

**ATLAS FRACTURE - JEFFERSON FRACTURE**



*"Atlas and the Hesperides", oil on board, 1925, John Singer Sargent.*

*Zeus was overjoyed when his son was born, he wanted him to be a great hero and protector of the mortals, however his wife Hera always loathed any of the offspring of her husband's - all too frequent - "liaisons". She would do everything in her power to hinder, and hopefully destroy them, and her loathing applied most especially to the great Heracles. When Heracles had grown to manhood, he was given the hand in marriage of Megara, the beautiful daughter of the king of Thebes, Creon. Heracles had many children with Megara, but then Hera in a rage of jealousy cast a powerful spell over him that sent him into a paranoid rage. Thinking he was surrounded by enemies on all sides he slew all of his children. When he realized what he had done he was inconsolable and went to the Oracle of Delphi to seek a means of penance and atonement. The hero was ordered to go into the service of King Eurystheus of Mycenae, as a common slave. The evil and dishonorable King Eurystheus was in fact a protégé of Hera, and so it seems that Hera herself had malignly influenced the sacred Oracle! Hera ordered King Eurystheus, to send Heracles on a suicide mission. Eurystheus, in his extreme eagerness to please Hera, did better than that - he ordered Heracles to ten suicide missions - which he later, extended to twelve, by trickery that showed a sick genius for manipulating contract law, which would have made his fortune in a later era! And so it was that Heracles was condemned to his famous twelve labours.*

*King Eurystheus was quite beside himself. Heracles had now successfully completed his allotted ten labours. The King was terrified of the wrath of Hera, she would not be pleased with him at all - he had to think quickly. He suddenly declared most deceitfully that Heracles had not completed two of his tasks fairly. Heracles was outraged and demanded to know which two labours had not been satisfactorily completed. King Eurystheus thought hard and quickly then pronounced that Heracles had cheated in his battle with the Hydra - the second labour - as he had had unauthorized assistance from his nephew Iolaus. He also declared that he had not fairly completed the fifth task the cleaning of the Augean stables, as he had accepted payment from King Augeus - even though King Augeus never did actually pay him! This kind of evil trickery would normally have sent Heracles into an ungoverned fury that would have undoubtedly led him to kill King Eurystheus, but he checked himself on this occasion as he was under a sacred oath to the Oracle of Delphi to complete whatever tasks were asked of him by King Eurystheus. "All right", he roared at the King, who took a quick step back in fright, "Give me another two tasks, and then let that be the end of this matter or I will appeal to my father Zeus, if there is any more deceit!" King Eurystheus breathed a sigh of relief, that Heracles had not killed him, but he now knew that he had played his last cards. Though he was scared of the wrath of Hera, this would be as nothing compared the wrath of Zeus! He had two extra chances now to bring Heracles undone - and so his last two tasks would have to be truly impossible. For Heracles' eleventh task he had just the thing - Heracles would have to procure for him the sacred golden apples of the Hesperides!*

*Many eons ago, when the Earth was very young, the mother of the Earth, and all the gods, Gaia, had given Hera a wedding present when she married Zeus. A bunch of the most beautiful golden apples. These apples were so beautiful that Hera had to have a very special hiding place for them. She entrusted them to the Hesperides - the daughters of the mighty Titan Atlas. When the Titans were defeated in their battle with the gods of Olympus, most were banished to live with Hades in the underworld, but Atlas had been sentenced to a particularly nasty punishment. He was condemned to support the weight of the sky on his shoulders for all eternity. The place at which he held his immense burden was at the very edge of the world, just beyond the straits of Gibraltar. He did have the*

*consolation however of being allowed to be near his daughters the Hesperides who guarded the golden apples of Hera in a beautiful garden. But just to be extra certain that no one could get anywhere near enough to steal the apples, even though their garden was at the edge of the world, the Hesperides kept a most monstrous one hundred headed dragon called Ladon to watch over the apples.*

*After many adventures Heracles eventually discovered the way to the secret garden of the Hesperides, after forcing the information out of the minor sea-god Nereus. When he arrived at the garden he found that it was guarded by Ladon the fearsome dragon. He decided that this dragon was simply too fearsome to take on and so he would have to use cunning and trickery. He said to Atlas that he must be very tired holding up the weight of the heavens, and that he would be happy to relieve him for a short while in exchange for a gift - the apples of his daughters, the Hesperides. Atlas agreed. Luckily Heracles was up to the task and he was able to support the weight of the heavens on his shoulders. Atlas much relieved, then persuaded his daughters to gather up the apples, as only they could soothe and subdue the fierce dragon, Ladon. Although unhappy, they would never disobey their father. They called off the dragon and Atlas gathered up the apples to give to Heracles - but by now he had decided that he would use some trickery of his own. He told Heracles that he would be happy to deliver the apples personally to King Eurystheus and save Heracles the trouble of a very long and difficult journey. Heracles suspecting a trick, agreed but that first Atlas would have to take back the weight of the heavens so that he could adjust himself into a better position as the heavens were not sitting evenly on his shoulders. Atlas, foolishly agreed, and no sooner had he retaken the load, he realized he himself had been tricked. Heracles merrily gathered up the apples and fled back to Mycenae, where he dropped them at the King's feet. The King could not believe that Heracles had brought back the apples. He was terrified that Hera would discover them in his possession and so he simply gave them straight back to Heracles. Heracles passed them on to his protector Athena, who then discreetly had them returned to the Hesperides.*

*The Hesperides myth has been a powerful leitmotif for artists over the centuries, but perhaps there is no more stunning depiction than that of John Singer Sargent's "Atlas and the Hesperides" of 1925. Sargent's main oeuvre was as one of the greatest portrait painters of the late Victorian and Edwardian eras, however he was able to adjust his work with the times as well. In his old age, he was able to produce brilliant works of Art Deco, then the main genre of the 1920s. We see this masterful adaptation in his "Atlas and the Hesperides" which he produced in 1925, the year he died.*

*The atlas bone is so named for the great Titan, who was condemned to hold up the vault of the skies for eternity. This bone holds up the skull, but like the Titan is somewhat prone to mischievous deceit! It may cunningly hide its injuries from our traditional methods of radiology of the past. Though classic descriptions are well known for the detection of the fracture of this bone on plain radiography, the signs can be quite subtle or not seen at all. So we must now, like John Singer Sargent, move with the times - suspected foul play of the Atlas, is best detected with the routine use of the CT scanner, rather than our traditional plain radiography.*

## ATLAS FRACTURE - JEFFERSON FRACTURE

### Introduction

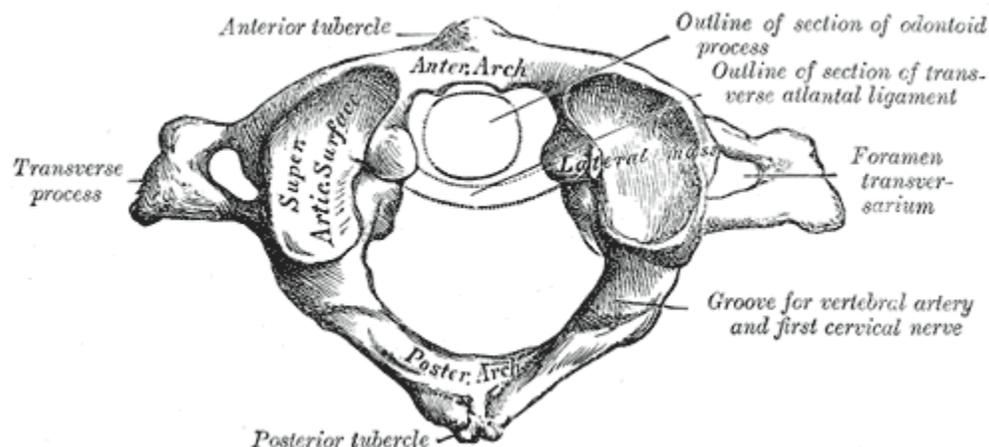
Two types of fractures are generally seen for the **atlas bone**:

- The burst (or Jefferson) fracture:
  - ♥ The **Jefferson fracture** is classically described as a 4 part burst fracture of the atlas, with combined anterior and posterior arch fractures, however variants with 2 or 3 part fractures are also generally included.<sup>1</sup>
  - ♥ This is a very **unstable fracture**, particularly if the **transverse ligament** is ruptured.
- Isolated posterior arch fractures:
  - ♥ Although usually considered mechanically stable because the anterior arch and the transverse ligament generally remain intact, this fracture is potentially dangerous because of its location.
  - ♥ Anterior displacement of the atlas greater than 1 cm can injure adjacent spinal cord.

### History

The **Jefferson fracture** is named after the British neurologist and neurosurgeon **Sir Geoffrey Jefferson**, (1886-1961) who reported four cases of the fracture in 1920.<sup>3</sup>

### Anatomy



*Atlas (C1), (Gray's Anatomy, 1918).*

The atlas (C1) is essentially a thin bony ring with broad lateral masses with articular surfaces that provide the only 2 weight bearing articulations between the skull and the vertebral column.

Unlike other vertebrae, it has no central body, rather this region receives the articulation of the dens of the axis, which is bound by the transverse ligament.

### Mechanism

#### Jefferson fractures:

Jefferson fractures are classically the result of an **axial compression injury**, that results in a *bursting* of the bony ring of C1.

The force drives the lateral masses outward, resulting in fractures of the anterior and posterior arches of the C1, with or without disruption of the transverse ligament.

Axial compression injuries are commonly caused by:

- Diving injuries
- Motor vehicle accidents, where the head strikes the roof of the car.
- Axial loading that occurs when a heavy object falls vertically onto the head.



*Diagram showing the “bursting” nature of the 4 fragments of C1, (Radiographics vol 20 no. 3, May/June 2000).*

#### Posterior arch fractures:

A posterior neural arch fracture of C1 results from compression of the posterior elements between the occiput and the spinous process of C2 during **forced neck extension**.

A vertical fracture line through the posterior neural arch is seen on lateral x-ray, (see appendix 1 below).

Although mechanically stable because the anterior arch and the transverse ligament generally remain intact, this fracture is potentially dangerous because of its location.

Anterior displacement of the atlas greater than 1 cm can injure adjacent spinal cord

### Complications

1. Associated injuries of the cervical spine are common with Jefferson fractures.
  - Approximately 40 % of atlas fractures are associated with fractures of the axis, (C2).<sup>2</sup>
  - Odontoid fractures are also commonly associated.
2. Neurological
  - Surprisingly of those patients that survive and arrive to hospital, there is *not* usually any associated neurological deficit, providing proper spinal precautions are taken.

This is because as the ring of C1 naturally widens when it fractures there is some protection with regard to cord compression.
3. These fractures are unstable.

### Investigations

#### Plain radiographs:

Views should include:

- A-P, these are usually not helpful.
- Lateral views, may suggest the fracture:
  - ♥ The may be some prevertebral soft tissue swelling, (this is not a sensitive or specific sign however).
  - ♥ The **pre-dens space** (distance between the anterior tubercle of C1 and the dens) may be widened due to pre-vertebral hemorrhage combined with disruption of the transverse ligament.

A pre-dens space greater than **3 mm in adults** or **5 mm in children** is abnormal
- Open mouth, (odontoid or peg view) of the C1/C2 region:
  - ♥ This is usually the most useful plain x-ray view.

- ♥ In particular look for bilateral (or unilateral) lateral displacement of the lateral mass of C1 on C2.

This suggests a fracture with disruption of the transverse odontoid ligament, which may otherwise constrain this displacement, (see appendix 1 below).

The spaces lateral mass to odontoid and lateral mass of C1 to body of C2 should be equal on both sides.

The Jefferson fracture may be difficult or impossible to recognize on plain x-ray if there is *minimal* displacement of fragments.

On plain radiographs, the **transverse ligament** is presumed to be disrupted if:

- The interval between the atlas and the dens is increased on a lateral radiograph

*Or*

- The lateral masses of the atlas extend laterally beyond those of the axis on the odontoid radiograph.

### CT scan

CT is the best investigation for the fracture and *must be done in all suspected cases*.

- It should be done when there is a suspicion of injury on the plain x-rays.
- **It should be done even when plain x-rays are normal yet clinical suspicion remains high for a cervical fracture,**

**See also cervical spine plain radiology assessment document.**

- CT is also done to further define the extent of injury, even when the fracture is obvious on plain x-ray. This is for possible spinal cord involvement and to look for any associated fractures.

### CT angiogram

This can be done to assess for any associated vascular lesions, particularly of the vertebral arteries.

It may be considered on the basis of clinical suspicion and/ or the nature and extent of the bony fracture.

### MRI/MRA:

- This should be done for any associated neurological deficit.
- It may also be considered in cases where CT scan findings are equivocal.

- MRA is also especially useful for detecting the presence of any associated vascular lesions, particularly of the vertebral arteries.

## Clinical Assessment

### *Important points of history*

- A history of the **mechanism of injury** is very important in raising the index of suspicion for this fracture.

**High energy axial loading injuries are high risk for C1 fractures.**

### *Important points of examination*

- Assessment of any immediate ABC issues
- Careful assessment for any neurological deficit.
- Full secondary survey, as for any multi-trauma patient.

*Examination findings for the fracture will include:*

- Midline cervical tenderness.
- Pain will usually be significant.

## Management

1. Immediate attention to any ABC issues.
  - If intubation is necessary, spinal precautions must also be taken with an assistant providing immobilization, whilst the procedure is being performed.
2. Cervical spine immobilization:
  - Although the fracture is not usually associated with neurological deficit it is unstable and secondary neurological injury may result from lack of proper spinal precautions
  - Patients should be immobilized in a Philadelphia collar in the first instance.

3. Surgical management:

This will usually involve:

- Immobilization in a halo fixation device for 3 months.

- Displaced fractures will require ORIF.

Disposition:

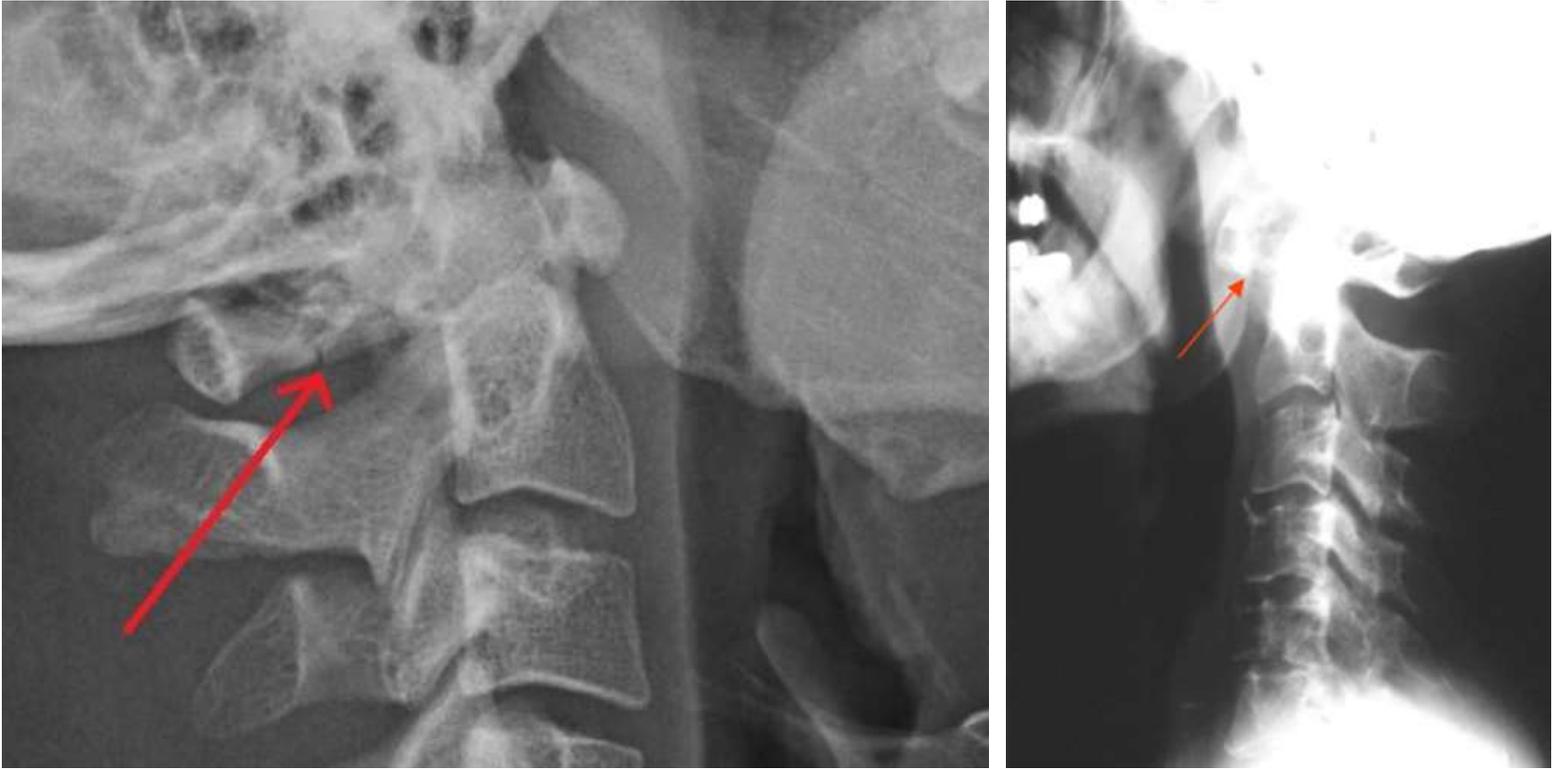
These patients are generally referred to the Orthopaedic Unit

These may also be referred to the Neurosurgical Unit, depending somewhat on local practice.

If an associated vascular lesion is suspected, then referral to the Vascular Unit is warranted.

## Appendix 1

### Plain radiography:



*Left: Lateral view showing faint fracture line through inferior margin of body of C1.  
Right: lateral view showing widened pre-dens (i.e between C1 and the odontoid) space.*



*Lateral displacement of the left lateral mass of C1 on C2 in a Jefferson fracture.*

*CT Scan:*



*CT scan showing a Jefferson fracture of the atlas, (C1).*



*“Atlas”, Art Deco Bronze, Lee Lawrie 1937, Rockefeller Centre New York.*

*The atlas bone is named for the ancient Greek god, Atlas, who supported the weight of the sky on his shoulders. The bony atlas supports the weight of the head.*

## References

1. Wheelessonline Website.
2. Atlas Fracture, ATLS Manual 8<sup>th</sup> ed, 2008.
3. Jefferson G: "Fracture of the atlas vertebra: report of four cases, and a review of those previously recorded". *Br J Surg* 1920; **7** (27): 407-22.

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