

Transitional Vertebra

A patient guide

In brief: A transitional vertebra is a vertebra that sits at the border between two regions of the spine and takes on features of both, so that it is not a clear member of either region. The spine is conventionally divided into the neck (cervical), chest (thoracic), lower back (lumbar) and the fused base (sacrum), but these regions blend into one another at their junctions rather than ending abruptly. A transitional vertebra is the visible expression of that blending: a segment at a junction that carries some characteristics of the region above and some of the region below. Such vertebrae arise at the cervicothoracic junction (where the lowest neck vertebra may bear a small extra rib), at the thoracolumbar junction (where the lowest rib-bearing segment may carry only a tiny or stunted rib), and most commonly at the lumbosacral junction (where the lowest lumbar vertebra is partly incorporated into the sacrum, or the topmost sacral segment is partly separated from it). The single most important idea is that a transitional vertebra is, in the great majority of cases, a common and harmless anatomical variant, usually discovered incidentally on a scan, and that its main practical significance lies not in causing disease but in making sure the levels of the spine are counted and named correctly.

What a transitional vertebra is, and why the spine blends at its borders

The human spine is usually described as a tidy stack of twenty-four mobile vertebrae arranged in three regions, seven in the neck, twelve in the chest and five in the lower back, sitting on top of the sacrum and tailbone. This neat description is useful, but it can give the impression that each region stops sharply where the next begins. In reality the regions shade into one another, and the vertebrae at the junctions are, by their nature, intermediate. A transitional vertebra is simply a junction segment that displays this intermediate character more obviously than usual, carrying recognisable features of both the region above and the region below.

The features that define each region are themselves a matter of degree. Thoracic vertebrae carry ribs; lumbar vertebrae do not, but instead have broad, wing-like transverse processes. The lowest cervical vertebra normally has no rib, yet it sits immediately above the first rib-bearing thoracic vertebra. At each of these borders, a vertebra can end up part-way between the two patterns: a neck vertebra with a small rib, a lowest thoracic vertebra with a rib so short it is barely a rib at all, or a lowest lumbar vertebra whose transverse process has grown large and joined onto the sacrum. None of these is a disease. Each is an example of the spine's regions overlapping at their edges.

Understanding a transitional vertebra therefore begins with letting go of the idea that the regions of the spine are sealed compartments. They are zones that merge, and the transitional vertebra is the natural product of that merging. This is why these vertebrae are so often described as variants of normal anatomy rather than abnormalities, and why they are usually noticed by chance rather than because they have caused a problem.

Why transitional vertebrae form: the developing spine and its genetic pattern

The reason the spine blends at its borders lies in how it is built before birth. Early in development, the body lays down a series of paired blocks of tissue called somites, arranged in a row from head to tail. Each future vertebra is assembled from parts of neighbouring somites, and the identity of each segment, whether it will become a neck, chest, lower-back or sacral vertebra, is assigned by a family of master control genes known as the HOX genes. These genes switch on in overlapping waves along the length of the embryo, and the particular combination active at any given level tells that segment which regional pattern to follow.

Crucially, the boundaries set by these genetic waves are not razor-sharp. Where one pattern fades and the next takes over, a segment can receive mixed instructions and develop a mixed identity. In the language of developmental biology this is sometimes called a borderline or homeotic shift, in which a vertebra adopts some of the characteristics of its neighbour. A vertebra at the thoracic-lumbar boundary may be told to make a rib but only weakly, producing a stunted rib; a vertebra at the lumbar-sacral boundary may be told, in part, to behave like a sacral segment and fuse to its neighbour. The same machinery explains why the total count of vertebrae in a given region can vary slightly between individuals, with some people having an extra rib-bearing or lower-back segment and others one fewer.

This developmental account matters because it reframes transitional vertebrae as an expected by-product of an elegant but imprecise patterning process, shared across the animal kingdom, rather than as a flaw. The genes that decide where ribs form and where the sacrum begins are doing an extraordinarily complex job, and a little blurring at the regional borders is the ordinary cost of that complexity.

The three junctional types

Transitional vertebrae are grouped by the junction at which they occur. There are three such junctions in the spine, and each produces a characteristic type.

****The cervicothoracic junction****, where the neck meets the chest, is the site of the cervical rib. Normally the seventh and lowest cervical vertebra has no rib, while the first thoracic vertebra below it does. In a cervicothoracic transitional vertebra, the seventh cervical vertebra develops a small extra rib of its own, an additional rib above the usual first one. These cervical ribs are uncommon, are frequently present on both sides, and in most people cause no trouble whatsoever. Their importance, where it arises, is anatomical: a cervical rib narrows the space at the base of the neck through which the nerves and blood vessels to the arm must pass, and so a minority of people with one may experience symptoms in the arm, a situation discussed below under thoracic outlet syndrome.

****The thoracolumbar junction****, where the chest meets the lower back, is the site of rib variation. The twelfth thoracic vertebra normally carries the lowest pair of ribs, and the first lumbar vertebra carries none. A thoracolumbar transitional vertebra blurs this line: the lowest rib may be unusually short, a so-called stump rib, or an extra small rib may appear on what would otherwise be the first lumbar vertebra. Such variation is common and, on its own, of little consequence to the person. Its chief significance, once again, is that it can make the counting of levels uncertain, because the "last rib-bearing vertebra" is the usual landmark for naming the bottom of the chest, and a stunted or extra rib can move that landmark.

****The lumbosacral junction****, where the lower back meets the sacrum, is the site of the best-known type, the lumbosacral transitional vertebra. Here the lowest lumbar vertebra may become partly incorporated into the sacrum, a process loosely called sacralisation, with its transverse process enlarging and articulating with or fusing to the sacrum; or, conversely, the topmost sacral segment may separate partly from the sacrum and take on the appearance of an extra lumbar vertebra, loosely called lumbarisation. Because this type is the most common and the most studied, it has its own detailed description and classification, set out below.

The lumbosacral transitional vertebra in detail

The lumbosacral transitional vertebra, often abbreviated to LSTV, is the most frequently encountered transitional vertebra and the one most often referred to in clinical writing. It describes a lowest lumbar vertebra, or a topmost sacral segment, that sits ambiguously between the mobile lower back and the fused sacrum. The defining feature is enlargement of the transverse process of the segment, which may simply be broadened, may form a false joint with the sacrum or pelvis, or may be fully fused to it.

The standard way of grading this anatomy is the Castellvi classification, described in 1984, which sorts lumbosacral transitional vertebrae into four types according to how the enlarged transverse process relates to the sacrum. In broad terms, type I describes a transverse process that is merely enlarged, without any joint; type II

describes an enlarged transverse process that forms a false joint, a pseudo-joint, with the sacrum; type III describes an enlarged transverse process that is solidly fused to the sacrum; and type IV describes a mixed pattern with a false joint on one side and a fusion on the other. Each type may be one-sided or present on both sides. This grading is purely descriptive: it records what the anatomy looks like, not how a person feels.

Lumbosacral transitional vertebrae are common. Across large imaging studies the reported prevalence ranges very widely, from around a tenth to roughly a third of people depending on the population studied, the imaging method used and the exact definition applied, with several sizeable series clustering in the region of fifteen to twenty per cent and some reporting a higher rate in men than in women. The wide spread reflects the differing definitions as much as any real difference between groups. The great majority of these vertebrae are found incidentally and cause no symptoms at all.

Why transitional vertebrae matter: level-numbering and avoiding wrong-level surgery

The most important practical reason transitional vertebrae are recognised has nothing to do with pain. It is that they disrupt the orderly counting of the spine, and accurate counting is the foundation of safe imaging reporting and safe surgery.

The levels of the spine are named by counting, and the usual landmarks for counting are the ribs and the sacrum. When a transitional vertebra blurs those landmarks, an extra rib-bearing segment here, a half-incorporated lumbar segment there, the count can drift, and a level that one observer calls, for example, the fifth lumbar may be called the first sacral or a sixth lumbar by another. If a scan limited to the lower back is reported without reference to the rest of the spine, this ambiguity can pass unnoticed. The danger is that an operation, an injection or a report might then be directed at the wrong level. Published work has highlighted that variant and transitional anatomy is a recognised contributor to wrong-level spine procedures, and that without whole-spine imaging the level can be mis-assigned in a meaningful proportion of cases.

The safeguard is straightforward in principle: count the vertebrae on an image that shows the whole spine, starting from a fixed and unambiguous landmark high up, conventionally the second cervical vertebra, and counting downwards all the way to the segment in question. A whole-spine localiser image, taken as part of an MRI or CT examination, makes this possible. Additional landmarks, such as the position of the iliolumbar ligaments or the level of the iliac crests, are used to help confirm the count at the bottom of the spine. The consistent message in the literature is that identifying a transitional vertebra, naming it explicitly, and making sure the same numbering is used by everyone involved, from the radiologist to the surgeon, is what prevents errors. This is a matter of careful communication rather than of treating the vertebra itself.

Biomechanics and pain associations

Beyond the question of numbering, transitional vertebrae are of interest because their altered shape changes, to some degree, how forces pass through the junction, and because a minority are associated with symptoms.

At the lumbosacral junction, a transitional vertebra alters the mechanics of the lower spine. When the lowest lumbar segment is partly fused or anchored to the sacrum, that segment moves less, and the segment immediately above it tends to take up more of the movement and load. Studies using computer models and large imaging series have reported that this redistribution is associated with a greater tendency to disc and joint wear at the level just above the transitional segment, and that the enlarged transverse process and any false joint it forms can themselves become sites of degeneration. Where a false joint between the transverse process and the sacrum becomes painful, or where the altered mechanics are thought to drive pain at the junction, the picture is sometimes given the name Bertolotti's syndrome, first described in 1917, which refers specifically to low back pain attributed to a lumbosacral transitional vertebra. It is important to keep this in proportion: most people with a lumbosacral transitional vertebra never develop such pain, and the variant is so common that its mere presence on a scan does not establish it as the cause of any given person's symptoms.

At the cervicothoracic junction, the relevant association is with thoracic outlet syndrome. A cervical rib narrows the confined space at the base of the neck through which the nerves and major blood vessels to the arm travel. In the minority in whom this causes compression, symptoms such as arm pain, numbness, weakness or circulatory changes may follow. Most cervical ribs, however, remain entirely silent, and only a fraction of people with one ever develop symptoms.

At the thoracolumbar junction, the associations are weaker still and relate mainly to the mechanical transition between the relatively rigid chest and the mobile lower back. Here the chief practical issue remains the accurate identification and numbering of the lowest rib-bearing segment rather than any strong link with pain.

Across all three junctions, the recurring theme is that an association reported across groups of people is not the same as a cause in an individual, and that the variant is overwhelmingly more often silent than symptomatic.

How transitional vertebrae are identified on imaging

Transitional vertebrae are identified on imaging, and the central principle is that they cannot be reliably identified, or correctly numbered, from a picture of only part of the spine. They are best recognised on images that display the spine as a whole.

****Whole-spine imaging and counting from a fixed landmark.**** The reliable method is to count the vertebrae on an image that shows the entire spine on one view, beginning from a fixed point near the top, conventionally the second cervical vertebra, and proceeding downwards segment by segment to the junction of interest. This is why MRI and CT examinations of the spine include a whole-spine localiser image: it allows the lowest rib-bearing segment, and the true position of the lumbosacral junction, to be established beyond doubt.

****Plain X-rays.**** Standard radiographs, including specially angled views of the lumbosacral junction, are a long-established way of demonstrating an enlarged transverse process and its relationship to the sacrum, and of looking for cervical ribs at the base of the neck or stump ribs at the thoracolumbar junction.

****Computed tomography, the CT scan.**** CT shows the bony anatomy in fine detail and is particularly good at demonstrating whether an enlarged transverse process forms a false joint with the sacrum or is fully fused to it, and at clarifying the count when plain films are ambiguous.

****Magnetic resonance imaging, the MRI scan.**** MRI shows both the bones and the soft tissues, including the discs, nerves and the iliolumbar ligaments that help confirm the level. A whole-spine localiser on MRI is widely regarded as the most practical safeguard against mis-numbering.

Together these methods allow a transitional vertebra to be recognised for what it is, graded where relevant, and, most importantly, numbered correctly so that everyone involved is referring to the same level.

What the evidence shows about significance and management — impersonal

It is important to state at the outset that the evidence concerning transitional vertebrae is drawn largely from anatomical studies of skeletons, from imaging surveys describing how common the variants are, from biomechanical and computer-modelling work, and from case series and narrative reviews. It is descriptive evidence about populations and mechanisms, not a body of trials defining treatment, and nothing in this account constitutes guidance for any individual.

****Recognition and correct numbering**** is the theme that dominates the literature. Because the chief practical risk of a transitional vertebra is mis-identification of the spinal level, the consistent message is that the variant should be looked for on whole-spine imaging, named explicitly in reports, and confirmed using fixed landmarks so that the same numbering is shared by all involved. This is described as the single most useful step, and it is a matter of careful observation and communication rather than treatment.

****Observation**** is the course described for the great majority of transitional vertebrae, which are incidental, symptomless and require nothing beyond accurate documentation. The variant is so common in the general

population that its presence on a scan is, in most instances, simply noted.

****Investigation of attributed symptoms**** is described in the minority in whom a transitional vertebra is considered a possible source of pain or, in the case of a cervical rib, of arm symptoms. Here the literature emphasises that establishing whether the variant is actually responsible, rather than merely present, is the central question, and that this typically involves correlating the imaging with the clinical picture and, in some accounts, with the response to targeted local injections. The published series report a range of conservative and, less often, interventional or surgical approaches for the small symptomatic minority, but they do so as descriptions of practice rather than as rules, and they emphasise individualised assessment.

In summary, the evidence points towards recognising and correctly numbering transitional vertebrae as the priority, observing the common symptomless majority, and reserving further investigation for the minority in whom the variant is genuinely implicated in symptoms, all within a framework of individualised assessment by the treating team rather than fixed thresholds.

Outlook

The outlook associated with a transitional vertebra is, for almost everyone who has one, entirely unremarkable, and this follows directly from the nature of the variant. A transitional vertebra is a common expression of the way the spine's regions blend at their borders during development, it is usually discovered by chance, and in the great majority of people it neither causes symptoms nor requires any action.

Its significance, where it has any, is twofold and modest. First and most important, it must be recognised and counted correctly so that the levels of the spine are named consistently and the wrong level is not acted upon; this is a matter of careful imaging and communication and is readily achieved with whole-spine views. Second, a minority of transitional vertebrae are associated with altered mechanics and, occasionally, with symptoms, a painful false joint or adjacent-level wear at the lumbosacral junction, or arm symptoms from a cervical rib at the base of the neck, but even here the association is loose and the variant is far more often silent than not.

The consistent themes across the field are that a transitional vertebra is a normal anatomical variant rather than a disease, that its main practical importance is accurate level-numbering, that any link with symptoms is a matter of association in groups rather than prediction for an individual, and that the meaning of any particular transitional vertebra is something to be assessed by the treating team in the light of the whole clinical picture rather than read from a category on a scan.