

Proximal Junctional Kyphosis

A patient guide

In brief: Proximal junctional kyphosis, usually abbreviated to PJK, is an abnormal forward angulation of the spine just above the top of a long spinal fusion. It is one of the most common findings after major surgery for adult spinal deformity, in which several vertebrae are joined together with screws and rods to correct a curved or collapsing spine. In its purest form PJK is a measurement seen on an X-ray rather than a problem felt by the person, and the great majority of those who develop it never need anything done about it. At the other end of the same spectrum lies proximal junctional failure, or PJF, in which the bone, the ligaments or the metalwork at the top of the construct actually give way, sometimes with pain, deformity or pressure on the nerves. The crucial distinction between the radiographic finding and the structural failure runs through everything that follows, and it is the single most important idea for understanding this subject.

What proximal junctional kyphosis is (and why it sits at the top of a long fusion)

To make sense of PJK it helps to picture what a long deformity fusion actually does. In adult spinal deformity, the spine has lost its normal balance: it may curve sideways, as in scoliosis, or tip forwards, losing the inward curve of the lower back that normally keeps a person standing upright over their hips. To correct this, a surgeon joins a long series of vertebrae together with pedicle screws and rods, often extending from the upper back down to the pelvis. The fused segment becomes a single rigid column. The vertebra at the very top of that column, the highest one holding a screw, is known as the upper instrumented vertebra, or UIV. The term is used throughout this field, and it matters here because PJK is, by definition, a problem of the junction immediately above it.

A fusion changes the mechanics of the spine in a fundamental way. Below the top of the construct, the rigid rods prevent movement and share load between the vertebrae. Above it, the spine is once again mobile and flexible. The point where stiff metal-reinforced bone meets soft, moving spine is a transition zone, and it is here that stress concentrates. The body weight of the upper trunk, which previously passed through a long, gently curved spine, must now pivot over the top of a stiff lever. The vertebrae, discs and ligaments just above the UIV bear this concentrated load, and over time the segment can tip forwards into kyphosis, the medical word for a forward-bending curve.

This is why PJK is described as a junctional problem. It is not a disease of the fused bone itself, which usually heals solidly, but of the boundary between the fused and the unfused spine. The same principle explains why the location of the top of the fusion matters so much, and why so much surgical thought goes into how that top level is built. The junction is the weak link in an otherwise strong chain, and proximal junctional kyphosis is the name for what happens when that link starts to bend.

The radiographic definition: the proximal junctional angle

The reason PJK can be discussed with any precision at all is that it has a measurable definition, set out by Glattes and colleagues in 2005. They described an angle, the proximal junctional angle, measured on a standing side-on X-ray. The angle is drawn between the lower endplate of the upper instrumented vertebra and the upper endplate of the vertebra two levels above it. In plainer terms, it captures how sharply the spine bends forwards across the two segments immediately above the top of the fusion.

The definition then sets two conditions, both of which must be met. The proximal junctional angle must be at least ten degrees, and it must also be at least ten degrees greater than it was before the operation. The first condition rules out trivial angles; the second ensures that the change has genuinely arisen at the junction rather than simply reflecting a curve that was always there. An angle that is large but unchanged from before surgery does not qualify, and neither does a small new angle. It is the combination, ten degrees of angle and ten degrees of change,

that defines proximal junctional kyphosis.

This careful, numerical definition is precisely what makes PJK a radiographic entity. It is identified by drawing lines on an image and measuring between them, not by how a person feels. A measurement may cross the ten-degree threshold while causing no symptoms at all, which is why so many people found to have PJK are entirely unaware of it. The definition has been used consistently across the major studies in the field, which is what allows the incidence to be compared between different groups of patients and different surgical techniques. It is, in effect, the common language of the subject.

Proximal junctional kyphosis versus proximal junctional failure

Here lies the heart of the matter, and the distinction that this guide exists to draw. Proximal junctional kyphosis, as just described, is a radiographic measurement. Proximal junctional failure, by contrast, is a structural and clinical event. The two are related but they are not the same, and confusing them is the commonest source of misunderstanding about this topic.

PJK is the angle. It is often gradual, frequently mild and very commonly silent. A person may have a proximal junctional angle that has increased past the defined threshold and yet have no pain, no visible change in posture and no functional limitation. In a large proportion of cases, PJK is detected only because someone measured it on a follow-up X-ray. The literature is broadly reassuring that mild, stable PJK of this kind does not, on average, worsen a person's quality of life.

PJF is the failure. It describes the situation in which the structures at the top of the construct actually break down. This can take the form of a fracture of the upper instrumented vertebra or the vertebra just above it, a pulling-out of the screws, a slipping of one vertebra on another, a rupture of the ligaments that should hold the segment in line, or, in the most serious cases, pressure on the spinal nerves producing a neurological deficit. Researchers have defined acute PJF using a sharper angular threshold, an increase of fifteen degrees or more, combined with these structural features or the need for further surgery to extend the fusion upwards. PJF, in short, is what happens when the junction does not merely bend but gives way.

The relationship between the two is best thought of as a spectrum of severity. At the mild end sits asymptomatic radiographic PJK, which vastly outnumbers the rest. At the severe end sits PJF, which is far less common but far more consequential. A useful tool developed to capture this gradient is the proximal junctional kyphosis severity scale, which scores several features together: pain, neurological involvement, problems with the metalwork, the degree of kyphosis and disruption of the ligaments, the presence of fracture, and the level of the top of the fusion. Higher scores correspond to worse symptoms and a far greater likelihood that revision surgery is contemplated. The scale exists precisely because the bare angle, on its own, says little about whether anything needs to be done.

A familiar parallel: degeneration versus disease, at the top of the spine

For anyone who has read about spinal fusion before, the PJK-versus-PJF distinction has a close and illuminating parallel. In the world of shorter, lower fusions of the lumbar spine done for degenerative conditions, surgeons distinguish between adjacent segment degeneration and adjacent segment disease. Adjacent segment degeneration is the radiographic wear-and-tear seen on a scan in the level next to a fusion, often without symptoms. Adjacent segment disease is the clinical syndrome that arises when that degeneration produces new pain or nerve symptoms. The radiographic finding is common; the symptomatic disease is much less so.

Proximal junctional kyphosis and proximal junctional failure are the mirror image of this pair, but located at the top of a long deformity construct rather than next to a short lumbar one. PJK is the radiographic finding, the counterpart of adjacent segment degeneration. PJF is the clinical failure, the counterpart of adjacent segment disease. The conceptual structure is identical: a common, often silent change visible on imaging, and a less common, more serious problem that is actually felt and that may need treatment.

It is worth being clear about how PJK differs from ordinary adjacent segment disease, because the two are sometimes conflated. Adjacent segment disease typically follows short fusions of one or two levels in the lower back, performed for degenerative problems, and it is driven by gradual wear at the neighbouring disc. PJK arises after long fusions that correct a whole-spine deformity, and it is driven principally by the mechanical stress and the disruption of the supporting tissues at the top of a long stiff construct. The two also differ from global sagittal imbalance, which is a failure of the whole spine to stay balanced over the pelvis rather than a localised problem at one junction. Distinguishing a localised junctional change from a generalised loss of balance is part of the assessment, because they have different implications and different solutions.

How and why it happens: the mechanisms

Several distinct mechanisms can produce proximal junctional kyphosis and proximal junctional failure, and they are worth separating because they behave differently.

The first is disruption of the posterior ligamentous complex, the strong band of ligaments and tissues running along the back of the spine that act as a tension band, resisting forward bending. Building the top of a fusion inevitably involves working close to these structures, and any weakening of this tension band at or just above the upper instrumented vertebra removes part of what normally holds the segment upright, allowing it to tip forwards. This is described as the soft-tissue or ligamentous mode of failure, and it tends to predominate when the top of the fusion sits high in the upper back.

The second is fracture of the bone itself, either of the upper instrumented vertebra or of the vertebra immediately above it. Here the concentrated load at the junction simply exceeds what the bone can bear, and the vertebra collapses. This bone mode is more common when the top of the fusion lies at the thoracolumbar junction, the region around the bottom of the rib cage, and it is strongly linked to weak, osteoporotic bone. One well-described pattern is early collapse of the top vertebra with the segment above slipping forwards, which can occur within the first few months and is the pattern most associated with pressure on the nerves.

The third is failure of the metalwork, in which the screws pull out of the bone or the implant loses its grip. Rigid constructs made entirely of pedicle screws create a particularly abrupt change in stiffness at the top, concentrating force at the very last screw. The fourth involves the disc and ligaments above the construct giving way over time. In practice these mechanisms overlap, and a single case of failure may combine fracture, ligament disruption and forward slippage. Studies that have catalogued acute failures find that fracture and soft-tissue disruption each account for roughly half of cases, with the balance shifting according to where the top of the fusion sits.

What raises the risk

The factors that make proximal junctional kyphosis and failure more likely have been studied extensively, and although the details vary between series, a consistent picture emerges. These are population-level associations drawn from the literature, not predictions about any individual.

Older age is a recurring factor, partly because it travels with weaker bone and stiffer, more degenerate tissues. Osteoporosis and low bone density stand out as some of the most important contributors, because they govern whether the vertebrae at the junction can withstand the concentrated load or whether they fracture. Over-correction of the spine is another major theme: when a surgeon restores a large amount of lordosis, the inward curve of the lower back, the upper spine must compensate, and an aggressive correction can leave the junction over-stressed. The modern understanding is that correcting an older spine all the way to the alignment of a young adult is itself a risk, and that aiming for an age-appropriate alignment is gentler on the junction.

The level at which the fusion ends matters too. Ending the construct at the thoracolumbar junction, around the bottom of the ribs, is associated with a different and in some respects higher-risk profile than ending higher in the upper back. Extending the fusion all the way down to the sacrum and pelvis, which makes the whole construct longer and stiffer, also raises the risk at the top. Greater pre-operative imbalance, a larger pre-existing thoracic

curve, and the use of major bone-cutting procedures such as three-column osteotomies have each been linked to higher rates. Combined front-and-back surgery has been associated with PJK in some series. The role of body weight is less settled, with studies disagreeing, so it is not regarded as firmly established. What unites most of these factors is that they either weaken the junction or increase the load it must carry.

How it is prevented: what the evidence describes

Because proximal junctional kyphosis is so common, a great deal of surgical effort has gone into trying to prevent it, and the literature describes a range of strategies. It is important to state that none of these is a guaranteed solution, that the evidence is of variable strength, and that the following is a description of approaches reported in the literature rather than guidance for any person.

One group of strategies aims to soften the abrupt change in stiffness at the top of the construct. Using hooks rather than pedicle screws at the very top level provides a more flexible anchor, and at least one study reported a striking reduction in PJK with this approach. Transition rods or tapered rods, which are more flexible near the top, work on the same principle of easing the mechanical step between rigid and mobile spine. A second group aims to reinforce the tension band: junctional tethers and ligament augmentation, in which strong bands are used to reconstruct or supplement the posterior ligaments above the construct, have been reported to reduce the change in the junctional angle and, in some series, the rate of failure.

A third group addresses the strength of the bone. Injecting bone cement into the upper instrumented vertebra and the one above it, a prophylactic vertebroplasty, has been studied as a way to prevent fracture at the junction, and the protective effect appears to depend on treating both levels rather than one. The evidence suggests this reduces early fracture and failure, though not necessarily the long-term radiographic angle. Alongside these technical measures sits the broader strategy of getting the alignment right in the first place: avoiding over-correction, aiming for an age-appropriate posture, and sparing the soft tissues and ligaments at the top of the construct as far as the operation allows. Optimising bone health before surgery, including treatment of osteoporosis, is a further strand, and one trial of a bone-building medication reported a lower rate of failure in patients with osteoporosis.

How it is managed

The management of proximal junctional kyphosis follows directly from the distinction at the heart of this guide, and once again what follows is a description of the literature rather than advice.

For the great majority, who have radiographic PJK that is mild, stable and causing no symptoms, the reported approach is observation. The angle is noted, monitored over time on follow-up imaging, and otherwise left alone, because the evidence indicates that mild PJK of this kind does not generally harm a person's quality of life or progress to anything worse. There is, in these cases, nothing that needs fixing, and the recognition that an X-ray finding is not in itself a problem to be treated is central to sensible management. Most people who develop PJK fall into this group.

At the other end, proximal junctional failure that causes significant symptoms is treated more actively. The features that move a case towards intervention are a neurological deficit from pressure on the nerves, severe and persisting pain, mechanical instability, broken or pulled-out metalwork, and a deformity that is progressing rather than holding steady. Where these are present, the reported treatment is revision surgery, most often extending the fusion further up the spine to capture the failed segment and re-establish a stable top to the construct, and relieving pressure on the nerves where this is needed. The severity scale described earlier helps to capture which cases sit towards this end, since it is the constellation of pain, nerve involvement, fracture and instrumentation problems, rather than the bare angle, that distinguishes a finding to be watched from a failure to be addressed. Decisions of this kind are individualised and made by the treating team.

Outlook

The outlook in proximal junctional kyphosis is, like the condition itself, best understood as a spectrum. For the large majority with mild radiographic PJK, the picture reported in the literature is reassuring: the angle is often stable, symptoms are typically absent, and the finding does not, on average, detract from the result of the original deformity correction. For these patients, PJK is a measurement on a scan rather than an event in their lives, and it is monitored rather than treated.

For the smaller number who develop proximal junctional failure, the outlook depends on the nature of the failure and how it is managed. Where there is fracture, instability or pressure on the nerves, the situation is more serious and may require revision surgery, which is itself a major undertaking. The recognition that most failures occur early, with a large proportion appearing within the first few months and the majority within the first couple of years, means that the period of closest attention tends to be the time soon after the original operation. Across the whole field, the consistent themes are that the radiographic finding is common and usually benign, that genuine structural failure is much less common but more significant, and that careful surgical planning aimed at the junction offers the best prospect of keeping a case at the milder end of the spectrum. Any individual outlook is a matter for assessment by the treating team rather than something that can be read from a category or an angle alone.