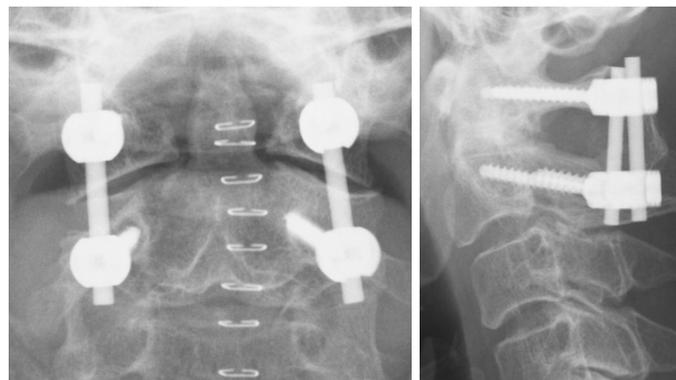
**Figure 2:** Pre-operative computed tomography in Case 1. Computed tomography reveals a right-sided lateral mass fracture of the axis in the coronal view and counterclockwise rotational dislocation of the atlas to the axis in the axial view in Case 1.

screws in the atlas and pedicle screws in the axis, with bone transplantation from the iliac (Fig. 3). Bone union was observed on X-ray at 6 months postoperatively. There was no implant failure or adjacent segmental disorder. His visual analog scale (VAS) score for pain at 15 months postoperatively was 20 mm. He experienced no disruptions in the activities of daily living.

### Case 2

An 81-year-old woman fell down in her field and experienced sudden severe pain from the right occipital region of the head to the posterior neck. No loss of consciousness occurred, and no abnormal vital signs or neurological deficits were observed. However, she had torticollis. Radiographs showed a Type III odontoid fracture and a lateral subluxation between the atlas and axis (Fig. 4a and b). CT showed a right-sided lateral mass fracture of the axis and a rotational dislocation of the atlas to the axis (Fig. 5). A comminuted-type fracture was observed in the superior articular process of the axis (Fig. 6). A right-sided hyper lateral flexion with counterclockwise rotational position was seen on CT.

Manual reduction and posterior fusion surgery at C1-3 were conducted under general anesthesia on the day of her initial visit (Fig. 7). Bone union was observed on X-ray at 6 months postoperatively. There was no implant failure or adjacent segmental disorder. Her VAS score at 15 months



**Figure 3:** Post-operative X-rays in Case 1. X-rays after C1-C2 posterior fusion surgery in Case 1.



Figure 4: Pre-operative X-rays in Case 1. A radiographic open mouth view shows a Type III odontoid fracture, a greater inclination of the right superior articular process of the axis, and a left-sided facet joint opening of C1-C2 in Case 2. A lateral view shows a flexion displacement of the odontoid process.

postoperatively was 15 mm. She had a mild limitation in the range of motion (ROM) for neck rotation (right rotation, 45°; left rotation, 20°). However, the torticollis had disappeared, and she had no disruptions in the activities of daily living.

**Case 3**

An 87-year-old woman fell down in her house and developed a strong bruise on the left side of her head. No loss of consciousness occurred, and no abnormal vital signs or neurological deficits were observed. However, she had torticollis.

Radiographs showed a Type III odontoid fracture and a greater subluxation between the atlas and axis (Fig. 8). CT showed a split-type lateral mass fracture of the axis (Fig. 9). A right-sided hyper lateral flexion with counterclockwise rotational position was revealed on CT. Because the patient and her family strongly refused operative treatment and halo fixation, she was treated conservatively using a soft collar. Bone union was observed at 12 months after the injury; however, she had torticollis (Fig. 10), severe neck pain, and a highly limited

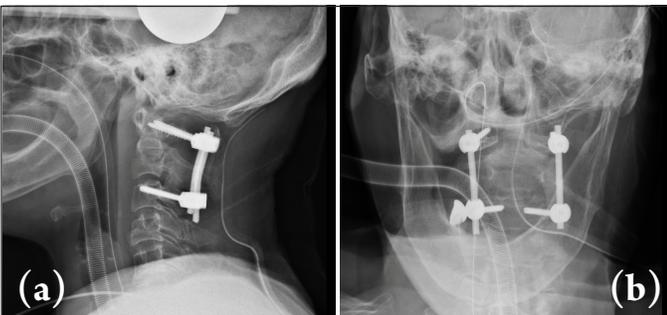


Figure 7: (a and b) Post-operative X-rays in Case 2. X-rays after C1-C3 posterior fusion surgery in Case 2.

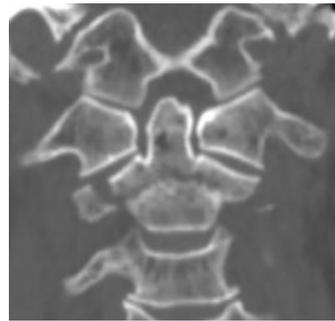


Figure 5: Pre-operative computed tomography in Case 2. Computed tomography reveals a right-sided lateral mass fracture of the axis in the coronal view.

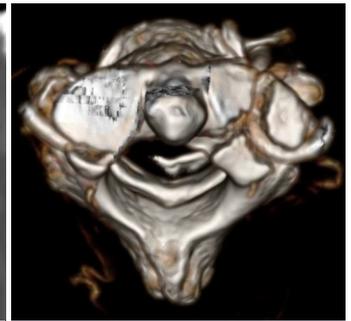


Figure 6: Pre-operative three-dimensional computed tomography in Case 2. In Case 2, the right superior articular process of the axis is revealed to be comminuted on three-dimensional computed tomography.

ROM at 24 months after the injury.

**Evaluation of clinical outcomes**

A comparative study of the clinical outcomes for conservative and surgical treatment of these fractures was performed using previously reported cases (Table 1) in addition to the present cases. In 12 cases, including the present three cases, the clinical outcomes were well disclosed. Of these cases, six were treated

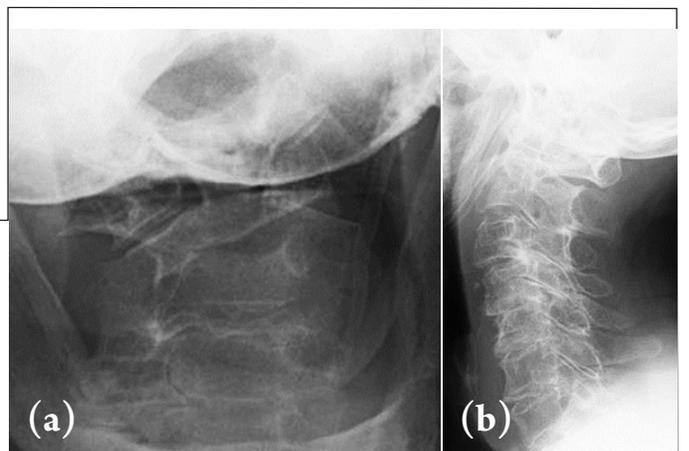


Figure 8: (a and b) X-rays at the injury in Case 3. A radiographic open mouth view shows a Type III odontoid fracture and greater inclination of the right superior articular process of the axis, and a left-sided facet joint opening of C1-C2 in Case 3, similar to that in the previous two cases.





Figure 9: Computed tomography at the injury in Case 3. In Case 3, computed tomography shows a split-type right-sided lateral mass fracture of the axis in the coronal view.

surgically, and six were treated non-surgically. Non-surgical cases tended to possess stronger neck pain, a higher frequency of torticollis, and larger limitations in the ROM of the neck after treatment compared to that in surgical cases (Table 2).

#### Discussion

The fractures in the current study are characterized by complex

fractures of the axis in the odontoid and unilateral C2 superior articular processes. This is an uncommon injury, with only 17 cases reported (Table 2) [1, 2, 3, 4, 5, 6]. Abel and Teague reported two cases of unilateral lateral mass compression fractures of the axis, accompanied by fractures through the base of the odontoid in 1979 [6]; however, critical details are unknown due to the lack of CT data. Signoret et al. referred to three cases of a fractured odontoid with a fractured superior articular process of the axis in 1986 [1]. In addition, Craig et al. described seven cases of similar fractures in a case-series report of superior articular process fractures [2]. Based on detailed pre-operative imaging evaluations, the authors concluded that a hyper lateral flexion combined with a rotated position causes these injuries. The present study is the first to demonstrate that such fractures can occur independently of the rotational direction, as a right-sided hyper lateral flexion with clockwise rotational position was observed in Case 1, while a right-sided hyper lateral flexion with counterclockwise rotational position was observed in Cases 2 and 3.

Hähnle et al. reported three cases of an axis body fracture combined with a C2 superior articular process fracture, described as a shear fracture through the body of the axis

vertebra [3]. The authors described six characteristic findings on plain radiographs, which were highly effective for the recognition of such uncommon fractures in the present cases. In addition, Signoret et al. classified fractures of the C2 superior articular process into three types as follows: Split-type, split with impaction, and depression-type [1]. In the present study, a

split-type fracture was observed in Case 3, a depression-type fracture was observed in Case 1, and a comminuted-type fracture, which is a novel fracture form, was observed in Case 2. Multi-planar reconstructed or three-dimensional reconstructed CT images are very effective in detecting the form of the facet joint fracture in detail. Regardless of the type of C2 superior articular process fracture, the patients sustained relatively high-energy injuries considering the mechanism of injury. However, there have been no reports of vertebral artery injuries in the literature.

As yet, there are no established treatment strategy principles for such uncommon fractures of the axis [1, 2, 3, 4, 5, 6]. The present study is the first to attempt a comparison between surgical and non-surgical treatment for these fractures. Overall, dislocation of the C2 superior articular process fracture tended to be great or unstable. Moreover, joint faces that were depressed (e.g., Cases 1 and 3) or comminuted and greatly



Figure 10: Computed tomography at the final observation in Case 3. In Case 3, bone union was found; however, computed tomography reveals torticollis in the coronal view at 24 months after injury.

dislocated (e.g., Case 2) were hardly reduced, even if surgical treatment was attempted. Non-surgical treatment for such cases must cause neck pain due to facet joint arthropathy, and a loss in the ROM for neck rotation or torticollis, which must eventually lead to disruption in the activities of daily living. Therefore, non-surgical treatment may be permitted in cases with a split-type fracture of the C2 superior articular process and little dislocation, while surgical procedures should be recommended in cases with great dislocation or depression- or comminuted-type C2 superior articular process fractures.

Of importance, the combined fractures shown in the current study may be considered as Type III odontoid fractures when diagnosed only by X-rays. Conservative treatment is generally recommended for Type III odontoid fractures. Therefore, when observing a great dislocation, the presence of comminuted fractures or torticollis of the odontoid should be ascertained on X-ray and CT images (especially coronal images).

**Conclusion**

The three presented rare cases of combined fractures involving the odontoid and unilateral superior articular processes of the

axis included a comminuted-type C2 superior articular process fracture, which has never been reported. Both clockwise and counterclockwise rotational forces, accompanied with a particular direction of flexion force, can lead to such injuries. Careful attention is necessary, as such combined fractures may be considered as Type III odontoid fractures when diagnosed only by X-rays. Surgical treatment should be recommended for most of these fractures.

**Clinical Message**

Combined fractures involving the odontoid and unilateral superior articular processes of the axis are rare. Of importance, the combined fractures shown in the current study may be considered as Type III odontoid fractures when diagnosed only by X-rays. Therefore, when observing a great dislocation, the presence of comminuted fractures or torticollis of the odontoid should be ascertained on X-ray and CT images (especially coronal images). To avoid neck pain, limitations in the ROM of the neck, and torticollis, surgery is recommended for the treatment of these fractures.

**Table 1:** A list of reported combined fractures involving the odontoid and unilateral superior articular processes of the axis

Authors	No.	Anderson classification	Neurological deficits	Conservative treatment	Surgical treatment
Abel and Teague (1979)	2	Unknown	Unknown	Unknown	Unknown
Signoret et al. (1986)	3	III	None	0	3
Craig and Hodgson (1991)	7	III5, II2	1 (Frankel D)	4	3
Hähnle et al. (1999)	3	III	None	3	0
Spoor et al. (2008)	1	III	1 (complete Brown-Sequard syndrome)	1	0
Zhang et al. (2014)	1	III	None	0	1
Current study (2017)	3	III	None	1	2

**Table 2:** Clinical outcomes and comparisons between non-surgical and surgical treatment

Treatment	Bone union	Severe neck pain	Torticollis	Highly limitation of range of motion of the cervical	Complications
Non-surgical (n=6)	6	2	2	2	Depression by halo vest fixator 1
Surgical (n=6)	6	0	0	0	infection 2 Hematoma 1



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**Source of Support:** Nil

**Consent:** The authors confirm that Informed consent of the patient is taken for publication of this case report

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