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AN ANATOMICAL STUDY OF LUMBOSACRAL TRANSITIONAL VERTEBRA

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ABSTRACT

Lumbosacral transitional vertebrae are congenital anomalies of the lumbosacral region which include sacralisation of fifth lumbar vertebrae and lumbarization of first sacral vertebrae. Lumbarization occurs when the uppermost segment of the sacrum is not fused to the rest of the sacrum but instead it is partially mobile constituting an 'extra' lumbar vertebra, often referred to as L6. Sacralization is described as having one fewer lumbar vertebra because the last lumbar segment (L5) is fused to the sacrum. Material and Methods: A study was conducted in the Department of Anatomy of K. J. Somaiya Medical College in which hundred adult dry human sacra were examined to study the incidence of lumbarisation and sacralisation. Results: 28% specimens showed anatomical anomalies of lumbosacral transitional vertebras out of which 16% showed anomalies of lumbarisation and 12% showed anomalies of sacralisation. The specimens showing lumbarisation and sacralisation were studied in detail. Conclusions: Sacralization of L5 vertebra is more common than lumbarization. The incidence between these anomalies is 2:1. Mutations in the HOX 10 and HOX 11 paralogous genes affect the normal pattering of lumbar and sacral vertebra. The consequences of the sacralisation may be the degenerative spondylolisthesis, disc herniation, low back pain and disc degeneration. Identification of lumbosacral transitional vertebrae (LSTV) is crucial for precise resolution of the number of vertebrae.

Keywords: Lumbosacral transitional vertebrae, Lumbarization, Sacralization, low back pain, Degenerative Spondylolisthesis, Disc Degeneration, Disc Herniation.

INTRODUCTION

The lumbar vertebrae are five in number and they help support the weight of the body, and permit movement. The pedicles of the lumbar vertebrae increase in sagittal width from 9 mm to up to 18 mm at L5. They increase in angulation in the axial plane from 10 degrees to 20 degrees by L5. The fifth lumbar vertebra is at the anterior end of the 9th rib and lies at the Transpyloric plane. Its body is much deeper in front than behind. This makes the Sacro-vertebral articulation prominent. The sacrum is a large, triangular bone formed by the fusing of sacral vertebrae S1–S5. It shows five segments and four pairs of sacral foramina. The ala articulates with the ilium at the L-shaped sacroiliac joints thus forming the pelvic girdle. The upper part of the sacrum connects with the L5 vertebra, and its lower part with the coccyx via the sacral and coccygeal cornua. Its primary functions are to bear the weight of the upper body when sitting as well as in upright posture, transmitting that weight from the axial skeleton to the lower appendicular skeleton during locomotion and in upright posture [1].

The lumbosacral joint, between the sacrum and the last lumbar vertebra, has, like all vertebral joints, an intervertebral disc, anterior and posterior ligaments, ligamenta flava, interspinous and supraspinous ligaments, and synovial joints between the articular processes of the two bones. In addition to these ligaments the joint is reinforced by two ligaments, an Iliolumbar ligament which passes between the tip of the transverse process of L5 vertebra and the posterior part of the iliac crest and the lateral lumbosacral lower border of the transverse

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process of the L5 to the ala of the sacrum. The movements possible in the lumbosacral joint are flexion and extension, a small amount of lateral flexion (from 7 degrees in childhood to 1 degree in adults), but no axial rotation. Between ages 2–13 the joint is responsible for as much as 75% (about 18 degrees) of flexion and extension in the lumbar spine. From age 35 the ligaments considerably limit the range of motions [2].

Lumbosacral transitional vertebrae are congenital anomalies of the lumbosacral region which include sacralisation of fifth lumbar vertebrae and lumbarization of first sacral vertebrae. Lumbarization occurs when the uppermost segment of the sacrum is not fused to the rest of the sacrum but instead it is partially mobile constituting an 'extra' lumbar vertebra, often referred to as L6. Sacralization is described as having one fewer lumbar vertebra because the last lumbar segment (L5) is fused to the sacrum [3].

Both sacroiliac joints, formed between the auricular surfaces of the sacrum and the two hip bones are a plane variety of synovial joint. They are Amphiarthrosis, almost immobile joints enclosed by very taut joint capsules. This capsule is strengthened by the ventral, interosseous, and dorsal sacroiliac ligaments. The most important accessory ligaments of the sacroiliac joint are the sacrospinous and sacrotuberous ligaments which stabilize the hip bone on the sacrum and prevent the promontory from tilting forward [4].

In this study, we focused on the incidence of lumbarisation and so as to enable clinicians and radiologists to investigate patients complaining of low back pain or even disc prolapses. It would also be helpful for anaesthetics in performing procedures like lumbar puncture and spinal anaesthesia. Improper numbering can lead to difficulties in lumbar puncture and with administration of epidural blocks.

MATERIALS AND METHODS

Hundred adult dry human sacra were examined in the Department of Anatomy of K. J. Somaiya Medical College. The analysis was done with respect to the number of sacral foramina present. Any variations in the number of sacral vertebrae were noted.

The following were selected for a detailed study:

1. The sacra with four segments and three pairs of sacral foramina
2. The sacra in which the 5^{th} lumbar vertebra was fused either completely or partially to the S1 vertebra showing six segments and five pairs of sacral foramina either unilaterally or bilaterally.

Observations:

Out of the 100 sacra examined 72 were found to be normal (72%) having five vertebrae constituting four pairs of sacral foramina.

Remaining 28% showed anatomical anomalies of lumbosacral transitional vertebras with 16% showing anomalies of lumbarisation and 12% showing anomalies of sacralisation. The specimens showing lumbarisation and sacralisation were studied in detail.

From the 16% sacra showing lumbarisation, 10% showed complete fusion and 6% showed partial fusion of L5 vertebra to the S1 vertebra and exhibited 5 pairs of sacral foramina. Among the 12 specimens showing sacralisation, there was no evidence of S1 vertebra and the specimen exhibited 3 pairs of sacral foramina.

	Normal	Lumbarisation		Sacralisation
No. of Specimens (100)		Total	Partial	
	72	10	6	12

In the vertebra which showed complete fusion, transverse process, pedicle and body of L5 was completely fused with that of S1 vertebra, ala of sacrum was formed by contribution of transverse process of L5 vertebra; Sacrum had 5 pelvic sacral foramina and 5 dorsal sacral foramina bilaterally.

In the 6 specimens which showed partial fusion, 4 were incompletely fused, the spine of L5 vertebrae was not fused with S1, leaving behind a large gap between the two spinous processes, On the pelvic surface, the body of L5 was not completely fused with the body of S1anteriorly and a 3-4mm gap which would be for the intervertebral disc could be visualised between the two bodies. On both sides the lamina and the inferior articular process of L5 vertebrae were partially fused with S1, hence the 1^{st} dorsal sacral foramina appeared large and irregular.

In 2 specimens there was complete fusion on right side while the left side showed a complete separation between L5 and S1, hence sacrum had 5 pelvic sacral foramina and 5 dorsal sacral foramina on the right side while on the left side there were 4 pelvic sacral foramina and 4 dorsal sacral foramina.

DISCUSSION

In the lumbosacral region, anatomical variations are common. This can be attributed to the dependency of the sacrum to the load related fusion of the bone structure. Failure to complete the ascending fusion may create a sixth lumbar vertebra, leaving a four piece or lumbarised sacrum [5].

Lumbosacral transitional vertebrae are congenital anomalies of the lumbosacral region which include sacralisation of fifth lumbar vertebrae and lumbarization of first sacral vertebrae. Lumbarization occurs when the uppermost segment of the sacrum is not fused to the rest of the sacrum but instead it is partially mobile. It constitutes an 'extra' lumbar vertebra, often referred to as L6 and contributes to the movements of the spine along with the lumbar vertebrae. Sacralization is often described as having

one fewer lumbar vertebra because the last lumbar segment (L5) is fused to the pelvis. It can either be fused to the sacrum below termed as central sacralisation, or rarely to the ilium at the sides termed as either unilateral or bilateral transverse sacralisation or both [6].

Bertolotti was the first to observe the lumbosacral transitional vertebra and classified them on the type of articulation between the transverse process of L5 and the sacrum [7]. Later Castellvi et.al classified the Lumbosacral transitional vertebra under 4 types: Type I includes unilateral (Ia) or bilateral (Ib) dysplastic transverse process, with a measured width of at least 19 mm. Type II includes incomplete unilateral (IIa) or bilateral (IIb) sacralization/ lumbarization with an enlarged transverse process which has pseudarthrosis with adjacent sacral ala. Type III includes unilateral (IIIa) or bilateral (IIIb) lumbarization/ sacralization with enlarged transverse process which is completely fused with the adjacent sacral ala. Type IV is mixed which include Type IIa on one side with Type IIIa on other side [8].

Castellvi et.al classified the Lumbosacral transitional vertebra under 4 types, on the basis of morphology (Table 1) but this classification system does not make a distinction between lumbarization (4-segment sacrum) and sacralization (6-segment sacrum) separately, and interchangeably uses the terms sacralization and lumbarization; the prevalence of LSTV is estimated at 12.5% (range, 4.0%– 35.9%).

In the current study we observed 10 specimens showing Castellvi's Type IIIb lumbarisation (bilateral complete fusion), 4 specimens showing Castellvi's Type IIb of lumbarisation (bilateral incomplete fusion) and 2 specimens showing Castellvi's Type IV of lumbarisation (Type IIa on one side with Type IIIa on other side). The classifications in the present study range from complete fusion of vertebrae to incomplete fusion of parts of the vertebrae. A number of studies have been done on lumbar sacralisation. The incidence of Sacralization of L5 in literature ranges between 3.6 to 21% [9,10,11,12,13,14,15,16,17] This can be due to a lack of a comprehensive classification scheme that can be used to differentiate lumbosacral variation according to morphological, developmental, and clinical variants [18].

Bertolotti's syndrome is characterized by sacralisation of the L5 vertebra resulting in pain along the 5th lumbar nerve root with constrained movements at the lumbo-sacral joint. This is then recompensed for by higher segments. Full fusion bilateral sacralisation results in accelerated strain and consequent degeneration through the L4 disc level. The centre of gravity at the base of the spine passes which passes through L5 and is the seat of spinal movement is raised. This is now altered and L4 becomes the 'new' spinal base. But it is deficient in protection rendered to L5 vertebra; as there are strong ligaments securing L5 to the sacrum. This can cause overuse syndrome and developmental instability of the L4 segment [7].

Sacralization of L5 vertebra is more common than lumbarization. The incidence between these anomalies is 2:1. Sacralization may be due the congenital anomaly or traumatic or age-related change which affects the normal biomechanics of the spine [19]. Mahato reported 3.9% of sacra with lumbarization, 2.1% with partial and 1.8% with complete separation of the S1. In sacra with partial lumbarization, parameters were normal but in those with complete lumbarisation parameters were smaller than normal [20]. Deepa et al 2013 reported 2 (1.7% vertebrae out of 117 sacra showing lumbarisation and 12 with sac [21]. Vandana A et al., (2011) reported 18.4% lumbosacral transitional vertebra of which 14.1% cases of sacralization and 4.3% cases of lumbarization [22]. In the current study, the prevalence of sacrum with three pairs of sacral foramina is 12%.

Identification of lumbosacral transitional vertebrae (LSTV) is crucial for precise resolution of the number of vertebrae and also to determine position of viscera which conforms to the specific vertebral level. Unilateral partial sacralisation is a challenging variant of sacralisation as its outcome is a complex one-sided disturbance of the biomechanics through the base of the spine. Hence, management of lumbar sacralisation commonly comprises of strengthening exercises of spine muscles particularly multifidus which has to be reinstructed to strengthen L4 vertebra as the raised seat of spinal movement. Simultaneously, stronger abdominal muscles will also generate a stronger retentive wall anteriorly [23].

Embryological Basis

The occurrence of lumbosacral transitional vertebrae is related to its embryological development. Embryologically, the vertebra is formed from caudal half of one sclerotome and from the cranial half of succeeding sclerotome. Thus, lumbosacral transitional vertebras are caused by the border shifts. Sacralisation of fifth lumbar vertebra is due to cranial shift and the lumbarisation of first sacral segment is due to caudal shift. Defect in formation, migration, differentiation, segmentation and union of somites result in anomalous spine. Two or more vertebra that are normally separated may be fused with each other completely or partially [24,25].

Genetic factors are responsible for the segmental development of the lumbosacral spine [26]. Absence of Hox 11 and Hox 10 function, results in sacral vertebrae not being formed and instead these vertebrae assume a lumbar identity [27]. Thus proving that changes in the axial pattern can result in Lumbosacral transition vertebra due to mutations in the Hox10 and Hox11 paralogous genes. Ossification defects can also be a probable basis of variation but it is extremely difficult to differentiate between ossification defects and developmental defects as both results in the same morphology [28].

Observations

Figure-1: Photographic presentation showing Pelvic Surface of Complete Fusion of fifth lumber vertebra and Sacrum. Sacrum showing 5 pairs of Pelvic sacral foramina.

Figure-2: Photographic presentation showing Dorsal Surface of Complete Fusion of fifth lumber vertebra and Sacrum. Sacrum showing 5 pairs of Dorsal sacral foramina.

Figure-3: Photographic presentation showing Pelvic Surface of Incomplete Fusion of Body of fifth lumber vertebra and Sacrum.

Figure-4: Photographic presentation showing Dorsal Surface of Incomplete Fusion of Lamina of L5 vertebra and Sacrum. Sacral Canal is open.

Figure-5: Photographic presentation showing complete fusion on left side while complete separation on right side between L5 and S1, hence sacrum had 5 pelvic sacral foramina on left side and 4 pelvic sacral foramina on rightside.

Figure-6: Photographic presentation showing complete fusion on left side while complete separation on right side between L5 and S1, hence sacrum had 5 dorsal sacral foramina on left side and 4 dorsal sacral foramina on right side.

Other factors responsible for lumbosacral transitional vertebrae could be trauma, extreme arthritic changes and deliberate spinal fusion surgery [29].

Clinical Significance

Lumbosacral transition vertebrae can cause lower back pain along with buttock pain, limited ipsilateral flexion, reduced mobility, muscle spasms, decreased coordination and flexibility, sciatic or radicular pain patterns and chronic back pain. Lumbarisation or sacralisation with inadequate articulation and variant anatomy of the vertebrae can lead to faulty biomechanics of spine causing low back pain. The consequences of the sacralisation may be the degenerative spondylolisthesis, disc herniation, low back pain and disc degeneration [30].

A sacrum with three pairs of sacral foramina can have not only clinical but also medicolegal consequences. Malanga and Cook reported wrong level emergency decompression in a patient with a Cauda equina syndrome, due to overlooking of complete lumbarization of S1. Improper numbering can tentatively lead to difficulties with the administration of epidural or subarachnoid blocks in

patients with lumbosacral transitional vertebra. Hence, to evade interventions at an inappropriate level, it is essential to identify the lumbarisation of first sacral vertebra and the sacralisation of fifth lumbar vertebra making it clinically relevant [31]. The present study of Lumbosacral transition vertebrae lays emphasis on variations of lumbarisation and sacralisation, and is important for anatomists, radiologists, morphologists, anaesthetists and forensic experts. Awareness of this variation is vital to diagnose lower back pain, sciatica, disc prolapse and is useful in procedures like lumbar puncture and epidural blocks.

Table 2. Comparison of incidences of lumbar sacralisation with our study

Author	Incidence (%)
Moore & Illinois (1925)	3.6
Brailsford (1928)	8.1
Bustami (1989)	16.0
Chaijaroonkhanarak *et al.* (2006)	4.4
Rajani Singh (2012)	16.6
Kubavat et al (2012)	11.10
A.H.M. Mostafa Kamal (2013)	21.1
Karan et al (2013)	6.6
Drakshayini. B. Kokati (2018)	11.42
Current study (2020)	16.0

CONCLUSION

Mutations in the HOX 10 and HOX 11 paralogous genes affect the normal pattering of lumbar and sacral vertebra as well as the changes in the axial pattern, such as lumbosacral transition vertebrae. The consequences of the sacralisation may be the degenerative spondylolisthesis, disc herniation, low back pain and disc degeneration. A sacrum with three pairs of sacral foramina has clinical and medicolegal implications. Identification of lumbosacral transitional vertebrae (LSTV) is crucial for precise resolution of the number of vertebrae. Awareness of this variation is vital to diagnose lower back pain, sciatica, disc prolapse and is useful in procedures like lumbar puncture and epidural blocks. It is also important for anatomists, radiologists, morphologists and forensic experts.

Competing interests:

The authors declare that they have no competing interests.

Authors' contributions:

SR drafted the manuscript, performed the literature review & SPS assisted with writing the paper.

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REFERENCES

1. Gray Henry, Gray's Anatomy (2005) –The anatomical Basis of Clinical Practice, Edited by Standring Susan; 39th ed., Reprinted 2006. Spain; Elsevier –Churchill Living stone, 528-531 P.
2. Frazer JE. (1958); Anatomy of the human skeleton, 5th edn; edited by Breathnach ASJ and A (Churchill Livingstone London) 33-38.
3. Singh Inderbir, Text book of Anatomy –volume II (2011); Thorax, Abdomen & Pelvis, 5th ed., New Delhi; Jaypee Brothers Medical Publishers (P) Ltd, 152-156 P.
4. Hollinshed WH (1961); Anatomy for surgeons, volume 3; The back and limbs, Chap-2 (The back Hoeber Harper publication) 92-119.
5. Joseph S Cheng MD, John K Song MD (2003); Anatomy of the Sacrum. Neurosurg Focus; 15(2)
6. Bron LJ, Van Royan BJ and Wuisman P. (2007); The Clinical significance of lumbosacral transitional anomalies; Acta orthopaedica Belgica; 73(6) 687-95
7. Bertolotti M (1917). Contribution to the Knowledge of the Vices of Regional Differentiation of the Spine with special regard to the Sacral Assimilation of Lumbar Vertebrae. Medical Radiology; (4): 113-114P.
8. Castellvi A.E, Goldstein L.A, Chan D.P.K (1984), Lumbosacral Transitional Vertebrae and their Relationship with Lumbar Extradural Defects. Spine; 9. 493-495.
9. Moore BH, Illinois C (1925); Sacralization of the fifth lumbar vertebra. J Bone Joint Surg;7:271-278.
10. Brailsford JF (1928); Deformities of the lumbosacral region of the spine. Brit J Surg; 16:562-627.
11. Bustami F (1989); The anatomical features and functional significance of lumbar transitional vertebra. Jordan Med J;23:49-59.
12. Chaijaroonkhanarak W, Umka J, Buranarugsa M, Namking M. (2006) Sacralization of the 5th lumbar vertebra in Thais; Srinagarind Medical Journal; 21(3):23-27.
13. Rajani Singh (2012); Analytical view of the simultaneous occurrence of sacralisation and congenital anomalies. Eur J Anat;16(2):127-130.

14. Kubavat DM, Nagar SK, Lakhani C, Ruparelia SS, Patel S, Varlekar P (2012); A study of sacrum with three pairs of sacral foramina in Western India. Int J Med Sci Public Health; 1:127-131.
15. A.H.M. Mostafa Kamal et al; Sacralization: Sacrum with Five Pairs of Sacral Foramina (2013); Bangladesh Journal of Anatomy July, Vol. 11, No. 2 pp. 54-57
16. Karan B K, Manisha B R. Sacralisation of lumbar Vertebra (2013); Indian Journal of Basic & Applied Medical Research;;6(2):510-514.
17. Drakshayini. B. Kokati, Shubha Nivargi (2018); A study of sacralisation of fifth lumbar vertebra in South Indian population; Int J Anat Res;6(1.3):5004-5006. DOI: 10.16965/ijar.2017.536
18. Mehmet Bulut, Bekir Yavuz Uçar, Demet Uçar, İbrahim Azboy, Abdullah Demirtaş, Celil Alemdar, Mehmet Gem, Emin Özkul; (2013) "Is Sacralization Really a Cause of Low Back Pain?", International Scholarly Research Notices, vol. 2013, Article ID 839013, 4 pages; https://doi.org/10.1155/2013/839013.
19. Savage C (2005); Lumbosacral transitional vertebrae: Classification of variation and association with low back pain. A thesis presented to the faculty of the graduate school University of Misssouri-columbia.
20. Mahato NK. (2010); Morphological traits in sacra associated with complete and partial lumbarization of first sacral segment; Spine 10(10)910-915.
21. Deepa TK, Martin KJ (2014); A study of lumbarisation of first sacral vertebra among the south Indians; Int J Med Res Health Sci;3(1):1-4.
22. Vandana A. Sharma Dr, D K Sharma Dr, D K Sharma C.K. Shukla (2011); Oesteogenic Study of Lumbosacral Transitional Vertebra in Central India Region; December;Journal of the Anatomical Society of India 60(2):212-217
23. Schmori G, Junghanns H (1971); The human spine in health and disease (2nd American Edition); Edited and translated by Basemann EF. New York: Grune & Stratton; 186-198.
24. Datta A.K, Essential of Human Embryology; 4th ed. 2000; Calcutta; Current Book International; 291-292 P.
25. Keith. L. Moore, T.V.N. Persaud (1973); The Developing Human, Clinically Oriented Embryology Skeletal system; 7th ed.; 1st Indian Print 2003, New Delhi, A Division of Reed Elsevier India Pvt. Ltd, 336-393P.
26. Tini PG, Wieser C, Zinn WM (1977); The transitional vertebrae of lumbosacral spine: its radiological classification, incidence, prevalence and clinical significance. Rheumatology & rehabilitation;16(3) 180-85.
27. Wellik DM, Capecchi MR (2003); Hox 10 and Hox 11 genes are required to globally pattern the mammalian skeleton; Science; 301: 363-67.
28. Sadler TW. Langman's Medical Embryology (2010); Lippincott Williams & Wilkins, Philadelphia: 11th edition :142.
29. Kim NH, Suk KS (1997); The role of transitional vertebrae in spondylosis and spondylolytic spondylolisthesis; Bull Hosp Jt Dis;56(3):161-6.
30. Mahato NK (2010); Variable positions of the sacral auricular surface: classification and importance; Neurosurg Focus; 28: E12.
31. Malanga GA, Cook PM. (2004); Segmental anomaly leading to wrong level disc surgery in cauda equine syndrome; Pain Physician 7(1) 107-110.