

## Original Article

# Management of combination fractures of the atlas and axis: a report of four cases and literature review

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**Abstract:** Four cases of combination fractures of the atlas and axis are presented. Three types of management were performed: plaster immobilization, odontoid screw fixation combined with atlantoaxial pedicle screw fixation, occipito-cervical fusion with anterior operation by staged. Based on a literature review and our experience, treatment strategies is discussed according to the stability of the upper cervical spine and neurological involvement, with a reminder that combined injuries in the upper cervical spine should be sought in any patient with a cervical injury and early surgical solution may bring benefits once injury attack.

**Keywords:** Cervical spine fracture, atlas, axis, plaster immobilization, cervical spine surgery

## Introduction

Although concomitant injuries of atlas and axis are relatively common which account for nearly 3% of cervical spine lesions and 12% of upper cervical spine fractures [1-3], they are rarely reported in the literature, and their characteristics and treatment strategies are not well known with a higher incidence of neurological morbidity than isolated C1 and C2 fractures [3]. These combinations most often caused by motor vehicle accidents in young adults [4] and occur with significantly higher incidence in the aged for whom falls are most likely the mechanism of injury in contrast [5, 6]. In particular, while cervical immobilization has long been recommended for the treatment of majority of isolated atlas and axis fractures, today it seems that surgical treatment is often proposed due to the occurrence of the two fractures in combination often implies a more significant structural and complex mechanical injury. The purpose of this retrospective study on a series of four cases is to discuss the management issues for C1-C2 combination fractures with our experience and a review of the literature.

## Observations

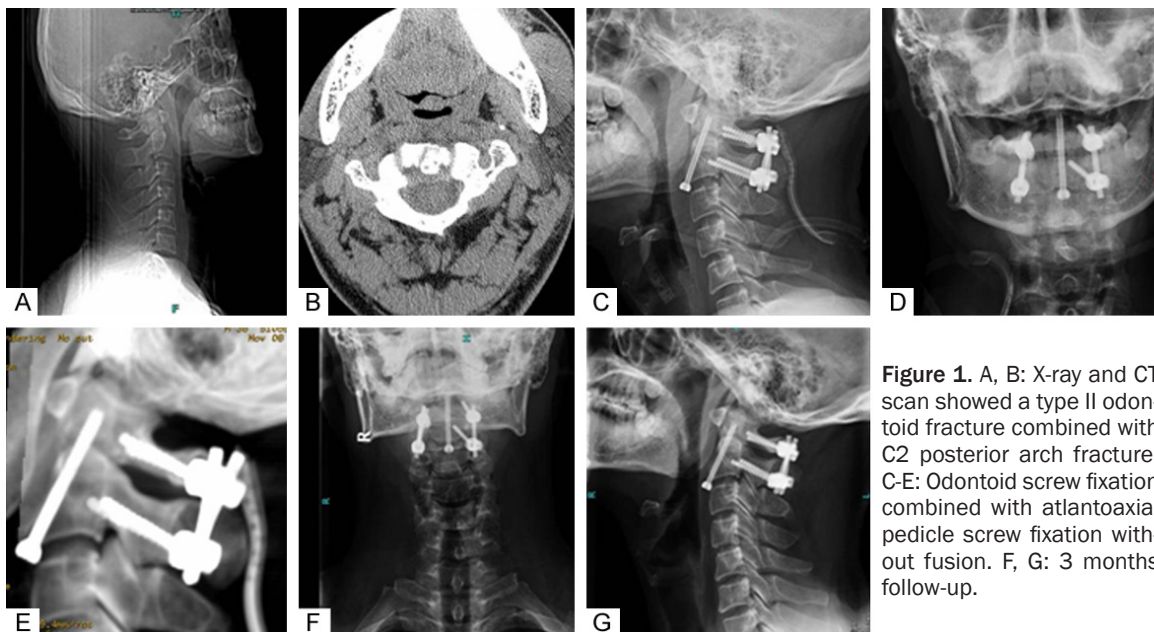
### Case No. 1

Patient No. 1, male, 38 years old, presented minor head injury and severe neck after being ejected during a low-speed motor vehicle collision (**Table 1**, **Figure 1**). X-ray and cervical CT demonstrated a type II odontoid fracture according to Anderson and D'Alonzo [7], backward sloping according to Roy-Camille [8], associated with a fracture of posterior C1 arch. The JOA score was 16, VAS score was 8 pre-operation. A cervical collar was put to preserve the neck. The patient remained with no neurological deficit but couldn't stand a long time external immobilization therapy period. To simplify nursing care and minimal the inconvenience of cervical collar, the patient underwent odontoid screw fixation combined with atlantoaxial pedicle screw fixation surgery without fusion followed by a neck collar for 6 week. The JOA score was 17, VAS score was 2 post-operation. After a 9 month follow-up, the fracture got healing and the VAS score was 0. Then the patient was followed via telephone interview and was asymp-

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**Table 1.** Summary of the four observations

Case No.	Age (years), sex	Circumstances of the accident	Type of lesion	Other Combination injury	Management	Follow-up (months)
1	38, M	Traffic accident	Type II odontoid + C1 posterior arch fracture	/	odontoid screw fixation combined with atlantoaxial pedicle screw fixation	9
2	18, F	High fall injury from 5m	Type II odontoid + Jefferson fracture	left humeral fractures, left fronto-temporal bone fractures, subdural hematomas	plaster immobilization	1
3	59, M	Traffic accident	C1 posterior arcs, Hangman fracture and miscellaneous fractures, dislocation of C2/3	Rib + anterior cranial fossa fractures, craniocerebral trauma	Occipito-cervical fusion with anterior operation by staged	6
4	56, M	High fall injury from 2m	Type II odontoid + Jefferson fracture	/	odontoid screw fixation combined with atlantoaxial pedicle screw fixation	30



**Figure 1.** A, B: X-ray and CT scan showed a type II odontoid fracture combined with C2 posterior arch fracture. C-E: Odontoid screw fixation combined with atlantoaxial pedicle screw fixation without fusion. F, G: 3 months follow-up.

tomatic but refused to return to clinic for evaluation though we wanted to remove the internal instruments in 6 month after the surgery.

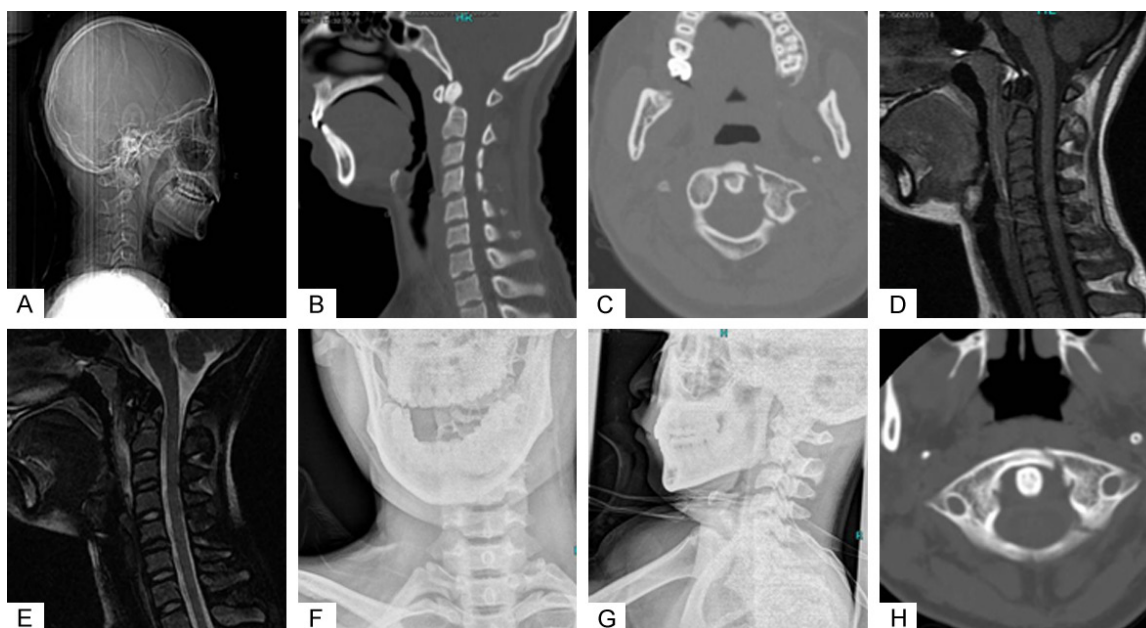
### Case No. 2

Patient No. 2, female, 18 years old, presented head and cervical spine injury with no neurological impairment resulting from a high falling about 5 m (**Figure 2**). X-rays and 3D-CT scan showed a type II backward sloping odontoid fracture with anterior displacement associated with a Jefferson fracture. This patient also suffering from left humeral fractures combined with left fronto-temporal bone fractures and subdural hematomas. The JOA score was 16,

VAS score was 9 pre-operation. A cranial halo device was put in place with bed traction to reduce anterior displacement. The patient was engaged in special industries and her relatives refused to choose operation, so plaster immobilization was performed and after 1 month follow-up, we lost contact with her.

### Case No. 3

Patient No. 3, male, 59 years old, presented with left upper extremity weakness suffered a car accident resulting in several fractures: fracture of the 2th right rib, frontal, right temporal parietal bone and multiple fractures of the anterior cranial fossa, frontal epidural hemato-



**Figure 2.** A-E: X-ray, CT scan and MRI showed a type II odontoid fracture combined with Jefferson fracture. F, G: Plaster immobilization. H: 1 month follow-up.

mas on the right frontal and parietal temporal mild subdural hematomas, subarachnoid hematomas. X-rays and 3D-CT scan showed bilateral posterior arch fractures of C1, traumatic spondylolisthesis of the axis fractures, miscellaneous fractures of the axis body, dislocation of C2/3 and hematoma formation of the spinal canal (**Figure 3**). The GCS score was 7, Frankel in grade C, JOA score was 9 pre-operation. He was performed craniocerebral operation emergency and a cervical collar was provided. The patient remained tracheotomy with no neurological improvement and rapidly presented pulmonary infection. After a 3 weeks' supporting treatment in ICU, occipito-cervical fusion was decided. The GCS score was 15, Frankel in grade E, JOA score was 17 after 6 weeks. An anterior operation was performed due to the patient suffered from dysphagia. Postoperative follow-up was simple with consolidation achieved with no secondary displacement at 3 months and satisfactory spinal function with mild pain in neck.

#### Case No. 4

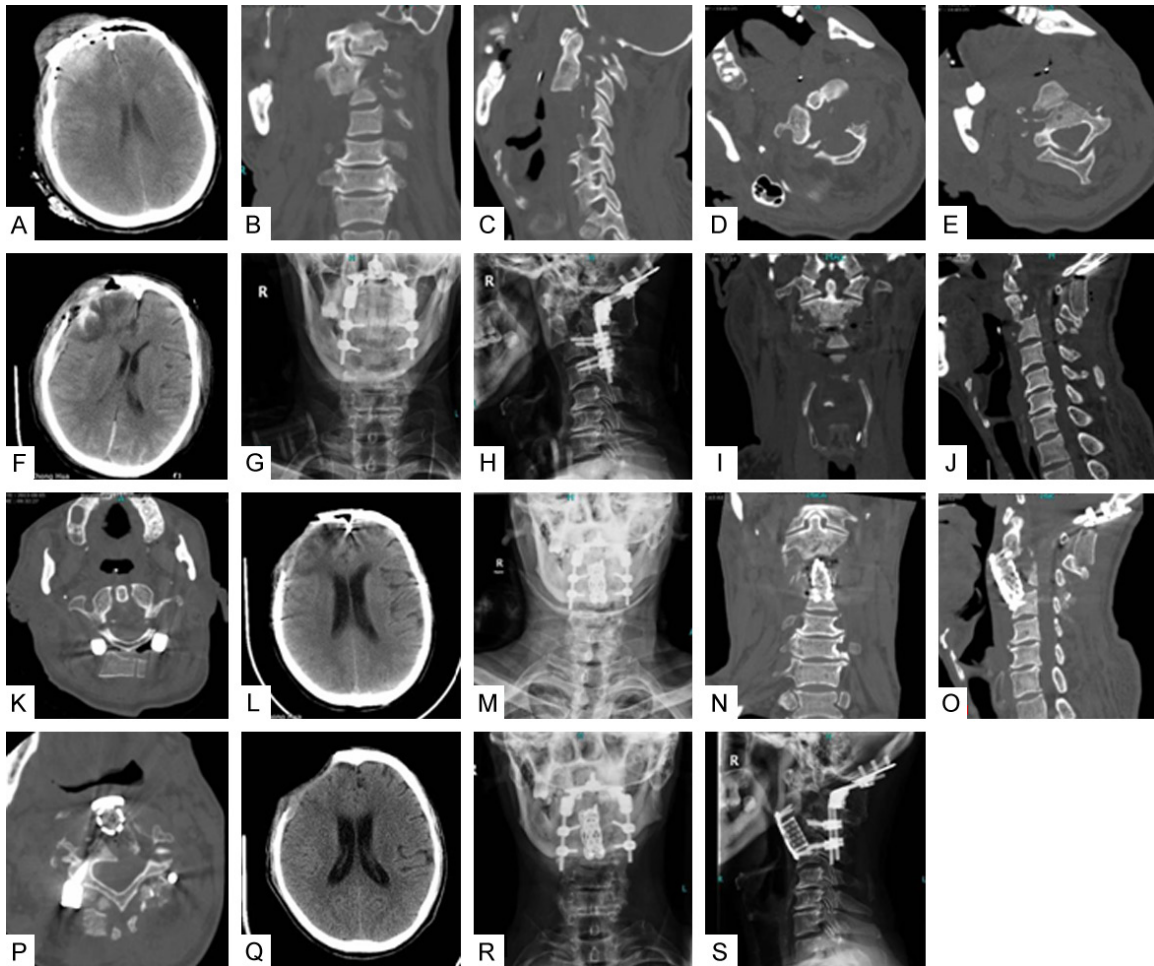
Patient No. 4, male, 56 years old, presented with progressive neck pain after a high fall injury from about 2m (**Figure 4**). 8 days before going to our clinic for evaluation he had taken a X-ray plain which just showed some mild cervical degeneration without any fracture traces.

3D-CT scan and MRI showed a type II backward sloping odontoid fracture with mild displacement associated with a Jefferson fracture, and showed instability of C1/2. The JOA score was 16, VAS score was 6 pre-operation. A cervical collar was put to preserve the neck. Surgery was performed on the tenth day after injury with odontoid screw fixation combined with atlantoaxial pedicle screw fixation followed by a neck collar for 6 week. The JOA score was 17, VAS score was 2 post-operation. Postoperative follow-up achieved healing at 3 months with no pain at 2.5 years.

#### Discussion

Although the first report of combination C1-2 fracture injuries was compiled by Sir Geoffery Jefferson in 1920 [9], combined injuries are seldom reported in the literature. This type of fractures represent about 3% of all cervical spine injuries [4], 43% and 16% of C1 or C2 fractures, respectively [2, 10, 11]. In reports focusing primarily on C2 fracture, the occurrence of C1 fracture has been identified in 5% to 53% of odontoid fractures [5, 10, 12, 13], 6% to 26% of Hangman's fracture [13-17]. Similarly, odontoid fractures have been reported in 24% to 53% of patients with C1 fracture [13, 18, 19]. That is to say any fracture of C1 can be accompanied by C2 and vice versa. The mecha-

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**Figure 3.** A: CT scan showed craniocerebral trauma. B-E: 3D-CT scan showed bilateral posterior arch fractures of C1, Hangman fractures, miscellaneous fractures, dislocation of C2/3. F: Craniocerebral operation. G-K: Occipito-cervical fusion. L: 6 weeks after craniocerebral operation. M-P: Anterior operation. Q-S: 3 months follow-up.

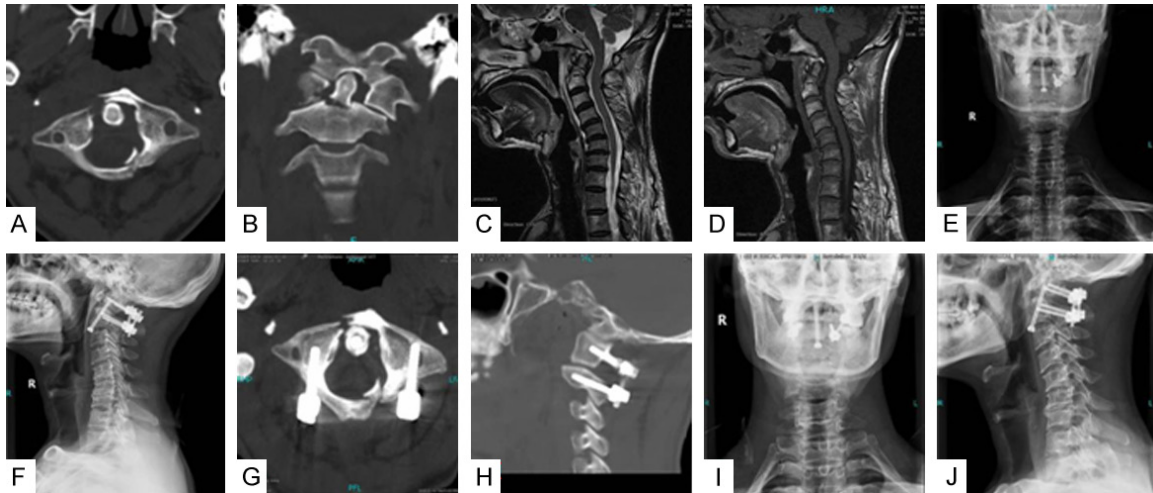
nism of injury seems to be reasonable that a sudden axial load producing the C1 fracture [3, 20] coupled with a flexion force that result in C2 injury (most commonly type II odontoid fracture) [21]. Acute combination fractures of atlas and axis are more frequently associated with neurological deficit, sometime fatal, than with isolated atlas and axis fractures: 12 to 34% neurological impairment for Dickman [4], Kesterson [22] and Fujimara, 83 to 86% mortality in the early treatment for Hanssen [12] and Fowler [23].

Individual injuries in the dens or C1 was reported and classified by Anderson and D'Alonzo and Jefferson, but there is no clear classification for combined injuries of C1 and C2 in which C1-type II odontoid fracture seems to be the most frequent according to Dickman [4], Guiot and Fessler [3], this is in agreement with the

report in ours (3 in 4). When a combined injury is recognized, management difficulties arise due to the unique anatomy and biomechanics of the atlantoaxial complex with the goals of reduction of fracture, alignment of spine, stability, and protection of spinal cord.

Though it is difficult to determine the specific treatment provided to and outcome for most of those patients, the treatment options are in relation to the stability of fracture and neurological impairment. The treatment of combination atlas-axis fractures based primarily on the specific characteristics of the axis fracture and the type of fusion whether C-1 and C-2 will be the only levels included in the treatment or require an occiput to C-2 wiring and fusion procedure, on the basis of the C1 fracture once surgery had been elected is recommended.





**Figure 4.** A-D: CT scan and MRI showed a type II odontoid fracture combined with Jefferson fracture. E-H: Odontoid screw fixation combined with atlantoaxial pedicle screw fixation. I, J: 3 months follow-up.

Studies showed stable fractures such as atlas fracture combined with type III odontoid fracture or type I Hangman fracture could be taken a halo cast or SOMI brace for 8-14 weeks, the majority could get better results. On considering a high risk (about 50%-85%) of nonunion [24] or a rupture of transverse atlantal ligament, alignment of the spine could not be maintained or non-surgical therapy have failed, “early” surgical intervention has been recommended for unstable fractures, especially in patients older than 50 years and in cases with displacement of the dens of 5mm or greater or angulation of C2-C3 of 11 degrees or greater [20]. The occiput was included in the fusion construct if there were bilateral or multiple ring fractures of atlas.

The clinical management consisted of atlantoaxial fixation (Gallie, Brooks, Fielding, posterior atlantoaxial pedicle screw fixation, etc.) and occipital-cervical fusion. The effect of clinical treatment of occipital-cervical fusion was not satisfactory and atlantoaxial fixation was more met physiological requirements in contrast. The C1-C2 pedicle screw fixation was a developed technique in recent years, confirmed by clinical practice in recent years that atlantoaxial pedicle screw could not only cure the atlantoaxial dislocation caused by transverse ligament injury, but also threat the fractures of C1 and C2. Combined with anterior odontoid screw fixation would further enhanced its stability, but for those complex C1-C2 fractures involving a Jefferson’s fracture with minimal displacement

or in which the transverse ligament is intact, halo vest immobilization in addition to an odontoid screw would be appropriate treatment, if the position of the vertebral arteries contraindicates screws or the integrity of the ring of the atlas is lose and gross C1-C2 instability, occipito-cervical instrumentation may be the only alternative. The combination of odontoid and bilateral transarticular C1-C2 anterior screw fixation (also known as triple anterior screw fixation) is another choice in treating C1-type II odontoid fractures [25] with the advantages of immediate stability and avoiding the prone position for the posterior fixation, obtaining stability with a single surgical procedure, but requires intact C1-C2 lateral masses, that is , it can be used when posterior stabilization is not feasible.

In our series, for the patients with type II odontoid fracture combined with C1 fracture (2 cases), posterior atlantoaxial fixation is the first choice, and odontoid screw fixation can also be added when MRI scan did not prompt the transverse ligament rupture preoperative, fusion wasn’t a necessary, and internal fixation could be removed until fracture healing to minimum reduction in range of motion. Two stages of combined posterior and anterior surgery were performed in one of our cases because of the dysphagia after occipito-cervical fusion. The experience we gained from treating this group of patients is in agreement with that reported by Dickman, Apostolides and Bernard and we believed that whether the complex atlantoaxial

fractures need surgical treatment mainly depend on the stability of the spine and bone ligament damage. All concurrent C1/2 or C2/3 instable complex fractures could be an early indication for surgery, rather than solely relied on the axis fractures types. Complex atlanto-axial fractures due to diverse fracture types, clinical manifestations and treatment programs, so that treatment plan of each class complex fractures was not identical. How to choose the appropriate treatment or the fixation method should be based on the fracture type and the surgeon's practical skills which was the key to successful surgery. With the fixation effect became more reliable and less complications, more and more physicians advocated early surgical treatment for these patients. In short, the understanding of combination fractures of the atlas and axis remained deficiencies, its classification and treatment need further exploration and research.

## Conclusion

Combination fractures of the atlas and axis occur so frequently enough to be looked for carefully that computed tomography is recommended in all patients with cervical fracture to evaluate for a combination injury, including those to the craniocervical junction and are associated with an increased incidence of neurological deficit compared with isolated C1 or C2 fractures. The combination has to be treated as a whole. Most patients with combination atlas-axis fractures can be treated successfully with an external immobilization. However, patients who are at high risk for nonunion or nonoperative therapy has failed require early surgical stabilization and fusion.

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## Disclosure of conflict of interest

None.

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