

## **Surgical management of combined fracture of atlas associated with fracture of axis vertebrae (CAAF): Case Series**

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**Abstract:** Combined fracture involving atlas together associated with axis (CAAF) accounts for approximately 3 % of traumatic cervical spine injury, CAAF are rarely reported, so modalities of management and outcome are not well understood, due to paucity of literature and only few reports reported in the form of isolated case report. CAAF management possess challenge as it is associated with high incidence non-union with previously conservative method. However, missed diagnosis and subsequent delay may be associated with catastrophic worsening in neurological deficit. So early diagnosis and management remains the key for successful neurological outcome. Such fractures are rare. Authors report five such cases of CAAF, all required surgical management with good outcome with no mortality. Current study, all cases were males (n=5), commonest mode of injury was fall (n=3), time interval since injury was within 24 hours in (n=4), however rest one presented after a gap of eight months. Commonest clinical feature was neck pain (n=3), neurological deficit (n=2), neck tenderness and swelling tenderness (n=3) Neuroimaging including X-ray, CT scan and MRI were carried out for all cases revealed fracture of arches of atlas (n=5), one case had multiple site fracture of both arches, odontoid fracture (n=2), lateral mass of atlas fracture in 1 cases. Astonishingly two cases had disruption of transverse ligament. Surgical procedures performed considering economic consideration included occipito-cervical fusion (n=3), transarticular C1-C2 fusion and anterior odontoid screw fixation in one cases each. Management options in CAAF and review of literature discussed in present study.

**Key words:** atlas fracture, axis fracture, atlantoaxial instability.

### **Introduction**

Traumatic cervical spine injury is one of common injury accounting approximately 4.3 % of all patients with trauma. The incidence of combined fractures, as a subset of C-1 or C-2 fractures, is 43% and 16%, respectively (1, 2). Atlantoaxial fractures are commoner in elderly but uncommon in young adults, however, most commonly caused by motor vehicle accidents (1). CAAF are often associated with higher incidence of neurological deficits or

have higher chances of neurological deterioration when compared to isolated atlas or axis vertebra injuries. Management is controversial. External immobilization or surgical intervention or initial trials of conservative therapy followed by delayed surgery have been advocated for management (1, 2, and 3). Consensus regarding definitive management of CAAF is still lacking. In this view author retrospectively analyzed five

cases of CAFF treated at Level I trauma centre in India and literature reviewed.

**Case Illustration**

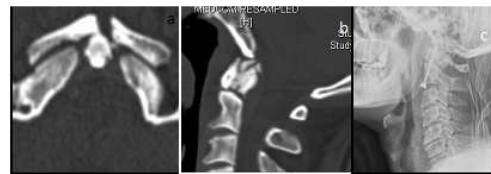
Case 1: A 20-year old male presented with complaint of severe non-radiating pain and swelling in neck developed following a fall while doing exercise in the gym. Detailed neurological evaluation on admission revealed swelling and tenderness in neck with restricted neck movements, however no associated neck deformity and rest of the neurological examination was unremarkable. X-Ray and CT scan of craniovertebral junction revealed multiple fracture of atlas ring, being one over anterior arch and two fractures on posterior arch causing expansion of atlas ring with associate type II odontoid process fracture causing reducible atlantoaxial dislocation (Figures 1a, 1b). MRI of craniovertebral junction revealed disruption of transverse ligaments with displaced fractured odontoid process causing thecal sac compression; however no associated cord contusions or edema was detected

He was planned for surgical management and occipito-cervical fusion carried out with rod and polyaxial screws to occipital bones to C 3, C 4 lateral mass screws (Figure 1 c). He was doing well at last follow-up 4 months following surgery. Neck pain subsided completely.



**Figure 1** - CT scan imaging of craniovertebral junction, (a) axial section and (b) sagittal image showing multiple fractures of anterior and posterior arch of atlas vertebra associated with type II odontoid fracture with displaced odontoid tip and (c) post-operative scan with in situ Occipito-cervical fusion (co-c 4 )

Case 2: A 50 –year- male had history of fall ten feet height, presented with complaint of severe neck pain. Neurological examination on admission revealed only restriction of neck movements and rest of examination were essentially within normal limits. CT scan of craniovertebral junction demonstrated type 2 odontoid fracture associate with right lateral mass of axis with anterior arch of atlas fracture (Figure 2 a, b). MRI revealed intact transverse ligament without cord signal alteration. He underwent anterior cervical odontoid screw placement (Figure 2c). Postoperative period was uneventful with complete relief at follow up of 3 months following surgery.



**Figure 2** - Axial (a) and sagittal (b) section of CT scan of Craniovertebral CV junction showing fracture of anterior arch C1 vertebra and associated Type II odontoid fracture (c) Post -operative CT scan showing precisely placed odontoid screw through anterior approach.

Case 3- A 30 –year- male presented with history of progressive spastic quadriplegia and associated with respiratory distress following motor vehicle accident, he was incubated at peripheral hospital and after resuscitation, was referred to our institute for further management. Examination on admission, he was quadriplegic with partial sensory impairment (ASIA grade B). X-ray and CT scan image revealed fracture of anterior arch on right side of C1 vertebra and fracture of vertebral body of C2, and C3; and associated fracture of lamina of C2, C3 and C4 causing significant cord compression (Figure 3 a, b). Patient undergone occipito-cervical rod and screw fusion, occiput-C3-4, on right side occipito-C2-3 fusion done on left

side (Figure 3 c). He needed tracheotomy in post-operative period for pulmonary toileting as he was on prolonged ventilator support. In postoperative period, he improved to ASIA grade C at the time of discharge at one month after definitive surgery.

Case 4: A 12- year old boy after sustaining injury following fall from tree of 12 feet about eight months back, presented with progressive spastic quadriplegia in outpatient service department. Examination on admission revealed neurological status was ASIA grade D, with hypertonia and exaggerated deep tendon reflexes and planter reflexes extensor bilaterally. On X-ray and CT scan evaluation of patient suggestive of right C1 posterior arch fracture with reducible atlanto-axial dislocation with transverse ligament injury (Figure 4 a,b). Patient underwent Posterior C1-C2 trans-articular screw fixation (Figure 4 c). Post-operative period was uneventful and good fusion at follow up of 8 month following surgery.



**Figure 3** - Axial section of CT scan of craniovertebral CV junction, (a), (b) depicting right side fracture of anterior C1 arch on and associated C2 body fracture with (c) Post operative CT scan Occipito-cervical fusion



**Figure 4** - Axial (a) and Sagittal (b) section of CT scan of CV junction shows posterior arch fracture C1 on right side with consequent atlanto-axial dislocation and (c) Post operative X-ray showing C1-C2 transarticular in position.

Case 5: A 19- year- male following motor vehicle accident and presented with pain in neck following trauma. Detailed neurological examination revealed no deficits except tenderness in neck. CT scan of Craniovertebral junction demonstrated fracture of posterior arch of atlas and body of C2 vertebrae with fracture of spinous process of C 7.

MRI examination revealed transverse ligaments injury. Patient underwent occipito-cervical rod and screw fusion (Occipito – C3-4-5). Post-operative period was uneventful and on follow up at 18 months, he had no deficits or pain.

### Discussion

Sir Geoffrey Jefferson described burst fracture of atlas involving fracture of anterior and posterior arch on both sides in 1920 (1). He defined all types of C-1 fractures, and elaborated 19 cases of CAFF. Its variants may include unilateral arch fractures, posterior ring fractures, and lateral mass fractures of atlas. It is most common type of atlas fracture; it is associated with high morbidity and mortality. Atlas fracture accounts for about 25% of atlantoaxial and complex up to 10 % of upper cervical spine fracture. Injuries involving the occipitocervical junction is often unstable and rapid diagnosis facilitates early stabilization reduce the risk of subsequent iatrogenic neurological deterioration (5). High-energy transmission during fall causes fractures of atlas, and commonly associated with contiguous cranio-cervical injuries in more than one third patients (6). It is commonly caused by road traffic accident or falling on to head especially in toddler.

Basic pathological mechanism is axial load producing the C-1 fracture is often coupled with a flexion force that leads fracture of axis, and odontoid process fracture constitutes one of the commonest association (1, 2, 3) The incidence is higher in the elderly due to brittleness of the bones caused by

osteoporosis (7). In the current study majority were young and fall was commonest cause. CAFF is associated to higher incidence of neurological deficits in comparison to isolated atlas or axis fractures (1).

Treatment of CAFF is difficult, challenging and no definite guidelines provides difficulty in selection of ideal procedure, which led to multiple surgical approaches to treat CAFF and usually differs from isolated atlas or axis fractures. Traditional conservative approaches which involved nonsurgical halo traction therapy (5). Lipson (7) advocated initial immobilization of the cervical spine with a halo vest, which allow spontaneous healing of the C-1 fracture, could be followed by fusion of C1–2, if continued instability became evident. But Dickman et al (1) advocated early surgery based on the type of type 2 odontoid fracture as there is high chances of non-union, especially in elderly and if displacement of fracture segment more than 6 mm, displaced, and early surgery is recommended for specially unstable fracture. Guiot and Fessler (8) after analysis, observed about 50% of their case failed to show bony fusion, who were managed with halo immobilisation, so authors further noted nonsurgical management of CAFF would appear to have a high failure rate and so advocated “early” surgical intervention. Age of patient, type of fracture of atlas ring, type of axis fracture and intactness of transverse ligament may help in selecting appropriate surgical approach and treatment for CAFF injuries; however treatment protocol should be individualised according type of injury, availability of intraoperative imaging facility, economic status of patients and associated comorbid illness, suitability for general anaesthesia. However major determinant is type of axis injury, rupture of transverse ligament of axis, associated atlanto-axial dislocation, reducibility.

The selection of type of fusion depends on the basis of nature of C-2 fracture. Treatment

option further guided by degree of offset of C1 arch, injury to transverse ligament, associated fracture of C2 or odontoid fracture. CAFF injury may include hangman or type II odontoid fracture. (8, 9, 10, 11)

Type II odontoid fracture with greater than 6 mm displacement is itself a surgical indication. Surgical option may include occipito-cervical fusion, C1 lateral mass and C2 pedicle screw, C1-C2 transarticular screws and anterior odontoid screw fixation

Anterior approach for odontoid screw fixation used with posterior sloping or horizontal fracture of odontoid. Halo immobilisation following anterior odontoid screw fixation in complex C1–2 fractures involving a Jefferson’s fracture with minimal displacement or bilateral anterior arch fracture and with intact the transverse ligament would be appropriate treatment, as in our case -2 limitation of anterior odontoid screw placement include forward sloping odontoid fracture making more suitable for posterior approach is preferred. Posterior transarticular screw fixation as in our case – 4, although a posterior approach may be preferable because the difficulty of per forming fusion via an anterior approach,

Occipitocervical fusion has been advocated by several authors as rescue solution. The occipital bone is to be included in the fusion construct, if associated bilateral or multiple ring fractures of the atlas arches. If C1–2 transarticular screw fixation is not possible because of the position of the vertebral arteries, then occipitocervical fixation is the remaining surgical alternative. However, anterior subluxation of C1 on C 2 may indicate rupture of transverse ligament and again highlighting fact about transverse ligaments integrity is also important factor in selection of surgical approaches in management of CAFF groups of patients.

An atlantoaxial dislocation or disruption of unstable C1-C2, with disrupted transverse ligament poses grave risk of injury to

brainstem and upper cervical cord. If associated odontoid fracture, odontoid fragment may migrate up into foramen magnum. However, in case of disrupted transverse atlantal ligaments and in some cases of Jefferson fracture of the atlas with widely splayed lateral masses, trans-articular screw fixation may be desirable. This procedure can be performed either via an anterior or posterior approach. These complex cases and our case no. 1, 4, 5, Occipito cervical fusion extending to C2 or C3-4 may be necessary, as these construct stabilises ring.

**Conclusion**

Combined fracture of atlas associated with fracture of axis vertebrae (CAAF) poses challenge for neurosurgeon. Age of patient, type of fracture of C 1 arch, intactness of transverse ligament and type of C2 fracture

may help in selecting appropriate surgical approach. Early surgery is safe and effective especially, if transverse ligament is injured, displaced odontoid fracture, with unstable atlanto-axial dislocation carries high chances of non union. High index of suspicious, and prompt and emergent treatment can halt the development of catastrophic neurological deterioration. However ideal selection of fusion method demands detailed evaluation of X-ray, CT scan. MRI imaging, age of patients, economic status of patient, expertise of surgical team and large number of surgical procedures in neurosurgical armamentarium further produces confusion as long term results are still awaited. However, in future study involving large number of Cohorts will definitely provide eye opening solution. However, treatment for these injuries should be individualised according their type of injury.

**TABLE 1**  
**Summary of Our patients with combined fracture of atlas associated with fracture of axis vertebrae (CAAF)**

Sr no.	Age (years/sex)	Mode of injury	Imaging of atlas vertebra with fracture of Arch	Imaging of axis and transverse ligament	Associated other vertebral injury	Surgical approach	Remarks
1)	20	Fall	Multiple site of anterior and posterior	Type II odontoid fracture + Transverse ligaments injury	-	Occipito-cervical fusion (O-C3-4)	Pain reduces completely
2)	50	Fall from height	Arch of atlas fracture	type II odontoid fracture + lateral mass C2	-	Odontoid Screw.	Good fusion at 9 months
3)	30	Motor vehicle accident	anterior arch on right side	C2 body fracture	C3 body fracture lamina of C2, C3 and C4 fracture	Occipito- cervical fixation (Rt- O- C3-4, Lt-O-C2-3)	Deficits improved post operatively. With good fusion at 20 months F/U
4)	12	Fall from height	Right side posterior arch	reducible atlanto-axial dislocation + transverse ligament injury		Posterior C1-C2 Trans-articular screw fixation	Good bony fusion at 8 months.
5)	19	Motor vehicle accident	posterior arch	Fracture of C2 vertebrae body + transverse ligaments injury	spinous process of C 7 fracture	occipito-cervical rod and screw fusion (Occiput – C3-4-5)	No complaint at 18 month F/U.

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## References

1. Jefferson G: Fracture of the atlas vertebra. Report of four cases, and a review of those Previously recorded. *Br J Surg* 1920; 7:407-422.
2. Gleizes V, Jacquot F, Signoret F, Feron J M. Combined injuries in the upper cervical spine: clinical and epidemiological data over a 14-year period. *Eur Spine J*.2000;9: 386-392
3. Aïcha K. B, Laporte C., Akrouit W., Atallah A, Kassab G, Jégou D. Surgical management of a combined fracture of the odontoid process with an atlas posterior arch disruption: A review of four cases. *Orthop Traumatol Surg Res* 2009; 95:3: 224-228.
4. Dickman CA, Hadley MN, Browner C, et al. Neurosurgical management of acute atlas- axis combination fractures. A review of 25 cases. *J Neurosurg* 1989;70:45-49.
5. McCabe JP, Waldron B, Byrne J: Occipitocervical fixation of a complex upper cervical
6. Apostolides PJ, Theodore N, Karahalios DG: Triple anterior screw fixation of an acute combination atlas-axis fracture. Case report. *J Neurosurg* 1997; 87:96-99.
7. Bellis Y M, Linnau K F, Mann F A. A Complex Atlantoaxial Fracture with Craniocervical Instability: A Case with Bilateral Type 1 Dens Fractures. *AJR* 2001; 176:978.
8. Lipson SJ: Fractures of the atlas associated with fractures of the odontoid process and transverse ligament ruptures. *J Bone Joint Surg (Am)* 1977; 59:940-943.
9. Guiot B, Fessler R G. Complex atlantoaxial fractures *J Neurosurg (Spine 2)* 1999;91:139- 143.
10. Liu C, Kuang L, Wang L, Tian J Management of combination fractures of the atlas and axis: a report of four cases and literature review. *Int J Clin Exp Med*. 2014 Aug 15;7(8):2074-80.
11. Wu AM, Wang XY, Chi YL, Xu HZ, Weng W, Huang QS, Ni WF. Management of acute combination atlas-axis fractures with percutaneous triple anterior screw fixation in elderly patients. *Orthop Traumatol Surg Res*. 2012 Dec; 98(8):894-9