

Odontoid Fracture

A patient guide

In brief: An odontoid fracture is a break in the upward-pointing peg of bone (the dens) that rises from the second bone of the neck and acts as the pivot around which the head turns. It is one of the most common neck fractures, particularly in older people after a simple fall, and certain patterns — especially a break through the narrow base of the peg — are notoriously slow and unreliable to heal. This page explains what the injury is, how it is classified, why one particular type behaves so differently from the others, and how it is told apart from look-alike conditions.

What an odontoid (dens) fracture is

The second bone of the neck is called the axis, or C2. Unlike any other bone in the spine, it carries a tall, tooth-shaped column of bone projecting upwards from its body. This column is the **odontoid process**, more often called the **dens** or, in everyday clinical shorthand, the **peg**. The word odontoid itself comes from the Greek for "tooth-like", and the dens does indeed sit like a peg or a tooth in the centre of the ring formed by the first neck bone above it, the atlas (C1).

The dens has a remarkable job. It is the bony post around which the head and the atlas rotate. Roughly half of the entire turning movement of the neck — the action of shaking the head to say "no" — happens at the joint between the first and second neck bones, the atlanto-axial joint, and the dens is the central pillar that makes this possible. It is held snugly against the inside of the front arch of the atlas by a strong band called the transverse atlantal ligament, which prevents the atlas (and the skull it carries) from sliding forwards on the axis. Above, the tip of the dens is anchored towards the base of the skull by the apical and alar ligaments.

An odontoid fracture is a break across this peg. Because the dens is the linchpin of the most mobile joint in the spine and sits immediately in front of the spinal cord at the top of the neck, a fracture here is taken seriously. Most odontoid fractures, fortunately, do not damage the cord, but the injury can leave the head and atlas inadequately tethered to the rest of the neck, which is why the pattern of the break and its stability matter so much.

The dens and its blood supply

To understand why odontoid fractures behave the way they do, it helps to understand how the peg is nourished. A landmark anatomical study by Schiff and Parke in 1973 mapped the arterial supply of the dens in detail, and what they found explains a great deal about its healing.

The dens receives blood from two directions. From below, paired anterior and posterior ascending arteries climb up from the vertebral arteries to feed the base and body of the peg. From above, small cleft perforating branches reach the tip of the dens by travelling along the apical and alar ligaments, ultimately deriving from the carotid circulation. The two systems meet somewhere in the middle.

The crucial consequence of this arrangement is that the **base or neck of the dens is a watershed zone** — a region supplied only at the far edges of two separate territories, and therefore comparatively poorly supplied. It is rather like the patch of garden that neither of two sprinklers quite reaches. When a fracture runs through this zone, the blood supply to the upper fragment can be disrupted just where healing depends on it most. Bone needs a good blood supply to knit, and a break through a poorly vascularised, narrow, cortical region of bone is biologically at a disadvantage from the outset. This single fact — the watershed at the base of the peg — is the dominant explanation for why one particular type of odontoid fracture is so prone to failing to unite.

The Anderson-D'Alonzo types (I, II, III)

Odontoid fractures are classified by where the break sits along the peg. The system used worldwide was described by Anderson and D'Alonzo in 1974, based on a series of forty-nine fractures, and it divides them into three types according to the level of the fracture line.

Type I is an oblique break through the very **tip of the dens**, at the point where the apical and alar ligaments attach. It is thought to be an avulsion — the ligament pulling off a flake of bone — and it is rare. In isolation it is usually stable and tends to heal well. The main caution attached to a Type I fracture is that, because of where it sits, it can occasionally be a marker of a more serious injury higher up, at the junction between the skull and the neck, and that more significant injury has to be excluded.

Type II is a break through the **base or neck of the dens**, where the peg joins the body of the axis, just above the level of the joint surfaces on which C2 sits. This is the **most common** type of odontoid fracture and, for the reasons set out below, the **most troublesome to heal**.

Type III is a fracture that runs **lower, down into the broad cancellous body** of the axis itself, often involving the upper joint surfaces. Because it passes through spongy, well-supplied bone with a large surface area, a Type III fracture has a comparatively **high union rate** and generally does well with external support such as a collar. In behaviour it has much more in common with a fracture of the C2 body than with a Type II.

A later refinement by Grauer and colleagues in 2005 subdivided the awkward Type II group by the direction and geometry of the fracture line, in order to help teams reason about which surgical approach, if any, suits a given break. In broad terms, a clean, undisplaced transverse Type II (Grauer IIA) is a candidate for external support; a break sloping from front-top to back-bottom (IIB) lends itself to a screw passed up through the front of the peg; and a break sloping the other way, or one that is comminuted (IIC), is unfavourable for that screw and tends to point towards a fusion at the back. This treatment-oriented scheme remains widely used.

Why the Type II fracture is the problem one

The Type II fracture is singled out across the whole literature because three separate disadvantages all converge precisely at the base of the peg.

The first is the **vascular watershed** already described. The base of the dens has the poorest blood supply of any part of the peg, and that is exactly where the Type II fracture line runs.

The second is the **shape of the bone**. The neck of the dens is a narrow, largely cortical (hard, dense) cross-section with little of the spongy cancellous bone that forms healing callus quickly. A Type III fracture, by contrast, passes through a broad cancellous bed with a large healing surface; a Type II has almost none of that advantage.

The third is **movement**. The upper fragment of a Type II fracture is a long lever sitting at the single most mobile joint in the entire spine. Every nod, turn and tilt of the head transmits flexion, extension and rotational shear across the fracture line. This repeated micromovement disrupts the fragile early callus before it can mature, much as a seedling cannot establish if it is tugged loose every day.

Put together — poor blood supply, hard narrow bone, and relentless motion — these three factors mean that a Type II fracture treated in a collar alone fails to knit in a substantial proportion of cases. Reported non-union rates in mixed series are broadly in the region of a quarter to a third, and considerably higher where the fracture is displaced, angulated, occurs in an older person, or is treated late. No other C2 fracture combines all three liabilities, which is precisely why the Type II carries the reputation it does.

It is worth noting that "non-union" does not always mean a poor outcome. In many people, particularly older people, a Type II fracture that does not knit with new bone instead settles into a stable scar-tissue, or fibrous, bridge. A growing body of evidence finds that such a stable fibrous union can give function and comfort indistinguishable from a fully bony union — a point returned to below.

How it differs from other C2 fractures and from os odontoideum

Several different injuries can affect the second neck bone, and the odontoid fracture is a distinct entity that should not be confused with the others.

A **hangman's fracture** is the injury most often muddled with an odontoid fracture in the public mind, but anatomically the two could hardly be more different. The hangman's fracture — more formally, traumatic spondylolisthesis of the axis — is a break through the bony ring **behind** the peg, specifically through the pars interarticularis on both sides, the slender struts of bone that form the back part of the axis. It is classified by a separate system described by Levine and Edwards in 1985. It is a fracture of the **posterior ring**, not of the central peg, and it tends to behave quite differently: most low-grade hangman's fractures are stable and unite reliably in a collar, because they pass through better-supplied bone and are not subject to the same watershed problem. The two injuries share only the bone they occur in. An odontoid fracture is at the front and centre; a hangman's fracture is around the back.

A **C2 body fracture** is a break through the main cancellous body of the axis, below the base of the dens. Like a Type III odontoid fracture, it runs through spongy, well-vascularised bone with a generous healing surface, and it generally unites readily. It does not carry the Type II's healing problem because it is nowhere near the watershed at the neck of the peg.

The most important chronic look-alike is **os odontoideum**. This is not a fresh injury at all but a long-standing finding: a separate, smooth, well-corticated little ossicle of bone sitting above a shortened (hypoplastic) dens base, with no bony continuity to the body of the axis below. Whether it is truly congenital or the remnant of an old, ununited childhood fracture is debated, and the answer is probably "both" in different people. The reason it matters here is that, on a scan, an old ununited dens fracture and an os odontoideum can look similar and can behave similarly, since both can leave the upper neck unstable. They are told apart by their appearance and history: an os odontoideum is typically a **smooth, rounded or oval, fully corticated** ossicle with a separation plane sitting well above the joint surfaces, often accompanied by an enlarged front arch of the atlas and with no history of recent injury. An acute Type II fracture, by contrast, shows an **irregular, recently broken, peg-shaped** edge, sits at the base of the dens, follows a definite injury, and shows signs of fresh injury on MRI. Distinguishing the two is a matter of careful imaging and history rather than guesswork.

How it tends to present (incl. the elderly low-energy fall)

Odontoid fractures show a strikingly two-peaked age pattern. There is a smaller peak in young adults, in whom the injury results from high-energy trauma such as a road collision or a fall from height. There is a much larger and steadily growing peak in older people — often around the age of eighty — in whom the very same fracture results from a low-energy event, most characteristically a simple fall from standing height, a trip in the home, or a fall against furniture.

In fact, the odontoid fracture is now the **single most common cervical spine fracture** in people aged sixty-five and over, and in the very elderly, fractures of the second neck bone make up the majority of all neck fractures. With populations ageing and with osteoporosis (thinning of the bones) widespread in later life, the number of these fractures is rising, which has turned what was once a relatively uncommon injury into a substantial and growing part of spinal practice.

The presentation can be deceptively undramatic. A younger person after a major accident is investigated thoroughly as a matter of course, so the fracture is usually found. An older person after a modest fall may have nothing more obvious than neck pain, stiffness, or pain on moving the head, and may have walked in to be seen. Pain at the back of the upper neck and a reluctance to turn the head are common. Because the symptoms can be mild and because pre-existing wear-and-tear changes can obscure the picture, the diagnosis can be missed if it is not actively considered — which is one reason imaging plays such a central role.

How it is assessed (CT, open-mouth view, MRI)

Three imaging tools are relevant, each with a different role.

Plain radiographs, including the open-mouth "peg" view taken through the open mouth to look straight at the dens, together with a side-on lateral view, are the traditional first films. However, they are insensitive: they frequently fail to show a dens fracture, especially in older people and where degenerative change clutters the picture. A normal-looking plain film does not exclude the injury.

Computed tomography (CT) is the main diagnostic scan. Thin-slice CT with reconstructions in several planes reliably shows the fracture line, pinpoints its level (which determines the Anderson-D'Alonzo type), and measures the angulation, displacement and any comminution of the break. CT is what most reliably confirms the diagnosis and characterises the fracture.

Magnetic resonance imaging (MRI) adds information that CT cannot provide. It shows the spinal cord and reveals any injury to the soft tissues and ligaments — in particular the transverse atlantal ligament, whose integrity is central to whether the atlanto-axial joint is stable. MRI also helps establish whether a fracture is **acute**: a fresh break produces fluid-sensitive signal change (oedema) in and around the bone, whereas a smooth, quiet, oedema-free ossicle points instead towards an old, established non-union or an os odontoideum. In this way, imaging is also the key to separating a new injury from its chronic look-alikes.

What the evidence shows about management (collar vs anterior screw vs C1-C2 fusion; the elderly debate)

The following describes, impersonally, the approaches a spinal team weighs up. It is a summary of the published evidence, not a recommendation; decisions are individualised by the treating team.

External immobilisation with a rigid cervical collar is the mainstay for stable, minimally displaced fractures and is a reasonable default for many frail older patients, achieving stable union — bony or fibrous — in the large majority with relatively little associated harm. The **halo vest**, a more rigid frame historically used to chase a fully bony union, has fallen out of favour in older people because it carries serious risks in that group. A frequently cited study by Tashjian and colleagues in 2006 reported markedly higher early mortality and major complications, chiefly chest and pressure-related, in elderly patients managed in a halo, and a related paper memorably questioned whether the halo amounted to a "death sentence" in this population. A UK cohort from Patel and colleagues in 2015 found no functional advantage of a halo over a collar, and reported that the great majority of elderly Type II and Type III fractures achieved either bony union or a stable fibrous union, with no difference in function between the two devices — supporting the view that fracture stability, rather than radiographic bony healing, is the meaningful goal.

Anterior odontoid screw fixation involves passing a single screw up through the front of the axis and across the fracture to pull the fragments together. Its great attraction is that it preserves the rotation of the atlanto-axial joint, since it does not lock any joints. It is best suited to recent, reducible fractures with a favourable line (the Grauer IIB pattern), in which union rates of around eighty-five to ninety per cent are reported. Apfelbaum and colleagues showed in 2000 that results are markedly worse when fixation is delayed — long-standing fractures fixed many months after injury fared considerably less well — so timing and fracture orientation both matter. The screw is less reliable in osteoporotic bone, in unfavourably angled (IIC) or comminuted fractures, and in barrel-chested individuals where the chest wall obstructs the angle the screw must take.

Posterior C1-C2 fusion is the most mechanically robust option and the usual salvage for non-union, gross instability, irreducible or unfavourably oriented fractures, and poor bone quality. Modern techniques include the Magerl transarticular screw and the Goel-Harms construct using screws and rods anchored in the first and second neck bones; the two are biomechanically comparable. Fusion achieves the highest union rates but does so by deliberately stopping movement at the atlanto-axial joint, sacrificing roughly half of neck rotation, and it is a

larger operation than a screw.

****The elderly debate**** is the central unresolved controversy in this field. Observational data from the AOSpine North America geriatric odontoid studies suggested a survival advantage for surgery over non-operative care, with non-operative treatment associated with substantially higher early mortality in some analyses. Other large cohorts, however, found no difference in mortality but more complications with surgery, and several groups argue that a stable fibrous union achieved in a collar is a perfectly acceptable, low-risk end-point. Because the high-quality randomised evidence needed to settle the question is only now emerging — through dedicated trials such as SCORE and INNOVATE — the balance between collar, screw and fusion in the older patient remains genuinely open, and is decided case by case.

Outlook

The outlook depends heavily on which type of fracture is present, the age and bone quality of the person, and how the break is managed. Type I and Type III fractures generally heal well, often with nothing more than external support. The Type II fracture is the one that may fail to knit with new bone, particularly when it is displaced, angulated by more than about ten degrees, occurs in an older person with thinned bone, or is treated late.

Even where a Type II fracture does not achieve full bony healing, however, the practical outlook is frequently good. A large proportion of these fractures settle into a stable fibrous bridge that is painless and functions well, and the evidence increasingly suggests that such an outcome can be every bit as satisfactory in daily life as a bony union. Where instability persists or where surgery is undertaken, modern fixation and fusion techniques achieve high rates of stable union. For the growing number of older people who sustain this injury after a simple fall, much current research and discussion is directed at finding the gentlest path to a stable, comfortable neck rather than insisting on perfect radiographic healing for its own sake.