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Kiran Nandivada's Stuck Blade in a Grinder Jar Degenerative Cascade by LSTV at L5-S1

Venkata Satya Kumar Kiran Nandivada[1], Nadavinamani Shivanand Raghavendra[2], Nandivada Nikhil Bharadwaja[3], Moola Sohith Mahadeva Reddy[4], Ahmed Usama Rizvi[5]

[1]Nandivada Ortho Spine Surgeon & Rheumatologist, Abu Dhabi, United Arab Emirates
[2]Senior Orthopedic Surgeon & Rheumatologist, Abu Dhabi, United Arab Emirates
[3]General Practitioner, Visakhapatnam, India
[4]Department of Medicine, Kamineni Institute of Medical Sciences, Telangana, India
[5]Department of Medicine, Tbilisi State Medical University, Tbilisi, Georgia
Email: drkiranindia@gmail.com

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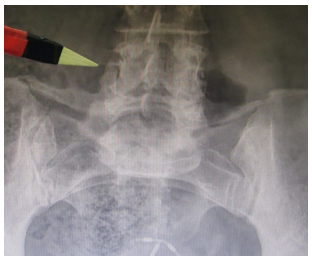
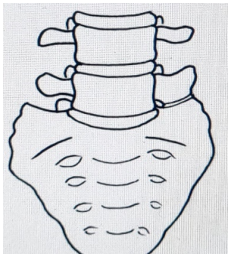
Abstract

Background: Mario Bertolotti, (1917) described LSTV-Lumbar spinal transitional vertebra as Bertolotti Syndrome a century ago and associated low back pain with it. Yet, it needs to be given significance in general orthopaedic practice even now, and radiologists underreport it. LSTV is a congenital anatomical anomaly that Castellvi classified into four varying types. **Purpose**: I titled this phenomenon "Kiran Nandivada's stuck blade in a grinder jar degenerative cascade by LSTV at L5-S1" to clearly explain how an abnormal mega-transverse apophysis with its various variations affects the weight-bearing mechanics as the L5-S1 which is a vital junction where the maximum body weight is directed into both the sacroiliac joints and if a transitional vertebra occurs it becomes detrimental and abnormally redirects the load-bearing forces and leads to a progressive degenerative cascade both proximally and distally. As the L5 vertebral rotations and other movements of flexion, extensions, lateral flexion are stuck like a bent grinder blade, the other areas of the region are damaged progressively as the pelvis, just like the grinder motor tries to move it, resulting in overheating and maybe even a burnout results in the form of facet arthritis, disc degeneration in the normal disc above, the transitional disc at L5-S1, foraminal osteophytes causing radiculopathy, sacroiliac joint arthritis. **Material and Methods**: Around 200 X-rays of children and adults with this congenital anomaly have been studied between 2020 and 2023. This is a retrospective study. **Results**: 1) Our study showed an Increased incidence of LSTV at 15%. 2) Patients ranged from asymptomatic, atypical lumbago to classical lumbago with sciatica and claudication. Findings supported facet and sacroiliac joint arthritis and the pain, relieved with physiotherapy,

posture corrections, weight reduction, and lifestyle precautions, negating the need for local steroid injections, radiofrequency ablation or surgical excision as per our experience. **Conclusion**: Other dysplastic congenital manifestations like associated scoliosis, facet tropism and nerve root, and sacroiliac joint anomalies can co-exist. These radiological findings must be clearly explained to the patient so that the inherently progressive nature of this phenomenon is well understood and the patient can take the required precautions to slow them and suitable conservative treatment can be planned. In rare cases, radiofrequency ablation or even rarely a surgical resection could be beneficial, but the surgical approach could be complex as normal anatomy is changed. Hence, prior anaesthesia blocks and even scintigraphy are essential steps to clearly define and confirm the LSTV to be the actual cause of the pain.





Keywords

LSTV, Bertolotti Syndrome, Transitional Vertebra, Facet Tropism, Congenital Dysplasia

1. Aim

Continuing Orthopaedic Educational Activity: The lumbosacral transitional vertebra was described in 1917 by Mario Bertolotti, known as Bertolotti Syndrome [1], a congenital anatomical anomaly and was classified by Castellvi into 4 types. In the literature, the studies and reports on Symptomatic LSTV are sparse [1].

2. Objectives

Retrospective study of 200 patients between 2020 and 2023: Radiological films were studied with the patient's consent, respecting their data privacy.

3. Aetiology

1) In the rudimentary stage, a LSTV could be a compensatory mechanism depending on the size of the developing Sacrum.

2) The explanation for the higher incidence of Smaller or larger SACRUM in cases of LSTV:

At a very rudimentary formation stage, a smaller sacrum incorporates the L5 to enhance the load-bearing capacity, while the opposite happens with a larger sacrum, which releases the S1 [2].

The ability to dissipate load from the Sacrum to each SI joint is proportional to the size and surface it shares with the SI joint [3].

3) Mutation in the 12 HOX10/HOX11 genes affects the axial pattern of lumbar and sacral LSTV [1].

4) LSTV (a lumbosacral transitional vertebra or a mega transverse process which can either be fused or exist as a pseudo arthrosis—"false joint") can cause unequal weight bearing, restricted rotation or other movements can cause a strain pattern leading to wear and tear on the nearby normal or dysplastic joints and degeneration in the transitional disc or the normal disc above.

5) The iliolumbar ligaments at the level immediately above LSTV are thinner and weaker and result in vertebral segment instability, which could subsequently lead to early disc degeneration. The formation of an LSTV may be an adaption to compensate for a weak iliolumbar ligament to preserve stability [4] through this pseudo articulation.

The prevalence of LSTV in Males: females are 28.1% vs 11.1% LSTV [3].

Sacralization is more common in males, and in females, accessory L5-S1 articulations and lumbarisation of S1 are more common [5].

A Ferguson radiograph, *i.e.* the 30˚ angled AP radiograph, as the reference method was the x-ray view of choice.

O'Driscoll *et al.* classified four types of L S junctions based on sagittal lumbar spine MRIs.

4. Pathophysiology

LSTV results in a slow progressive cascade, exemplified by the events after a rotatory grinding blade in a grinder jar gets stuck. Similarly, due to altered biomechanics and weight bearing at the LSTV, there are various cascades of degenerative features as follows:

If a transitional vertebra occurs, then it becomes detrimental and abnormally re-directs the load-bearing forces and leads to a progressive degenerative cascade both proximally and distally causing dysfunction and disability as it involves load transmission from the flexible lumbar to the fixed sacral segments and the sacroiliac joints. When this anomaly occurs, it affects the proximal L4 vertebra by increasing its range of motion as the L5-S1 motion is prevented [1] [2], meaning when the L5 vertebral rotations and other movements are stuck like a stuck grinder blade, the other areas of the region are damaged progressively as the grinder motor tries to move it resulting in overheating and maybe even a burn out seen as the facet arthritis, disc degeneration in the normal disc above, degeneration in the transitional disc at L5-S1, foraminal osteophytes causing radiculopathy, Sacroiliac joint arthritis.

It is essential to differentiate and confirm that the low back pain is caused by the transverse mega-apophysis false joint only and not from other sources of the low back region in patients with LSTV [6].

1) Decreased mobility at L5-S1 causes increased stress on the muscles around the SI joints and LS junction (A useful tip for the role of conservative therapy)

[7] [This highlights the importance of the role of physiotherapy to address the muscles and not the pinched nerve to obtain temporary relief].

2) Pain in the facet joint is due to additional stress on the normal contralateral joint, Low back pain is caused by the LSTV from the disc above and the contralateral facet (in unilateral LSTV). Hence, it is to avoid intervention or surgery at an incorrect level, the confirmation of the causative site is significant.

3) LSTV is often inaccurately detected and classified on standard AP radiographs and MRI. "[5] the importance of which is realized at the time of surgery or when the spine surgery is done at a wrong level" [5].

4) Pseudo articulation or "false joint" is susceptible to arthritic changes and osteophyte formation, which may lead to nerve root entrapment and Radiculopathy [5]. Lumbago is more often seen in LSTV types II and IV.

5) Above the LSTV, hypermobility and abnormal torque moments are seen, and below the LSTV, restricted movement between the L5 and S1 vertebra is seen [8].

6) Above LSTV, disc protrusions and extrusions [45.3%] Disc degeneration [52.8%], Facet degeneration [60.4%], Nerve root canal stenosis [52.8%] are more frequently found compared to patients of lumbago without LSTV [9].

75.9% of the lumbar disc herniations occurred on the same side as the transitional vertebrae [10].

7) As per Otani *et al.*, 83% of patients with disc herniation plus LSTV had symptoms from the last caudal mobile segment, and 59% of Patients with disc herniation without transitional vertebrae had symptoms from the second last mobile segment [11].

8) This osseous bridging can be complete where the transitional disc is protected from degeneration or incomplete where degeneration is seen more in the transitional disc.

9) Spondylolysthesis may be seen in the L4 vertebra to a greater percentage in the sacralised [19.3%] than in lumbarised patients [14.5%] compared to the normal population of 11.4% [4].

Smaller Pars interarticularis may predispose spondylolysis and spondylolisthesis at the lumbosacral junction when LSTV variation is present and requires alertness to avoid Iatrogenic Injuries [2].

10) The false joint shows micromotion and is observed radiologically by sclerotic changes and osteophytes near the false joint [12]. "Micromotion" at the dysplastic facet joints causes Osteoporosis at the level below. It can cause extraforaminal entrapment of the spinal nerve and radiculopathy [13].

11) Localized stress at the articulation contributes to low back pain and is seen after scintigraphy as a high uptake at the false joint [14].

12) Neuropathy of S1 nerve root: Pinching of a lumbar spinal nerve can occur as a "Far-Out Syndrome."

13) New bone formation below an LSTV can cause neural compression (13%) and cause symptoms in up to 70% of these patients.

14) An LSTV can co-exist with a concomitant thoracolumbar TV (TLTV)

[15].

15) Left-side LSTV was more common in unilateral cases and remains unexplained [6].

16) For surgical purposes, it is to be noted in lumbarisation, the main vessels in the sagittal section, right renal artery, the aortic bifurcation, IVC confluence, celiac trunk, and superior mesenteric artery root are 1 - 3 levels more caudal and 1 - 3 levels cephalic than usual in the case of sacralisation [16].

The rectangular shape of the L5 is the sign of the last vertebra, which is a surgical landmark, but in the scenario of LSTV where L4 - L6 exist, this becomes confusing and may result in a wrong-level surgery.

17) Before planning for an epidural or selective nerve root block, one should be aware of a transitional segment before initiating the injection.

18) Lumbarization displays a dermatome gap between the lumbar dermatomes and the sacral dermatomes S2 and S3 as hence they are more ventral.

A lumbarised spine is a relative contraindication for lateral transpsoas interbody fusion at L5 and L6 as it becomes unapproachable at L5 and L6 due to the variations in the neural anatomy due to migration. Hence pre-operative Axial MRI and Intra Operative Advanced Neuromonitoring are needed to avoid injury.

Vascular variation is also likely, and surgical dissections may have to be altered accordingly.

Ascending disc disease: Lumbago may be progressive due to the concentration of external stress on adjacent vertebral levels.

5. Treatment

Conservative treatment:

Alexander technique and Pilates method-based exercises are effective modalities while observing for recovery or deterioration managing chronic Lumbago [17].

One patient showed 100% relief after L4/5 joint radiofrequency sensory ablation for 16 months in 1 patient with an LSTV [18].

Injections of steroids or local anaesthetics into the transverse process false joint can be of diagnostic value and may provide immediate but temporary pain relief [19].

Bone scintigraphy aids in evaluating patients with LSTV & low back pain.

Posterolateral fusion may be considered in cases of a degenerated transitional disc when the disc above the vertebra is intact [20].

Selective radiography demonstrated foraminal nerve root impingement between the lateral bony spur and the medial intervertebral disc.

Approach to the false joint: either anterior or posterior, is a difficult choice for the surgeon as both are challenging. Obtaining a good visual field is difficult in both.

The reason why pedicle screws should be directed more obtusely in the sagittal plane and at a reduced downward inclination is that lumbarisation of S1 re-

sults in more obtuse pedicles in the sagittal plane and reduced distance between the facet and sacral promontory.

The mega transverse process shows a reduced number of trabeculae of cancellous bone, which may result in difficult screw placements or subsequent pullouts.

Facet asymmetry is seen in all LSTV subtypes. So, facet tropism must be explained well to the patient.

Below a lumbosacral segment, the disc height is significantly decreased.

In LSTV, when thoracolumbar injuries occur, there may be neurological discrepancies as the (TLCM).

Thoracolumbar conus medullaris is higher in a state of sacralisation and lower down in lumbarisation of S1 [10].

Neurologic symptoms after the L6 nerve root compression are similar to the L5 rather than the S1 nerve root compression (Chang *et al.*); the root emerging from L6/S may result in deficits like S1, S2.

6. Review of the Physical Exam and Image Findings

The patients comprised asymptomatic and symptomatic groups in the younger age groups.

In the middle age group, some form of clinical presentation manifested in the form of pain due to facet arthrosis, L4 - L5 disc herniation, S1 nerve root entrapment causing sciatica and ankle and foot weakness, burning pain, and repeated ankle injuries were noticed supported by increasing manifestation of the LSTV.

7. Discussion

The biomechanical forces at the l5-S1 junction are already high in a typical spinal segment without any congenital anomaly.

Patients are frequently diagnosed with a transitional vertebra. However, unfortunately, in most patients, it is a passing diagnosis. Bertollotti syndrome can cause a cascade of degenerative changes in both proximal and distal joints to the L5-S1 junction, which links a mobile part of the spine–the last spinal segment of the lumbar spine to the immobile part S1 vertebra of the fused Sacrum. Being inclined (the L-S angle of 140 degrees). This L S junction allows mostly flexion and extension, with minimal lateral flexion and rotation.

At this junction-the biomechanics have a specific role to play, and the main movements are REDUCED whenever there is an Accessory articulation in the form of a transitional vertebra. To understand how it becomes a cascade of progressive deterioration of anterior and posterior functions is demonstrated by this asymmetrical movement, which is supported by the invaluable study made in the article by Mahato NK, Dhason R, who studied a computer-stimulated model created with a left-sided transitional vertebra at L5 and they gave the following findings [21]:

1) Normal L5-S1 has a Flexion of 3.05 degrees reduced to 2.25 degrees in AA.

2) Normal L5-S1 has an Extension of 3.02 degrees increased to 3.12 degrees in AA.

3) Normal L5-S1 has left lateral bending of 4.34 degrees reduced to 3.09 degrees in AA.

4) Normal L5-S1 has a right lateral bending of 4.33 degrees reduced to 2.86 degrees in AA.

5) Normal L5-S1 has left axial Rotation of 1.32 degrees reduced to 0.55 degrees in AA.

6) Normal L5-S1 has a left axial Rotation of 1.40 degrees reduced to 1.03 degrees in AA.

- "Alterations in L5-S1 disc space heights, and dimensional and orientation changes of the facet joint and the sacral auricular surface areas, changes that are often linked with low back pain."
- More loading occurs in the posterior vertebral elements in LSTV.

I coin a term here to make the learner understand better "Kiran Nandivada's stuck blade inside the grinder jar degenerative cascade by LSTV at L5-S1" to explain the phenomenon of degenerative Cascade when this happens.

When the L5 Vertebra is normal, both the transverse processes are free. The facets can smoothly glide and allow a gradual accommodation for the movements.

The congenital alterations that occur in the region around the transitional vertebra are as follows [22] explaining how the L5 vertebra in LSTV behaves like a stuck blade in a grinder jar formed by the sacral ala and ilium on the two sides:

1) The results obtained from the study indicate that (a) the overall dimensions of the Pars Interarticularis, as well as the laminae in the vertebrae L4 associated with the sacralisation of the L5, are smaller than the normal (L5) counterparts that constitute the normal (L5-S1) lumbosacral junctions.

2) The heights of the L4 pars in sacralised specimens are significantly smaller than the normal ones.

3) The widths of the laminae in these vertebrae (L4) have been detected to be smaller than the corresponding vertebrae.

4) Other dimensions measured in these samples were comparable to the normal and those observed in the L5-S1 accessory articulated L5 vertebrae.

5) All parameters about the PI and the laminae associated with the L5 related to accessory L5-S1 articulation demonstrated smaller dimensions than the normal ones.

6) These L5 vertebrae, however, possessed larger dimensions for all parameters used in this study when compared to the L4 vertebrae involved with a sacralised transitional state.

7) The samples with unilateral L5-S1 accessory articulation demonstrated smaller dimensions of PI and laminar parameters on the affected sides as compared to the normal side in the same vertebra.

The presence of a transitional vertebra indicates the possibility of three different levels where a cascade of degeneration is ongoing:

1) Changes at upper-level l4 vertebra?

I wish to give an apt example for easier understanding. When one of two colleagues at the same workplace falls sick, the workload automatically increases on the fit colleague, wearing him down. If the same analogy is applied to the L5 vertebra—it has been dysfunctional since birth due to a malformation. It does not move according to the daily needs of the L5-S1 junction, which automatically raises the demand for more flexibility on the L4 vertebra, which was not made for such extra mobility. It has to take up now L5 vertebra-like functions which will increase the loads, wear down the L4 vertebra facets, and cause early degeneration of the L4-L5 disc, which may lead to any of the four stages of disc herniations at L4-S1.

"It is defined by the presence of a transverse mega-apophysis that articulates with the sacrum or the ilium, which leads to an alteration in the lumbosacral transition and, therefore, to a change in the biomechanics of the axial skeleton."

It may lead to dysfunctional loading and may cause MODIC changes in the vertebral end plates or the whole vertebral body itself due to changes in the vascular supply of the vertebral bodies. It is an anomalous enlargement of the transverse process of the fifth lumbar vertebrae that either fuses or articulates with the sacrum or ilium bone and causes L4-L5 disc disease.

2) Altered lumbo sacral nerve roots and compressions?

In LSTV, a lot could happen to the underlying last lumbar nerves and the 1st Sacral nerve.

a) Congenital duplication.

b) Congenital atresia of nerve roots.

c) Congenital spinal canal or foraminal stenosis.

d) Congenital facet joint hyperplasia or facet tropism.

3) Stress to one or both sacroiliac joints?

Sacroiliac joints are an essential zone for transmitting the body weight forces as the central line passes through the Sacrum into both SI joints equally, and once the L5-S1 segment has reduced disc space or nil range of movement, this transition of body weight biomechanics gets altered and one or both S I joints degenerate and may end up in earlier onset of Arthritis causing sciatica-like pain radiation into the buttocks, thighs and legs.

8. Clinical Examination Findings

On movement of the spine, pain can be felt on the bending in the lower back and limitations to full Rotation can be felt. The straight leg raised test may or may not be negative. The reflexes, sensations, and lower limb power may vary accordingly.

9. Conclusion

I coined this term "Kiran Nandivada's stuck blade in grinder jar degenerative cascade by LSTV at L5-S1" where the stuck grinder blade is compared to the abnormal transitional transverse processes of the L5 or S1 vertebra and the grinder jar is compared to the crater formed by the both Ilium and the Sacral ala, which explains the cascade of degenerative mechanisms which slowly but surely

destroys the most critical L5-S1 flexibility and overloads the l4 vertebra above and may even cause ascending degenerative disc disease in the future causing a progressive detrimental scenario at this lumbosacral spine which, unfortunately, in a significant number of patients is not getting the clinicians or the radiologist's attention that were needed so that the patient could be counseled about it so that it could be slowed down if not prevented as it is a congenital anomaly.

Disclaimer

This retrospective study was done as per the declaration of Helsinki.

Conflicts of Interest

There are no conflicts of interest in this article.

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