A pictorial review of odontoid peg fractures: imaging features, classification and clinical significance.

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Learning objectives

- Understand the epidemiology, aetiology and clinical manifestations of common odontoid fractures.
- Identify the anatomy and imaging features of different types of odontoid peg fractures.
- Understand the clinical significance of specific fractures.
- Be aware of potential pitfalls and how to avoid them when imaging the odontoid peg.

Background

Odontoid peg fractures account for 15% of cervical spine fractures following a motor vehicle accident or fall [1]. They can present with a spectrum of clinical findings from the complete absence of neurological signs, up to complete quadriplegia with respiratory centre involvement. It is essential that the radiologist is aware of the relevant anatomy and imaging findings in order to prevent significant morbidity.

Findings and procedure details

Epidemiology

Odontoid peg fractures are thought to occur following extreme hyperextension or hyperflexion of the cervical spine. This can be caused by low-impact forces, such as falls in the elderly, or as a result of high-impact forces, such as road traffic collisions in young or middle-aged patients [2]. Odontoid fractures are the most common isolated cervical spine fracture in patients over the age of 70 years [3]. Neurological injury is uncommon but due to the risk of atlantoaxial subluxation and proximity of the medulla oblongata, when it does occur, it may be serious or even fatal.

Classification System

The Anderson and D’Alonzo classification system is the most widely used. They characterised odontoid peg fractures according the plane of the fracture [4]. The classification system is summarised in Table 1 and Fig. 1 on page 5. The fracture types may then be further classified as displaced or non-displaced.
<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency</th>
<th>Anatomic Location</th>
<th>Stability</th>
<th>Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-3%</td>
<td>Oblique fracture through upper part of the odontoid process caused by bony avulsion by alar ligaments</td>
<td>Stable</td>
<td>High rate of fusion</td>
</tr>
<tr>
<td>2</td>
<td>54-60%</td>
<td>Fracture at junction between the odontoid process and the body of the axis</td>
<td>Unstable</td>
<td>High rate of malunion</td>
</tr>
<tr>
<td>3</td>
<td>39-42%</td>
<td>Fracture that extends down into the cancellous bone of the body of the axis and is in reality a fracture of the body of C2</td>
<td>Usually stable</td>
<td>High rate of fusion</td>
</tr>
</tbody>
</table>

**Type 1 fractures**

Type 1 odontoid process fractures are rare and somewhat controversial. They are thought to be avulsion fractures of the alar or apical ligaments and occur above the level of the transverse ligaments, hence their stable nature ([Fig. 2 on page 6](#)). However, they may be unstable if there is bilateral alar ligament avulsion, or an associated occipital condyle fracture [6].

**Type 2 fractures**

Type 2 odontoid process fractures, occurring through the base of the peg, are the most common ([Fig. 3 on page 7](#), [Fig. 4 on page 8](#)). They are inherently unstable, with a risk of atlantoaxial subluxation if not promptly immobilised ([Fig. 5 on page 9](#)). They have a high incidence of nonunion, probably due to disruption of blood supply to the peg.
The risk of non-union is directly related to the degree of displacement (Fig. 6 on page 9) [8].

Hadley et al suggested a modification of the Anderson & D'Alonzo classification system with the inclusion of a subtype of type 2 odontoid process fractures (type 2A) [9]. This subclass, accounting for 5% of Type 2 fractures, also involves additional chip fracture fragments at the base of the dens, making it more unstable and definitely necessitating surgical stabilisation to prevent non-union (Fig. 21 on page ) [10].

Type 3 fractures

Type 3 fractures are relatively common. As they involve the body of the axis and have a relatively large surface area they are relatively stable and have a much lower risk of malunion (Fig. 8 on page 11, Fig. 9 on page 12). However, one should ensure careful examination in 3 orthogonal planes to exclude extension of the fracture into the posterior elements (Fig. 10 on page 13).

Radiological investigations & Pitfalls

Plain radiography

A high degree of suspicion for peg fractures is needed when reviewing imaging of the head and cervical spine.

Plain radiography

Displaced odontoid peg fractures can be identified on lateral radiographs (Fig. 11 on page 14). Lateral radiographs may appear normal in the case of undisplaced Type 2 or 3 fractures, or demonstrate prevertebral soft tissue swelling (Fig. 12 on page 15). However, they may be clearly seen on an open mouth view (Fig. 13 on page 16). It may not be possible to exclude fractures on plain radiographs when there are degenerative changes present, in which case one must obtain a CT. However, even on CT degenerative changes can draw one's eye away from acute fractures (Fig. 14 on page 17).

CT

CT is essential to rule out minimally displaced fractures in patients with inadequate radiographs or degenerative disease. It is also useful to demonstrate the anatomy of
fractures in order to aid surgical planning. However, due to the transverse plane of odontoid fractures, they may not be apparent on axial imaging, and hence coronal and sagittal reformats should be obtained. The radiologist should also remember to review this area in 3 orthogonal planes on CT head examinations, as peg fractures may not be clinically suspected in elderly patients who have had a fall (Fig. 15 on page 18, Fig. 16 on page 19).

Useful information may also be gained by reviewing the CT in the soft tissue window. Haematoma may point to a subtle fracture in a degenerative neck or disruption of the posterior ligamentous complex. Fig. 17 on page 20 demonstrates a haematoma in the spinal canal, prompting further investigation with MRI.

Finally, one should be aware of anatomical variations which may mimic fractures. An os odontoideum, which may mimic a type 1 or 2 fracture, usually occurs with a hypoplastic dens. This is thought to occur secondary to a previous fracture of the synchondrosis and may cause instability. Conversely, a persistent ossiculum terminale is due to failure of fusion of the secondary ossification centre, closer to the tip of the odontoid process than the synchondrosis, and may mimic a type 1 fracture (Fig. 18 on page 21) [7].

MRI

Although CT is the gold standard for bony anatomical detail, MRI is useful in assessing soft tissue and neurological injury. It may also be useful in problem solving to distinguish between acute and old fractures. Fig. 19 on page 22 shows a distracted type 2/3 odontoid peg injury in a patient who also sustained a serious head injury, making a clinical neurological assessment impossible. Due to the degree of distraction, an MRI was performed prior to surgical stabilisation, to assess soft tissue and neurological injury (Fig. 20 on page 23).

Images for this section:
Fig. 1: The Anderson and D'Alonzo classification. Adapted from: Anderson LD, D'Alonzo RT. Fractures of the odontoid process of the axis. J Bone Joint Surg Am 1974;56:1663-74.
Fig. 2: Type 1 odontoid process fracture, which occurred in association with a burst fracture of the atlas.
Fig. 3: Non-displaced type 2 odontoid peg fracture, coronal CT.
Fig. 4: Non-displaced type 2 odontoid peg fracture, sagittal CT.

Fig. 5: Displaced type 2 odontoid peg fracture with atlantoaxial subluxation.
Fig. 6: Nonunion of a type 2 peg fracture with greater than 5mm posterior displacement.
Fig. 7: Type 2A (comminuted) odontoid process fracture.
**Fig. 8:** Undisplaced type 3 odontoid process fracture (coronal CT).
Fig. 9: Undisplaced type 3 odontoid process fracture (sagittal CT).
Fig. 10: Displaced type 3 odontoid peg fracture with associated fractures of C2 and C3 spinous processes.
**Fig. 11:** Displaced type 2/3 odontoid fracture on lateral radiograph.
Fig. 12: Lateral cervical spine radiograph demonstrating prevertebral soft tissue swelling at the level of the odontoid peg.
**Fig. 13:** Open-mouth radiograph demonstrating an undisplaced type 3 odontoid peg fracture.
Fig. 14: Severe degenerative change at the atlantoaxial level with an acute type 2 odontoid peg fracture.
Fig. 15: Displaced type 2 odontoid peg fracture on the edge of a CT head examination (coronal reformat).
Fig. 16: Displaced type 2 odontoid peg fracture on the edge of a CT head examination (sagittal reformat).
Fig. 17: Undisplaced type 2 odontoid peg fracture with haematoma extending into the spinal canal.
**Fig. 18:** Persistent ossiculum terminale may mimic a type 1 odontoid process fracture (coronal CT).
Fig. 19: Distracted type 2/3 odontoid peg fracture (sagittal CT).
Fig. 20: Sagittal T2 MRI demonstrating distracted type 2/3 odontoid peg fracture with haematoma extending into the spinal canal and high signal in the spinal cord at that level.
Conclusion

Odontoid peg fractures may present with a wide spectrum of clinical and imaging findings. Knowledge of the salient imaging features of these entities and their associated complications is of utmost importance, which impacts on prognosis and management. It is of paramount importance for the radiologist to raise the alarm quickly, to prevent serious neurological sequelae.

Personal information

References