

Research article – Basic and applied anatomy

Study on incidence of sacralisation of fifth lumbar vertebra in South Indian population

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Abstract

The lumbosacral region is of interest because of increased incidence of low back pain resulting from stress and strain. The lumbosacral spine supports and transmits weight of the body to the inferior extremity and thus plays an important role in posture. In lumbosacral transitional vertebra either the fifth lumbar vertebra may show assimilation to sacrum (sacralisation) or the first lumbar vertebra may show transition to lumbar configuration (lumbarisation). Due to the association between lumbosacral vertebral anomalies with low back pain, early disc degeneration in young individuals and other spinal pathology, the present study was conducted in the Department of Anatomy, ESIC Medical College & PGIMS, Chennai, India. Sacral bones were observed for sacral cornua, sacral hiatus and variations like sacralisation of fifth lumbar vertebra. Sacralisation was observed in three bones, complete in one and incomplete in two bones. The possible origin of the anomaly and its relevance to clinics are discussed.

Key words

Low back pain, Lumbar vertebrae, Sacralisation, Transitional vertebra

Introduction

The human sacrum is a wedge shaped bone with its base uppermost between two iliac bones at sacroiliac joints, forming posterior wall of pelvis. Its superior wide base articulates with fifth lumbar vertebra at lumbo-sacral angle and its blunt caudal apex articulates with coccyx. Normally there are five sacral vertebrae between fifth lumbar vertebra cranially, and first coccygeal vertebra caudally, forming four pair of sacral foramina.

Lumbo-sacral transitional vertebra is a common congenital anomaly of lumbosacral spine, which includes sacralisation or lumbarisation and is frequently encountered. In sacralisation of 5th lumbar vertebrae, the lumbar vertebra acquires sacral characteristics and articulates with first sacra vertebra. In lumbarisation, the first sacral vertebra shows signs of transition to a lumbar configuration (Hollinshead, 1961). Being fused or semi-fused the L5 segment has more in common with its sacral neighbours than its lumbar ones, so it is said to be sacralised.

Varied forms and degree of sacralisation have been reported in earlier studies such as complete sacralisation consisting of a complete bony union between the abnormal transverse process and the sacrum. Incomplete sacralisation shows presence of a dis-

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tinct joint line between the process and the sacrum. Both forms may be either unilateral or bilateral (Moore, 1925). In frank sacralisation sacrum shows 5 pairs of sacral foramina and 6 vertebral segments. Occult sacralisation is where sacrum is high in pelvis and spinous process of last lumbar vertebra is above the iliac crests (Andrew, 1954).

Sacralisation may be either developmental or due to traumatic/age changes which affect stability of the spine and its bio-mechanics (Williams et al., 1989). L5 sacralisation contributes to the development of orthopaedic diseases like degenerative spondylolisthesis, lumbar disc degeneration, herniation and low back pain (Kong et al., 2008). Due to the association between lumbosacral vertebral anomalies with low back pain, early disc degeneration in young individuals and other spinal pathology, the present study was taken up to study the frequency of sacralisation in the South Indian population. Failure to recognize such vertebral anomalies during spinal surgery may have serious consequences.

Materials and methods

The study was conducted at the Department of Anatomy, ESIC Medical College & PGIMSR, Chennai. We have studied 50 sacral bones for any obvious morphological anomaly. Old, worn out and broken bones were excluded from the study. All the



Figure 1 – Ventral surface of sacrum (Sp. 12) showing five pairs of ventral sacral foramina between six vertebral bodies and incomplete fusion of L5 and S1 vertebra with distinct disc space between them.



Figure 2 – Dorsal surface of sacrum (Sp. 12) showing five pairs of dorsal sacral foramina between laminae and incomplete fusion of laminae between L5 and S1. A prominent L5 spinous process is also seen.



Figure 3 – Ventral surface of sacrum (Sp.18) showing five pairs of ventral sacral foramina between six vertebral bodies and complete fusion of L5 and S1 vertebrae.



Figure 4 – Dorsal surface of sacrum (Sp. 18) showing five pairs of dorsal sacral foramina between six vertebral bodies and complete fusion of the laminae of L5 and S1 vertebrae without any disc space between them.

sacra were observed for any variations like sacralisation and lumbarisation, number of ventral and dorsal sacral foramen, number of vertebral bodies, sacral hiatus and sacral cornua. All the observations were noted and tabulated.

Results

In the present study on 50 sacral bones we observed 3 bones with sacralisation of L5 vertebra. In one there was a distinct residual space present between L5 and S1 whereas in two bones there was no space between them. Bilateral fusion of transverse processes of L5 to ala of sacrum was seen in all the three. Incidence of sacralisation of the fifth lumbar vertebra in the present study was 6%. Complete and incomplete forms of sacralisation were observed in the present study. Two bones showed incomplete form while one sacrum showed complete sacralisation. The three mentioned sacral bones with sacralization of L5 presented with 5 pairs of ventral and dorsal sacral foramina and showed six vertebral bodies; sacral hiatus and sacral cornua appeared to be normal in contour.

Discussion

A transitional vertebra at the lumbosacral junction signifies that one sacral vertebra forms a part of lumbar spine above or that a lumbar vertebra is a part of pelvis



Figure 5 – Ventral surface of sacrum showing five pairs of ventral sacral foramina between six vertebral bodies and incomplete fusion of L5 and S1 vertebrae with a distinct space between them.



Figure 6 – Dorsal surface of sacrum showing five pairs of dorsal sacral foramina between six vertebral bodies and complete fusion of lamina of L5 and S1 vertebrae without distinct disc space between them.

below. A transitional vertebra has characteristics of two types of vertebra. In sacralisation of L5 the individual appears to have four lumbar vertebrae. Conversely in lumbarisation there are six lumbar vertebrae. Sacralisation of fifth lumbar vertebra is most common, compared with lumbarisation (Frymoyer et al., 1991).

The incidence ratio of sacralisation to lumbarisation was reported as 2:1 and this condition is more common in males (Eyo et al., 2001). Castellvi et al (1983) reported an incidence of 1.7-14%, Sharma et al. (2011) of 14.1% in central India and Kubavat et al. (2012) of 11.1% in Gujarat.

Embryologically vertebrae are bi-segmental in development and each vertebra receives contribution from the caudal half of one sclerotome and the cranial half of succeeding one (Breathnach, 1958). The neural arch, pedicles and costal elements develop almost entirely from the dense caudal half of a somite and thus attach to upper half of vertebral body. Thus cranial shift results in sacralisation of the last lumbar vertebra and caudal shift results in lumbarisation of first sacral vertebra. Improper formation, migration, differentiation and union of somites results into segmental vertebral abnormalities. Cranial shifts are dominant over caudal shifts, so sacralisation is more common than lumbarisation (Sharma et al., 2011).

Ossification defects are other potential causes of variation; it is highly difficult to differentiate between ossification and development defect as both results in the

same morphology (Tini et al., 1972). Ossification occurs from 3 primary centres and 7 secondary centres in lumbar vertebrae, that fuse between 17 to 25 years of age. Sacrum has 21 primary and 14 secondary centres and completes ossification at 25 years of age. Any defect in these ossification centres leads to variant morphology of the vertebrae (Sharma et al., 2011).

Genetic factors have also been implicated in the segmental development of the lumbosacral spine. In absence of Hox 11 function, sacral vertebrae are not formed and instead these vertebrae assume a lumbar identity (Sadler, 2010). The association of lumbosacral transitional vertebra and low back pain is known as Bertolotti's syndrome. This syndrome is characterized by a variation of the fifth lumbar vertebra having a large transverse process, either articulated or fused with the sacral base or the iliac crest and producing a chronic, persistent low back pain due to arthritic changes occurring at the site of pseudoarthrosis (Bertolotti, 1917).

Sacralisation is not necessarily related to low backache; it may remain asymptomatic for many years, but later may give rise to pain due to compression of nerve trunks, ligament strain or pseudoarthrosis of the anomalous joint. Eyo et al. (2001) reported 50% chance of getting low back pain in patients with sacralisation. In an anatomical study on 70 cadavers, ilio-lumbar ligament above L5 was much thinner and weaker than normal which explained why this would have been a causative factor for low backache and the importance of its identification in patients with low backache should not be ignored (Aihara et al., 2005).

A sacralised vertebra alters the biomechanics of lumbar spine. There is limited motion between L5 and sacrum due to anomalous articulation or bony fusion. At the level of fusion the load is effectively absorbed by the fused transverse process or aberrant joint, decreasing motion and relieving stress on the intervertebral disc and thereby preserving disc integrity, whereas there is resultant overwork on the disc one level higher causing arthritis, disc changes and spinal cord compression. Therefore increased disc degeneration above the sacralised vertebra is attributed to its relative hypermobility (Steinberg et al., 2003). Abnormal torque movements are produced above the sacralised vertebra because of fixation of L5 to S1 which results in degeneration of intervertebral disc above the sacralised vertebra (Aihara et al., 2005). Lumbosacral intervertebral disc becomes narrow and the intervertebral disc above the sacralised vertebra degenerates causing disc protrusion and herniation (Tini et al., 1972; Aihara et al., 2005). Nerve root stenosis was found over the sacralised vertebra which may also explain low backache.

Sacralisation demands vigilance and modifications during anaesthetic and surgical intervention. It leads to formation of differential active motion segments and may be associated with non-traumatic lower back pain and spinal pathology. Knowledge of sacralisation or lumbarisation is important for orthopaedic and neuro-surgeons operating in this region to avoid surgery at an incorrect level and also for anaesthetists during administration of intradural and epidural anaesthesia.

Variations such as sacralisation are important for radiologists while reporting computerized tomography, magnetic resonance imaging, single photon emission computed tomography and X-rays for correct clinical and radiological assessment and for physicians to rule out secondary spinal disorders like disc degeneration, disc herniation or facet arthritis.

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References

- Aihara T., Takahashi K., Ogasawara A., Itadera E., Ono Y., Moriya H. (2005). Intervertebral disc degeneration associated with lumbosacral transitional vertebrae: clinical and anatomical study. *J. Bone Joint Surg. Br.* 87: 687-691.
- Andrew J. (1954). Sacralization: An aetiological factor in lumbar intervertebral disk lesions, and a cause of misleading focal signs. *Br. J. Surg.* 42: 304-311.
- Bertolotti M. (1917). Contributo alla conoscenza dei vizi di differenziazione regionale del rachide con speciale riguardo all'assimilazione sacrale della V lombare. *Radiol. Med.* 4: 113-144.
- Breathnach A. S., Ed. (1958). *Frazer's Anatomy of the Human Skeleton*. 5th edn. J. & A. Churchill, London. Pp. 33-38.
- Castellvi A. E., Goldstein L. A., Chan D. P. K. (1983). Lumbosacral transitional vertebrae and their relationship with lumbar extradural defects. *Spine* 9 :493-495.
- Eyo M. U., Olofin A., Noronha C. Okanlawon A. (2001). Incidence of lumbosacral transitional vertebrae in low back pain patients. *West Afr. J. Radiol.* 8: 1-6.
- Frymoyer J. W., Hadler N. M., Kostuik J. P., Weinsttein J. N., Whitecloud T. S. (1991). *The Adult Spine: Principles and Practice*. Vol. 2. Raven Press, New York. P. 2099.
- Hollinshead W. H. (1961). *Anatomy for Surgeons*. Vol. 3: The Back and Limbs. Hoeber-Harper, New York . Pp. 92-119.
- Kong C. G., Park J. S., Park J. B. (2008). Sacralisation of L5 in radiological studies of degenerative spondylolisthesis at L4 L5. *Asian Spine J.* 2: 34-37.
- Kubavat D., Nagar S. K., Malukar O., Trivedi D. (2012) A study of sacralization of fifth lumbar vertebra in Gujarat. *Natl. J. Med. Res.* 2(2): 211-213.
- Moore B. H. (1925). Sacralisation of the fifth lumbar vertebra. *J. Bone Joint Surg. Am.* 7: 271-278.
- Sadler T. W. (2010). *Langman's Medical Embryology*. 11th edn. Lippincott Williams & Wilkins, Philadelphia. P. 142.
- Sharma V. A., Sharma D. K., Shukla C. K. (2011). Osteogenic study of lumbosacral transitional vertebra in central India region. *J. Anat. Soc. India.* 60: 212-217.
- Steinberg E. L., Luger E., Arbel R., Menachem A. Dekel S. (2003). A comparative roentgenographic analysis of the lumbar spine in male army recruits with and without lower back pain. *Clin. Radiol.* 58: 985-989.
- Tini P. G., Wieser C., Zinn W. M. (1977). The transitional vertebra of the lumbosacral spine: its radiological classification, incidence, prevalence and clinical significance. *Rheumatol. Rehabil.* 16: 180-185.
- Williams P. L., Warwick R., Dyson M., Bannister L. H. (1989) *Gray's Anatomy*. 37 edn. Churchill Livingstone, Edinburgh.